EVERYDAY WITH PRACTICAL ELECTRONICS

JUNE 1993

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.80

FUZZY LOGIC EXPLAINED
We investigate the growth technology of the nineties

QUIZ MONITOR

SNOOKER SCOREBOARD

IMMERSION HEATER CONTROLLER

TEACH-IN '93 – EXPERIMENTS WITH FIBRE OPTICS

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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. **£19.00 ref 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

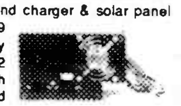
IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R. 3 metre version £6.00 ref 6P50.

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

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 aerial & 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!

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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INCORPORATING ELECTRONICS MONTHLY

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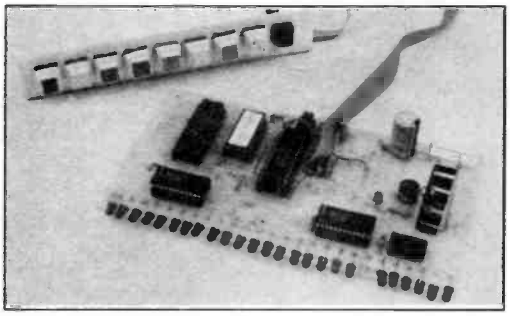
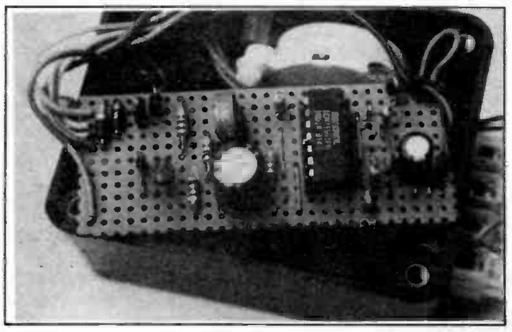
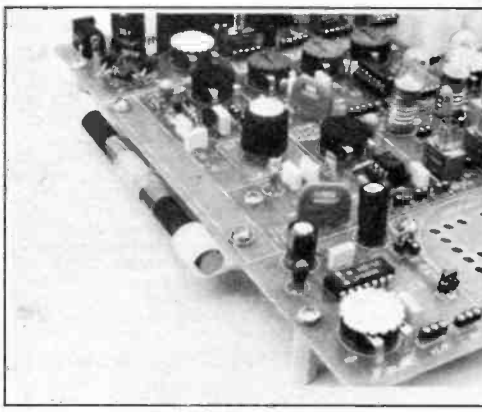
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







Our July '93 Issue will be published on Friday, 4 June 1993. See page 395 for details.

Projects

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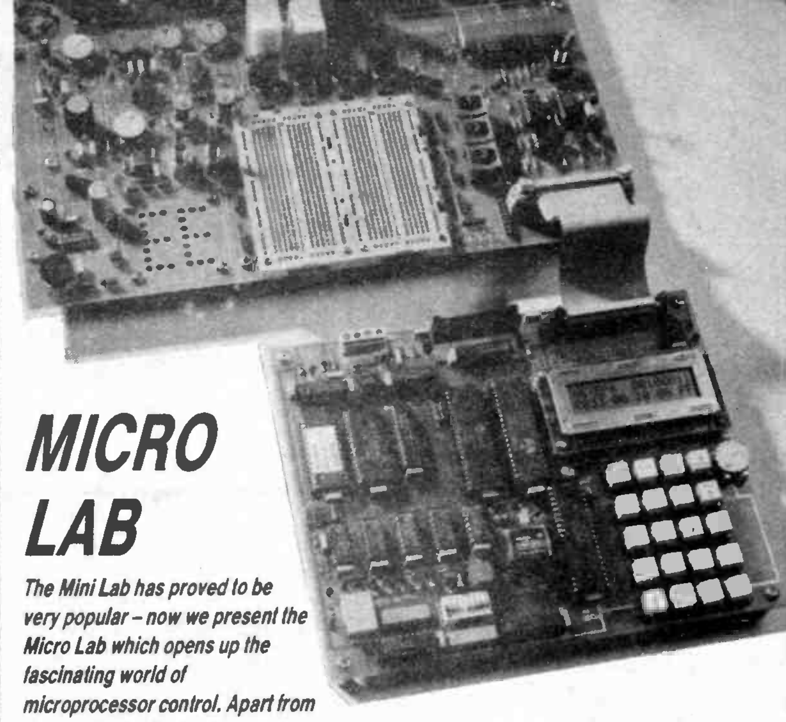
Features

NEXT MONTH



MICRO LAB

The Mini Lab has proved to be very popular – now we present the Micro Lab which opens up the fascinating world of microprocessor control. Apart from demonstrating the basic aspects of these devices, the Micro Lab is also a general-purpose 8-bit microprocessor control unit which can form the heart of many control and measurement systems. It features built-in demonstration routines and a custom written user-friendly operating system to make life as painless as possible.

Don't miss this exciting micro development board.

SOLAR WALKMAN SUPPLY

"Green power" for your personal stereo or radio. This unit employs a 10 x 12 cm solar panel and NiCad cells to provide the power. The panel gives up to 100mA charge to the cells which fill-in when the sun goes in. Just right for those beach holidays and it could show a good saving on battery costs.

XENON STROBE

The stroboscope described in this article is a mains-powered piece of apparatus which provides brief bursts of intense blue-white light at a flash rate adjustable from about 3Hz up to 260Hz. A xenon flash tube is used as the light source, and an external opto isolated trigger input is provided so that the flashes may be synchronised to an external signal source.

The energy output is greater than 100mJ below 60Hz and 30mJ at 250Hz.

MODERN MANUFACTURING TECHNIQUES

We investigate one of the most important developments ever in the electronics industry. Surface mount technology has many advantages but requires some sophisticated techniques and equipment to build p.c.b.s. We show you the components, the equipment, the techniques and the finished boards.

EVERYDAY WITH PRACTICAL ELECTRONICS

JULY ISSUE ON SALE FRIDAY 4th JUNE

BARGAINS – Many New Ones This Month

P.C. OPERATING SYSTEMS. Fully user documented and including software. MS-DOS 3.20, £5, Order Ref. 5P207: MS-DOS 3.3, £5, Order Ref. 5P208: MS-DOS 4.01, £10, Order Ref. 10P99.
720k 3½" FLOPPY DISKS. Double sided. By top maker (Epson). 4 for £1, Order Ref. 914.
PUSH BUTTON EDGE SWITCH gold plated contacts, 1A 50V. Top push counts up, bottom push counts down. BCD switching. Switches clip together. 2 for £1, Order Ref. 915.
DC VOLTAGE REDUCER 12V-6V @ 500 mA on quite small pcb with heatsink. £1, Order Ref. 916.
CAR SOCKET PLUG tubular construction to take small pcb etc. £1, Order Ref. 917.
THIS COULD SAVE YOU EXPENSIVE BATTERIES an in-car unit for operating 6V radio, cassette player, etc. from car lighter socket. £2, Order Ref. 2P318.
READY BUILT ·5W FM TRANSMITER tested and working. Very compact unit, with electret microphone, 3V operated, £6, Order Ref. 6P29. Will fit, with batteries, in our project box, Order Ref. 876.
METAL PROJECT CASE nickel plated, size 15½ x 5½ x 2½" so ideal to take the Philips laser with its power supply or just a power supply. Has instrument type mains input plug, output socket and built in on/off switch. £7.50, Order Ref. 7.5P9.
SUPER STRIPPER originally intended to be a power supply unit, this has many top class, easily removable, components including 2 power mosfets, power rectifiers, 2 HF transformers, a complete mains input fused and filtered, plus dozens of other top class components. Component value probably over £50, yours for only £5, Order Ref. 5P212.
WIRE WOUND RESISTORS mainly 5W and 6W. Almost a complete range available with prices from **20p** each for small quantities, to **10p** each for 100 of a value. Just order values required or send for list.
SILENT EFFORTLESS MOVEMENT with our 14mm ballrace complete with removable spindle. 4 for £1, Order Ref. 912.
45A DOUBLE POLE MAINS SWITCH mounted on a 6 x 3½ aluminium plate, beautifully finished in gold, with pilot light. Top quality, made by MEM, £2, Order Ref. 2P316.
FULLY ENCLOSED MAINS TRANSFORMER on a 2m 3 core lead terminating with a 13A plug. Secondary rated at 6V 4A. Brought out on a well insulated 2 core lead terminating with insulated push on tags. £3, Order Ref. 3P152. Ditto but 8A. Order Ref. 4P69.
ILLUMINATION PANEL. 16 6V bulbs, coloured red with a foil reflector panel. Intended for any log effect fire. £2, Order Ref. 2P317. (The transformer described above, Order Ref. 3P152, is the one intended to operate this).
SWITCHED BC CORD GRIP LAMPHOLDERS. Always useful. A good make, 3 for £1, Order Ref. 913.
SCREWDRIVERS – pocket sized. Will save you having to worry where you left the last one! 10 for £1, Order Ref. 909.
STEPPER MOTOR BARGAIN. This is just a mini motor, 12V operated and 7.5° step angle. Offered at the very low price of only £1, Order Ref. 910.
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.
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.
INSULATION TAPE 5 rolls of assorted colours, only £1, Order Ref. 911.
GENERAL PURPOSE FAN KIT comprises beautifully made "Boxer" fan, transformer and switch to give dual speed and off from the mains. Complete kit £6, Order Ref. 6P28.
DOUBLE HEADPHONE OUTLET. A standard type stereo plug with 2 leads coming out, each terminating with a standard size stereo socket thus enabling 2 people to listen from the one outlet. Very well made. Price £2, Order Ref. 2P312.
12V POWER SUPPLY. Plugs into 13A socket and gives 200mA d.c. out. Price £2, Order Ref. 2P313.
ASTEC 135W PSU. Mains input, 3 outputs;- +12V at 4A, +5V at 16A, and −12V at ½A. In plated steel case, brand new, £9.50, Order Ref. 9.5P4.
INFRA RED RECEIVER CONTROLLER made by Thorn to channel switch their T.V. receivers. Mounted on panel with luminous channel indicator, mains on/off switch, leads and plugs all yours for £2, Order Ref. 2P304.
HIGH QUALITY KEY SWITCH single pole on/off or changeover through panel mounted by hexagonal nut. Complete with 2 keys. Regular price £3, our price £1.50, Order Ref. 1.5P12.
DIGITAL MULTI TESTER M3800 single switching covers 30 ranges including 20A a.c. and d.c. 10 meg input impedence, 3½ LCD display. Complete with lead. Currently advertised by many dealers at nearly £40, our price only £25, Order Ref. 25P14.
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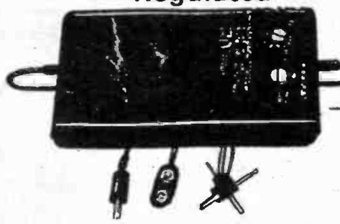

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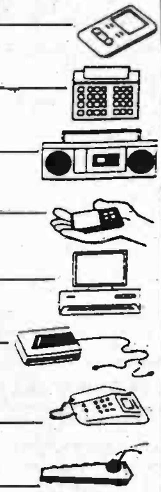

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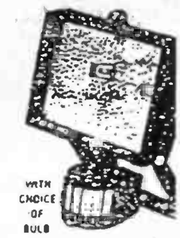

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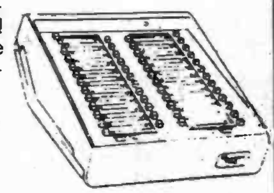

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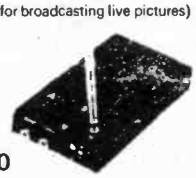

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VOL. 22 No. 6 **JUNE '93**

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FUZZY FUTURE

Anyone who takes a Sunday paper and is interested in technology cannot have failed to notice how, quite suddenly, everything from cars to videos is being advertised as using fuzzy logic. A few years ago fuzzy seemed to be something of a joke. Then we heard that the Japanese were designing a new computer system to control the Tokyo underground and that it would use fuzzy logic.

Once again a Western idea (fuzzy was developed in the U.S.A. by Professor Lofti Zadeh in 1965) had been taken up by the Japanese. The very name of the "new" form of logic is off-putting and probably did not help it to be taken seriously. Now we are stuck with the name perhaps it is time that we found out just what all the fuzzy fuss is about.

UNDERSTANDABLE

I must admit that although I had picked up some idea of how fuzzy "worked", until recently I had not seen an easy to understand explanation. Indeed one or two authors who we asked to write about fuzzy also seemed to be unsure, or should I say a little fuzzy about the subject (no, perhaps I should not).

Anyway an approach to Ross Bannatyne who works for Motorola in Scotland finally cracked the problem. I am sure you will agree his article provides an easy to understand description of the basis of fuzzy logic. So now when you read those ads. proudly proclaiming that the latest technological whizz-bang uses fuzzy logic all you have to wonder about is whether you can afford one.

No doubt fuzzy will revolutionise the user friendliness and smooth operation of everything from microwave cookers and irons, to computers, cars and robots. At least it will allow even more "revolutionary" products to be designed and give the technology selling machine, that the consumer electronics industry thrives on, another angle with which to continue to sell ever developing products.

The sales pitch seems to be "the logic that allows equipment to think like a human being". It's already in cars and camcorders, and microwave cookers that know what is in them will be here soon. The fuzzy future is about to be launched by the high tech, companies.

Mike Kenward

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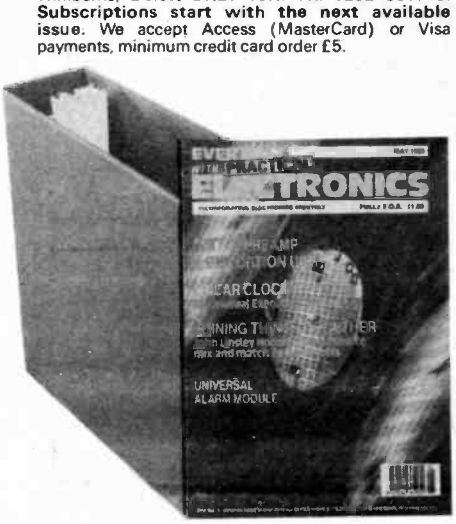

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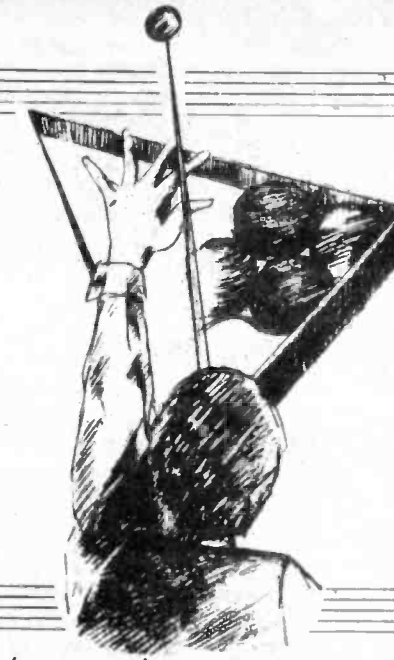
Constructional Project

ELECTRONIC SNOOKER SCOREBOARD



TREVOR BROWN

Make a break from tradition with this high-tech score accumulator. With all the action of the "green baize" at your fingertips, you can cue the scores of the champions.

SNOOKER is a traditional game that can trace its origins back to Mary Queen of Scotts. The original game bore little resemblance to today's version, the tables were bare wood with no felt or cushions. The game was refined and added to as the years progressed, but the scoreboard seems to have been neglected, the system of sliding wooden pointers seems to have escaped through the ages with little updates or changes until now.

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 scoreboard resets, after first testing the lamps and sounding the buzzer, ready for the next game.

A microprocessor is used to read the push buttons, make the necessary calculations and up date the display. The software is stored in a pre-programmed EPROM so no involvement with it is needed.

However the programme is documented (available from *EPE Editorial Offices* – see *Shoptalk*), so that those who wish to delve into this black art may do so. The Z80 microprocessor used is purported to have one of the most humanly understood instruction sets, and as many helpful comments as possible have been added to the full source code listing, so as to present the software in a friendly form.

DISPLAY

The l.e.d. display is laid out in just the same way that the traditional wood pointers were. The first 19 l.e.d.s represent the score 1 to 19 and only one of these l.e.d.s is illuminated at once. The next l.e.d. has the value 20, and then 40, and then 60 incrementing up to 140 and only one of these l.e.d.s is illuminated at once so the score is the addition of the two l.e.d.s (159 maximum).

This display was chosen so as to be as near to the old wooden sliding pointers as possible and thus make the older snooker buffs as happy as possible with this hi-tech unit. The l.e.d.s used were 3mm or 5mm types, if you want to enlarge on this and fit brighter displays then it would be a good idea to fit standard TTL rather than LS chips in place of IC5, IC6 and IC7.

The display shows only one player at once with a switch to alternate the display between players. This system was chosen to keep the cost of the display down.

PUSH BUTTONS

The operational controls are one switch to select which player's score to display and a set of push buttons to update the selected score. The pushbutton switches are colour coded to match the balls so all that is required is to select the player and press the colour button that corresponds to the ball that has been pocketed.

All the pushbutton switches are the normally open kind and are non-latching; with the exception of the Player-1/Player-2 switch which is a push-on push-off type or could even be a simple toggle switch.

OPERATION

When the scoreboard is first switched on and the Reset switch S1 pressed, all the l.e.d.s are tested in a rather eye catching display, then all the l.e.d.s are extinguished. If the Red push button is pressed then the first l.e.d. lights (score 1), if the Yellow button is then pressed l.e.d. one is extinguished and l.e.d. three is illuminated (2 + 1). If Green is now pressed then l.e.d. three is extinguished and l.e.d. six is illuminated (1 + 2 + 3).

If the player switch is now thrown the display will be extinguished. If the Red push button is pressed then l.e.d. one will be illuminated – new player's score. If we switch back to the other player the display will revert to six, the previous player's score.

Should the cue ball be pocketed inadvertently then switch to your opponent and advance his score by four (except for "in-offs" on higher scoring colours) by pressing the Brown/White button. When a score is entered then this is acknowledged by a bleep to give confidence that the key press has been accepted.

CIRCUIT

The complete circuit diagram for the Electronic Snooker Scoreboard is shown in Fig. 1. The basis of the circuit is a Z80 microprocessor IC2 that runs a programme stored in the 2764 EPROM (IC3). These two chips form what must be one of the simplest ever computers.

All computers need a clock oscillator and this one is no exception. It is made from three hex inverter gates IC1f, IC1e and IC1d (74LS04) and associated timing components. The crystal X1 is not critical and can be between 1MHz and 4MHz, the only thing that will be affected is the speed of the lamp test display and pitch of the keyboard sounder.

INTERFACE

The 8255 (IC4) is a computer interface chip that provides 24 input/output lines for the computer. Eight of them are used to input information from the seven non-locking score buttons (S3 to S9) and the eighth (S2) toggle switch or latching push button, that is the Player One/Two selector.

Eight lines are used to carry the score information to the l.e.d.s. This information is coded so as to drive 26 l.e.d.s. The coded score information is decoded by IC5, IC6 (two 74LS154's) and IC7 (74LS42).

One I/O line is used to drive the low impedance sounder LS1, via resistor R9 and the buffer transistor TR1. The resistor R10 in series with the small sounder can have its value increased should the bleep be too loud. The Reset push-button switch S1 is of the push-to-make type along with the score buttons and should be non-latching.

CONSTRUCTION

The unit was put together in a single evening using a single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 832.

The printed circuit board topside component layout and details of the underside (full size) copper foil master pattern are

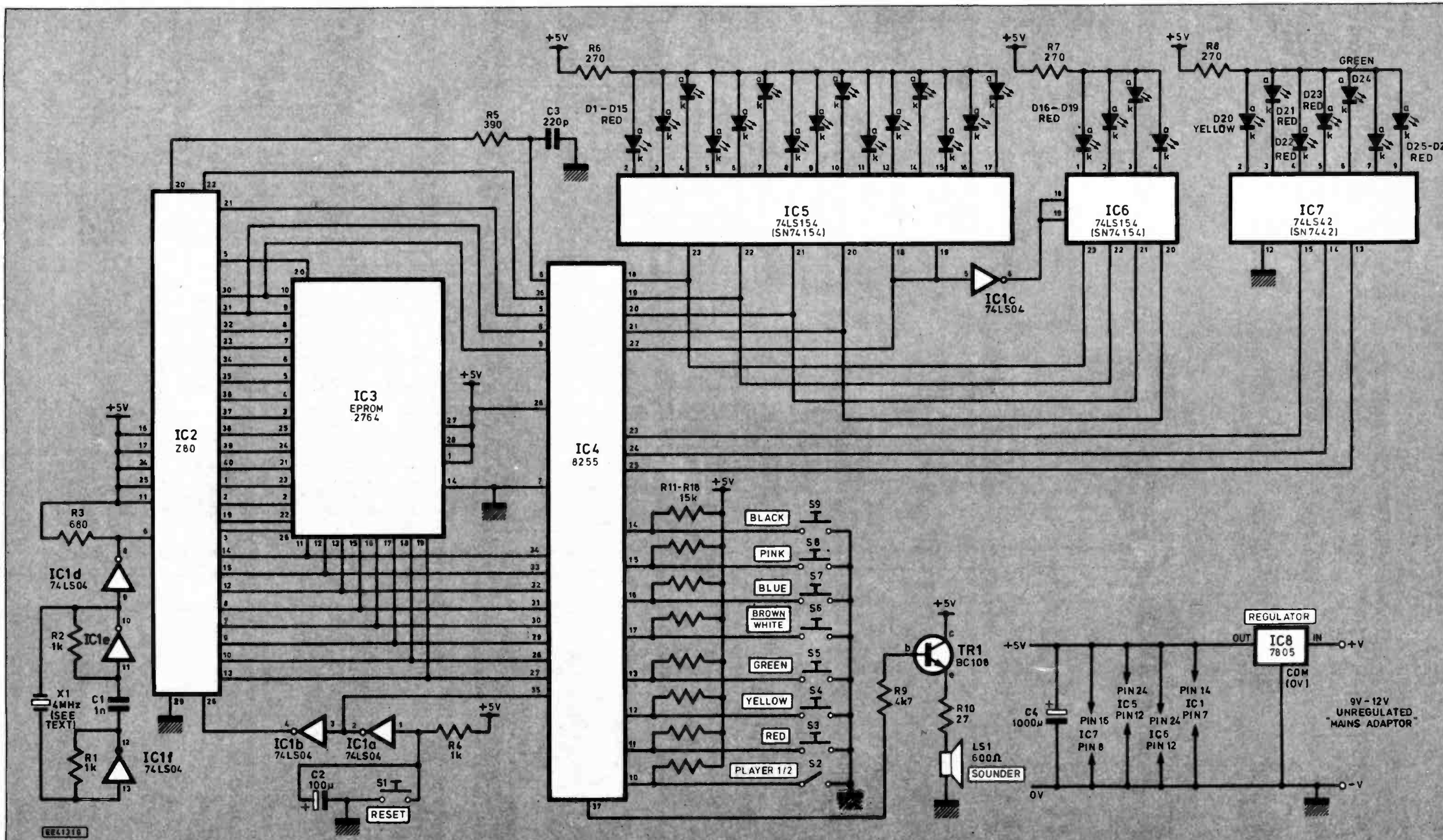


Fig. 1. Complete circuit diagram for the Electronic Snooker Scoreboard. If brighter displays are required then fit standard TTL 7400 series i.c.s in place of the LS devices used for IC5, IC6 and IC7. If a four-point "foul stroke" is made then the Player switch is changed and the Brown/White button is pressed.

given in Fig. 2. There are the inevitable links to fit on the component side of the p.c.b., this is always the price you have to pay when using a single-sided p.c.b., and these should be double-checked before mounting any components. Also, extra care must be taken when soldering as some of the copper tracks are very close together and can easily be "bridged". Good quality sockets should be used for all the chips.

The l.e.d.s are mounted in a single row along one edge of the board, care must be taken to get them the correct way round. (The cathode (k) connection identified by a "flat" on the body). The display can be further improved by using coloured l.e.d.s for the 40, 60, 80 section.

SWITCHES

The pushbutton switches are the normally open kind and are connected to the board via flying leads. The connection pads are located at the side of IC4 and are identified with the colour of the push button, the other (common) connection is to the pad marked *X* which is located at the other side of the pull up resistor (R14-R18). Remember that the push buttons are all non-locking with the exception of the Player 1/Player 2 switch S2 which is a *latching* pushbutton or toggle switch. The pad for this switch is labelled PL.

A solder pad has been provided for the Reset push switch S1 next to, and joining, the positive end of capacitor C1. The 0V (common) connection is made to the other switches, see Fig. 3.

The sounder LS1 is a simple earpiece or small moving coil microphone with an impedance of around 600 ohms. The series resistor R10 may have its value changed if it proves to be too loud.

POWER SUPPLIES

The whole unit is powered from a single five volt rail, but an on board regulator IC8

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R4	1k (3 off)
R3	680
R5	390
R6, R7, R8	270 (3 off)
R9	4k7
R10	27 (see text)
R11 to R18	1k to 15k (not critical – see text) (8 off)

All 0·6W 5% carbon film

Capacitors

C1	1n ceramic
C2	100μ tantalum bead, 16V
C3	220p ceramic
C4	1000μ radial elect., 25V

Semiconductors

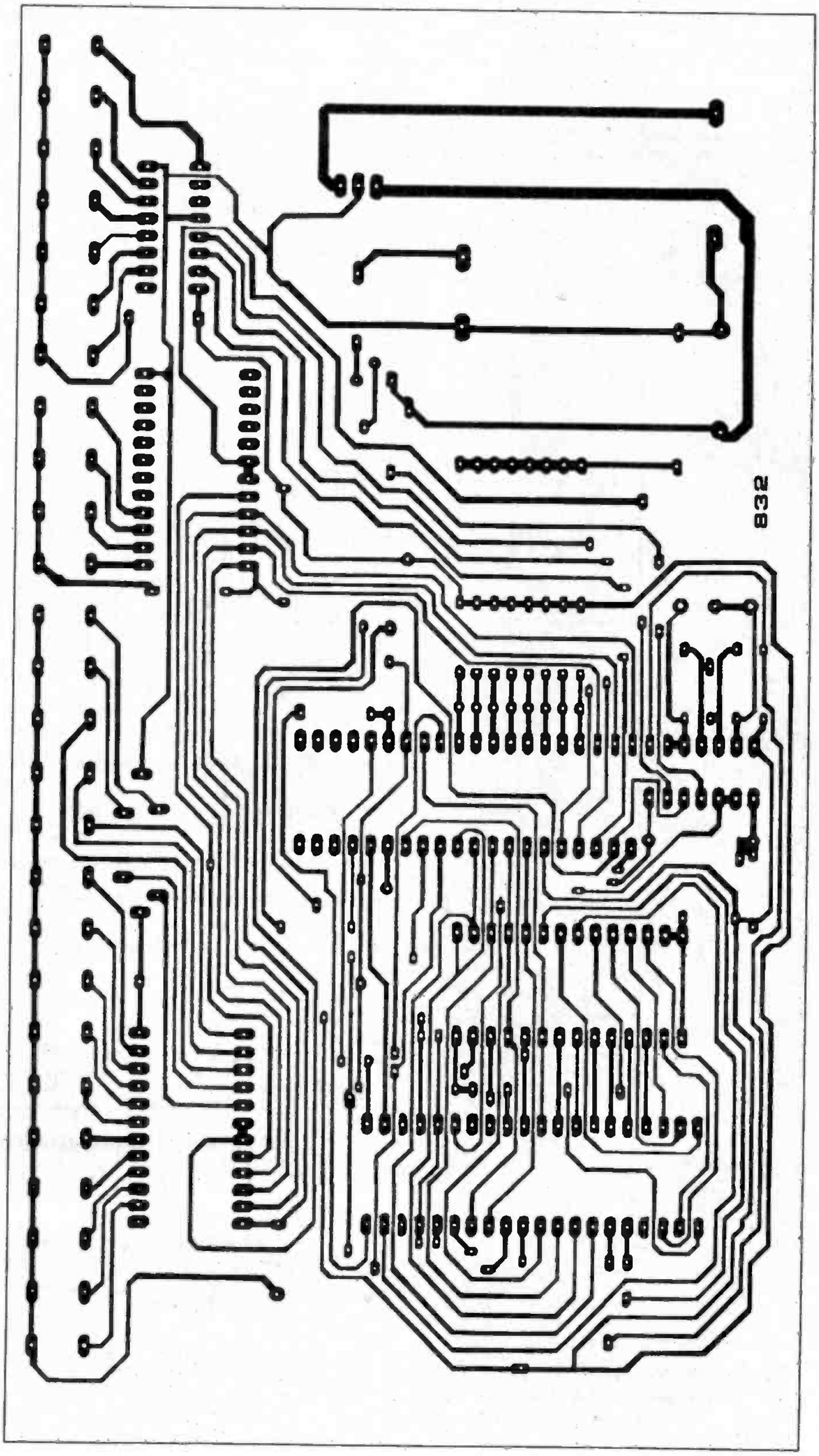
D1 to D19, D21 to D23, D25, D26	3mm or 5mm red l.e.d. (24 off)
D20	3mm or 5mm yellow/orange l.e.d.
D24	3mm or 5mm green l.e.d.
TR1	BC108 *npn* silicon transistor
IC1	74LS04 Hex inverter
IC2	Z80A-CPU 4MHz microprocessor
IC3	2764 pre-programmed EPROM
IC4	8255 24-line I/O interface
IC5, IC6	74LS154 4-line-to-16-line decoder (2 off)
IC7	74LS42 BCD-to-Decimal decoder
IC8	7805 +5V 1A voltage regulator
X1	Crystal, between 1MHz and 4MHz (not critical – see text)

Miscellaneous

S1, S3 to S9	Push-to-make, non-locking, keyboard switch, with tops for coloured card inserts to match balls (8 off)
S2	Push-on/Push-off latching pushbutton or toggle switch
LS1	600ohm approx. earpiece, speaker or moving coil microphone insert

Printed circuit board available from *EPE PCB Service*, order 832; 14-pin d.i.l. socket; 16-pin d.i.l. socket; 24-pin d.i.l. socket (2 off); 28-pin d.i.l. socket; 40-pin d.i.l. socket (2 off); finned heatsink for IC8; multi-voltage (9V-12V) *unregulated* 800mA mains adaptor; solder pins; solder etc.

Approx cost guidance only **£50** *excl. Mains Adaptor*



is provided so the power requirements can be anything from 9V to 12V. A mains power pack is preferable. The one used with the model was self-contained in a rather overgrown plug top.

This type of power pack restricts the Live wire to a separate unit and removes any danger of electric shock when working on the scoreboard unit. It does have the disadvantage of a switch that can change polarity of the output and cause damage, but this was disabled long ago with the aid of Superglue.

The Scoreboard can be run from batteries but is a little power greedy and as such a mains driven power pack was the

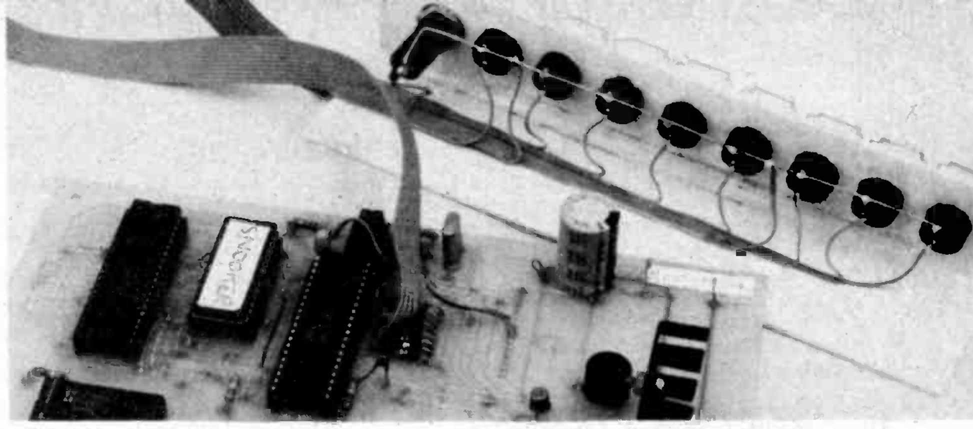
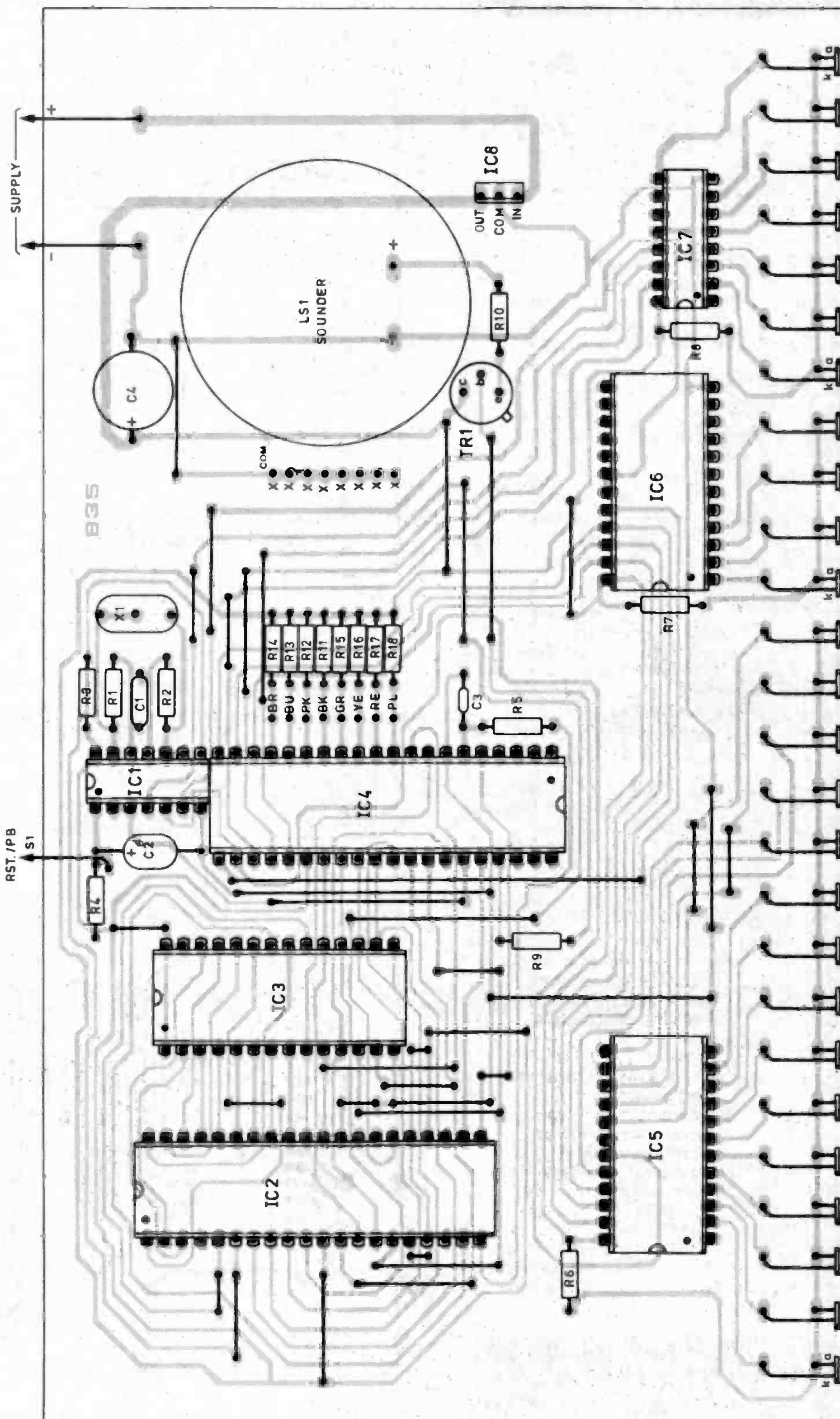


Fig. 2. (left and right). Printed circuit board component layout and full size underside copper foil master pattern. The group of common pads, marked "X", will be useful if the coloured switches are displayed according to their ball positions on the "table".



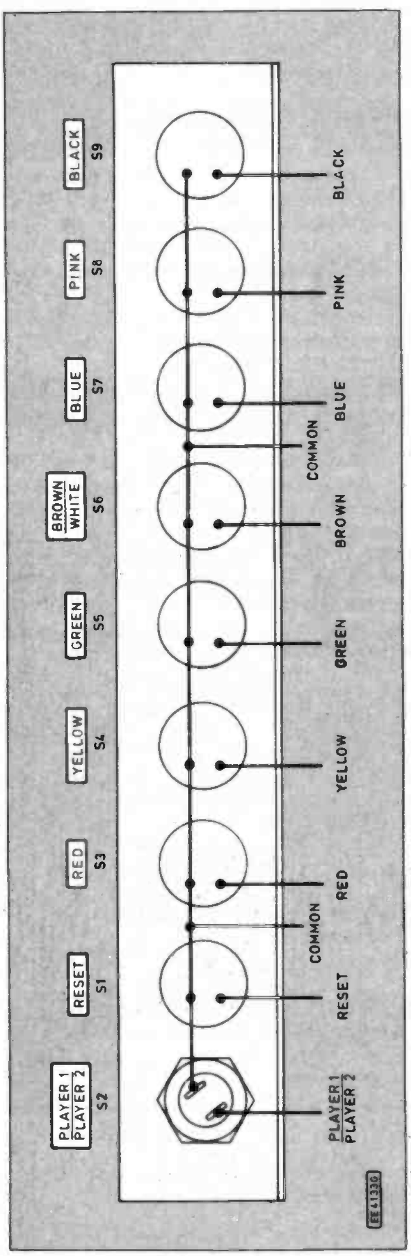


Fig. 3. Interwiring of the score switches, reset switch and the Player 1/Player 2 selection switch.

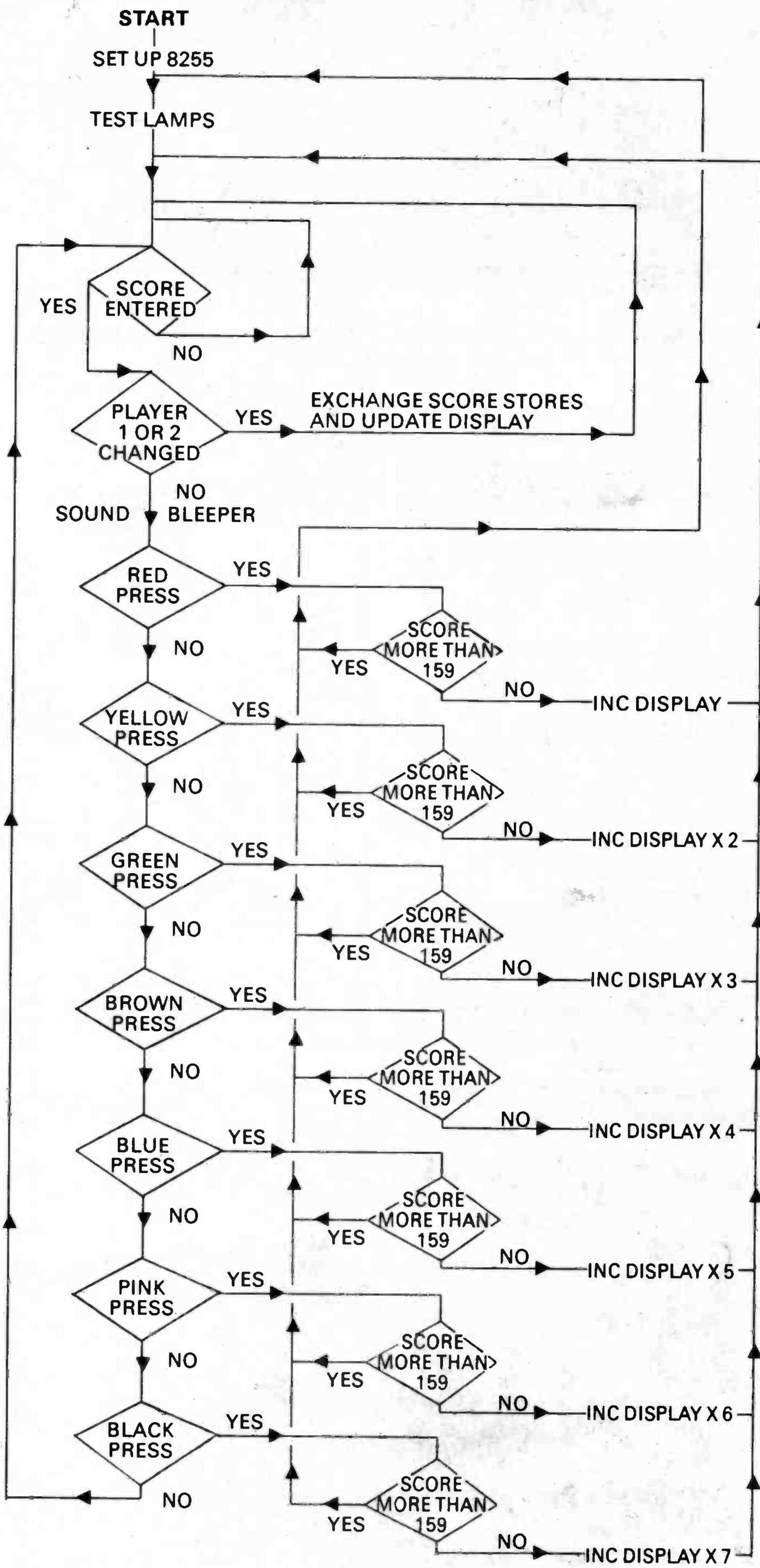


Fig. 4. Software flow chart. All decisions being shown as a question with two answers Yes or No, different solutions being executed depending on the answer.

most elegant solution. The regulator should ideally be fitted with a small heatsink and as such space is left on the p.c.b. around the regulator IC8 to accommodate a suitable one.

SOFTWARE

The software program instructions for the Scoreboard are stored in the pre-programmed EPROM IC3. The author is prepared to supply a ready programmed version of the 2764 EPROM to anyone who does not have the facilities, or want, to program their own i.c. – see *Shoptalk* page

The software listing would take up far too many magazine pages to be included here. However, for those readers who wish to program their own EPROM, a listing in the form of a "source code", with labels and comments so that it can be changed or customised by those readers with an understanding of these things, is available from the Editorial Offices – see *Shoptalk*.

The software instructs the computer chip to check for any push-button presses, when it finds one it identifies the button and adds its value to whichever score is selected and updates the l.e.d. display, and then generates a small burst of tone which is routed to the sounder LS1.

SOFTWARE OUTLINE

The software is shown as a flow chart in Fig. 4. This is the starting point for any program with all decisions being shown as a question with two answers *Yes* and *No*, different solutions being implemented depending on the answer.

The source code program which is derived from the flow chart, is written, in this case, in Z80 assembly language. The language is then converted via a piece of computer software into executable computer code.

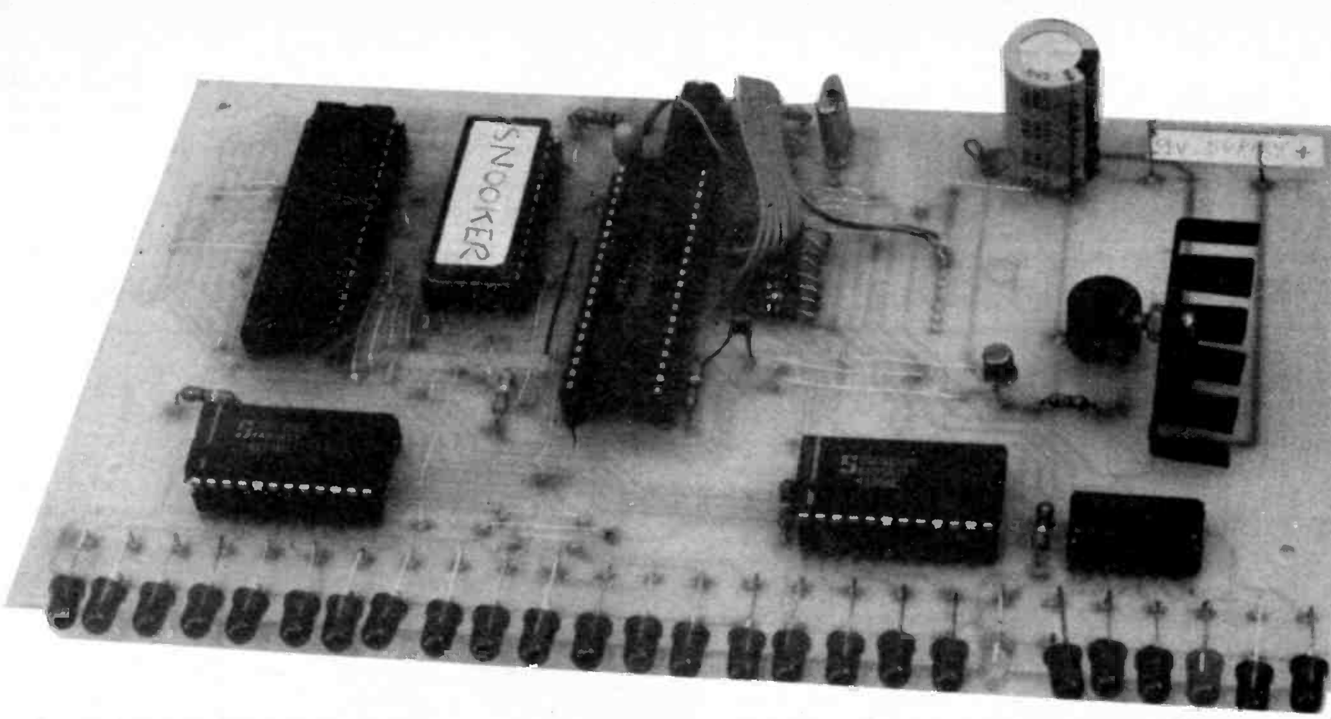
The source code listing shows all this in an understandable form, understandable that is to humans. The computer only understands numbers and it is these numbers that are programmed into the Eprom (third column). The reason for reproducing the software as source code is to help aid and understand how the Scoreboard works and the computer code is an integral part.

The alternative is a "hex dump" where only the numbers shown in the third column of the listing are provided, these can still be copied into EPROM and run, but an understanding of the code is not possible. Computer software that will disassemble executable code does exist and this will turn the hex numbers back into source code, but the comments would be lost and the labels that have been given meaningful names to would just be reproduced as meaningless expressions such as label 1, label 2 and so on. This renders computer code difficult to understand and even more difficult to extend and build on, but never the less is the form all commercial software is supplied in, source code is always very guarded and will never be released by any commercially minded organisation.

SOFTWARE DETAILS

The programme works by first of all a look up table which is the coded score displays from 1 to 159. The software starts at zero and jumps around this table to 00AF.

Here there is a small delay loop because the Z80 and the 8255 are both reset from



the same hardware circuit, at the same time. The Z80 recovers quicker and so must wait for the 8255 to recover before it can have a meaningful data exchange with it.

Next the 8255 is initialized by being told that port C is an input, and A and B ports are outputs. We do this by sending 89 hex to its control register. Now we can test the lamps by quickly sending all the scores from 1 to 159 in sequence to the displays.

The next task is to load the two register pairs hl and de with the address of the start of the score look up table. It is now a simple task to pole the input keyboard looking for score buttons to be pressed, and the Player One/Player Two switch S2 to be changed, if the switch is changed then we swop the contents of hl and de and update the display.

In this way hl always points to the score of the selected player. The routine of ld a,(hl) ld bc, display, out (c),a will update the display l.e.d.s with this score. When a coloured score button is pressed it will load the button press into the accumulator, remove the player one/two information and bleep.

Now we examine the accumulator, and decide which button has been pressed. We then jump to the routine that corresponds to that button, where the score pointer will then be incremented the appropriate number of steps up the "look up" table, and the information at that location sent out to the displays. If the score is incremented beyond the end of the look up table the software detects this and resets.

A look up table was used for the display information so that it could be re-written to change the displays to the 7-segment kind if the l.e.d. bargraph proved unacceptable. The system works well and has seven output lines spare for any future additions.

TROUBLE-SHOOTING

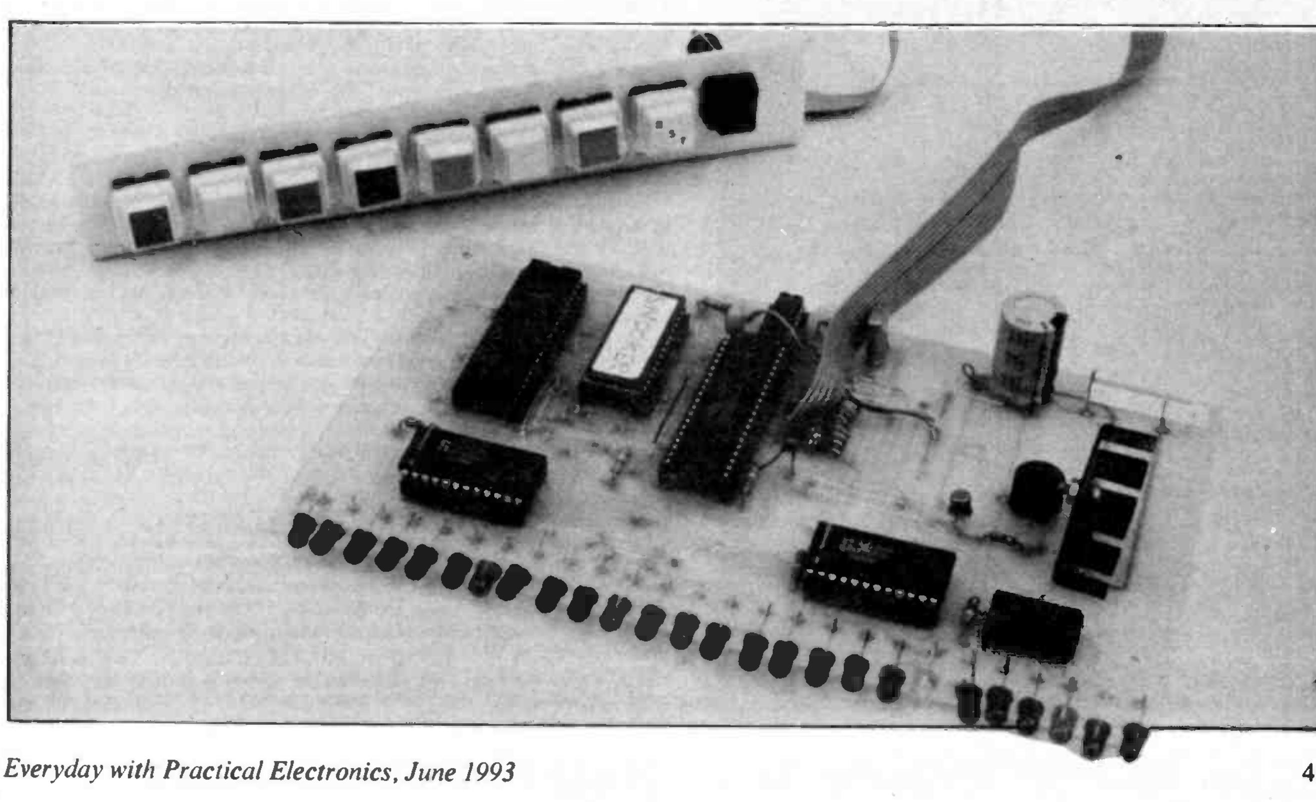
Hopefully the unit will work first time but there could always be the odd solder splash dry joint or sometimes a faulty component. First check the obvious that all the i.c.s are in the correct positions and are the correct way round. Check for the correct supply rails on all the chips.

The clock oscillator should be producing a good logic level square wave on pin 8 of IC1d, check using a oscilloscope or better still a logic probe. Pin 26 of the micro IC2 should go *low* when the Reset button of switch S1 is pushed and *high* when it is released; the reverse of this should happen on pin 35 of IC4.

If all this is well then check for pulses on the EPROM data bus pins 11 to 13 and 15 through to 19. If no activity is present then check all the +5V pins on the micro IC2 are really going to the +V line and the same with the EPROM.

If the unit only partially works with some l.e.d.s not functioning then if the non functioning l.e.d.s share a common driver i.c. try a replacement. If any non-functioning l.e.d.s do not have a common driver i.c. then try another 8255, these chips often fail; mostly through misuse.

The sounder is not essential and the unit will function without it. Last but not least if you have copy typed the data into your own EPROM double-check it, one wrong digit will stop the unit from working completely. □



Innovations

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

Electronic Horse Speedometer breaks new ground

– by Hazel Cavendish

EXHIBITING the inherent inventiveness which has long been a part of the British character, a small group of talented elecronic scientists in Yorkshire have produced what they believe to be a "world first" – a horse speedometer. The product, for which a patent application has just been filed, will revolutionise the training of race horses, and York Equipment – a company founded by Professor Tony Robards of the University of York's Institute of Applied Biology which will market the device – is already looking over its shoulder at the device's potential in the sport of camel-racing in the Middle East.

The inventors, Professor Greville Bloodworth of the University of York and Mr Graham Long of the University's Electronic Centre, originally sat down with a team to devise an electronic method by which a horse rider could measure his speed of travel. Without a wheel or wheels, a conventional speedometer could not be utilised, so they set out to develop a self-contained speed indicator which did not require contact with the ground, was portable, battery-powered and did not necessitate the placing of ground markers or beacons.

The result is a small unit approximately the size of a miniature transistor radio attached to the rider's safety helmet which works by analysing the Doppler shift in frequency between a transmitted microwave beam projected either forwards or backwards from the moving subject, and the reflected beam.

An illuminated display is worn by the rider in a wrist-watch style of monitor, and can also be conveyed to an observer on the ground – the horse's trainer for example – by a radio data link. Signal processing electronics are carried in a belt worn by the rider which also incorporates a rechargeable battery.

Testing of the device took place earlier this year, and preliminary results have exceeded expectations. "It is apparent that the technology is both feasible and commercially exploitable," says Professor Tony Robards, adding that the constructional costs will be low because all components (apart from "boxing") are off-the-shelf. "We estimate a cost of around £100 a unit, including construction, and possibly lower if sales volume is high. We believe the market will stand a maximum selling price of a 'simple' speedometer of £250-£300, and at present these appear to provide acceptable figures within which to work."

Horse speedometer electronics. The microwave "gun" mounted on the riders helmet with wrist readout, belt mounted electronics and battery, and the remote speed readout incorporating a radio data link.

Equimed has benefitted by a £45,000 DTI grant and a similar one from a consortium comprising the Animal Health Trust in Newmarket, private individuals and a local enterprise group to fund an equine heart-rate meter and pulse oximeter – the latter measuring the oxygen in a horse's blood – which can be combined with the speedometer in a more sophisticated unit for the use of horse and camel trainers.

The heart-rate meter consists of a transducer that emits a beam of infra-red light and collects the reflection, and is strapped under the base of the horse's tail in the form of a sensor. Because it detects the pulse by measuring the amount of light that is absorbed, it will enable the amount of oxygen in the blood to be calculated.

"The heart-rate meter has the potential for applications in several distinct market sectors," declares Professor Robards. "Not only will it be valuable in general training, veterinary and medical spheres, but it can be used by horse breeders as a foaling alarm, and by livestock breeders on cattle, pedigree sheep and camels. We anticipate it can be used by equine eventers and other riders for improving the fitness of their animals, and has a unique potential as an aid for trainers of flat racers, trotting horses and camels."

Praise for the usefulness of the invention comes from Dr Roger Harris, acting head of the Department of Physiology at the Animal Health Trust, where much of the country's equine research is carried out. Predicting that it was likely to revolutionise horse training schedules, he remarked on its particular usefulness in saving the racing industry more money and time in evaluating whether a horse was a 'sprinter' or a 'stayer'.

3D-TV

WHAT is claimed to be a revolutionary 3D TV system has been invented by a New Zealand man. The inventor says that most people who see his invention are astonished. The system uses conventional TV signals and gives regular TV programmes a 3D effect.

Invented by accident it is claimed that the system would be totally affordable and give normal viewing angles and range of distances yet add depth to the pictures. Having filed for patents the inventor is now trying to interest manufacturers in his discovery. He says "If they'd only take the time to come an see it, of course it's hard to believe if you haven't seen it."

Pen Activated Organizer

ONE or two companies seem to be claiming world firsts for pen activated organisers but the first one we have received full information on is the Sharp IQ-9000. Sharp say that the launch of the IQ-9000, the first organizer to feature pen activated touch screen technology and wireless communications, provides the platform for a new generation of personal information tools.

As simple as pen and paper, yet powerful and innovative, the IQ-9000 features the latest in advanced LCD touch-screen technology with easy to use graphic user interface software (GUI). The pen can be used to jot notes or hand-draw graphics directly onto the screen and store them in the scrapbook for future reference. The user can then cut and paste the graphics,

ideal for linking a sketched map to an address stored in the database.

A built-in infra-red port situated at the back of the machine provides the ability to transmit data directly between two IQ-9000's or, using an infra-red interface, print-out on a printer or download to a PC.

The IQ-9000 carries a suggested selling price of £349.99 including VAT and is available from leading high street stores including Boots, Dixons, Rymans and all Sharp Personal business Centres and the IQ Mail order Service

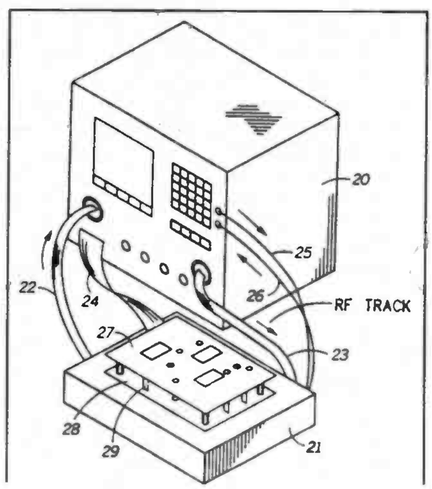
THE THINGS PEOPLE PATENT!

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.

Improving charge state of battery

In UK patent 2250872 Mercedes-Benz AG describe a process for improving the charge state of a battery in a motor vehicle. The output voltage of a generator which charges the battery is controlled so that it does not exceed a limit value. After starting an engine which drives the generator, the limit value is increased for a period if certain operating conditions are met.

The limit value is normally controlled so that it decreases as the ambient temperature in the engine compartment increases. In one version, if the engine temperature is below a threshold and the limit value would have been set, in dependence on the ambient temperature, below a specific value, the limit value is raised to that specific value. In an alternative, the limit value is increased by an incremental value if the engine temperature is below a threshold. The incremental value may be constant or may increase with a rise in the ambient temperature.



Testing electronic circuits

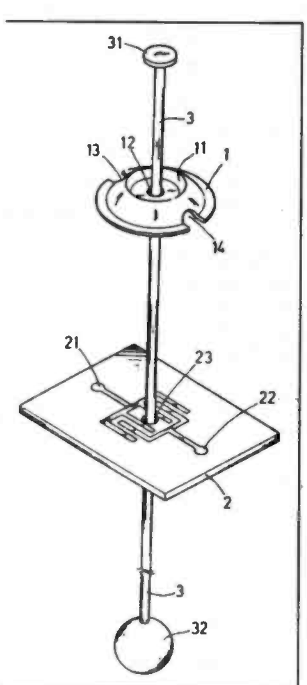
In UK patent 2241081 Motorola describe an apparatus for testing electronic circuits (27). It comprises a test jig (21) and has probes (29) for contacting predefined positions on the circuitry, input and output lines (22, 23, 25, 26) for feeding signals to and from the probes and means for providing selective connection with the predefined positions via the probes.

The jig has control means and a bus (24) for control of the selective connection. The apparatus comprises a signal generator (20) for inputting signals to the test jig and means (20) for measuring signals from the test jig in predefined analysis routines. The probes may be electrically controlled to move to make and break contacts. Alternatively they may be fixed but energised or not energised by appropriate switch circuitry.

Pull Switch

In UK patent 2249667 Yew-Tabg Liu describes a pull switch. It comprises a resilient conductor (1), a base (2) and a lead wire (3). The conductor (1) is secured on the base (2) which has two conducting surfaces (21, 22) and a through hole (23) to provide free pulling of the lead wire secured to the conductor at a top end and a knob (32) at the bottom end.

When the lead wire is pulled down, the resilient conductor touches the two conducting surfaces on the base to close a circuit. On release of the lead wire the conductor reverts to its original open circuit position due to its resilience.



Micro Alarm

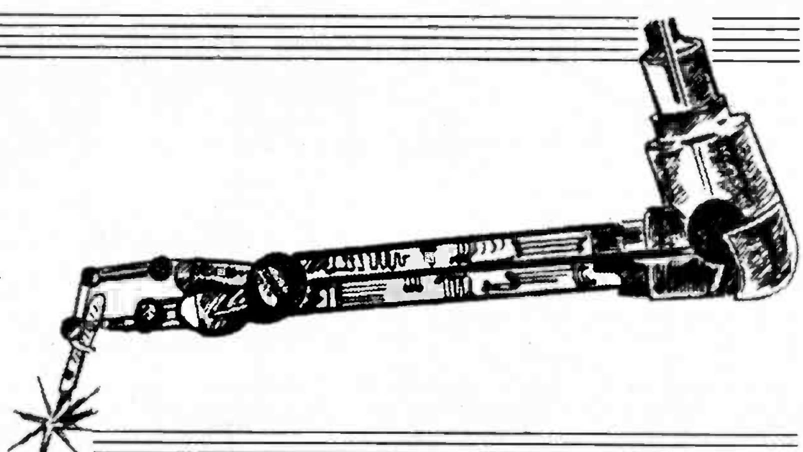
KNOWN as the 2000 Series, two new microprocessor based alarm control units have been announced by Autona. The new panels provide all the neccessary functions required for controlling security systems from the most basic up to the advanced multi-sensor installations found in commercial applications.

The two new models differ only in the method of switching offering a choice of keyswitch or keypad operation, the keypad version permitting the use of pass codes with two to twelve digits to be set by the user.

Simplicity of operation combined with ease of installation were two of the major design objectives which contributed to the decision to use an 8-bit microcontroller to look after the various loop monitoring, alarm switching and timing functions required in this type of product, additionally it also permitted the loop response time to be accurately defined thereby ensuring a high degree of immunity to any radiated or mains-borne interference.

Supplied with a detailed instructional leaflet describing the operation and installation the 2150 (keyswitch) is priced at £49.95 +VAT whilst the 2250 (keypad) is available at £54.95 +VAT. For further information contact Autona Ltd on 084 445740.

CIRCUIT SURGERY



MIKE TOOLEY B.A.

Welcome to* Circuit Surgery, *our regular clinic which deals with readers' problems. This month, in response to several requests from readers, we shall be describing means of boosting the output of a portable CD player. We begin by attempting to throw some light on the design of simple analogue to digital convertor circuit.

Analogue conversion

Matt Manktelow from Northern Ireland and *P. Gardner* from Bristol have both asked for details relating to the design of simple analogue to digital converter (ADC) circuits. The task of building an ADC is greatly simplified by the use of a purpose-designed LSI device. Fortunately, several of these devices are readily available from most major component suppliers.

Before starting out, however, it is important to give some thought to the required resolution and accuracy of the converter. For the benfit of the newcomer, it is worth pointing out that *resolution* is quite different from *accuracy*.

Resolution refers to the number of discrete voltage steps which the converter will recognise. This, in turn, is related to the number of bits used in the binary code which represents the analogue quantity.

If, for example, a four bit code was to be used there would be sixteen discrete states (from 0000 to 1111). If eight bits were to be used, the number of discrete states recognised by the circuit would increase to 256 (00000000 to 11111111). From this you should see that the resolution increases dramatically as the number of bits increases.

For many purposes an 8-bit ADC will prove to be adequate. The added benefit of using such a device is that it will interface directly to a standard 8-bit data bus or I/O port (a byte of data being transferred at a time between the ADC and the processor).

Simple ADC

The circuit of a simple ADC based on an 8-bit CMOS ADC (the ADC0804) is shown in Fig. 1. This device incorporates a tri-state data latch and thus can be directly connected to a microprocessor's data bus without the need for an I/O port. Most modern ADC are, in fact, "bus compatible" and it is worth using such a device whenever possible.

The ADC0804 requires an external voltage reference (this reference determines the *accuracy* of the ADC circuit). A precision band-gap voltage reference (ZN423, or similar) is ideal for this purpose.

Another advantage of the ADC0804 is that it contains its own clock circuitry (several other popular ADC require an external clock circuit). The frequency of the ADC0804's internal clock is determined by external timing components, resistor R2 and capacitor C2. The values of these components are not particularly critical, however C2 should preferably be a polystyrene or mica component.

Scaling of the input voltage can be achieved by means of a simple voltage dividing arrangement (comprising preset VR1, R3 and R4). The input resistance of this circuit is nominally 1M and VR1 should be adjusted so that full-scale reading (ADC output code = 11111111) occurs with an input of 25·5V. With the 10:1 input attenuator, the converter responds in steps of 100mV. Without the attenuator, the steps are 10mV.

Some form of address decoder will be required in order to produce the active low ENABLE signal. The ENABLE line should be taken low whenever an I/O operation is being performed to the ADC. The ADC should be allocated a unique address (i.e. an address which is not shared with any other I/O device).

It will normally only be a simple matter to gate together the IORQ signal together with appropriate address lines (a few NAND, NOR or NOT gates will be all that is required).

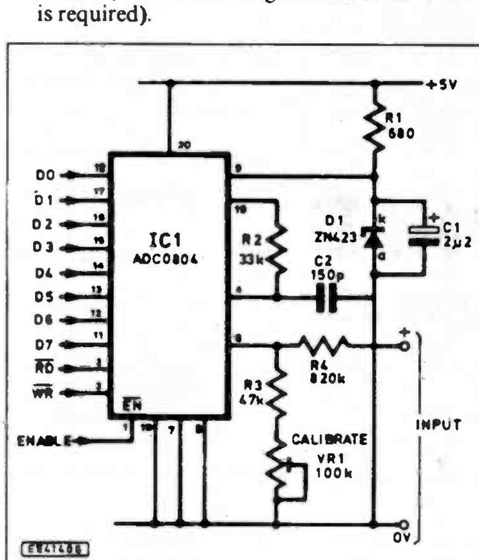


Fig. 1. Basic ADC circuit using an ADC0804.

In order to start the conversion process, it is necessary to send a code of 11111111 (hex. FF) to the ADC. In Z80 code, for example, this is achieved by the following assembly language statements:

```
LD A,FFH
OUT (nn),A
```

where **nn** is the I/O address for the ADC.

Reading the ADC is even easier. Again using Z80 code the input value (transferred into the accumulator) is obtained using a statement of the form:

```
IN A,(nn)
```

Compact stereo

Alex Morton a student from West London writes with a query concerning the use of a portable CD player:

"I am looking for a means of boosting the output of my portable CD player. The amplifier needs to operate from a car battery or mains supply and have a flat response with a gain of around 50."

Bill Fox from West Sussex has a similar query:

"My CD player has a headphone output. I have connected this to a pair of bookshelf speakers but there is insufficient output – can you suggest a simple amplifier circuit?"

Fortunately, this is an easy one! Several months ago I decided that my elderly cassette tape deck would greatly benefit from the addition of a small "monitor amplifier" that would drive a pair of reasonably efficient bookshelf speakers. Accordingly, I searched for a small i.c. that could be tucked away in the vacant recesses of the machine and which would be capable of providing good quality audio at about 3W per-channel.

The complete circuit of my Compact Stereo Amplifier is shown in Fig. 2. The TDA2004/TDA2005 makes an ideal choice for use in this circuit. It contains two independent power amplifiers each of which is capable of producing an output of up to 6W r.m.s. into a 4 ohm load.

The voltage gain of the two power amplifiers is determined by the ratio of resistors R2/R1 and R5/R6. The values specified provide a voltage gain of a little over 60 which is perfectly adequate for most CD and cassette players. Where a greater value of gain is required, R2 and R6 can be increased to 2k2 or 3k3.

Specifications for the Compact Stereo Amplifier

Voltage Gain: 60 (approx)
Maximum output power:
3·5W per channel into 4 ohm at 1kHz
Frequency response:
20Hz to 50kHz at –3dB
Distortion:
Less than 1% THD measured at 3W output into 8 ohm at 1kHz

(All specifications measured with a 13·8V d.c. supply)

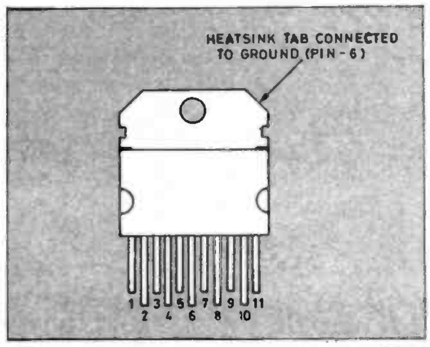


Fig. 3. Pin connections for the TDA2004

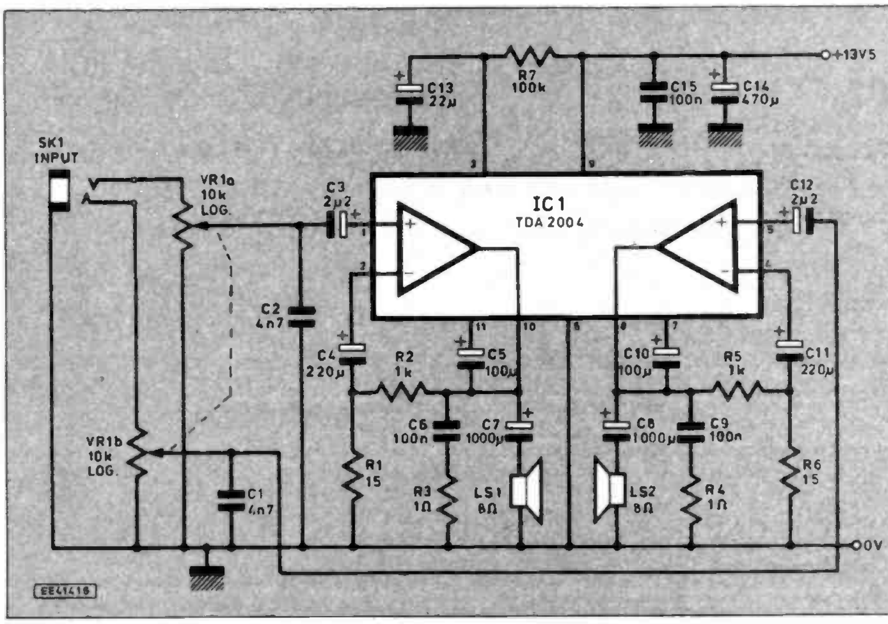


Fig. 2. Complete circuit diagram of the Compact Stereo Amplifier.

The circuit can be built on a small piece of matrix board. However, care must be taken to ensure that connections (notably the common 0V rail) are kept reasonably short. The supply decoupling capacitors C14 and C15 should be positioned close to the integrated circuit. Short lengths of screened audio cable should be used to connect the input socket, SK1, to the matrix board. The outputs can be connected via DIN loudspeaker sockets (not shown in Fig. 2).

A nominal 12V power supply is required (actually any input voltage from about 6V to 18V will be suitable). The circuit assumes that the supply has a reasonably low impedance and is "ripple free".

When power is derived from an existing d.c. power supply (as in my case) this will not usually be a problem (provided that the main reservoir capacitor has a reasonably large value). Where this is not the case (or when a separate mains supply has to be built in order to provide power for the amplifier) C14 can usefully be increased in value to 2200µ or 4700µ (rated at 25V). If a 12V vehicle battery is used, no additional supply decoupling will be necessary.

The pin connections of the TDA2004 are shown in Fig. 3. It is important to note that a substantial heatsink (4 deg.C/W or better) is required.

COMPONENTS

Resistors
R1, R6 15
R2, R5 1k
R3, R4 1
R7 100k
All 0·5W ± 5%

See SHOP TALK Page

Potentiometer
VR1 10k dual (stereo) rotary carbon, log

Capacitors

C1, C2	4n7 miniature ceramic (2 off)
C3, C12	2µ2 tantalum 35V (2 off)
C4, C11	220µ radial elect. 25V (2 off)
C5, C10	100µ radial elect. 25V (2 off)
C6, C9	100n polyester (2 off)
C7, C8	1000µ radial elect. 25V
C13	22µ axial elect. 25V
C14	470µ radial elect. 25V
C15	100n polyester

Semiconductors
IC1 TDA2004 integrated stereo amplifier

Miscellaneous
SK1 3·5mm miniature stereo jack connector
DIN loudspeaker sockets (2 off); heatsink 4 deg.C/Watt (or better); small metal or ABS enclosure (approx. 118mm x 98mm x 45mm); Small piece of matrix board (approx. 100mm x 70mm); Terminal pins (9 off)

Approx cost guidance only **£14** *excl speakers*

Next month: Will be of particular interest to radio enthusiasts as we shall be describing several useful circuits for aligning and calibrating receivers and testing aerials.

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.

MALTECH
ELECTRONIC COMPONENTS

MAINS TRANSFORMER Prl. 120V-0V, 120V-0V.
Sec. 0V-12V, 0V-12V, at 3VA £2.62 each

PROJECT BOXES A range of high quality boxes moulded in black high impact ABS, easily drilled or punched to produce a professional looking end product

TYPE	W	L	H	PRICE
T2	75	56	25	£0.77
T4	111	57	22	£0.92
MB1	79	61	40	£1.35
MB2	100	76	41	£1.47
MB3	118	98	45	£1.71
MB4	216	130	85	£5.19
MB5	150	100	60	£2.35
MB6	220	150	64	£3.95
MB 7	177	120	83	£3.42
MB8	150	80	50	£2.22

All sizes are in millimetres

SPECIAL OFFER – PROJECT BOX
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60p each 10 for £5.00

KEY SWITCH
3 Position keyswitch £2.35

CRYSTAL OSCILLATORS

4.0 mhz	ALL
7.5 mhz	£1.50 each
12.0 mhz	OR
18.432 mhz	4 FOR
33.33 mhz	£5.00

MICRO SWITCH roller arm operation spdt 40p each

MINIATURE TOGGLE SWITCHES

spdt	60p each	spdt 3 position c/off	70p each
dpdt	70p each	dpdt 3 position c/off	80p each
spdt biased	60p each	spdt 3 position c/off biased both ways	70p each
		dpdt 3 position c/off biased one way	80p each

MINIATURE TOGGLE SWITCH pcb mounting 3pdt 50p each 10 for £4.00
MINIATURE PUSH TO MAKE SWITCH 50p each
DIL RELAYS 5 volt dp/changeover 60p 10 for £5.00
12 volt dp/changeover 80p 10 for £6.00
RELAY 10 amp contacts sp/changeover 12 volt coil £1.20 each
CAR HORN RELAY in metal can with fixing lug, s/pole on 10 amp contacts £1.00 each 6 for £5.00
20 AMP RELAY dp on 12 volt coil £1.50 each 4 for £5.00
REED RELAY 12 volt 50p each 10 for £4.00
240 VOLT AC RELAY. 3-pole c/o 10 amp contacts £1.50 each 4 for £5.00

DIL SKTS

8 pin	10 for	£0.60
14 pin	10 for	£0.90
16 pin	10 for	£1.00
18 pin	10 for	£1.00
20 pin	8 for	£1.00
24 pin	8 for	£1.00
28 pin	6 for	£1.00
40 pin	5 for	£1.00

'D' CONNECTORS

	plug	socket	cover
9 pin	30p	30p	35p
15 pin	40p	40p	35p
25 pin	50p	50p	40p

ALL COMPONENTS FULL SPECIFICATION DEVICES

SEMICONDUCTORS – TRANSISTORS – ICS – DIODES – REGULATORS – ETC

TIP31B	30p each
TIP 3055	90p each
2N3055H	60p each
2N3771	£1.20 each
741 op-amp	25p each
555 timer ic	30p each
LM324 quad op-amp	30p each

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7812/7805/7912/7905 all 35p each, any 4 for £1.20
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MICRO IC'S –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

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5mm rnd red/yellow/green/amber 10p each 12 for £1.00 any mix
5mm rnd high brightness red/green 20p each 6 for £1.00 any mix
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5mm rnd bi-colour 35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green 30p each, 4 for £1
LED mounted in a black bezel red only 25p each, 5 for £1.00
PLASTIC BEZEL for 5mm rnd leds 10 for 40p
High brightness bi-colour l.e.d., rectangular, red/green, two leads 40p each

LCD DOT MATRIX GRAPHICS DISPLAY
made by Hitachi
part No. LM225
module size
270w x 150h x 13t (mm)
display area
239w x 104h
640 x 200 dots
data sheet supplied
ONLY £23.50

COOLING FANS – BRAND NEW!
230V a.c. 50/60Hz impedance protected 80mm x 80mm x 25mm £6.96 each
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SIREN AND ZENON STROBE PCB
12V d.c. supply, on board Ni-Cad battery, anti-tamper connection +ve or −ve triggering requires a 8ohm speaker for the siren output. £8.75 each.

RESET TIMER PCB
Gives a timed relay closure following a momentary input. Requires 12V d.c. supply SP c/o relay output LED indication. 19 different time intervals from 25sec to 35min 20sec. £5.98 each.

ALARM CONTROL UNIT
Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.
Facilities: – Normally closed loop for pir sensors, door/window contacts etc.
Normally open loop for pressure mats,
24-hour loop for personal attack button
Visual indication that the system is operational.
Automatic entry/exit delay.
Automatic system reset.
Alarm output cmos logic level.

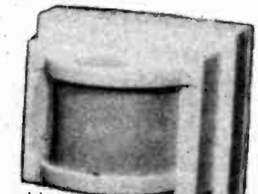
SIREN
12 volt dc for external use
115db £8.95

BELL BOX
A plastic bell box cover supplied with backplate. Red/yellow/white £8.99 each

PRICE COMPLETE WITH FULL INSTRUCTIONS £8.95
BELL/SIREN INTERFACE BOARD COMPLETE £3.95

PASSIVE INFRA-RED ALARM SENSORS

SUB-MINIATURE PASSIVE INFRA-RED SENSOR ONLY £5.95
Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.



EX INSTALLATION SENSORS tested working.
Type 1. Measures 180 x 112 x 70mm with walk test led, relay output and tamper protection. 12 volt dc supply required £8.50 each
Type 2. As above but a smaller unit 123 x 62 x 50mm £11.75 each
Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. £15.70 each

DOOR/WINDOW CONTACTS
Surface or flush mounting, white £1.10 each
JUNCTION BOX
white 6 way 60p

Please note: There may be variations in the size of the above passive infra red sensors depending on stock at the time of ordering. But the unit will certainly be within the stated sizes.

DUAL TECH SENSOR Microwave and passive infra-red combined. Separate led indication for each function. Measures 120 x 75 x 50mm. 12 volt d.c. supply, Relay output. Tamper protection. £29.95 each

BREADBOARDS – CAPACITORS – SOLAR CELLS – HEATSHRINK – ETC
SOLAR CELL 2 volt 150mA max, size 60 x 100mm £1.35 each 5 for £6
BNC SOCKETS 50 ohm single hole fixing 50p each 10 for £4.00
MIN BNC PLUG AND SOCKET 2 pairs for £1.50

MERCURY TILT SWITCH
Standard on/off £1.00 each
4 Contact (Directional) £1.50 each
PIEZO VIBRATION SENSOR
with data sheet £1.00 each

BREADBOARD
173 X 65mm 840TP £5.25 each
TEXTOOL ZIF SOCKET
28 pin zero insertion socket £5.95 each
SOLID STATE RELAY
Switch mains up to 7 amp 12 volt control voltage. Data supplied. £2.95 each

6 VOLT NI-CAD PACK 5AA NI-CADS, fast charge type £3.95
CAPACITOR 10,000 mfd 25 volt with fixing clip 60p each
CAPACITOR 470 mfd 400 volt £1.50 each 4 for £5.00
EPROMS 27C256 – 30 27C512 – 25. Once programmed but never used eprom. Mounted on a plastic carrier, can easily be removed from the carrier or used with a low insertion force socket.
27C256 £1.00 each 6 for £5.00 **27C512** £1.20 each 5 for £5.00
Suitable low insertion force socket 28 pin 40p each 3 for £1.00
MULTITURN PRESETS 20mm RECT, 500R, 1K, 5K, 10K, 20K, 50K, 100K 1MO. 40p each, 3 for £1.00
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100db PIEZO SOUNDER
2KHz note, 3-12V d.c. 40Ma, 45mm dia. x 26mm £1.76 each
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Originally a bike alarm. There is a short delay after activation then the piezo sounder operates for a preset period. £3.76 each
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D (HP2) 1200 mAH £2.40 each PP3 8.4V 100 mAH £4.77 each
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Constructional Project

QUIZ MONITOR

ROY BEBBINGTON

No more arguments on your "Quiz-Nite"! Quiz controller with a chairperson master unit.

THE 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 (for simplicity, the circuit shows only four key-pads).

The Question Master's control panel is equipped with an On/Off switch, a Reset pushbutton, a seven-segment l.e.d. display and an "appealing" audible output tone that differentiates between contestants. The entire system is battery operated.

The unit can be used for any quiz game where it is necessary to register a contestant or team with the quickest response. For example, in a quiz, after each question, the first contestant to press a button takes precedence in answering. This is indicated in three ways:

1 – The contestant's l.e.d. (light-emitting diode) remains on even if the pushbutton is released.

2 – A brief bell-like tone sounds, tuned to a different pitch for each contestant.

3 – A numerical indication (1 to 8) of the successful contestant is displayed on the seven-segment l.e.d. of the question master's control panel.

The l.e.d.s of all other contestants are inhibited once an answer button has been pressed. After an answer, the question master presses the Reset button to return the circuit to its quiescent state in readiness for the next question.

INHIBITING PRINCIPLE

Inhibiting is achieved by using a thyristor in each of the contestant key-pad circuits. It relies on the fact that if a certain current value is exceeded in a thyristor, its resistance drops and the current through it rises sharply (the avalanche effect).

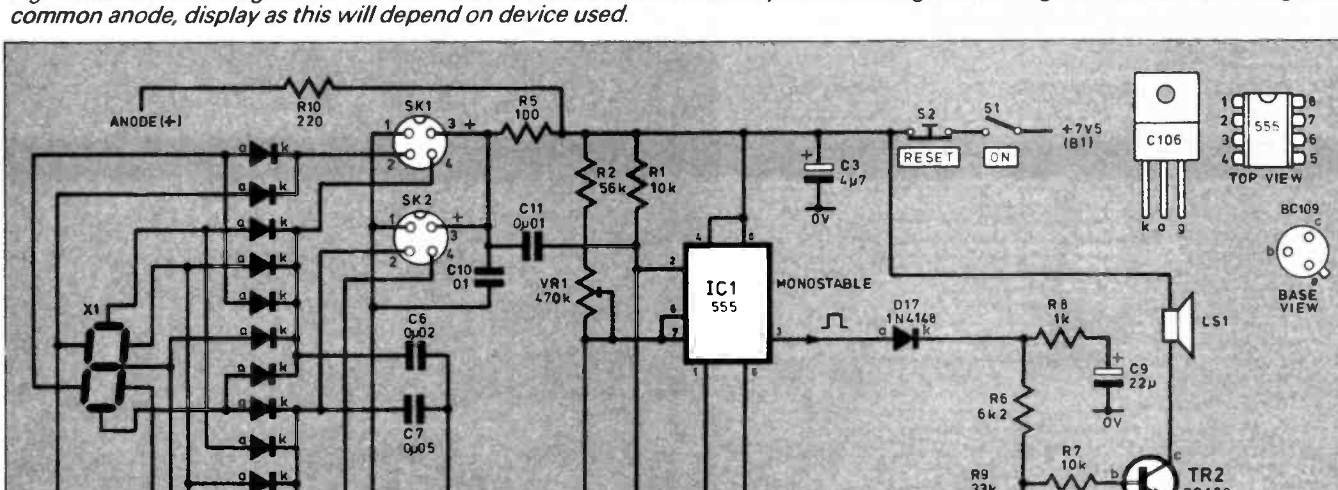
As the thyristors of all contestant key-pads receive their voltage supply through a common resistor, when a contestant presses a pushbutton, one thyristor "fires", and the resultant voltage drop across the common resistor will not leave sufficient voltage for any of the other thyristors to fire.

The pushbutton on each key-pad provides a connection for a small control voltage to trigger the gate of the contestant's thyristor. Once the thyristor has triggered it is latched into the conducting state by the current flowing through it and its associated l.e.d.

Changes in battery voltage or components could cause a particularly sensitive thyristor to fire under certain circumstances. To provide "belt-and-braces" security against this happening, Zener diodes are included in the gate circuits, which would not conduct in the reduced voltage condition (i.e. after a thyristor has been triggered).

In the prototype, one particularly sensitive thyristor was able to fire after another had triggered. This was cured by increasing the value of the resistor in series with the Zener diode from 47 kilohms to 100 kilohms.

Fig. 1. Main circuit diagram for the Quiz Master's control console. No pin numbering has been given for the seven-segment, common anode, display as this will depend on device used.



CIRCUIT DESCRIPTION

The circuit diagram for the Quiz Master's control console is shown in Fig. 1 and four contestant "key-pads" in Fig. 2. All identical key-pads are supplied from the +7·5V rail via the common resistor R5. In the quiescent condition, no current is drawn through R5 by the thyristors, CSR1-CSR4, because the gates are held down to the 0V rail by the 47k resistors (R11, R13, R15, R17).

The anodes of all the l.e.d.s (D19, D21, D23, D25) therefore stand at +7·5V. However, when a "contestant" button (S3-S6) is pressed a small current flows via the relevant gate resistor and Zener diode to provide a gate voltage to trigger the thyristor. In this avalanche mode, current flows through the common resistor R5, the relevant light-emitting diode and thyristor to the 0V rail.

Once a thyristor has fired, the current through this circuit is maintained. Consequently, it produces a voltage drop across resistor R5 of about three volts. (Applying Ohm's Law: V = IR = 30mA × 100 ohms = 3V.

This means that there is insufficient voltage to trigger any of the other thyristors. As mentioned, the 4·7V Zener diodes are included in the gate supply lines to ensure that no other thyristors will fire because of circuit tolerances.

The question master's seven-segment l.e.d. display X1 is wired effectively in parallel with the key-pad l.e.d.s, but the anode is supplied via a current-limiting resistor R10 from the +7·5V rail. The 16 diodes, D1 to D16, serve to isolate the different display segments that are common to two or more of the key-pad numbers.

The CMOS 555 timer IC1 is wired as a monostable circuit to provide a short positive output pulse to initiate the audible tone oscillator when a contestant presses a button. When a thyristor fires, the negative-going level on the common supply line is applied via C11 and pin 2 to trigger IC1.

The length of the positive-going output pulse on pin 3 of IC1 is independent of the time the button is held down and can be varied by preset VR1. Resistor R2, preset VR1 and capacitor C1 determine the duration (the time constant is calculated from $T = 0{\cdot}64CR$ in Farads and Ohms).

HARTLEY OSCILLATOR

The output pulse from the timer IC1 is fed, via diode D17, to a Hartley audio oscillator circuit formed by transistor TR1 and its associated components. The basic frequency of oscillation is determined by the tuned circuit of tapped coil L1 and capacitor C5. The coil consists of about 600 turns of wire on a pot-core.

The basic frequency, determined by the inductance of L1 and C5, serves for tuning the audible tone of key-pad 1. When other key-pads "capture" control of the game, capacitors C6, C7 or C8 provide additional shunt tuning (via the appropriate thyristor) to produce individual musical tones for each key-pad. These capacitors may be selected on test to suit individual musical taste.

To give a bell-like sound, the supply voltage pulse from the 555 is sustained briefly by charging the electrolytic capacitor C9 via diode D17 and resistor R8, which, after the positive-going supply pulse, discharges through R8 and the collector of transistor TR1. This causes the sound to decay slowly, the duration depending on the *CR* time constant of C9 and R8. Diode D17 is necessary to isolate the 0V level of the 555 output pulse which would otherwise terminate the sound abruptly, on its trailing edge, by preventing the slow discharge via TR1.

OUTPUT

The output across TR1 collector load resistor R6 is directly coupled to the base of output transistor TR2 by resistor R7. The base current is limited by R7, which in turn limits the quiescent collector current (4mA) to conserve the battery.

Transistor TR2 is supplied via the collector load LS1 from the full supply rail. When the circuit is active, the current drain is about 60mA. This is only for the duration of the audio signal initiated by the timer output.

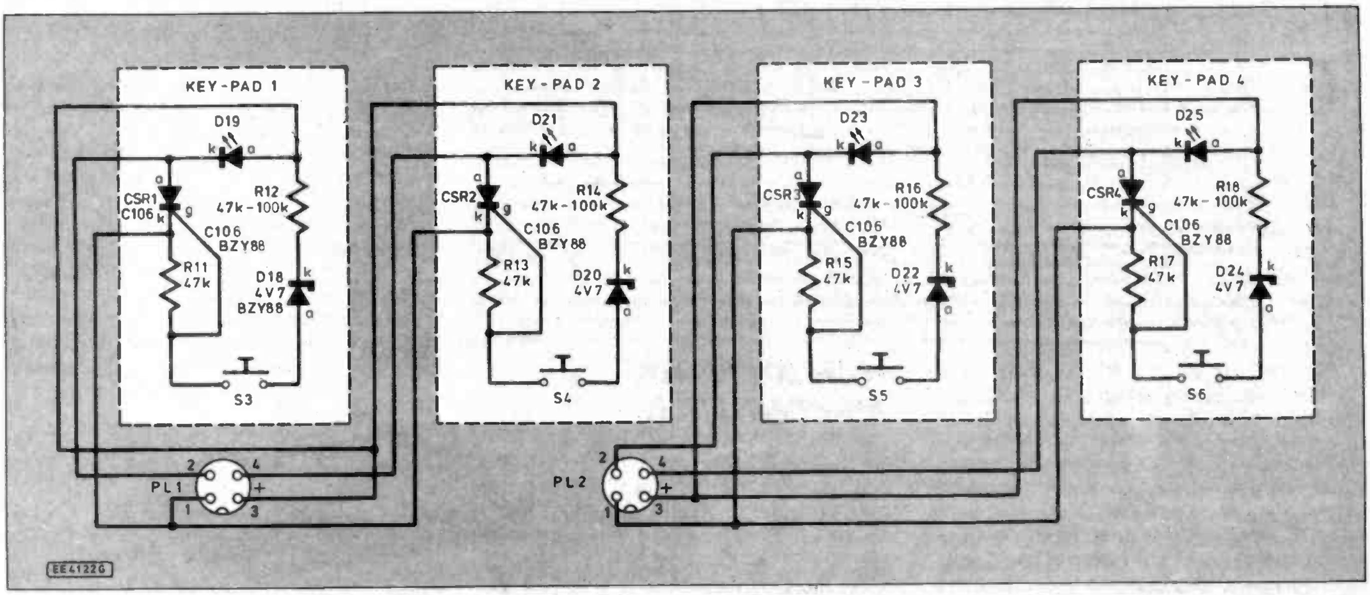
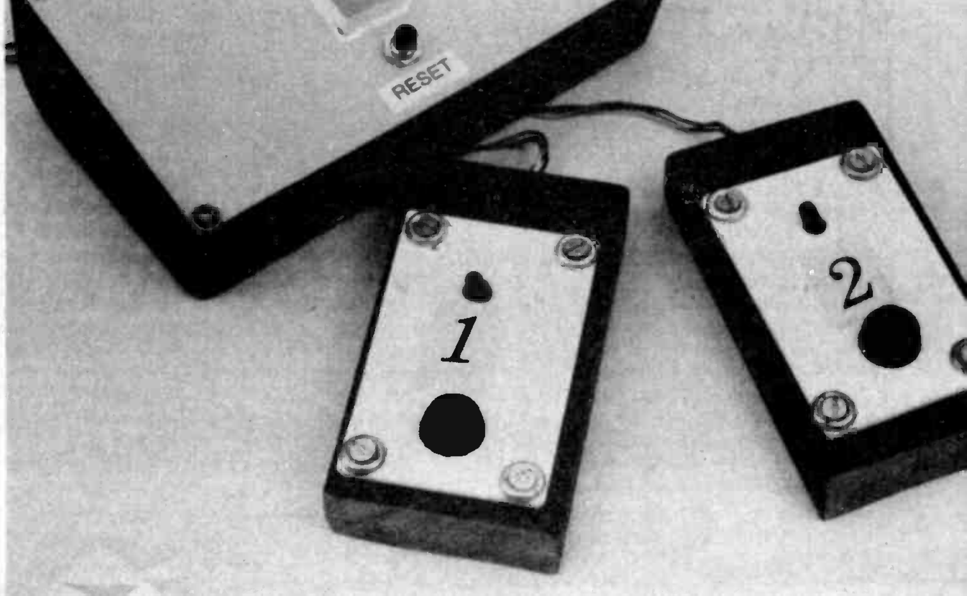


Fig. 2. Circuit arrangement for four contestant key-pads. The key-pads are wired to two DIN plugs in pairs. (below) The completed Quiz Monitor showing two prototype key-pads.



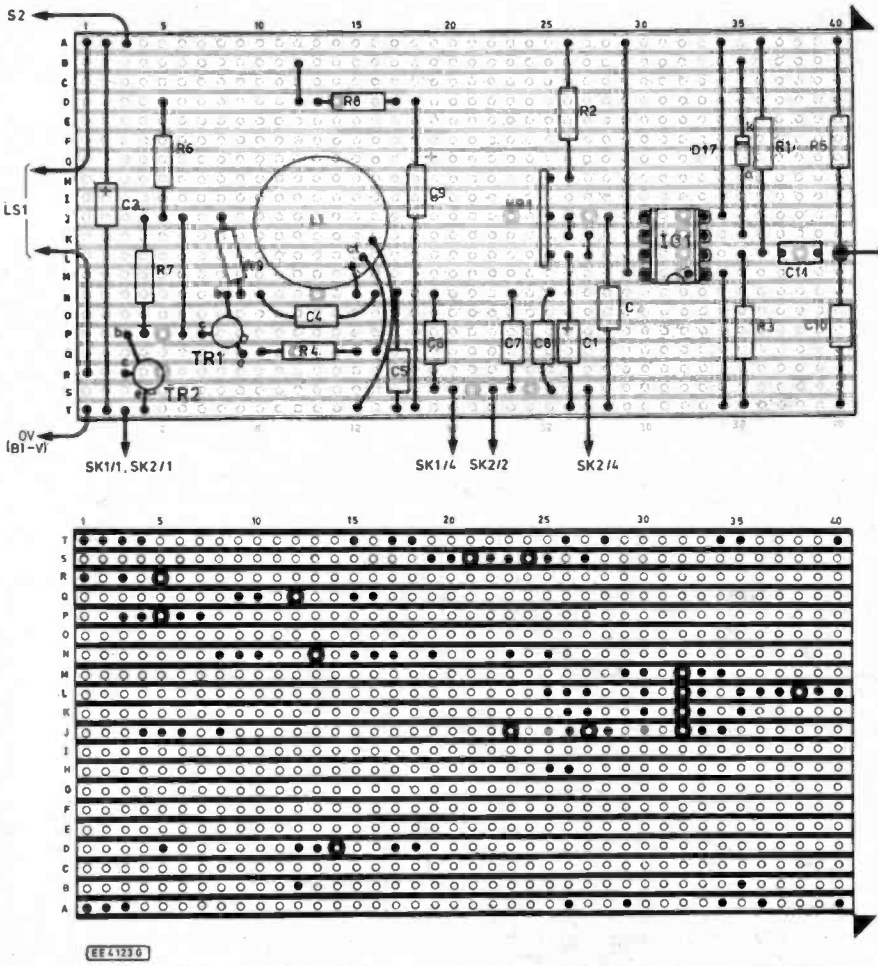


Fig. 3. Stripboard component layout and details of breaks required in the underside copper tracks. Note that a solder pin is used at the junction point for R5, C10 and lead to SK1/3, SK2/3.

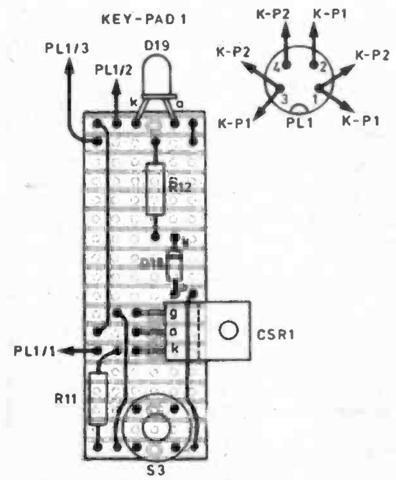


Fig. 4. Component layout and wiring for a single key-pad. The thyristor CSR1 is mounted with the "metal face" uppermost. Note that the switch contacts are in "pairs".

CONSTRUCTION

The coil L1 consists of about 600 turns (300+300) of fine (39s.w.g.) enamelled wire, scramble-wound on a 25mm diameter ferrite pot-core. The tapping should be approximately at centre-point, but this is not critical. After bringing out a loop of wire for the centre-tap connection, continue winding in the same direction for the second half of the coil.

Connecting the emitter of TR1, via resistor R4, to the centre-tap makes the two halves of the winding in anti-phase, the correct condition for oscillation. If a pot-core is not available, a suitable alternative for L1 can be made by winding 500 plus 500 turns of fine wire on a 50mm length of ferrite rod. Failing this, a centre-tapped audio driver transformer can be pressed into service for the coil.

MASTER CONTROL

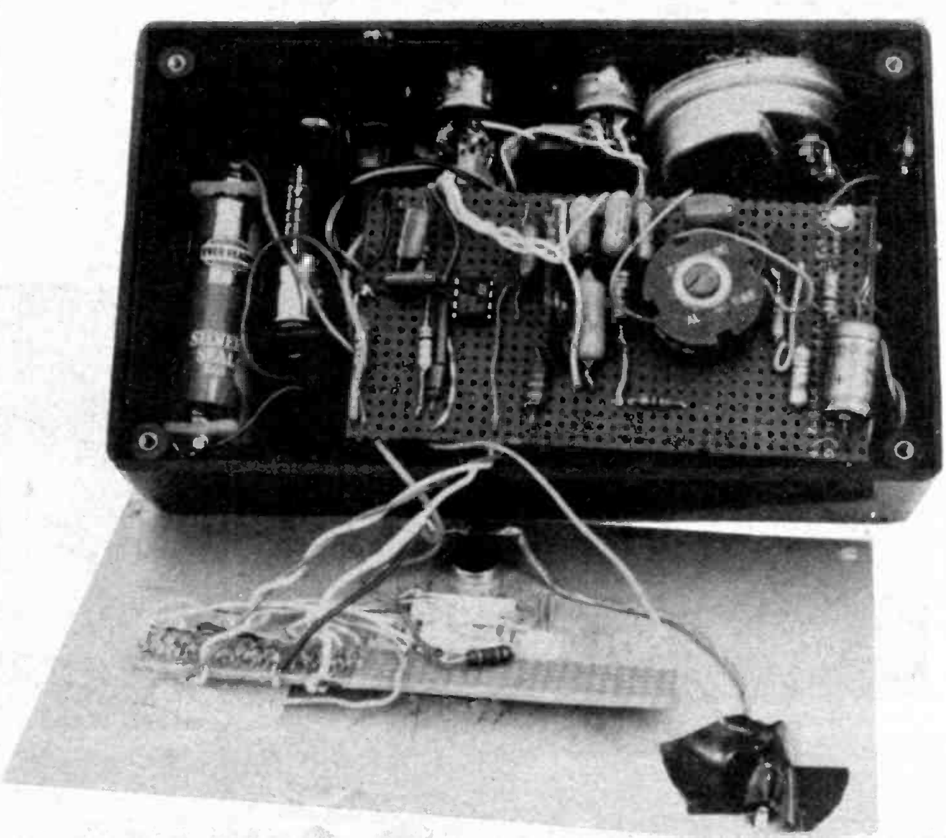
The Question Master's control panel is constructed on two pieces of 0·1in. matrix stripboard. The main circuit components are located on the larger piece of stripboard (20 strips x 40 holes). The topside component layout and the underside soldered connections and breaks on the copper strip side are shown in Fig. 3.

As seen in the front panel wiring diagram, Fig. 5, the smaller stripboard (6 strips x 39 holes) is used to mount R10, the limiting resistor to the common anode of the seven-segment l.e.d., and the diode matrix D1 to D16 that decodes the key-pad signals one to four. This strip is mounted on the rear of the front panel adjacent to the seven-segment l.e.d.

Connections to the l.e.d. X1 will differ according to the type used as several types of common-anode display l.e.d.s are advertised. If in doubt, about the pinning, the segments can each be identified by connecting a 9V battery with a one kilohm resistor in series between the common anode (to battery positive) and one of the other pins.

The question master's circuit was housed in an ABS Box (M1005), the sloping front panel providing a good viewing angle for the display. The two 4-pin DIN sockets SK1 and SK2 can be mounted on the back panel. These should be marked 1, 2 and 3, 4 respectively to correspond with the contestants' key-pad numbers. The speaker (or earpiece) LS1 was only 1·75in. diameter so this was glued to the back panel of the box after drilling an array of small holes for the sound output.

Components packed inside the control case.



COMPONENTS

QUIZ MASTER'S CONTROL

Resistors

R1, R3, R7	10k (3 off)
R2	56k
R4, R10	220 (2 off)
R5	100
R6	6k2
R8	1k
R9	33k

All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometer

VR1	470k skeleton preset (vert.), linear

Capacitors

C1	1µ tantalum bead, 35V
C2, C10, C11	0µ01 polyester (3 off)
C3	4µ7 axial elect., 63V
C4, C8	0µ1 polyester (2 off)
C5, C6	0µ02 polyester (2 off)
C7	0µ05 polyester
C9	22µ axial elect., 35V

Semiconductors

D1 to D17	1N4148 signal diode (17 off)
TR1, TR2	BC109 *npn* silicon transistor (2 off)
IC1	555 timer i.c.
X1	7-segment l.e.d. display, common anode

Miscellaneous

SK1, SK2	4-pin DIN sockets (2 off)
S1	Single-pole on/off toggle switch
S2	Min. push-to-break, non-locking, pushbutton switch
LS1	64 ohm speaker or earphone insert
L1	Ferrite wound pot-coil (approx. 600 turns, centre tapped) – see text
B1	7·5V battery pack (5 x AA cells)

Stripboard 0·1in. matrix, size 20 strips x 40 holes, and 6 strips x 39 holes; plastic case, size 150mm x 80mm x 50mm (M1005); 8-pin d.i.l. socket, socket to suit display X1; stranded connecting wire; solder etc.

CONTESTANT'S KEY-PAD (multiply by number of key-pads – max. 8)

Resistors

R11	47k
R12	47k to 100k (see text)

All 0·25W carbon film

Semiconductors

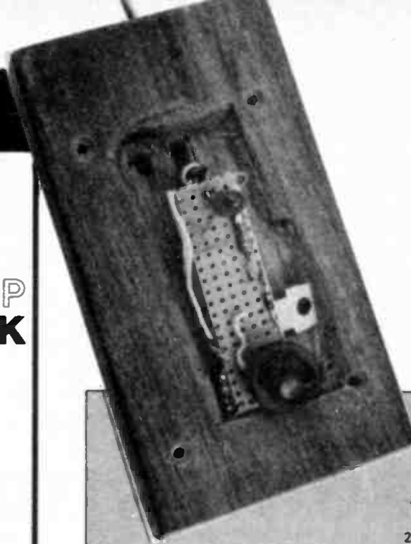
D18	BZY88 4V7 Zener diode
D19	5mm l.e.d., red
CSR1	C106 5A 400V thyristor

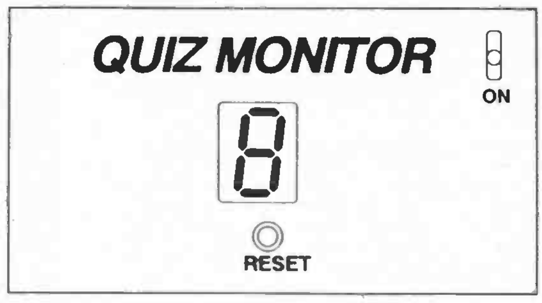
Miscellaneous

PL1	4-pin DIN plug, one per two key-pads
S3	Push-to-make, non-locking, pushbutton switch

Plastic case, size approx. 120mm x 65mm x 40mm; l.e.d. mounting kit; stranded connecting wire; stranded figure-8 twin-flex for inter-linking units; solder etc.

Approx cost guidance only **£18.50**
(four key-pads) plus cases





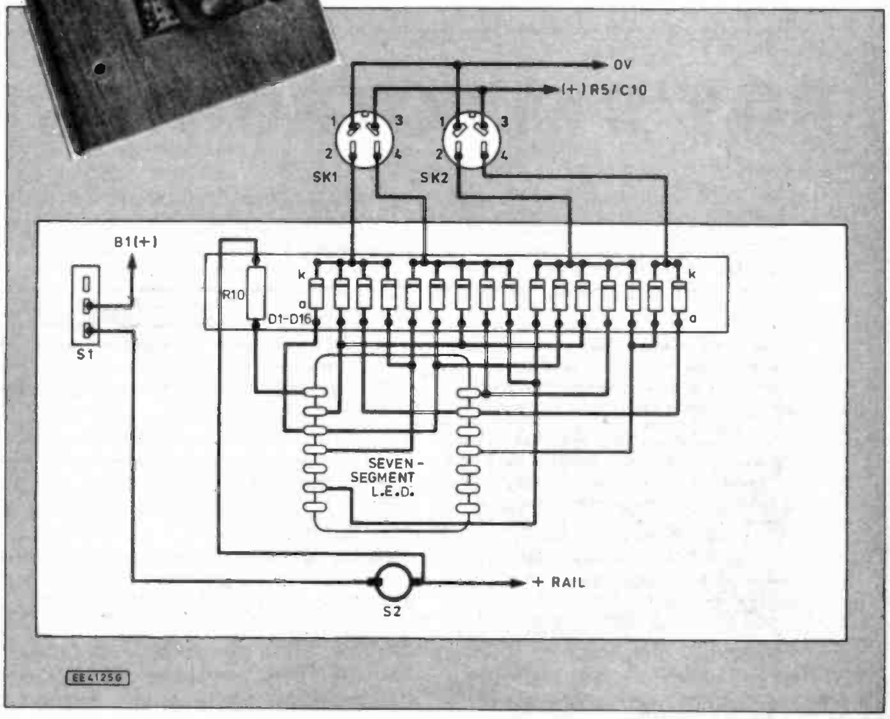


Fig. 5. Wiring to the rear panal mounted components of the control unit.

The battery box used in the prototype housed four AA batteries. Although the unit worked off a good 6V supply, it was found that there was insufficient margin of voltage for reliable operation. As a battery holder for five cells was not readily available, a four AA and a single AA battery holder were connected in series.

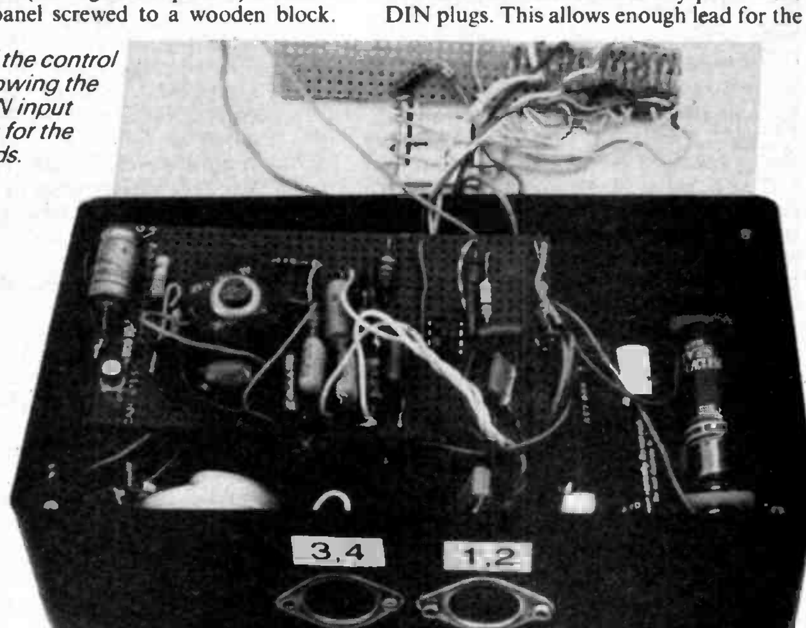
KEY-PAD

In the prototype model, each key-pad circuit was mounted on a small piece of stripboard (see Fig. 4 and photos) behind a plastic panel screwed to a wooden block. The block was hollowed out slightly to take the stripboard with the six circuit components.

The key-pads could be small plastic project boxes (approx. size 120mm x 65mm x 40mm), but the heavier wooden bases proved more stable on the table when pushbuttons were thumped in the heat of the contest. Felt pads under the blocks will help keep down the noise and protect table-tops.

About two metres of twin "figure-8" flex was used to connect each key-pad to the DIN plugs. This allows enough lead for the

Rear of the control unit showing the two DIN input sockets for the key-pads.



contestants to be spaced out opposite the question master. The Quiz Monitor has been successfully tested at a youth club and also in the physics laboratory at Felixstowe College.

QUESTION TIME

The circuit is simple to use, inexpensive and reliable. Many other precedence switches use several logic gates in each key-pad circuit. This circuit uses only one integrated circuit.

Once the "team" or "individuals" have been selected, up to eight persons or eight teams, they are each given a key-pad which they activate when they wish to answer a question. In the case of a team event, an individual can be elected to "punch" the answers button or the key-pad can be positioned so that all team members can reach it.

When a question is put to the contestants, the first person to press their answer button "locks-out" the other participants key-pads until the question master accepts the answer or "opens it to the floor". Even if the contestant releases the pushbutton, the key-pad l.e.d. remains on so that points can be allotted, or deducted for a "false buzz".

The key-pad individual l.e.d.s indicate which contestant has "captured" the question, and the numerical display on the question master's console enables him to locate quickly the "winning" contestant. The seven-segment display is also useful for any quiz where scores are allotted on an individual basis.

To set you on your way to holding you own "Quiz Night", we include a collection of "Roy's Electronics Questions. Best of luck. □

ROY'S ELECTRONICS QUESTIONS

1. In a household electric circuit, where should fuses and switches be fitted? (a) in the neutral wire; (b) in the live wire; (c) in the earth wire; (d) in the library with a blunt instrument!
2. Two 6-volt bulbs are to be lit from a 12-volt battery. Should they be connected in parallel or in series?
3. Two six-volt bulbs are connected across a 12-volt battery, where in the circuit can you put a switch? (a) between the bulbs; (b) between the + battery terminal and a bulb; (c) anywhere in the circuit.
4. Circuit symbols are used to: (a) to simplify drawings; (b) to show the physical layout.
5. What is the unit of resistance? (a) the watt; (b) the ampere; (c) the ohm.
6. What current will flow through a 12-volt 24 watt car headlamp? (a) 0·5 amps; (b) 2 amps; (c) 3 amps.
7. In a simple mains power supply, what are the two other component blocks after the mains transformer?
8. A transistor has a relay coil as its collector load. What component is used to protect the transistor against reverse voltages? (a) a capacitor; (b) a diode; (c) a resistor; (d) a buffer.
9. What kind of switch is needed to connect the car battery to the turning indicator lights? (a) a "make" switch; (b) a 1-pole changeover switch; (c) a 2-pole changeover switch.
10. What sensing device can switch on a dusk-to-dawn street light? (a) light-dependent resistor; (b) light-emitting diode; (c) optocoupler.
11. What does a bridge rectifier provide? (a) direct current; (b) full-wave alternating current; (c) square-wave pulses.
12. What component is used to block current in one direction? (a) a diode; (b) a capacitor; (c) a surge limiter.
13. What does a capacitor block? (a) a.c. current; (b) d.c. current.
14. What is the unit of inductance? (a) Farad; (b) Henry; (c) Ohm.
15. A 6-volt a.c. supply is connected to a lamp in series with a diode. Will the lamp be lit?
16. A 6-volt d.c. supply is connected to a lamp in series with a diode. Firstly, will the lamp be lit? (a) Yes; (b) no; (c) possibly. Secondly, what circuit change can be made if the lamp is not lit? (a) reverse the diode; (b) put the diode in parallel with the lamp.
17. The colour-code bands reading from one end of a resistor are brown, black orange, what is its value in ohms?
18. The ends of a rheostat are connected across a 6V battery and the slider is set to midpoint. Firstly, what is the p.d. between both ends of the rheostat? Secondly, what is the p.d. between one end and the slider?
19. An LDR is connected in series with an l.e.d. in a low voltage circuit. Does the l.e.d. glow brighter when a light is shone on the LDR? Does the resistance of the LDR increase or decrease when light falls on it?
20. What instrument is used to measure potential difference? (a) a voltmeter; (b) an ammeter: (c) a wattmeter.
21. All the signals going into an NAND gate are logic "ones", what signal will come out?
22. What sensor can be used to detect an interrupted light beam?
23. What sensor can be used to detect changes in heat?
24. A logic 1 into a NOT gate gives what kind of signal out?
25. A logic 1 on any input of an OR gate gives what kind of signal out?
26. If the output of an OR gate is wired back to one input, when a logic 1 is applied briefly to another input, what is the signal condition on the output? (a) briefly logic 1; (b) permanently latched to logic 1; (c) briefly logic 0.
27. A burglar alarm protects two doorways with LDR sensors. What kind of gate circuit is needed? (a) an OR gate; (b) an AND gate.
28. What kind of sensor is needed to detect the presence of smoke?
29. Bottles of milk on a conveyor belt needed to be counted. What kind of sensor could be used?
30. What three basic components are needed to design a personal alarm for an elderly person?
31. **Never do this,** but what electrical condition occurs if a switch is connected directly across a battery? (a) an open-circut; (b) a short-circuit.
32. What is the unit of power? (a) the watt; (b) the volt; (c) the ampere.
33. What is the unit of capacitance? (a) the henry; (b) the farad.
34. A resistance of 50 ohms is needed, but you only have resistors of 100 ohms. How can you get 50 ohms?
35. A heater designed for use on 240V mains has a resistance of 60 ohms. What current will it take?
36. Two 6V, 36W bulbs are connected in series across a 12V car battery. What is the total power? (a) 72W; (b) 36W; (c) 18W.
37. Twenty Christmas lights are strung in series across the 240V mains. As usual, one fails on Christmas Eve. What voltage replacement is needed? (a) 240V; (b) 12V; (c) 20V.
38. A fan must operate if it gets too warm, or if someone desires fresh air. What two input sensors are needed?
39. Fans and heaters need large amounts of current. What kind of output device is suitable for controlling them?
40. A 2V l.e.d. must operate through a resistor from a 6V battery. Firstly, what voltage needs to be dropped across the resistor? Secondly, what resistor is needed for the l.e.d. to draw 20 mA of current.
41. A security lock uses a solenoid, a coil of wire with an iron bolt in it. What happens to the coil when electricity flows through it?
42. Capacitors are two metal electrodes with a thin insulating layer in between. What is this layer called? (a) the plate; (b) the dielectric (c) the sandwich.
43. A capacitor is colour-coded brown, black, red. How many picofarads is it? (a) 100p; (b) 1000p.
44. What is another name for a variable resistor? (a) a shunt; (b) a potentiometer.
45. You have to design an alarm to alert a deaf person. What kind of output device would be suitable?
46. A blind person needs to be signalled. What output device is suitable?
47. The collector load of a transistor is connected to the +6V line. Is this a *pnp* transistor or an *npn*?
48. A lamp is in the collector circuit of an *npn* transistor. What kind of signal on the base will make the lamp work? (a) a positive-going signal; (b) a negative-going signal.

Pupils of Felixstowe College being put to the test.

49. Semiconductors need to be handled carefully; what can damage them? (a) static electricity; (b) vibration.
50. Which connection of an l.e.d. needs to be at the more positive end of a circuit? (a) the anode; (b) the cathode.
51. Two 5 microfarad capacitors are connected in parallel. Which is the total capacitance? (a) 10µF; (b) 2·5µF.
52. Two 1 microfarad capacitors are connected in series. What is the total capacitance? (a) 2µF; (b) 0·5µF.
53. On an American airbase a step-down transformer is needed to provide 120V from the 240V mains supply. If the primary turns are 5000 how many secondary turns are needed? (a) 2500; (b) 10000.
54. A step-down transformer has a turns ratio of 10:1. If 240V mains is connected to the primary side, what will be the potential difference measured across the secondary side? (a) 2·4V; (b) 24V.
55. What instrument is used for measuring current flowing in a circuit? (a) a wattmeter; (b) an ammeter.
56. How should an ammeter be connected to measure current flowing in a component? (a) in series with the component; (b) across it.
57. How should the available voltage of a battery be measured? (a) with the circuit connected; (b) with the circuit disconnected.
58. What are separate units that make up a battery called?
59. What are the three legs of a transistor called?
60. An OR gate followed by a NOT gate is known as?
61. An AND gate followed by a NOT gate is known as?
62. What is the advantage of a relay over a transistor switch? (a) larger currents or voltages can be switched; (b) fast switching.
63. What is a relay? (a) a "make" switch; (b) a mechanical switch operated by an electromagnet.
64. Name two main advantages of a transistor switch?
65. Name two disadvantages of a transistor switch?
66. A potential divider connected across a 4·5V battery divides the voltage into two parts. Firstly: what voltage do the parts add up to? Secondly: is the bigger voltage across the bigger resistance?
67. Generally, a sensor changes its resistance when something changes around it. Name two sensors other than a switch.
68. What is a thermistor used to measure? (a) pressure; (b) light; (c) temperature.
69. What is a reed switch? (a) a switch for a reading lamp; (b) a push-button switch; (c) contacts sealed in glass and operated by a magnet.
70. A digital electronic system recognises two voltage logic levels. What are these?
71. What circuit is used with slow rising waveforms (e.g. changes in temperature or light) to switch over logic levels at a set value? (a) a transistor switch; (b) a comparator circuit.
72. What does a NOT gate do to the level on its input?
73. A Rain Sensor consists of a mesh of parallel plates spaced close together. What happens when rain drops fall on it?
74. When a burglar steps on to a pressure pad momentarily an alarm buzzer sounds. To make this buzzer sound continuously we need? (a) press-to-make switch; (b) a latch circuit; (c) a relay.
75. The brightness of a bulb in the collector load of a transistor needs to be controlled. How should this be done? (a) by varying the base current; (b) by varying the collector voltage.
76. Where does the main current flow in a transistor? (a) base to collector; (b) emitter to base; (c) collector to emitter.
77. When there is no current flowing into the base of a transistor what is the resistance between collector and emitter? (a) high; (b) low.
78. Name the three stages of an electronic detector system.
79. Why do fluorescent lights affect a light sensor?
80. It is only possible to draw a few milliamps from a logic gate. What extra stage can be added to be able to drive, say, a light bulb? (a) another logic gate; (b) a transistor.
81. A motor generally needs more current than can be provided by one transistor. Two transistors can be wired so that one switches the second and the motor shares the combined collector current. What is this arrangement called? (a) a motorcade (b) a Darlington pair.
82. If a voltage to be measured is not known, to which range should the voltmeter be set? (a) highest V range; (b) lowest V range.
83. What precaution should be taken when measuring ohms in a circuit? (a) use the low ohms range; (b) switch off all voltage sources.
84. What precaution must be taken when wiring electrolytic capacitors in a circuit?
85. What component stores an electric charge? (a) a capacitor (b) a diode.
86. A transistor can be used as a switch. Name two other uses.
87. What instrument can be used to look at the difference between A.C. and D.C.?
88. What component can be used to produce half-wave rectification? (a) a bridge rectifier (b) a diode.
89. What device gives full-wave rectification? (a) a Zener diode: (b) a bridge rectifier (four diodes).
90. Do the laminations or core in a transformer increase or decrease its inductance?
91. Name two very good insulators out of the following: mica, wood, air, polystyrene, copper, ceramic, manganin.
92. What substance makes the contact in a tilt switch? (a) silver; (b) mercury; (c) alcohol.
93. Is a dry joint? (a) a bad connection; (b) an arthritic conductor: (c) an American campus that has run out of Coca Cola!

ANSWERS TO QUIZ MONITOR QUESTIONS

1b; 2 series; 3c; 4a; 5c; 6b; 7 rectifier, smoothing (capacitor); 8b; 9b; 10a; 11a; 12a; 13b; 14b; 15 yes; 16c; a; 17 10000 ohms; 18 6V; 3V; 19 yes, decrease; 20a; 21 logic 0; 22 LDR; 23 thermistor; 24 logic 0; 25 logic 1; 26b; 27a; 28 LDR; 29 LDR; 30 battery; switch (tilt); buzzer; 31b; 32a; 33b; 34 two 100 ohms in parallel; 35 4 amps; 36a; 37b; 38 thermistor; switch; 39 relays; 40 4V, 200 ohms; 41 It generates a magnetic field; 42b; 43b; 44b; 45 flashing light; 46 buzzer; 47 npn; 48a; 49a; 50a; 51a; 52b; 53a; 54b; 55b; 56a; 57a; 58 cells; 59 emitter, base, collector; 60 NOR gate; 61 NAND gate; 62a; 63b; 64 fast switching, no moving parts and cheap; 65 can be partly on/off, easily damaged by high voltages/currents; 66 4·5V, yes; 67 LDR, thermistor; 68c; 69c; 70 logic 0 (low), logic 1 (high); 71b; 72 invert it; 73 the drops lower the resistance between plates; 74b; 75a; 76c; 77a; 78 input sensor, processing, output; 79 the light switches on and off at 100 times per second; 80b; 81b; 82a; 83b; 84 connect right way round to observe polarity; 85a; 86 amplifier, oscillator; 87 Oscilloscope; 88b; 89b; 90 increase; 91 mica; ceramic; polystyrene; 92b; 93a.

New Technology Update

Ian Poole reports on Silicon On Insulator technology.

SILICON On Insulator (SOI) technology is much nearer being used for standard production i.c.s. It offers many advantages over ordinary techniques, especially as levels of integration rise and more circuitry needs to be placed on individual chips. Using standard techniques a number of problems have arisen. One is a phenomenon called electron punch – through which occurs when junctions are placed too close together on a base of bulk silicon.

Capacitance

In addition the SOI structure means that the levels of parasitic capacitance are dramatically reduced to a level where they can almost be ignored. This makes the process an ideal choice for many high speed applications. It can also be used for combined signal devices which need both r.f. and digital technologies.

One application where this type of i.c. could find a large market is in equipment for the new Global Positioning System (GPS) which uses satellites to enable position fixing to better than a few metres over the whole surface of the earth.

Another advantage which SOI has to offer is its ability to be run from low voltage supplies. In view of the increasing change to 3.3 volt logic in many of the new pocket computers, SOI i.c.s could be in great demand. Finally it has been found that i.c.s manufactured using this process can operate at much higher temperatures.

What Is SOI?

In a normal i.c. transistors and components are grown directly into or onto the bulk silicon using processes like diffusion and epitaxial growth. This gives rise to comparatively high levels of coupling between the individual circuits and components. To overcome this SOI involves first growing a oxide layer onto the substrate. Having done this a layer of silicon is then deposited above the oxide layer. The transistors and other components can then use this layer.

Using this method much higher levels of isolation can be achieved because the silicon layer is isolated from the substrate beneath, and the coupling to the bulk silicon is very much reduced.

New Production Techniques

For many years one of the main problems associated with the production of SOI has been the inconsistent wafer quality. However a new system using ion implantation has been developed by Ibis Technology Corporation and this has managed to overcome many of the problems. Using the system, wafers of up to eight inches in diameter can be fabricated, the size enabling the silicon dioxide layer to have a much higher degree of uniformity than was previously possible.

The new ion implantation method uses a parallel scanning beam system. This removes many of the defects which were previously present. The implantation itself is carried out at a temperature of 600 degrees C.

As a result of a much improved temperature control system a thinner and more uniform layer of oxide can be produced – typically about a quarter of the thickness which could previously be obtained. Through-put has also been increased. This has been accomplished by using a higher beam current.

One of the disadvantages of SOI is that the wafers cost about three times as much as those used in the more standard technologies. Whilst this is a very significant increase in material cost it is expected that it can be recouped by the reduction in the number of processes that are needed as a result of the advantages of SOI.

Design Transfer

With the many advantages which SOI has to offer the next stage is to convert some of the existing i.c. designs over to the new technology. Fortunately this should not be too difficult because the technology lends itself very well to accepting existing designs from standard silicon technologies. As a result the development costs of transferring designs onto the new technology should be small.

Once designers realise that SOI chips are commercially available it is expected that their use will increase very rapidly. Increased performance and the comparatively small increase in cost should encourage many more users.

High Temperatures

One of the advantages of SOI is that it can operate at very high temperatures. Normally it is good design practice to keep the running temperatures of devices within reasonable limits. By doing this the reliability of the equipment is improved.

One only has to look at normal domestic electronic equipment to see that any components which dissipate reasonable amounts of power and get hot are far more likely to fail than those which run cool.

Nowadays temperatures of devices are normally kept well below 100 degrees C if at all possible. Anything approaching this temperature would be treated with suspicion in most design environments.

However there are some instances when high temperature operation is required. There are a number of instances in the automotive industry as well as for some military applications.

Up until now silicon i.c.s have only been able to operate up to a maximum temperature of about 200 degrees C. Now a team of engineers in Belgium are investigating even higher temperatures using SOI.

The team have produced a range of SOI chips from analogue amplifiers to a variety of digital circuits which will operate at temperatures in excess of 300 degrees C. Even though these high temperature circuits are still being investigated it seems as though there will be a fairly large market for them.

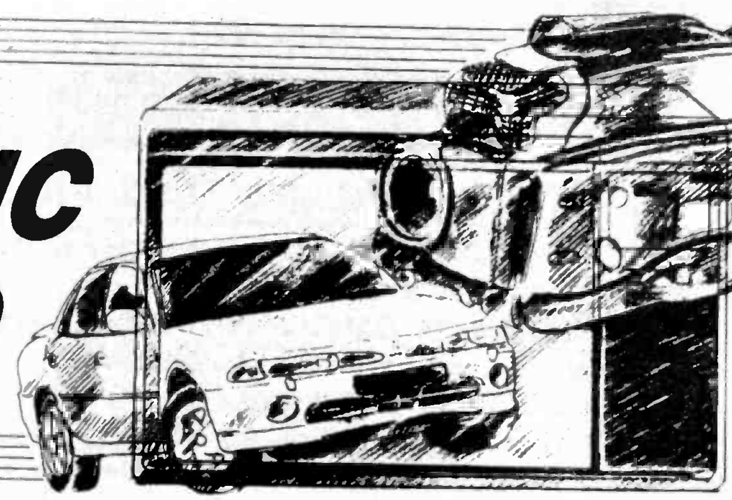
Whilst many of the applications may not utilise their full temperature range, SOI chips will be able to operate at higher temperatures with a much greater degree of margin than the standard silicon products. This will greatly improve the reliability of the equipment. A factor which is very important for any military equipment.

High Voltages

In another development, high voltage SOI chips are being investigated. With the general advance in i.c. technology the levels of integration on i.c.s are rising quite rapidly. In some instances this means much larger memories or microprocessors. However another way in which the level of integration can increase is by placing new types of components onto chips that had to be discrete components before. One new requirement is for high voltage i.c.s which contain all the necessary drive circuitry.

This type of requirement is not at all easy to fulfil. The small internal dimensions within the i.c. do not lend themselves to high voltage operation.

Using SOI researchers at Kawasaki in Japan have made some major advances. They have managed to produce 500 volt devices on some 10μm wafers. To achieve this they have used a specialised type of transistor called an insulated gate bipolar transistor (IGBT). Development of these circuits is in its early stages but it promises to produce some very interesting results.



FUZZY LOGIC EXPLAINED

ROSS BANNATYNE

Many consumer products, including camcorders, washing machines and even cars, are now being sold with a fuzzy logic "sticker". Here we explain the basic principles of fuzzy and its advantages.

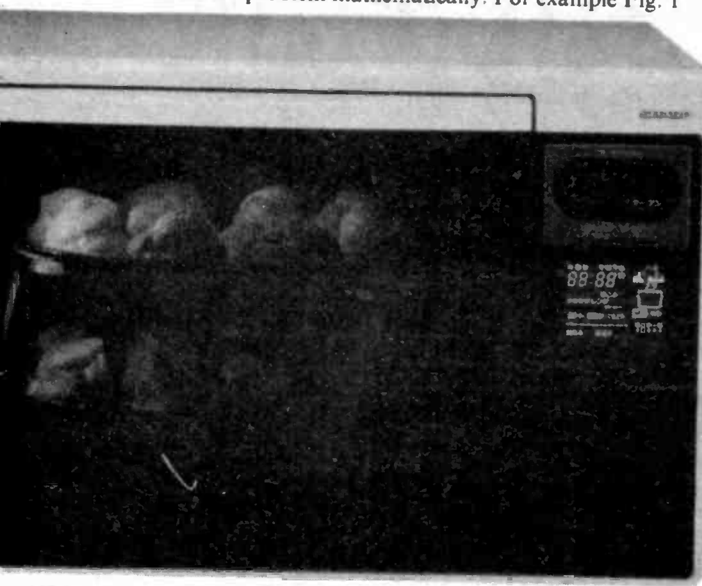
FUZZY LOGIC is quickly establishing itself as the top growth technology of the nineties. The reason for which is very simple; user-friendliness is reaching new levels of simplicity and the order of the day is to optimise human interface where at all possible – hence the new generations of pen-based computing 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.

FUZZY SET THEORY

Fuzzy Set Theory was formalised by Professor Lotfi Zadeh at the University of California in 1965. What Zadeh proposed is very much a paradigm shift that first gained acceptance in the Far East and its successful application has ensured its adoption around the world.

A paradigm is a set of rules and regulations which defines boundaries and tells us what to do to be successful in solving problems within these boundaries. For example the use of transistors instead of vacuum tubes is a paradigm shift – likewise the development of Fuzzy Set Theory from conventional bivalent set theory is a paradigm shift.

Bivalent Set Theory can be somewhat limiting if we wish to describe a "humanistic" problem mathematically. For example Fig. 1



New generation of Sharp microwave ovens (now available in Japan) employ fuzzy logic to recognise food and dish types and cook to optimum conditions.

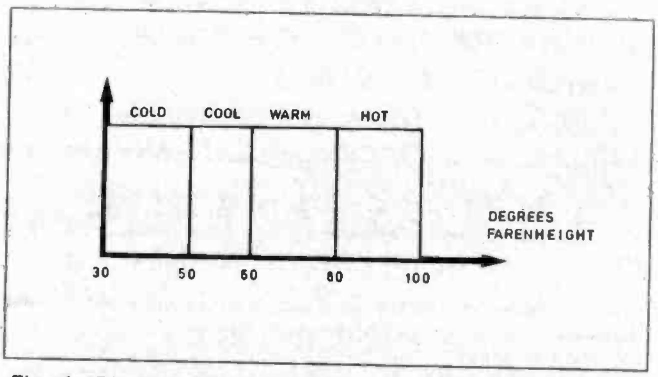


Fig. 1. Bivalent sets to characterise the temperature of a room.

illustrates bivalent sets to characterise the temperature of a room. The set descriptors are given as cold, cool, warm and hot (as we would use to describe such phenomenon as heat).

The most obvious limiting feature of bivalent sets that can be seen clearly from the diagram is that they are mutually exclusive – it is not possible to have membership of more than one set (opinion would vary widely as to whether 50 degrees Fahrenheit is "cold" or "cool" hence the expert knowledge we need to define our system is mathematically at odds with the humanistic world). Clearly it is not accurate to define a transition from a quantity such as "warm" to "hot" by the application of one degree Fahrenheit of heat. In the real world a smooth (unnoticeable) drift from warm to hot would occur.

This natural phenomenon can be described more accurately by Fuzzy Set Theory. Fig. 2 shows how fuzzy sets quantifying the same information can describe this natural drift. This is done by

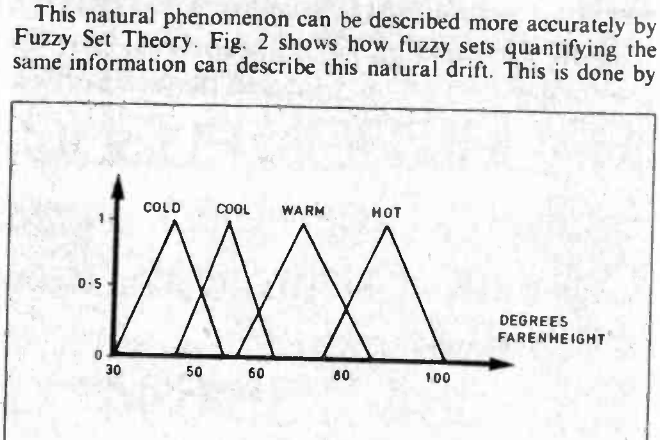


Fig. 2. Fuzzy sets quantifying the temperature of a room.

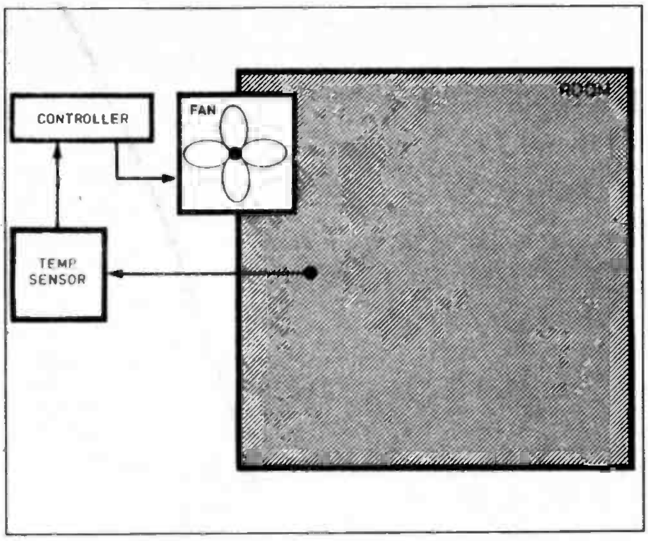


Fig. 3. Room temperature controller illustration.

using overlapping sets. Complete membership in one particular set is given as unity (as with bivalent set theory), however it is possible for a particular value to have membership of more than one set. For example at a temperature of 50 degrees F, there is a degree of membership of 0·5 in both the cold and the cool sets.

As the temperature increases, membership of the "cool" set becomes greater as we drift from "cold" and the set mathematics weighting increases proportionally. In this example triangular sets are used as the triangle provides an excellent approximation to the Normal Distribution curve – the optimum mathematical description of a natural phenomenon like heat. Likewise the shape of the "fuzzy sets" can be adjusted to best suit the quantity which is being described.

TEMPERATURE CONTROLLER EXAMPLE

One of the reasons for the increasing popularity of fuzzy is that it offers a very simple, intuitive way for an engineer to describe a complex problem using the design methodology of fuzzy set theory. The following example of a simple temperature controller illustrates how the basic concepts of fuzzy logic can be applied to an engineering application. The controller is illustrated in Fig. 3.

This example employs a sensor to detect room temperature which generates an input to a controller which in turn applies a control force to adjust the heater fan speed. The room temperature controller example is precisely the type of problem which fuzzy is best applied to; therein exists a tolerance for imprecision in the solution which can be exploited easily.

A conventional thermostat circuit operates as a simple on/off switch. The "cut-off" temperature could be selected at which the heater is activated when the actual ambient temperature falls below that level. Fig. 4(a) illustrates the operation with the cut-off set at 65 degrees F – when the temperature reaches this level the heater is turned off. This conventional set-up leads to the temperature in the room being excessively warm or cool as a result.

The new CX6 camcorder from Mitsubishi employs fuzzy logic to provide automatic operation.

FUZZIFICATION

The fuzzy controller, illustrated in Fig. 4(b), incorporates the grey or "fuzzy" areas where the definition of cold/cool/warm/hot is less clear and more open to interpretation. Temperature ranges are considered as overlapping – 65 degrees F is described as 60 per cent warm and 20 per cent cool (this is known as "Fuzzification").

The triangular shapes are known as membership functions; these are defined for the output variable (fan speed) as well as the input, room temperature. A fuzzy logic controller is similar to a conventional controller in that it accepts inputs, performs some calculations and generates an output value – this process is known as the Fuzzy Inference Process. There are three steps (shown in Fig. 5):

1. Fuzzification – crisp input values are translated into fuzzy values.
2. Rule Evaluation – fuzzy output truth values are computed.
3. Defuzzification – fuzzy output is translated into a crisp value.

STEP ONE

Step one, fuzzification, involves defining the range of values over which our membership functions are characterised. This information is imparted from the applications engineer and can be modified or turned to adjust the system easily. Fig. 4(b) shows a possible configuration. The labels such as "cool" and "warm" are chosen to allow the system to be described in the most intuitive terms possible.

STEP TWO

Step two, rule evaluation, involves defining the rules which are simply expressions governing the required relationship between the input and output variables in terms of the membership functions. The temperature regulation by the controller is based on how the ambient temperature value is positioned with respect to the membership function ranges and the rules. This example could be defined by rules such as:

Rule one – If temperature is "cold" then fan speed "fast"
Rule two – If temperature is "cool" then fan speed is "quick"
Rule three – If temperature is "warm" then fan speed is "medium"
Rule four – If temperature is "hot" then fan speed is "slow"

Clearly this is a very simple example with only one input so a limited number of possible rules will exist. Where there are more

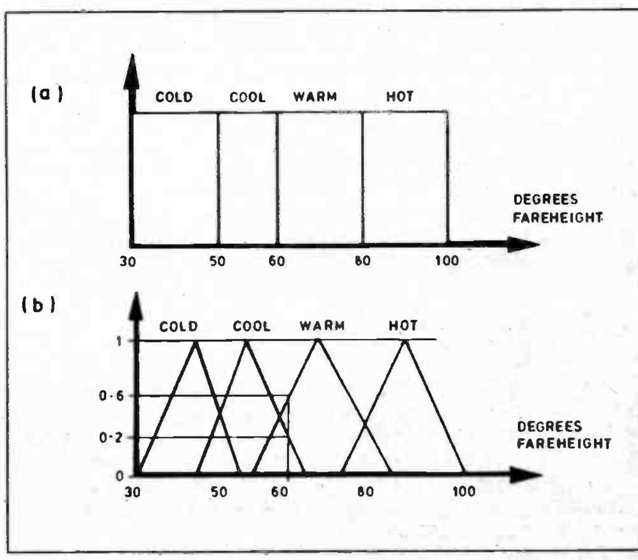


Fig. 4(a). Conventional thermostat system. (b) Fuzzy system.

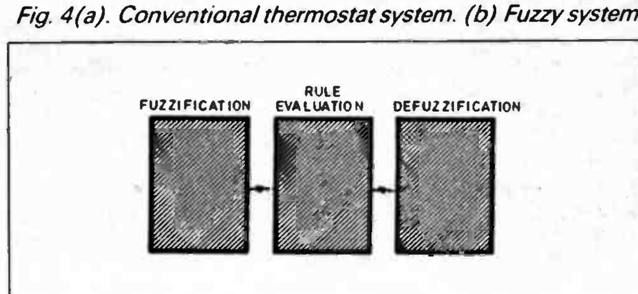


Fig. 5. The Fuzzy Inference Process.

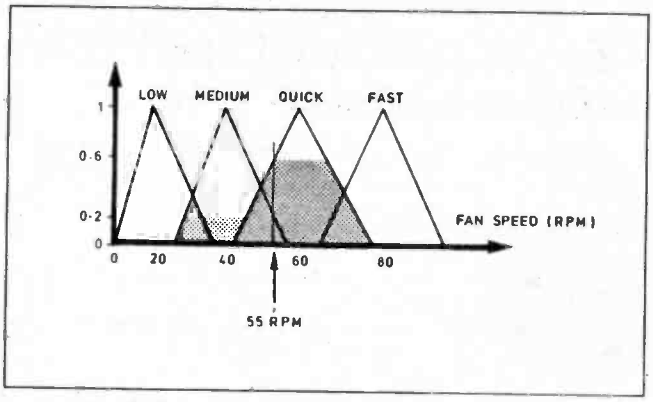


Fig. 6. Calculating the "centre of gravity" point.

input variables (say humidity was a consideration) we can use the "and" statement:

If temperature is "cool" and humidity is "high" then fan speed is "fast"

Steps one and two perform a very straightforward function. They break down the problem into a discreet number of rules or decisions. One advantage of using fuzzy logic is that in order to obtain a satisfactory solution (that is a solution which exploits whatever tolerance exists in the output) it is not necessary to define all combinations of possible rules. A solution which has an acceptable degree of accuracy in it can be obtained from defining only a portion of the possible rule base. Likewise where ultra-accurate results are required, additional membership functions (hence rules) may be concentrated.

Thus a trade-off is made which enables an engineer to select which rules are required to optimise the solution. Fuzzy logic provides a formal framework to determine the decisions which must be made and may be avoided, which doesn't require the experience and applications specific knowledge that conventional algorithm optimising techniques rely on.

The diagram shown in Fig. 4(b) illustrates the fuzzification step where crisp input value 65 degrees F is translated to a truth value of 0·6 in the set "warm" and 0·2 in the set "cool". During the rule evaluation step, the entire set of rules is evaluated and some rules may "fire". For the four rules given above, only the rules defining temperature warm and cool will be active. Rule number 2 will have a degree of truth of 0·2 and rule number 3 will have a degree of truth of 0·6 (for the input temperature of 65 degrees F). Rules number 1 and 4 will each have a degree of truth of zero. As the input temperature changes, the degree of truth of each rule will alter.

STEP THREE

Step 3, Defuzzification, combines the truth values of each of the rules and uses one of several techniques to produce a crisp output value. Fig. 6 illustrates the membership functions of the output fan speed with truth values applied (the shaded region). Using a defuzzification method known as "centre of gravity", the COG point in the shaded region is calculated at 55 r.p.m. (by integration).

ADVANTAGES OF FUZZY LOGIC

The output fan speed is determined without the necessity of defining equations or mathematical relationships between inputs and outputs. Memory-hogging look-up tables are also avoided. The temperature controller example with one input is very simple but the principles are equally applicable to more complex systems. Tuning the membership functions is simple and has an effect only on the desired area of control.

In a conventional solution defined with equations, it is difficult to adjust problem areas without affecting the entire system. The most appealing advantage to the Engineer however, is that when a system does become difficult to define using conventional methods of mathematics (perhaps there are many inputs whose interaction with each other and the output are uncertain) the Engineer can describe in humanistic terms the relationship between the variables in the system in order to generate the desired outputs.

As well as providing this "high level language" which allows engineers of different disciplines to communicate, due to the technique where only the rules which are required to generate particular outputs need be selected, fuzzy is a very efficient and highly non-linear method of mapping input/output structures using a minimum of code and in a very robust manner.

Designers are turning to the fuzzy methodology as design complexity is simplified. It typically takes only a few rules to describe systems that may require complex mathematics and software routines – in particular non-linear systems. As development effort is a function of design complexity it follows that time to market is reduced significantly. The adoption of fuzzy has given many companies a competitive edge in terms of time-to-market for products (not to mention the prestige of a "fuzzy logic" decal).

APPLICATION AREAS

Most of the success that has been attributed to fuzzy logic has been enjoyed by manufacturers in the consumer segment; washing machines, refrigeration, camcorders and such like have all been widely publicised as "fuzzy" products. Fuzzy is now a standard design methodology for Engineers operating in an embedded control environment (using a microcontroller with software). The software option is by far a more flexible and cost-effective option than custom hardware which has also appeared on the market.

Without exception, automotive manufacturers and suppliers are investigating and in many cases already utilising fuzzy control in cars. Engine management, ABS, climate control, automatic transmission, adaptive suspension, cruise control and navigational systems are among the embedded control areas that have been given the fuzzy treatment. Particularly clever "adaptive" systems are already being used in which membership functions are tuned in real-time to suit particular characteristics of the driver/road to optimise the ride.

Some of the most spectacular (in a financial sense) systems that have been based on fuzzy logic have been open-loop expert systems in the world of finance. Already a system has been developed to model uncertainty in market trends and risk analysis to make buy/sell decisions on the stock market.

THE FUTURE

It must be borne in mind that however many applications fuzzy has been incorporated in already, we are looking at a new technology which should be considered under-utilised in terms of the expanse of possible application areas where it has not yet been considered. One estimate claimed that by the year 2000 more than 90 per cent of the embedded control market would employ fuzzy logic in some format (software or hardware). Signs are already that the significant growth indicates this is likely.

Fuzzy logic is only one of a whole range of emerging technologies which are at the forefront of the user-friendly revolution. Artificial neural networks have already been used in conjunction with fuzzy to offer more powerful solutions and their mutual coexistence will be a further development in the coming decade.

DEVELOPMENT TOOLS

Getting started in fuzzy logic is easy. There already exists a number of commercially available development tools which run on PC's to support the design of membership functions and rules. Motorola offer freeware which includes a graphical interface and kernels which will generate source code (from the fuzzy logic) which can be used with their standard range of HC05 and HC11 microcontrollers.

At the top end of the market in development tools, Aptronix offer a professional software development kit (Fuzzy Inference Development Environment) which provides a complete package for using fuzzy logic. This system provides software which also supports simulation and advanced debugging features. □

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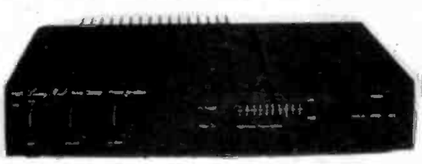

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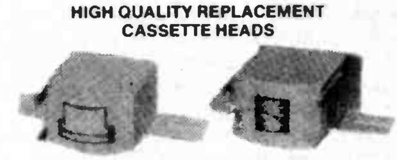

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Teach-In '93

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

Part 8

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.

COMMUNICATION: *something (as information) conveyed in writing, speech or signals* - so our computerised thesaurus tells us. This definition could actually have been written with the GCSE student in mind. We have shown how "information" can be represented in electronic systems by a *signal*, which itself can either be an **analogue** wavy line or a crisp on-off **digital** logic state. If we use a suitable input transducer, it is possible to convert "information" like temperature or light into an electrical signal which can then be processed by an electronic system to fulfil a particular purpose.

Output transducers are also available which can be driven from analogue or digital systems without difficulty. These devices could perform electromechanical functions, e.g. a relay or motor, or alternatively in the case of buzzers or lamps, are a means of communicating with human beings – the System Users.

We have to interface the various parts of the system (i.e. the subsystems) together so that the information "written" by one subsystem is compatible with the "reading" requirements of the next. Broadly speaking, logic systems have no problems in this respect because each gate or logic function recognises a "1" or "0" providing that the same logic family is used throughout the system; analogue systems however need some design thought to ensure that the electronic signal generated by one subsystem can be processed effectively by a subsequent block of the system.

SYSTEMS

Communications concerns the transmission and reception of this information. Fig. 8.1 is a block diagram which contains all the essential elements of a communications system – remember that such diagrams depict the general flow of *information*, not an actual *electrical current* or signal. The latter is only of interest at circuit diagram level.

The **information source** is the point at which information or data is collected. This will utilise an input transducer such as a microphone in an audio system, or perhaps a keyboard button in a computer data transmission system. The information gathered then has to be converted into a suitable form of electrical signal using an **encoder** (don't worry about the jargon – see later) before the information is in a suitable state for it to be **transmitted** over a distance to the **receiver**.

At the receiving end of things, the information has to be **decoded** before it can be processed and used to drive an **output device** (like a loudspeaker, in the case of a radio system). Every communications system has a **medium** through which the information has to be transmitted. The medium is the "stuff" through which the information passes from the transmitter on its way to the receiver. Some "baby listeners" or wireless intercoms encode the speech signal into a form which can be transmitted through the medium of the ring mains. It can be received by a similar unit sharing the same electrical ring mains.

In the case of a radio system, the broadcasting station can transmit information either through *the atmosphere* or a *vacuum* like outer space. Either medium is effective. Radio signals can actually be bounced off certain layers of the atmosphere so that they can be received further round the Earth.

A telephone system will often transmit information through overhead or underground *copper wires* or, as we will demonstrate later, through optically-based systems which use *light* as the information carrier. A complex communications system will use a combination of several forms of media, as technology permits. Now for some history lessons.

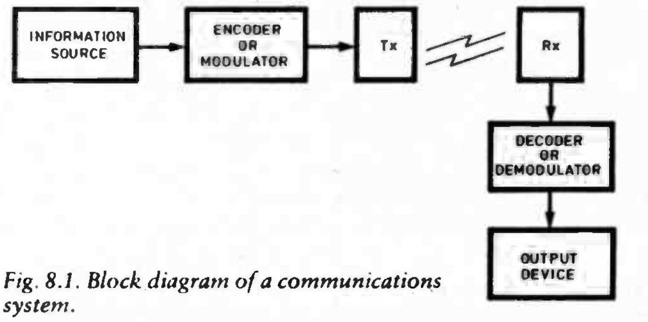


Fig. 8.1. Block diagram of a communications system.

MORSE

Samuel Finley Breese Morse Esq., created the Morse Alphabet in America during the mid 1800's as the basis of a simple communications system, where each letter was represented by a group of "dots" and "dashes". An operator manually translated or *encoded* a message into these pulses by tapping a Morse key, letter by letter. A simple electrical pulse was transmitted down through the medium of a *wire* to the *receiving station* where it caused a tapping sound on the receiving apparatus, producing long or short intervals. Another operator *decoded* this noise, like a clattering relay, and wrote down the message. We can only guess what things were like when his pencil broke!

In the late 1800's, crude attempts were made by engineers to transmit Morse code by a system of *radio telegraphy* – sending Morse code in the form of *radio waves* to a receiver located several miles away, rather than using copper wires as the transmission medium. It was Marconi who successfully transmitted a brief burst of Morse code across the Atlantic Ocean in 1901 using radio waves, but the quality of transmission across such a distance was so poor as to render the system of little use until amplification techniques could be perfected. Dr. Crippen had the dubious honour of being the first criminal to be apprehended (in 1910) as a result of a transatlantic transmission, using ship-to-shore radio.

At this juncture we should point out that it is completely impractical to construct a radio transmitter of any form on the *Mini Lab*, and it is illegal and potentially dangerous to assemble and use one yourself unless you have suitable experience and have passed the appropriate Radio Amateur examinations. Badly made "home-brewed" transmitters could cause widespread interference with regular radio signals, or worse, could interfere with essential emergency services' radio broadcasts. We will certainly explore radio *reception systems* – but transmitters will not be described in any depth at all.

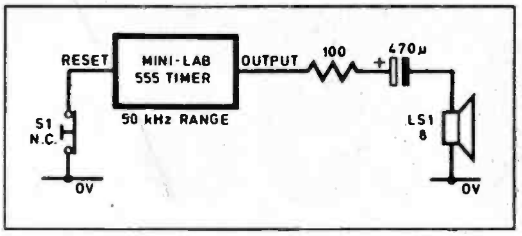


Fig. 8.2. Simple Morse practice oscillator.

MORSE PRACTICE OSCILLATOR

A simple Morse practice oscillator is shown in Fig. 8.2. This uses the *Mini Lab* 555 Timer, set to oscillate at an audio frequency (use the 50kHz range). The output drives the *Mini Lab* loudspeaker which is unhooked from the Audio Amplifier. When the reset terminal is at 0V, the audio tone is inhibited, so by using a *normally-closed* push switch, pressing the switch will produce a note. Use the switch like a Morse key to generate code. We show the Morse code in Table 8.1, for you to have some fun with.

An experimental two-way Morse communicator is shown in Fig. 8.3. Again the 555 Timer is utilised as an audio oscillator, but by switching both the input

Table 8·1 The Morse Code

A	• –	N	– •
B	– • • •	O	– – –
C	– • – •	P	• – – •
D	– • •	Q	– – • –
E	•	R	• – •
F	• • – •	S	• • •
G	– – •	T	–
H	• • • •	U	• • –
I	• •	V	• • • –
J	• – – –	W	• – –
K	– • –	X	– • • –
L	• – • •	Y	– • – –
M	– –	Z	– – • •

Morse key and the output loudspeaker over as shown, a simple send/receive system could be built. It is necessary to build a "remote station" using another normally-closed switch and a second loudspeaker, connected to the *Mini Lab* via three-core wire using the "EXTERNAL INPUT" terminal block if you like. The lucky *Mini Lab* operator has full control of the send/receive function by operating both change-over toggle switches simultaneously (or even better, use a d.p.d.t. switch instead).

Obviously this arrangement is very primitive. The quality of transmission is determined by the length of the wire, its cross sectional area (a smaller C.S.A. has a higher resistance) and the integrity of all the connections. A poor joint somewhere may result in loss of information, and further *losses* will occur if an excessive cable length is used, because its higher electrical resistance is bound to degrade the signal. We will look at more advanced communication systems later on.

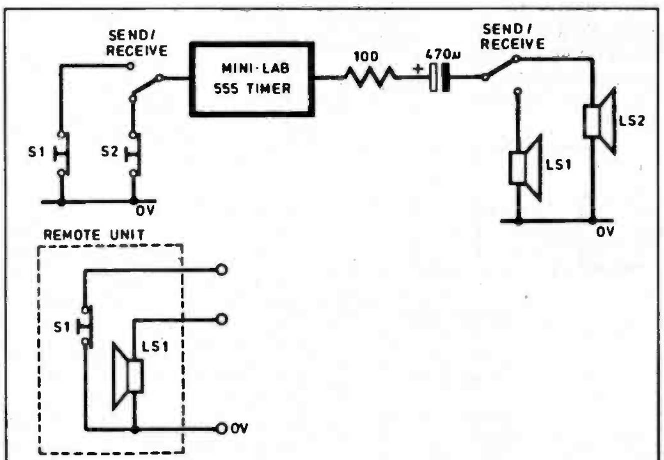


Fig. 8.3. Experimental 2-way Morse system.

RADIO SYSTEMS

Man's natural desire to communicate has ultimately resulted in our directing coded signals into outer space, with a view to establishing contact with any extraterrestrial life forms – an idea which would have been deemed completely absurd one hundred years ago when the pioneers of electricity like Fleming, Hertz (and Marconi) were engaged in their crude experiments. We only hope an alien doesn't reply!

Physicists will know of the principles of the **electromagnetic spectrum**: the fact that light, radio, x-rays and similar phenomena are actually electromagnetic *waves*, rather than, say, particles in motion. Because the various parts of the spectrum are all waveforms, they are characterised by their **wavelength** (signified by the Greek letter lambda, symbol λ).

The electromagnetic spectrum doesn't include *sound waves* which are mechanical pressure waves generated by the movement of physical matter, relying on air molecules colliding with each other in order to be transmitted. However, unlike sound, electromagnetic waves can travel happily through a vacuum (e.g. outer space) as well as air.

For a regular waveform (like a sine wave) **the wavelength is the distance measured** between two points in the wave at a given time: it could be the distance between two peaks, for example, or two troughs. Contrast this with the *frequency* of a waveform which as we know is the number of complete cycles passing a point, per second, see Fig. 8.4. Radio waves, like all electromagnetic (e.m.) waves, travel at the speed of light, literally, which is 3×10^8 metres/second or 300,000 kilometres per second.

At a given frequency *f*, the wavelength in metres is:-

$$\lambda = 3 \times 10^8 / f(\text{Hz}) \text{ metres}$$

In other words $\lambda \times f = 3 \times 10^8$.

If BBC Radio One broadcasts on both 1053kHz and 1089kHz, the wavelength of the radio wave is 285 metres and 275 metres, respectively. (Indeed BBC Radio One confirmed this in its pre – f.m. jingles.) Notice, the *higher* the frequency, the *shorter* the wavelength. This has to be true because a higher frequency means that more waveforms are "bunched in" – resulting in a shorter, more compressed wavelength.

FREQUENCY BANDS

Below, for comparison, is a table showing the orders of magnitudes of frequencies of the relevant part of the electromagnetic spectrum. We also show light frequencies, for comparison. Note how we can cook with e.m. waves too! The audio (sound) frequency range covers 0 to 20kHz but electromagnetic waves can be transmitted at frequencies from roughly 10kHz upwards.

FREQUENCY RANGE	FREQUENCY BAND	APPLICATIONS
150kHz – 300kHz	LONG WAVE	RADIO (LW)
500kHz – 1500kHz	MEDIUM WAVE	RADIO (MW)
10^6 TO 10^9 Hz	SHORT WAVE	RADIO (SW, VHF), UHF TV BANDS
10^9 TO 10^{12}Hz	MICROWAVES	RADAR, MILITARY, COOKING(!)
10^{15} Hz	(VISIBLE LIGHT)	

Radio waves are that part of the electromagnetic spectrum with wavelengths from roughly 0.1 metres (10^{-1} metres) to roughly 10,000 (10^4) metres. Radio waves are created by coupling an oscillator circuit to an **aerial**, to form a transmitter, and the aerial radiates the radio waves into the atmosphere where they can be received by another suitable aerial system.

Given that radio waves are inaudible, information (let's say a simple audio frequency (a.f.) sinewave) is transmitted by radio waves using the clever technique of **modulation**, where the information is "carried" or superimposed onto a stable, regular high frequency radio waveform called a **carrier wave.** Fig. 8.5 shows information in the form of an audio signal, and a radio carrier wave, finally followed by both waveforms mixed together to make a waveform which is suitable for transmission by radio systems.

MODULATION

Two principal methods are used for transmitting everyday music and entertainment programmes by radio. **Amplitude Modulation or a.m.** transmission systems cause the amplitude or "height" of the carrier wave to be varied in sympathy with (modulated

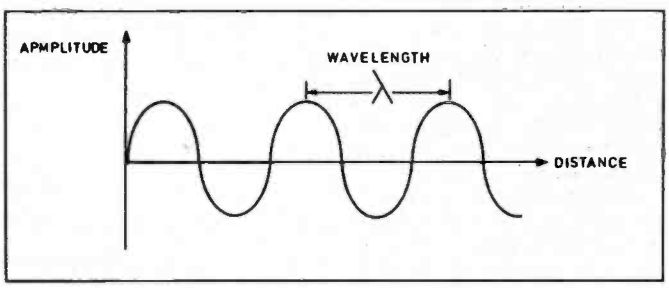


Fig. 8.4. Measuring the wavelength of a sine wave.

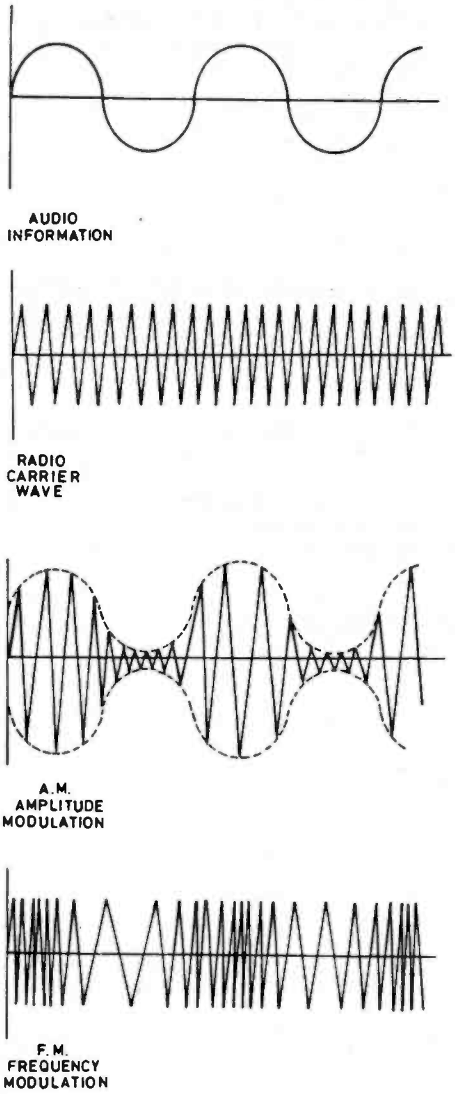


Fig. 8.5. A.M. and f.m. techniques.

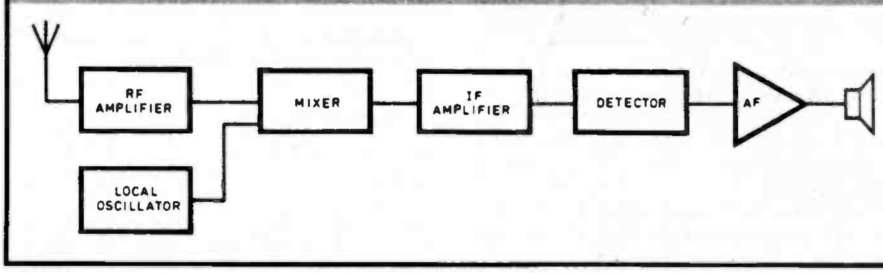
THE SUPERHET

A more sophisticated receiver uses the principles of **heterodyning** to improve the sensitivity and selectivity of reception. It might be used in SW (Short Wave) receivers where the aforementioned characteristics become critical. A systems diagram is shown below. R.F. signals are received by an aerial and fed into tuned radio frequency (t.r.f.) amplifier, which helps to single out the desired amplitude-modulated frequency that we're interested in.

Within the receiver is a **local oscillator** which generates a stable waveform at a somewhat higher frequency than the r.f. carrier. This is fed, along with the t.r.f. amplifier's output, into a **mixer**. Interesting things happen here: have you ever heard a twin-engine propeller aeroplane pass overhead? You might notice a "drumming" or "throbbing" noise, caused by the slight difference in pitch of both engines, when they gradually work into or out of phase with each other. This "beating" phenomenon is called *heterodyning*.

Exactly the same happens in the mixer circuit. A "beat" is produced and the main result is that the high r.f. carrier wave is reduced in frequency to a much lower one, now called the **intermediate frequency** or **i.f.** Because of the physics behind the heterodyning effect, the mixer's output frequency is equal to the *difference between* the r.f. carrier wave and the local oscillator frequency.

The programme information is still there, now superimposed on the intermediate frequency instead. The **i.f. stage** has the job of amplifying the i.f. signal – much easier to handle accurately than the previous high r.f. frequencies – which can be filtered as necessary to precisely pick out the required frequency of transmission. Finally, the signal passes through an **a.m. detector** which demodulates the information, leaving us with a very finely tuned audio signal free of interference from adjacent broadcasts.



by) the information signal. Alternatively, **frequency modulation** or **f.m.** systems modulate the carrier wave's frequency in sympathy with the audio signal, instead. In the latter case, the amplitude of the carrier wave remains constant – refer to Fig. 8.5.

The end result is the same: information encoded onto a radio carrier which can be transmitted and then received by a suitable receiver. Which system is better, a.m. or f.m.? The trouble with varying the *amplitude* of the carrier in an a.m. system is that this enables unwanted information to *interfere* with the amplitude modulation process.

Electric motors, petrol engines (electrical noise caused by spark plugs) or other sources of electric pulses can cause undesirable amplitude peaks to be added to the a.m. signal. This is reproduced as crackling interference on the receiver's loudspeaker. It can be minimised by *suppressing* the interfering appliance (e.g. a food mixer's electric motor) with suitable inductors and capacitors, and by *shielding* sensitive signal-carrying cables (see later).

However a frequency-modulated system does not take into account any variations in amplitude, and is only interested in the frequency of the carrier wave itself, something which noisy electric motors cannot impinge upon. So an f.m. system has an improved **signal-to-noise ratio** which inherently rejects more interference than a more simple a.m. receiver. Additionally, f.m. systems offer a generally improved audio quality, which hi-fi buffs really appreciate.

CRYSTAL SET

The earliest example of a radio receiver was the "crystal set", the circuit of which is shown in Fig. 8.6. It uses no batteries, and has very few components. The two components L1 and VC1 are a coil and capacitor wired in parallel to form a **tuned circuit** (also called a "tank" circuit) because it is "tuned" to a particular frequency. There is no battery, but the *aerial* (or "antenna") when connected as shown, provides a source of energy for the crystal set in the form of electromagnetic waves which have been generated by transmitters.

When energised in this way, the tuned circuit is "tickled" or stimulated and will actually *oscillate* at a frequency *f* which is determined by the values of L1 and VC1:

$$f = 1/2\pi\sqrt{LC}$$

where *f* is the frequency of oscillation in Hertz, C is the capacitance of the "tuning capacitor" VC1 in Farads, and L is the value of the inductor L1 (which is measured in units called "Henrys") π is the constant "pi" = 3.1415927...

By making either the inductor or the capacitor variable, it is possible to alter the oscillating frequency of the tuned circuit: hence we can "tune" the circuit to a particular frequency – that of the r.f. carrier

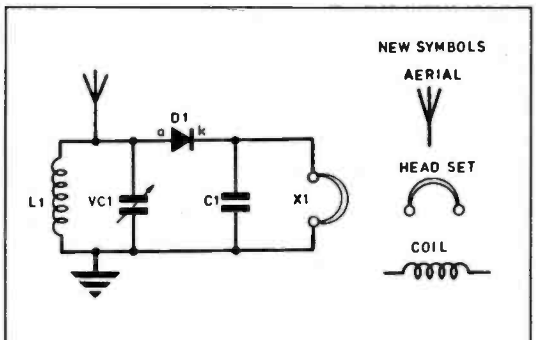


Fig. 8.6. Basic "crystal" receiver.

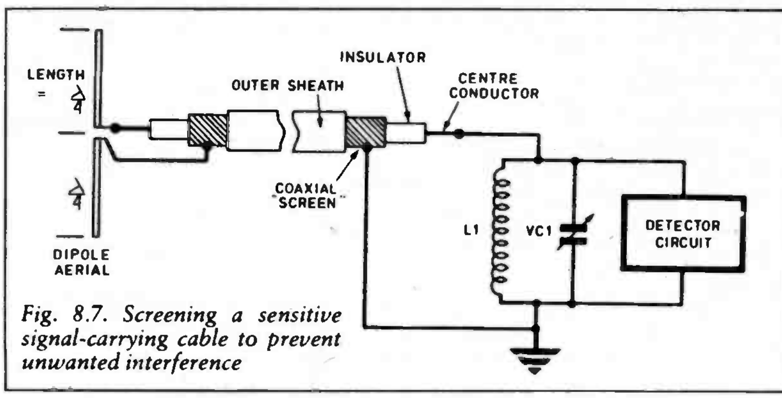


Fig. 8.7. Screening a sensitive signal-carrying cable to prevent unwanted interference

wave. This type of circuit is suitable for receiving a.m. radio signals.

The desired size of the aerial system is closely linked to the wavelength of the radio waves being transmitted or received. For instance a basic **dipole** aerial should be $\lambda/2$ in length for best results, so that the aerial conductors can resonate at the same frequency as the tuned circuit, see Fig. 8.7. This means that each element of the dipole should be $\lambda/4$ in length.

SHIELDING

As a way of "protecting" the received signal, the aerial has been connected to the receiver using **coaxial cable** (like TV aerial wire) as shown in Fig. 8.7. The cable has an *inner conductor* surrounded by a *screen*. The dipole aerial elements, of suitable length, are connected at one end. The screen would be connected to the 0V rail/earth and the a.m. signal would be carried by the inner core; the screen shields the signal and helps prevent unwanted pickup from other signal sources. Special "low noise" coaxial connectors could be utilised as necessary to help shield the signal and prevent interference or unnecessary losses.

The aerial picks up a.m. radio signals and causes the tuned circuit to oscillate at its natural or "resonant" frequency. This signal would tend to cancel itself out because it has an equal and opposite "mirror image" as shown in Fig. 8.5 earlier. However, one half of the resultant waveform is rectified by the diode D1. The reason for the name "crystal set" is because in early days, the diode D1 was fabricated from a crystalline compound like galena.

The result of rectifying the signal is a waveform which has the audio information imposed on the rectified radio signal. The **filter capacitor** C1 has a value which is chosen to filter out the r.f. contents of the rectified waveform. The capacitor's impedance is very low at high radio frequencies, but represents a high impedance to audio-frequency waves. In Part 2 we described the impedance symbol Z (or more precisely, "capacitive reactance", symbol X_C) of a capacitor as being related to the applied frequency:

$$X_C = 1/2\pi fC \text{ ohms}$$

Thus a small-value capacitor will present a very low impedance path to r.f. waves whilst barely affecting audio waves (which are no higher than roughly 20kHz). Calculate the impedance of a 1nF capacitor at r.f. (say 1 MHz) and a.f. (say 1 kHz) – 159Ω and 159kΩ respectively – so the higher r.f. is filtered to 0V and the lower audio frequency remains.

Hence we are left with the audio signal itself – the a.f. information which originally modulated the carrier wave. The process of rectifying and filtering out the r.f. content is often called "detection" by radio experts. The audio signal can sometimes be heard over *high impedance* headphones or a crystal earpiece – in theory anyway.

CRYSTAL SET EXPERIMENT

The trouble is, this circuit is so crude that it is nearly impossible to obtain any worthwhile results without the help of extra audio amplification, so the *Mini Lab* Audio Amplifier can be used. For the next demonstration, try assembling the crystal receiver by soldering the components to each other point-to-point. The components can later be recycled for use in the *Mini Lab* Radio Tuner module, so refer to the *Mini Lab* components list this month.

Our own aerial took the form of a 6 metre long wire dangling out of an upstairs window! It was soldered directly to the junction of L1 and VC1. The coil L1 can be several hundred turns of 0.19mm (roughly) enamelled copper wire on a 7mm dia. by 100mm long ferrite rod (ferrite is a metallic compound which greatly improves the inductance of the coil). Otherwise you could try a ready-wound inductor of any nominal value.

The variable capacitor is a miniature a.m. tuning capacitor, connecting to the terminals designated "Antenna" and "Ground". The detector diode D1 should be a **germanium** signal type (e.g. OA91). You can try using a crystal earpiece for the "headphones", but you will probably have little success in discerning a radio transmission.

To be honest, using just a crystal earphone we couldn't hear a thing – apart

TEACH-IN GCSE QUESTIONS

The more advanced questions posed in GCSE or GCE Papers require several pages and are thus too long to reproduce in *Teach-In '93*, much as we would like to. This month, we use by kind permission of the University of London Examinations and Assessment Council, a straightforward question concerning radio reception. It appeared in the Summer 1990 Examination, Paper 1 (1505/1 1506/1) held by the London East Anglian Group. The answer is the work of the Authors, not the Examining Board, and may not represent the only possible solution.

19. The diagram of a simple Radio Receiver is shown in **Figure 20**.

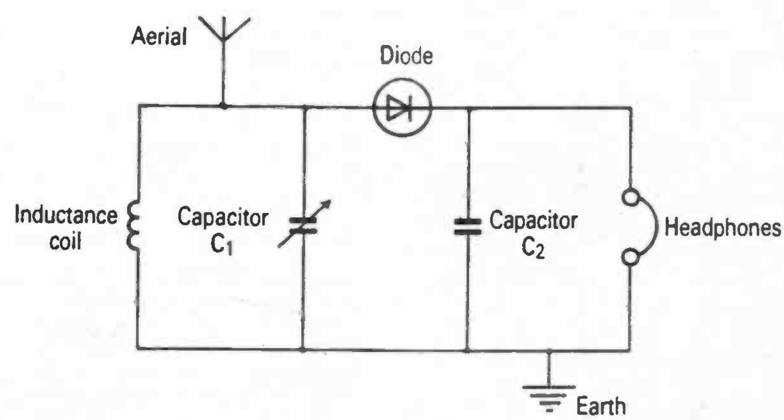


Fig. 20

(a) Which component:

(i) picks up radio waves? ....

(ii) is adjusted to tune the receiver? ....

(iii) filters radio frequencies (RF) to earth? ....

(iv) demodulates (detects) the signal? ....

(b) What type of capacitor is C_1? ....

(c) What other device(s) would be needed **in addition to** the ones shown in **Figure 20**, in order to drive a **high power** loudspeaker?

....

(d) Here is a list of frequencies:

0.5 Hz **700 Hz** **400 kHz** **90 MHz**

Which is

(i) an audio frequency (AF)? ....

(ii) an amplitude modulated (AM) radio frequency? ....

(iii) very high frequency (VHF)? ....

from crackling interference, which proved that electromagnetic energy was present in the tuned circuit so at least the aerial was picking up *something*. However, by feeding the audio signal into the *Mini Lab* Audio Amplifier instead, we clearly received a radio broadcast from Radio Moscow, in English.

Try tuning the capacitor, and try adding more turns on the ferrite rod to increase the tuning scale. A great deal of experimentation may be needed, but have a go. It's a good idea to try listening at the top of the hour, when many stations broadcast a station I.D. followed by a news or information bulletin.

At the other end of the tuned circuit, (the "earthy" end) it is possible to connect this to a good earth – such as a water pipe going into the ground. This provides a kind of mirror image of the aerial, doubling its effective size. It's certainly worth a try. *(I once did this and received a live broadcast from Nashville, Texas! A.W.)*

Your trials with this circuit will be very much hit and miss, but should provide an hour or two's fascinating entertainment. Write and tell us if you have any success. Clearly, an amplifier is almost essential, and it's also essential that the tuned circuit is buffered somehow so that it is not unduly loaded, otherwise degradation of the signal will result.

SATELLITE SYSTEMS

Radio waves have different ranges over which they can be transmitted effectively, depending on their frequency, and we take advantage of various phenomena to improve their effective distance. A **direct wave** (or "space wave") travels in a straight line from transmitter to receiver whilst a **ground wave** (or "surface wave") closely follows the curvature of the earth's surface but, depending on the frequency, may have a severely restricted range.

Just as light can be reflected down a fibre optic light guide, it's possible to bounce radio waves off the various layers which make up the earth's atmosphere. The returned signals can also reflect off the Earth and back into the atmosphere again. A **sky wave** is a radio wave which has been reflected from the *ionosphere* and it can be received far away round the globe. It's a crucial technique for world-wide communications. Unfortunately the reflective properties of the atmosphere are variable and can be disrupted by weather and sunspot activity.

For reliable long-distance communication, orbiting **space satellites** are used to receive signals called **space waves**, beamed into space *through* the ionosphere from one part of the Earth, and retransmit them to another. Because of their extreme altitude, one small satellite can cover all of Europe for example. They are generally placed in **geostationary orbit** so that the speed of the satellite matches that of the earth's rotational speed, hence the satellite appears stationary above a particular point. (The writer Arthur C. Clarke actually predicted this technique long before it was feasible.)

Some geostationary satellites are used for communications of data round the planet. Digital information is transmitted directly between computers whilst *telecommunications traffic* lets us talk or send facsimile pictures ("faxes") to any country in the world. Several communications media have to be used in complex systems like these, including undersea cables, satellites and fibre optics.

For long distance coverage, analogue signals from the telephone are converted into digital, then converted back to analogue – probably at your local exchange if it has been modernised. Hence, long distance phone calls often have a much higher clarity than the short distance local call which may be 100 per cent analogue.

NAVIGATION

An area of direct interest to co-author Keith Dye is **satellite navigation systems**. A system called **Transit** was devised by military planners where several satellites circled the globe transmitting information about their current orbit. From this, a receiver could track the satellites and deduce its position to within 150 metres. The low number of satellites meant that information was not always instantly available on tap – you had to await the next passing satellite. Then several would come along at once, like buses! The system was later made available to everyone, especially mariners.

Transit has been superseded by the **Global Positioning System** (GPS) which uses a large number of satellites to form a web of information around the globe. From any point of the earth's surface, three or more satellites will be "visible" at any one time. Ultra high accuracy atomic clocks in each satellite mean that the user can choose the three strongest signals and instantly display his location to within a few *metres*. The set-up used in the Dytronics workshop, fixed on up to five satellites at a time and agreed *precisely* with an OS map of our area in South Humberside. (It's actually more accurate than the map!). It can also tell us our altitude, speed and direction of travel where applicable.

The downside is that it is *too* accurate for public use, as deemed by the military authorities who deliberately corrupt the information for civilian users, to about 100 metres or so. Professional surveyors however have overcome this with error-correction techniques, and an accuracy of *millimetres* is feasible, measured anywhere around the world. Hand-held GPS receivers paid a key role in the Kuwait desert conflict, and one British tank commander commented that he threw away his maps and relied on the GPS system. In fact, the GPS system will see a need for correcting many existing maps which have been proven as inaccurate.

We will look briefly at the effect of electronics upon society in the next part of Teach-In. We all take electronics far too much for granted and the GCSE syllabus requires some appreciation of its impact on the way we live.

BANDWIDTH

Amplitude modulation actually produces not only a modulated carrier wave but also additional neighbouring frequencies as a side-effect, which are related to the frequencies of the carrier wave and the information signal. Allowances have to be made for these extra frequencies, to ensure that they don't interfere with neighbouring transmissions. So when allocating places on a tuning scale to a particular station, a "window" is reserved for it, which should contain all the frequencies of information likely to be transmitted, without interfering with the contents of a neighbouring "window". The window is called the **bandwidth** whose limits are called the **upper** and **lower bandwidths**.

However, with overcrowded wavebands, it may not be possible to allocate a reasonably-sized bandwidth to a station, so limits are imposed. This places constraints on the frequency range of the information signal which the station can transmit, resulting in a compromise in the quality of the radio signal. These restraints particularly affect stations on the older a.m. bands. The newer f.m. band (also called "v.h.f." for very high frequency) enable stations to have a wider bandwidth, which permits a wider (audio) frequency range to be broadcast – another reason why f.m. stations have a higher fidelity.

It's now possible to analyse our complete a.m. radio reception system in terms of the block diagram shown in Fig. 8.1. The *information source* would be a microphone, tape, record or compact disc player – whichever medium the programme presenter used. The *encoder* is actually a **modulator** which would impress the audio signal onto a carrier wave.

The *transmitter* itself does the job of propagating the radio signal through the aerial. The receiver, as we have seen, contains a *decoder* or **demodulator** which is responsible for filtering out the r.f. content of the signal, leaving the audio programme to be heard on the *output transducer*. We will shortly see how the same principles can be applied to information which is transmitted through a different medium: light.

A **tuned radio-frequency (t.r.f.)** receiver has several tuned circuits followed by audio amplification sections, to form a more sensitive radio receiver. R.F. transformers are used for coupling between stages – they are those funny little square silver cans you may have seen in the back of a radio set. The use of several tuned circuits in tandem means that the receiver is more *selective* and can eliminate unwanted transmissions. Also see the separate panel on the **superheterodyne receiver** or "superhet" which outlines a further refinement in radio reception.

On a practical note, it isn't always possible to construct a radio receiver on a breadboard, because the rows of contacts act like capacitors having air as the dielectric. Manufacturers even have to be careful with the design of printed circuit boards, in order to eliminate any unwanted "stray"

GCSE QUESTION ANSWERS

This question related to the "Crystal Set" and Teach-In readers should have found no difficulty in answering it. The tuning scale of an AM/FM radio might help you with (d).

(a) (i) Aerial.
(ii) Capacitor C1.
(iii) Capacitor C2.
(iv) Diode.

(b) A variable tuning capacitor.

(c) A transistor or i.c. audio amplifier system.

(d) (i) 700Hz.
(ii) 400kHz
(iii) 90MHz.

capacitances between copper tracks which might affect the circuit.

It is possible to reduce the size and number of components in a receiver with chips which have a complete radio detection and amplification function all in one. The *Mini Lab* Radio Tuner uses such a device – the ZN414 which in conjunction with the Audio Amplifier, produces an effective a.m. radio receiver. The detailed analysis and demonstration of f.m. radio systems is regretably beyond the scope of *Teach-In*.

SATELLITES

Satellite communications (satcomms) systems enable us to transmit information around the world – one application of satcomms is that of **satellite navigation systems**. See the separate panel. Radio systems have been with us a long time – about a century – but the advent of computers and information technology (IT) has brought about an enormous demand for **data transmission systems**.

Just as the original Morse systems were restricted by the distances that could be covered with wires, radio signals too are subject to degradation, interference and eavesdropping, and high-speed communications technology now regularly utilises another medium, in order to transmit information. (In fact the growth in communications has placed such a strain on the telephone network that all UK 'phone numbers are set to be changed in 1995 by adding an extra digit.)

LIGHT

The **fibre optic** medium uses strands of clear plastic or special glass to carry pulses of light which represents information. A fibre optic light guide is shown in Fig. 8.8. It consists of a glass-like polymer core surrounded by a tough sheath. It's fairly resilient and flexible, but most of all it is an excellent conductor of light waves. It relies on the fact that if a light beam strikes a reflective surface at a particular angle (the angle of incidence), then it will all be reflected back off at the same angle (the angle of reflection) and no light will escape. Hence, light which is shone into one end, will tunnel its way down the fibre, bouncing off the inside walls of the fibre, finally appearing at the other end, many miles away if necessary – or more.

A fibre optic communications system is identical in principle to the block diagram shown in Fig. 8.1. An information source (like a telephone system, or a computer) generates data – either digital or analogue, depending on the system. A **light source** has to be **modulated** with this information, then the light is transmitted through the fibre optic medium. At the receiving end, the light signal has to be decoded or **demodulated,** and the resultant information can then be processed – perhaps feeding into a telephone system or another computer. The advantages over a radio or cable system are these:

★ No interference from other transmission systems.
★ Wider bandwidth, means more capacity to transmit more channels of information.
★ Lower losses than a comparable wire system.
★ Overall, cost is cheaper than a comparable wire medium.
★ Not affected by atmospheric conditions.
★ Safe to use – no high voltages involved.
★ Complete electrical isolation of the transmitter and receiver.

On the down side, fibre optics rely on the *mechanical integrity* of the fibre. Severe vibration or physical damage like crushing might degrade the information. Fibres have to be connected together using optically-perfect dust-free splices, and the actual ends of the fibres need to be as perfectly smooth and polished as possible to transmit the maximum amount of light.

This subject is a fascinating one and demonstrating fibre optics in action is great fun using the *Mini Lab*. Various fibre optic components are available from some suppliers and in order to prove that fibre optics can indeed transmit information take a look at Fig. 8.9(a), which is a basic optical system for sending Morse code. It is in fact the optical equivalent of the simple Morse system of Fig. 8.2.

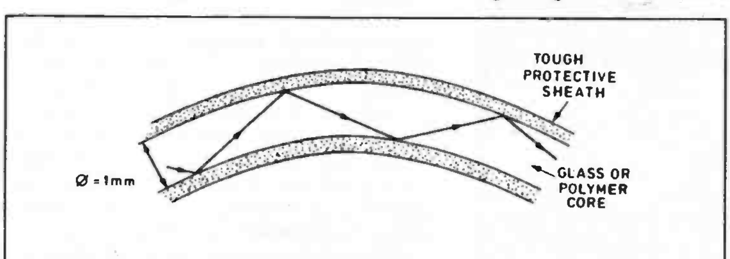


Fig. 8.8. How light "tunnels" down a fibre-optic light guide.

FIBRE OPTIC SYSTEM

This system uses D1 as a **visible light emitter** – a Motorola type MFOE76 – for a source of light. This device is simply an efficient l.e.d. but it is fitted with a mechanical coupling which enables one end of the fibre to be securely clamped to it. R1 is a series limiting resistor and S1, when closed, operates the light source. Light is then *transmitted* down the fibre.

The *receiving* end of the fibre shines onto D2 which is a Motorola **detector** type MFOD71. This is a light sensitive diode – a **photodiode.** It too has a coupling, so that the fibre can fit securely without letting outside light interfere. Notice how the photodiode is *reverse biased.* When it is illuminated by light impinging on it, the current through D2 increases which increases the voltage at TR1 gate terminal.

This device is a "Fetlington" – a high gain field-effect transistor or f.e.t. Darlington (see Part 5). TR1 basically acts like a switch, which turns on when the gate terminal is high. When light shines down the fibre light guide, TR1 conducts so the drain terminal is near to 0V, hence the output – marked "X" – is low. This modest receiver or light-sensitive switch has several applications in the field of communications.

Obtain the components in the usual way and assemble both the fibre-optic transmitter and receiver on the breadboard. The Motorola opto-electronic components will both push-fit into the breadboard directly, but *note that they have differing pinouts.* The pinout for the f.e.t. is also given in Fig. 8.9(b). Follow the circuit diagrams carefully, remembering that D2 is to be reverse connected.

A fibre optic medium is used to link the emitter and detector, and a 10 metre length proved successful in our trials. We recommend purchasing between 5 and 10 metres of fibre optic light guide in one continuous length or as much as you can afford. (You could use just two or three metres to prove the demonstration works.) It *must* be 2.2mm outer diameter with a 1mm diameter fibre, in order to match the emitter and detector couplings.

Hold one end of the fibre next to a strong light (e.g. a halogen bulb) and see how light

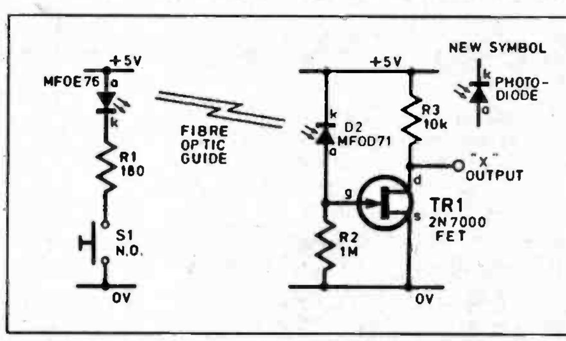


Fig. 8.9(a). Simple fibre-optic transmission system.

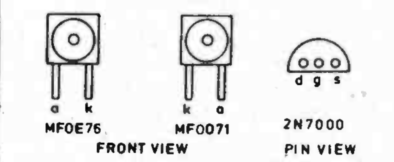


Fig. 8.9(b). Motorola emitter/detector and f.e.t. pinouts.

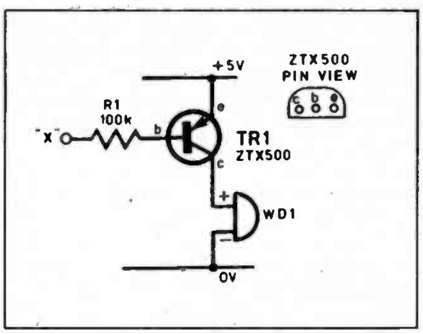


Fig. 8.10. Interfacing an output transducer to the fibre-optic light guide.

appears at the other end of the fibre. It's best to slice each end of the fibre cleanly, using a very sharp knife blade or scalpel, in order to improve the transfer of light. Strip approximately 5mm of outer sheath from each end, then push the fibre very firmly into D1 until it "clicks" positively into place. Tighten the ring nut.

Only fit the fibre to the emitter to begin with, then switch on the 5V rail and press S1 – look down the other free end of the fibre and you will clearly see visible red light, which has travelled down the fibre from the source. The light guide itself can remain as a coil on the bench top – but do *not* bend or kink the guide sharply or it will be damaged. Then fit it to the photodiode D2.

Connect the L.E.D. Voltmeter (5V f.s.d.) to the output "X" and it should read roughly 0V when S1 is pressed, and 5V when the switch is open. Do ensure that you do not twist the wire leads of the optical components; tape down the light guide if necessary.

INTERFACE

A suitable interface which drives the *Mini Lab* buzzer from the light receiver circuit of Fig. 8.9(a) is shown in Fig. 8.10. Because the f.e.t. inverts the signal (a "high" at the gate produces a low output at "X"), we used a *pnp* transistor switch TR1 to invert the signal back again.

When the base is 0.7V less than the emitter (remember it's a *pnp* transistor) then the transistor saturates and completes the circuit to the buzzer which sounds. Build this extra interface on the *Mini Lab*; pressing S1 should therefore cause the buzzer to operate. Experiment further by replacing WD1 with a bulb or an l.e.d. with series resistor if you like.

This arrangement is the most fundamental data transmission system which could be used as a completely solid-state version of the simple Morse key system we met at the start. It proves that light can indeed be used to transmit information, albeit in a basic form in this demonstration. In fact it's a simple *digital* data transmission circuit which deals with two states – the "dot" and "dash" of the Morse code.

RADIO GUIDE

The next section uses the Mini Lab *Radio Tuner as a source of information, which will be transmitted through the fibre optic guide.*

Analogue information – in the form of speech or music signals, for instance – can also be transmitted by opto-electronic systems but it then becomes necessary to *modulate* the light source, so that the intensity of the emitter is varied in sympathy with (i.e. modulated by) the information. It's exactly like modulating a radio carrier wave with the programme information. (Perhaps you recall the simple siren we suggested in Part 6, where an audio frequency oscillator in the form of a 555 astable, was modulated by another sawtooth signal on its control voltage pin, to produce a police car sound effect.)

A very basic but effective modulator (encoder) is shown in Fig. 8.11(a), which replaces the simple push-switch encoder used to drive the light source previously. An *npn* transistor switch is based around TR1, wired as an emitter follower. The light source D1 will illuminate whenever the base is about +2.5V or more. This can be built on the breadboard hooking up to the *Mini Lab* 47k preset resistor, which adjusts the sensitivity of the emitter l.e.d.

Keeping the L.E.D. Voltmeter connected to the f.e.t., switch on the 5V rail and trim VR1 so that the voltage at the receiver output (point "X") is at half the supply rail, 2.5V approximately. The system is then ready to accept an analogue signal which can be taken directly from the Radio Tuner output. It's necessary to couple this audio signal to the modulator by passing it through a suitable blocking capacitor, say 100nF or so, as shown in Fig. 8.11(b).

TRANSMISSION SYSTEM

Turn on the 5V rail and adjust the gain control of the Radio Tuner as needed. Hopefully, the tuner output will be seen as flickering variations on the L.E.D. Voltmeter ("dot" mode is much better, seen in a subdued light), which demonstrates the entire transmission process: the modulation of the audio signal, the transmission and reception through the light guide and the *demodulation* by the photodiode and f.e.t. receiver.

The circuit of Fig. 8.11(c) indicates how the output from the demodulator ("X") can be connected to the Audio Amplifier where the signal from the Radio Tuner will clearly be heard. Remember that the signal you are listening to has modulated a visible light signal which has been transmitted down a fibre optic, and has then been demodulated at the receiver. (If your results are poor, try re-making the fibre-optic connections, and ensure that the fibre ends are firmly pushed into the Motorola components.)

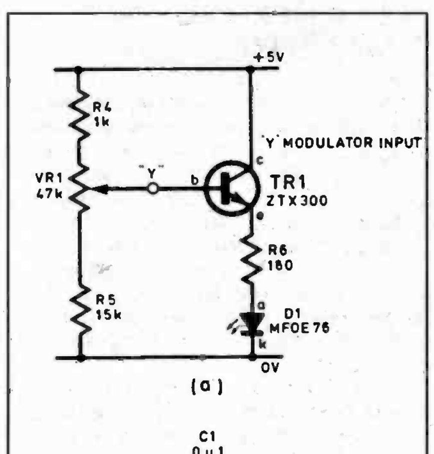


Fig. 8.11. (a) Simple modulator for encoding a signal into a light form. (b) Coupling the Radio Tuner to the fibre-optic encoder. (c) Monitoring the demodulated output with the Mini Lab *Audio Amplifier.*

You will recall that the input of the LM380 amplifier circuit already incorporates a d.c. blocking capacitor, so it is not necessary to decouple the signal from the demodulator any further. Simply connect the f.e.t. through the potential divider as shown, then hook it directly to the Audio Amplifier. Don't forget to turn on the 12V rail! Keep the L.E.D. Voltmeter in place, but you might like to change to the 2.5V setting to observe the audio signal.

Experiment further by using a changeover toggle switch to alternate the input of the Audio Amplifier (common) between the Radio Tuner output and the f.e.t. demodulator output "X". Changing the switch over will demonstrate the difference between a direct wire link and transmission through the fibre optic system. We think you'll be impressed! The quality of the audio signal does depend directly on the quality of your ferrite rod aerial, however, and the adjustment of the 47k preset is critical for successful operation. Retain the f.e.t. demodulator for further use afterwards.

DATA LOGGING

Data logging concerns the *gathering and recording of information.* This data could actually be either analogue or digital in nature. Perhaps you want to monitor the elapsed time during a particular laboratory experiment (like our charging capacitor demo. in Part Two) or maybe record the temperature of an electronic component under varying loads: the results produce analogue data in the form of a wavy line that could be plotted on a graph. When jotting down and recording this important information, we often say that we have "captured" the data.

Digital data might be generated by a very sophisticated computer system, such as a satellite tracking station or a space observatory watching the planets. Of course we now know in basic terms how to interface both digital and analogue information to an electronic system which is capable of processing it further.

Our next demonstration uses a fibre optic transmission system as part of a simple data logging application. Fig. 8.12(a) is a systems diagram of a proposed experiment which will allow us to monitor ambient light levels. We included this partly because it is such a neat application of a readily available light-sensor i.c., the Texas TSL220. Light levels are captured by a transducer and the information is then encoded into a suitable form which can then be transmitted down the medium of a fibre optic light guide.

At the reception end, the information/data is then decoded (demodulated) so that it can be displayed on a suitable output device. In our case, we used the analogue display of the L.E.D. Voltmeter to give a direct reading of light levels. The point to note is the fact that data has been captured at a place which is *remote from* the place where it will be displayed. The distance between the two points is determined by the length of the fibre optic, which has to be limited to a

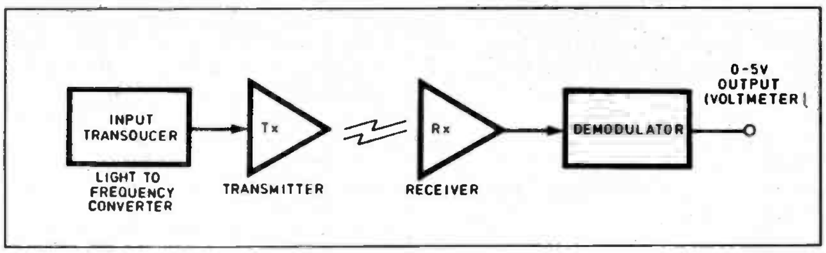


Fig. 8.12(a). Simple data logging application.

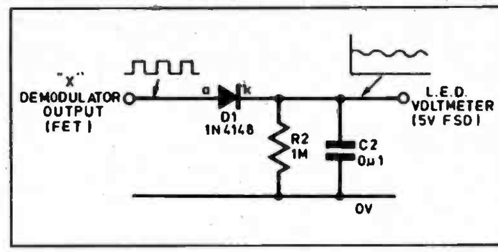


Fig. 8.13. Peak level detector for observing data on the L.E.D. Voltmeter.

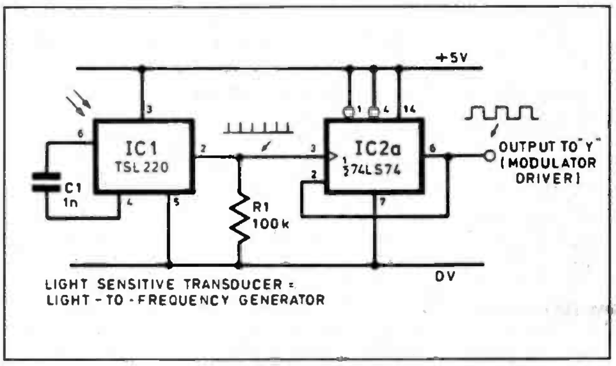


Fig. 8.12(b). Coupling the Radio Tuner to the fibre-optic encoder.

maximum depending on the "strength" of the signal passing down the light guide.

Often a "booster station" might be used to amplify the data during transmission, to prevent loss of information (signal degradation) over great distances of several miles. However, fibre optics do not of course suffer from problems with "noise" or interference and the fibre does not need any form of electrical shielding.

LIGHT WORK

The proposed circuit diagram is given in Fig. 8.12(b). IC1 is the TSL220 chip. This fascinating device is a completely transparent i.c. which incorporates a large photodiode to monitor ambient light levels. (You can actually see the silicon "chip" as well, inside.) It generates a pulse waveform, the frequency of which is dependent upon the light levels. This pulse stream appears at pin 2 but the mark-to-space ratio is small and the result is a stream of extremely narrow pulses.

A divide-by-two circuit was added to modify the signal from the Texas i.c., IC2a is half of a 74LS74 D-type flip-flop which provides a more usable square wave, remembering that the flip-flop is *edge-triggered* and ignores the *time period* of the clock pulse, so it's ideal here. The data generated by IC1 finally appears at pin 6 of IC2a as a stream of pulses the frequency of which is controlled by the light level detected by the TSL220 chip. The data is connected to point "Y" of the modulator circuit, which forms the transmitter of our fibre optic system. Hence, the MFOE76 optical emitter will flash at a rate determined by the ambient light.

At the receiver, the incoming (digital) data is represented by a stream of light pulses which have to be decoded and converted into an *analogue* signal before it can provide a meaningful display on the L.E.D. Voltmeter. Therefore a suitable interface is needed between the output of the f.e.t. decoder (point "X"), and the input of the L.E.D. Voltmeter, see Fig. 8.13. This will "iron out" the pulses and provide a variable d.c. voltage, the level of which depends on the frequency of the incoming pulses.

This interface is a "peak level detector" in which an incoming pulse charges up the capacitor C2. When the input reverts to a low logic level, the diode D1 prevents the capacitor discharging back, and instead because D1 is now reverse biased, the charge on C2 is stored. This results in the voltage level across the capacitor being displayed on the L.E.D. Voltmeter. The capacitor slowly discharges into the 1M resistor (and also into the voltage divider network on the voltmeter circuit), so eventually the p.d. across the capacitor drops away.

Because the data received is a *stream* of pulses, C2 keeps "topping up" its charge and the p.d. across it is averaged out. When the data frequency rises then the average voltage across the capacitor rises too, resulting in the L.E.D. Voltmeter displaying a higher voltage. It's the basis of a *frequency-to-voltage converter.*

DATA LOGGING DEMONSTRATION

Assemble the whole system on your *Mini Lab*, starting with the TSL220 circuit (easy), which is linked into the fibre-optic emitter circuit. The fibre optic receiver based around the f.e.t., is wired through the peak-detector interface, finally to the L.E.D. Voltmeter (5V f.s.d.). Switch on the 5V rail and hopefully an arbitrary reading should appear on the voltmeter. If you have an oscilloscope, monitor the pulses at the TSL220 output and also the ripple across the peak detector. Adjust the 47k preset as needed.

This circuit has an extremely rapid response time and we found that the circuit was so sensitive that just walking around the room was enough to cause a steep change of reading on the L.E.D. Voltmeter. Well done for getting this far!

Obviously this simple demonstration is limited by the fact that everything has to be constructed on the *Mini Lab* board where the power supply is located; in real-life applications, the principles used in this experiment could be applied to any data logging application where the *source* of data is located remotely from the place where it is to be *recorded.* Thus, we've shown how it's possible to capture data, encode it, transmit it over a distance, receive it, decode it and finally *display* it.

Other applications of data logging systems might involve monitoring the geographical location of a vehicle and displaying this at a control centre on a "moving map"; laboratory experiments to observe and record temperature, pressure or velocity; geophysical experiments monitoring volcanic activity. The data might be logged into a computer or displayed on a chart recorder.

MULTIPLEXING

Fibre optic transmission systems like this are used in a much more sophisticated form to handle *telecommunications.* In order to encode digital information into a form which can be sent down an ordinary phone line, a **modem** (modulator/demodulator) is used. A similar unit at the receiver demodulates the information again so that it can be processed by a system.

A **simplex** system can only handle one "channel" of information, like our one-way Morse code communicator earlier. A **duplex** system has *two* channels – like an ordinary telephone, where you can both talk to the other party *and* listen to him at the same time. Fibre optical systems are not cheap and it is wasteful to let a light guide handle one channel of information only. A technique called **multiplexing** is used whereby the fibre (or a cable, for that matter) can be made to handle many streams of information at once.

A block diagram representing a simple multiplexing technique is shown in Fig. 8,14(a). Two sources of information – A and B – are fed into a *multiplexer* which reads the information alternately, here behaving like a simple changeover switch. The **combined data** is then modulated and transmitted as usual. At the receiver, a *demultiplexer* decodes the information and splits it into its original form, A and B.

We have shown a *highly* simplified version of what really happens. The "changeover switches" in the multiplexer and demultiplexer have to be timed or *synchronised* with each other so that they are simul-

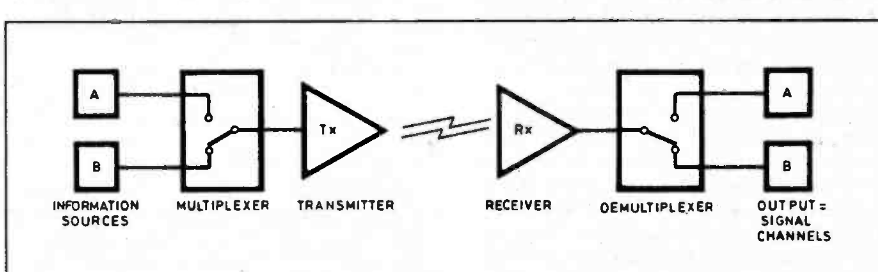


Fig. 8.14(a). Simple multiplexing system, block diagram. The multiplexer and demultiplexer are synchronised with each other.

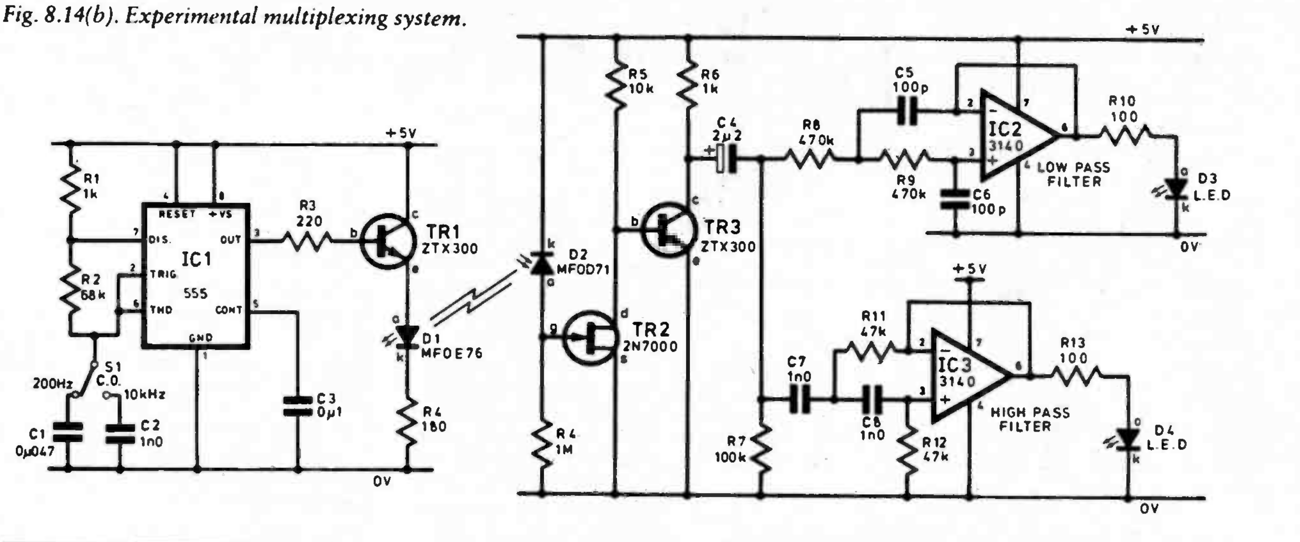


Fig. 8.14(b). Experimental multiplexing system.

taneously reading the same information. In practice, extra data might be included in the signal so that the system can synchronise everything and put the data into the right "pigeonhole" after reception.

The circuit diagram of Fig. 8.14(b) demonstrates how data from several sources can be multiplexed and transmitted through a fibre optic system, after which it can be unscrambled again and pigeon-holed. The circuit is given for experimental purposes only, partly because of the difficulties encountered when filtering square waves.

A 555 astable provides a signal source which drives a buffer transistor TR1. The output frequency is altered using two push switches. "Data" is thus generated as, say, two nominal frequencies which are transmitted down a light guide.

The data is detected by the photodiode D2, and the f.e.t. TR2 switches at the frequency determined by the signal. A clean 5V square wave is produced at TR3 collector. It's now necessary to *demultiplex* this data to split it into its component parts – the "low" frequency or the "high" frequency. In our simple demonstration, we can unscramble the two frequencies by using a high-pass and low-pass filter to block low and high frequencies respectively.

FILTERS

Two f.e.t.-input op-amps IC2 and IC3 are used as non-inverting amplifiers. The data passes through an *RC* network on each op-amp's non-inverting input (see Part Four – Filters and Part Five – Op.amps) so that either the high or low frequency data is rolled off. The end result is that the information is demultiplexed so that it is channelled to the appropriate l.e.d. indicator. It's definitely worth experimenting with component values, also use an oscilloscope, if available, to trace the original square wave signal through the circuit. We emphasise that this is an *experimental* circuit although it worked perfectly in our own trials.

More suggestions for experimenters: try using the 8038 square wave generator instead of the 555 astable circuit. Use the Frequency and Duty Cycle controls to change the frequency. Watch the two l.e.d.'s gradually change over. Again use your C.R.O. to monitor the data at all stages.

As another experiment, try sending clock pulses down the fibre, then decode them and count them using the decade counter arrangement we described last month. Show the result on the Digital Display.

British Telecom uses fibre optics extensively, and multiplexing techniques are standardised throughout the communications industry. Often, fibre-optic systems are interfaced to microwave transmitters (maybe using portable satellite dish aerials or the dishes seen on the Post Office Tower in London) which broadcast over exceptional distances. Eventually, the signal is channelled through copper wires to the final point of reception – such as the plug-in phone jacks used in domestic and commercial premises. So it's normal for several forms of transmission media to be used in our own broadcasting and telephone systems.

We hope you are as fascinated as we are by fibre optic techniques. We have attempted to demonstrate how "information" can be used to modulate radio waves or light pulses which can then be transmitted over a distance (halfway round the world, if you use a satellite) before being decoded at the receiver. It is the fundamental basis of all communications systems. Data logging systems let us monitor and record information at arm's length, which could be of benefit in hazardous environments or when the information source is at an inaccessible location.

EPE MICRO LAB

Next month: to start with, we take a short break from practical work and discuss the changes in society which electronics has brought about. Many younger readers will perhaps not be aware of the implications and effect, devastating at times, for which electronics technology – the fastest moving of them all – has been responsible.

Then, we move on to the final phase of Teach-In when we introduce the **Micro Lab** – our 8-bit microprocessor development system, designed for *more advanced constructors*. Apart from demonstrating the basic aspects of these devices, the *Micro Lab* is also a general-purpose microprocessor control unit which can form the heart of many control and measurement systems. It also features built-in demonstration routines and a custom written user-friendly operating system to make life as painless as possible. A specially-written Reader's Manual covers the *Micro Lab* in more depth, freeing the pages of EPE for more GCE "A" Level syllabus material (and more besides). The *Micro Lab* will be pressed into service in Parts Ten to Twelve.

All that is needed to build the *Micro Lab* is the ability to use a fine-tipped low power soldering iron skilfully to assemble the board really neatly. Otherwise the *Micro Lab* is very satisfying but fairly straightforward to construct. We will follow up with interesting applications to help you get the most from your investment, and we especially want to encourage school users to find applications for the *Micro Lab*, too. The *Mini Lab* is now complete. Use it at the heart of your experiments, or in conjunction with the *Micro Lab*.

FURTHER READING

By now you may be hungry for further knowledge (understandable!) and the following books may help you to increase your understanding of electronics at GCSE/GCE "A" Level:

Electronics for Today & Tomorrow – Tom Duncan ISBN 0 7195 4183 2

Simple, clear, authoritative. Written by a physicist for GCSE students. Plenty of examination questions and answers.

GCSE Electronics – Tom Duncan ISBN 0 7195 4633

Easy-going all-round introduction to electronics for GCSE candidates and school students. Maths-free, with clear diagrams. Plenty of self-test questions and check lists.

The Art of Electronics – Paul Horowitz and Winfield Hill ISBN 0 521 37095 7 2nd edition.

Our suggested "best buy" for those wishing to advance further into the subject. 1,125 pages covering fundamentals up to intensive treatment of microprocessors, this excellent American book deals authoritatively with most aspects of modern microelectronics. Strongly recommended for advanced/university students, trainee technicians, engineers and more serious constructors. £35. Optional accompanying **Students Handbook**.

CORRECTIONS

In Fig. 7.1 (Page 368) the l.e.d. D1 should connect with the **output pin 3,** and not as shown.

The captions for Fig. 7.14 and 7.15 have become rather confused. What is shown as *Fig. 7.14 (A complete 3-digit . . .)* should say *Fig. 7.15 A Digital Reaction Timer.* What is shown as Fig. 7.15 *(A Digital Frequency Meter)* should say *Fig. 7:14. A complete 3-digit decade counter module.*

A correction is also due for the GCSE Answer in Part 6, regarding the symbol for a NOR gate – we showed an OR gate symbol in error.

These were editorial errors for which we appologise. – Ed.

SHOP TALK

with David Barrington

Electronic Snooker Scoreboard

Some of the components needed to complete the construction of the *Electronic Snooker Scoreboard* may prove difficult to find locally and others require further comment. Some items may even be a bit cheaper if approached on a "bulk" order basis.

The first and most important device to be purchased is the programmable EPROM. This must be a 2764 type and to save a lot of extra programming time and worries a pre-programmed version is available from the author. He is prepared to supply a ready-programmed EPROM for the sum of £15 (inclusive of p&p) and orders should be sent, with monies, to **Mr. T. Brown, 14 Stairfoot Close, Adel, Leeds, LS16 8JR.**

For those who wish to program their own memory chips, a copy of the listing in the form of a "source code", with labels and comments, is available from the *EPE Editorial Offices* for the sum of £1.50. Please enclose a large stamped self-addressed envelope.

The rest of the semiconductors should be readily available and not cause any concern. The Z80A microprocessor used in the model is the 4MHz version. Likewise, the "non-critical" values for resistors R11 to R18 and the crystal frequency shown in the circuit diagram are the same as those used in the prototype model.

As 26 l.e.d.s are required for the "score" display, it might pay to approach some of our components advertisers for a "special discount", you might be offered a green and yellow device free! It is certainly worth a try as bargains are often on offer at this time of year – it's their stocktaking period.

The "ball" push-switches specified work out fairly expensive and come as switch and switch top which, when added together, totals up to nearly a £1 each (eight required). These are keyboard type switches with a two-part square key top. A considerable saving could be made by purchasing the popular miniature pushbutton switches, you will of course have to find a means of colouring the buttons.

The model is powered from an *unregulated*, 9V to 12V, mains adaptor and "stabilised" to 5V by a voltage regulator. The adaptor is rated at 800mA, looks like a large "three-pin mains plug", with a low-voltage output lead, and was purchased from Maplin (code YM85G). Similar mains adaptors are stocked by advertisers but it is the 750mA to 800mA, or better, unregulated version that is required.

The large printed circuit board is available from the *EPE PCB Service*, code 832. Some of the copper tracks on this board are very close together and extreme care should be exercised when soldering components on the board, checking carefully after each solder join.

No case has been specified for the scoreboard and is left to individual choice. If the coloured score buttons are to be positioned on the "spots" in a similar layout to a snooker table, then there are sufficient copper pads on the p.c.b. for each switch.

Immersion Heater Controller

The device chosen to carry out the daily timing routine in the *Immersion Heater Controller* project is a ready-made quartz clock module. This was thought to be the most economical and accurate way of tackling the task.

The clock operates from a crystal controlled oscillator and is accurate to within 15 seconds per month. The module used in the unit is a chiming clock movement purchased from **Maplin**, code YU66W (Melody Clock).

It is most essential that heavy-duty cable is used where specified, particularly at the relay contacts. Be sure to make the "double" breaks in the board copper strips around the relay to isolate the mains voltages.

The relay used MUST be adequately rated. A 3kW immersion heater requires a current of 12·5A on 240V mains and it is vital that the relay contacts can handle this load repeatedly over a long period of time.

The specified relay (Maplin code YX99H) has silver cadmium oxide contacts with a rated life of 100,000 operations minimum at 20A. Other relays can, of course, be used, but beware of cheap relays which seem only just within "spec," – they may overheat and fail in service.

Readers are warned that constructing the controller involves making high current mains connections. Anyone who is at all unsure of doing the work safely MUST consult a qualified electrician. Also, special attention should be paid to the regulations about installing immersion heaters outlined in the article.

Quiz Monitor

Looking down the list of items required to build the *Quiz Monitor*, nothing seems too sinister and the only nightmares are likely to be the winding of coil L1 and the setting of questions.

No pin numbering has been shown for the seven-segment display as there are quite a selection of devices on the market, many with different pin layouts. When ordering ask for the "common anode" type. If your favourite local supplier cannot furnish the pin details then follow the simple, resistor and battery, procedure given in the article.

Although DIN plug pin numbering is supposed to conform to a standard it seems that each manufacture adopts their own arrangement. The numbering we have shown is the one most commonly shown in our advertisers catalogues. But provided you link socket pin to plug pin it should work out OK.

Switched-On Reminder

We do not expect any component buying problems to be encountered when shopping for parts for the *Switched-On Reminder*. Most of our component suppliers should be able to offer an identically rated d.c. piezoelectric buzzer and many also stock auto-type wire and connectors.

It is important to use 3A auto-type cable and connectors where recommended. The Scotchlok connector should be available from any car accessory shop.

Finally, make sure you disconnect the vehicle battery *before* installing the unit and double-check all wiring before reconnecting the battery.

Mini Lab (Teach-In '93)

This month's subject for our *Mini Lab (Teach-In '93)* "test bed" is a simple, single i.c., *A.M. Radio Tuner* for linking to the on-board Audio Amplifier module. Several buying points relating to the tuner have come to light, notably that the choice of tuning capacitor is important.

The correct 150pF miniature a.m. tuning capacitor must be used to avoid problems of matching the p.c.b. The fixing centres are critical or it won't fit on the board. The one used on the module is the miniature type, encased in a clear plastic cover, and was obtained from Maplin, code FT78K.

When mounting the tuning capacitor, do not screw the mounting screws in too far or they will "foul" the tuning vanes. Use screws no longer than 6mm with enough washers under each screw head to restrict the amount of thread entering into the capacitor to no more than 3mm.

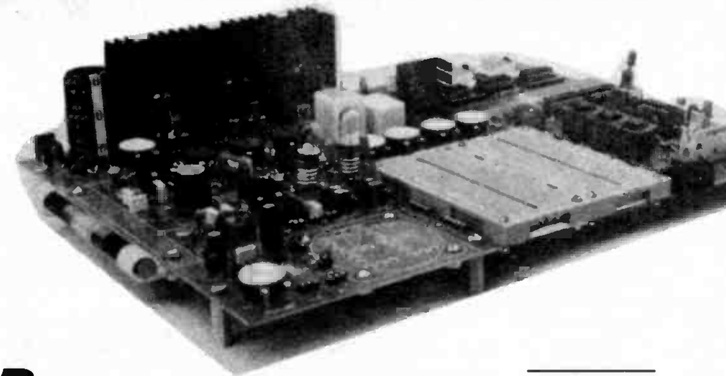
A selection of kits for the *Mini Lab*, including the *A.M. Radio Tuner*, has been specially prepared by **Magenta Electronics** (☎ *0283 65435*). These include the single Euroboard which replaces the two original Veroblocs (discontinued).

The large *Mini Lab* printed circuit board is available from the *EPE PCB Service*, code MINI LAB (see page 467).

Logic Probe

Two letters arrived concerning the *Mini Lab Logic Probe* module. This unit has three l.e.d.s (Pulse/High/Low) to indicate the logic state. Unfortunately we failed to point out that with *no input presented at all* to the module, the middle (High) l.e.d. will be continually illuminated whenever the power is switched on. This is not a fault in the unit.

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.

THE *Mini Lab* Radio Tuner is the very last module to be built. This is a t.r.f., a.m. (amplitude modulation) radio which uses an integrated circuit to both detect and amplify an r.f. signal, all in one. Being a *tuner* rather than a *receiver*, its output cannot drive a loudspeaker directly and so it's designed for use in conjunction with the *Mini Lab* Audio Amplifier.

The circuit diagram of the Radio Tuner is shown in Fig. 1. L1 and VC1 form a tuned circuit and the tuning frequency is selected by adjusting the capacitor. In fact, L1 performs the job of both aerial and inductor, and consists of a coil of copper wire wound around a ferrite rod. The resultant r.f. oscillation is detected by IC1, a popular ZN414Z integrated circuit which is made in a three-pin package resembling a transistor.

The i.c. requires a stable, low-voltage power supply and a Zener diode is used to provide an improved regulated supply. R3, R4 and VR1 set a d.c. voltage of 1·8V or so at TR1 base. Due to emitter follower action, the voltage at the emitter will be 0·7V less than this, about 1V. VR1 actually provides a form of **gain control** which varies the voltage at TR1 emitter from between +0·7V to about +1·1V.

The coil value is such that the circuit will readily detect signals in the middle of the a.m. (medium wave) band – typically 1000kHz or so. The Radio Tuner therefore should clearly receive BBC Radio One on its Medium Wave transmissions and any nearby local a.m. stations. Of course, it's incapable of receiving stereo broadcasts.

CONSTRUCTION

It is essential that the specified parts are used, in order to obtain best results and ensure that they will match the p.c.b. Commence assembly by fitting the discrete components in accordance with Fig. 2, observing the polarity of the integrated circuit and the Zener diode. The two parts which need special mention are the aerial (L1) and the tuning capacitor VC1.

Inductor L1 consists of approximately 40 to 50 turns of enamelled copper wire, 38 s.w.g./ 0·19mm, wound on a ferrite rod 7mm diameter × 100mm long, see Fig. 3. Firstly, wrap a single sleeve of paper or tape 25mm wide in the centre of the ferrite, then wind the copper turns neatly onto this. Tape over the resultant coil with Magic tape, for instance, to prevent it unwinding. Allow 40mm leadouts from each end of the coil.

The ferrite is retained on the p.c.b. using two 3/8 inch nylon "P" clips bolted to the board, so that the ferrite overhangs the edge – see photograph. Then scrape some of the lacquer varnish from the enamelled wire leads and solder them to the two solder pins marked "L1". It will help reliability if you secure the delicate copper leadouts to the board and the ferrite by using several drops of glue after finalising the assembly.

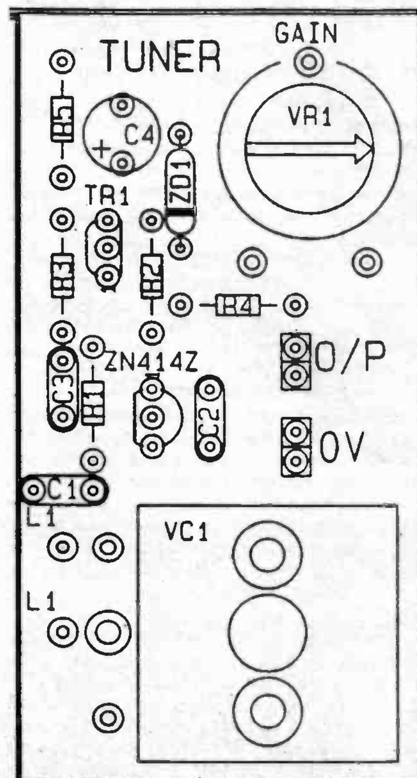


Fig. 2. Component layout for the Radio Tuner.

VARIABLE CAPACITOR

Variable capacitor VC1 *must* be a miniature 150pF variable a.m. tuning capacitor, having M2·5 (= 2·5mm diameter) mounting bushes distanced by 14mm. This is screwed to the *underside* of the p.c.b. so that the tuning shaft protrudes up through the central hole. **IMPORTANT: the mounting screws will damage the vanes of the capacitor if they are screwed in too far.** Use two M2·5 screws no more than **6mm** in length. *Even then you* **must** add *four* M2·5 washers under *each* screw head, to reduce the length of the thread screwing into the body of the capacitor to no more than **3mm.** Don't rush this aspect or you will damage the tuning capacitor.

The three connections of VC1 (one of which isn't actually used by the p.c.b.) are

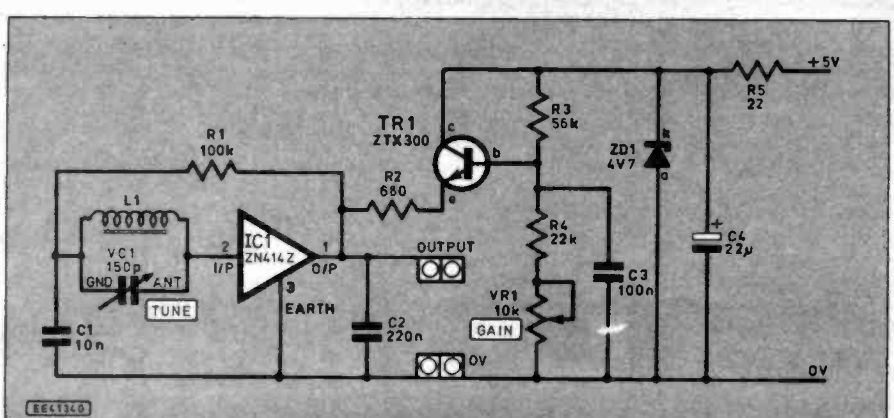


Fig. 1. Circuit diagram of the Mini Lab Radio Tuner.

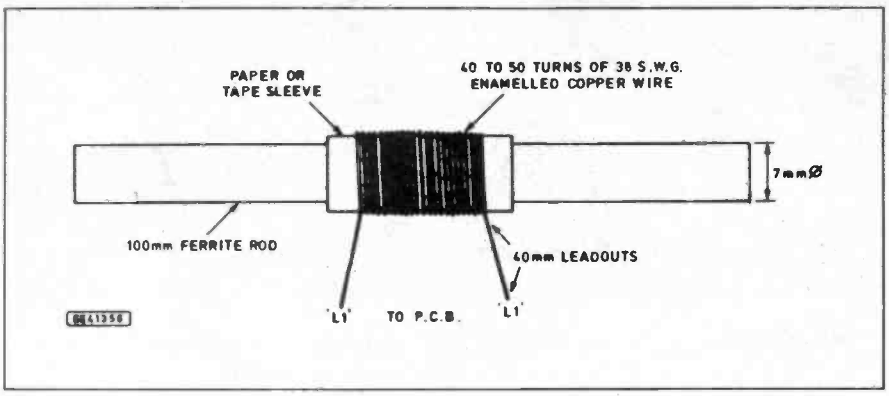


Fig. 3. Construction of L1 on the ferrite rod.

then soldered on the copper foil side of the board. The shaft of the tuning capacitor can be extended to accept a knob, to enable VC1 to be adjusted. Do this using an M2·5 × 10mm screw to secure the shaft extension supplied. Then a knob suitable for push-fitting onto a 6mm diameter (*not* 6·35mm) can be fitted. Suitable types are recommended in *Shop Talk*.

After assembly, simply connect the "O/P" terminal to the Audio Amplifier input and switch on the 5V and 12V rails. You should hear at least *something*. Adjust the gain and volume controls as necessary and then try to tune in to a station. The performance of this modest station is quite good and should pick out stations around 1100kHz.

If necessary, experiment with the number of turns on the ferrite. You may need to turn or point the *Mini Lab* board in order to improve reception. It isn't hi-fi but we found it more than acceptable when working on the *Mini Lab* demonstrations at two in the morning! Finally. . .

Congratulations on having completed the construction of your Teach-In Mini Lab. *We hope you have enjoyed the process of learning the fundamentals of modern electronics and found the* Mini Lab *a satisfying challenge. Now you can explore electronics further by using the versatile modules of the* Mini Lab *to develop and experiment with your own designs, or assemble and test* EPE *projects before committing to a hard-wired version. The* Mini Lab *contains all you need to demonstrate electronic systems up to quite an advanced level, and we hope your* Mini Lab *will accompany you in your discoveries for many years to come.*

The p.c.b. foil pattern and silk-screen print was designed by Keith Dye using a p.c.b. computer-aided design system based on a 386 PC. and is copyright Dyetronics 1992.

MICRO LAB

Next month we commence our introduction to **microprocessor systems**. This is relevant to both GCSE and "A" Level students, although only Advanced students are required to study this aspect in depth. The Teach-In ***Micro Lab*** accompanies this section, it is powered from the *Mini Lab* board, and will be of great interest to those seeking hands-on experience using this most crucial component of microelectronics.

It includes a keypad and a liquid-crystal display to enable you to "program" the *Micro Lab* yourself. Additionally, it has a battery back-up and will read specially-written "EPROM" (erasable-programmable read-only memory) memory chips, which we have programmed – available separately – to perform specific tasks. An accompanying Reader's Manual offers a more detailed analysis of operation.

Teach-In continues with our easy going style, taking you step-by-step through to Part Twelve. Although it is an advanced design, to assemble the *Micro Lab* successfully, all you need is the ability to use a fine tipped soldering iron. This is a must! It's even worth investing in a suitable iron if you don't have one already. The sophisticated specially commissioned design is constructed as one single project, and afterwards we will follow up with interesting *Micro Lab* applications to help you obtain ongoing value from your demonstration unit.

MINI LAB COMPONENTS

Resistors

R1 100k
R2 680
R3 56k
R4 22k
R5 22
All ¼W 5% carbon film

Potentiometer

VR1 10k 0.25W preset and thumbwheel

Capacitors

C1 10n polyester
C2 220n polyester
C3 100n polyester
C4 22µ radial elect. 16V
VC1 150p a.m. tuning capacitor c/w shaft extension

Semiconductors

IC1 ZN414Z t.r.f. i.c.
ZD1 4.7V 400mW Zener Diode (BZX55C4V7)
TR1 ZTX300 *npn* transistor

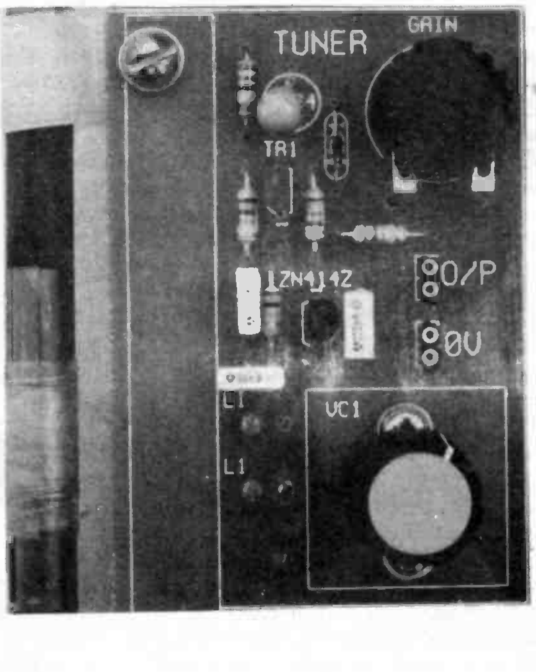
Miscellaneous

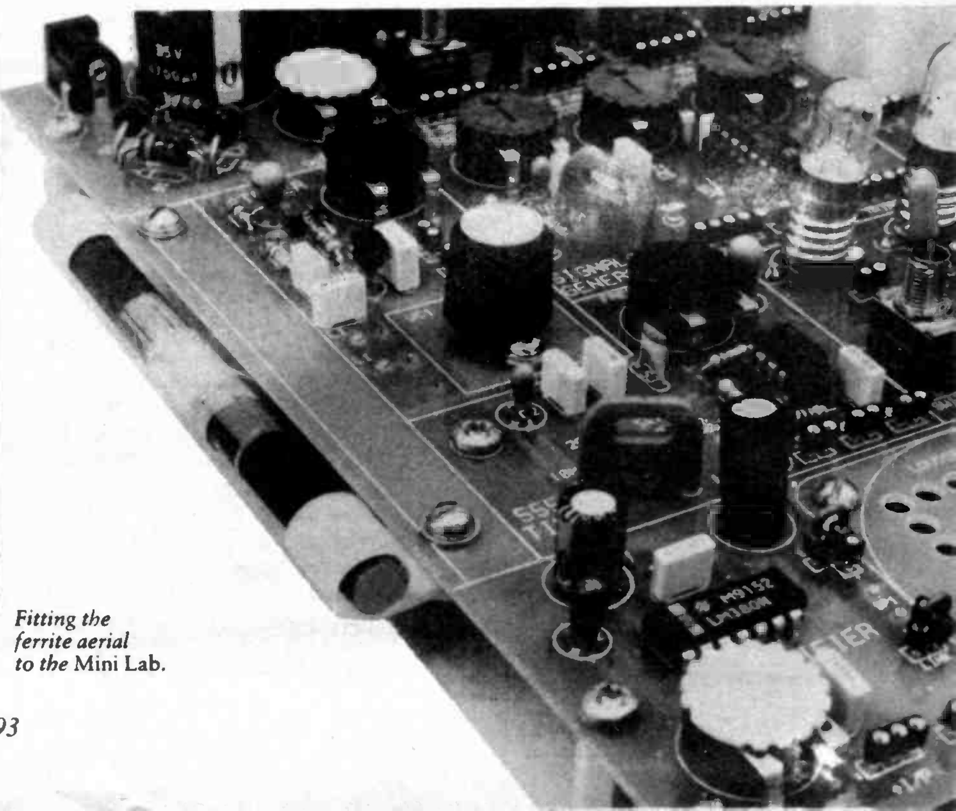
L1 40 to 50 turns of 8s.w.g./0·19mm enamelled copper wire on a 7mm × 100mm long ferrite rod

S.I.L. sockets (4 off); 2 × ⅜ in nylon "P" clips and M3/4BA fixings; M2·5 × 6mm hardware – see text; M2·5 × 10mm roundhead screw; 6mm push fit collet-type knob.

IMPORTANT! Parts must be as specified - see *Shop Talk* for buying information.

Price £6 *Approx*





Fitting the ferrite aerial to the Mini Lab.

FOX REPORT

by Barry Fox

IN THE BOX

So Prince Charles will not be helping anyone with their enquiries on how his personal phone conversations came to be recorded and published. Neither has Princess Di. That, of course, is what the press have been assuming all along.

There are at least three laws (the Wireless Telegraphy Acts, Tecommunication Act and Interception of Communications Act 1985) under which the police can prosecute anyone who eavesdrops on a phone call and publishes what they hear. But to make a prosecution stick, the police would need the vitim to give evidence in court. Can you imagine either Charles or Di going into the witness box?.

So it does not matter how the calls came to be taped. Perhaps they were just run of the mill cellphone calls, picked up by a run of the mill scanner which someone was working inside the cell where the mobile was being used. Although both Cellnet and Vodafone have created a smokescreen by saying that it is very difficult to target calls and hear both sides of the conversation, this is nonsense.

A scanner picks up both sides for the simple reason that the phone system mixes them. That is why we hear what we say into a telephone microphone, through its own earpiece. To target a victim all the eavesdropper need do is park a car near someone's home or office and listen for their voice. It would be tedious but so is any surveillance work.

SECURITY?

Perhaps the calls were taped professionally, by the security services and then leaked by re-broadcasting. Commonsense tells that the security services will be listening to the Royals' calls, because they know that terrorists will be listening for clues to their movements.

Perhaps the calls were taped by private detectives working for one half of the family to collect evidence against the other. As David Mellor found out there is no legal bar to tapping a phone in your own home, even though someone else may be using it.

Over recent months we have seen any number of "experts" on TV, talking about tapping. Usually they have just happened to work for firms which sell scrambling devices. So far these have been clumsy beasts which require both ends of the line to fit matching electronics. Now Cellnet is testing a single-ended system developed by GEC-Marconi Secure Systems of Liverpool. There is no need for the other party to use a matching descrambler.

SCRAMBLE

Existing double-ended systems scramble by "inversion". The analogue speech frequency band is split into two halves, high and low, and the high band is converted into low frequencies, with the low band converted into high frequencies. This is easy to hack, if only by buying or stealing a matching descrambler.

GEC-Marconi's catchily named CPU 100 fits the handest of a car or transportable cellphone, and the transceiver. Hand portables do not have enough power to drive it reliably. The CPU scrambles the signal before it is sent by radio to the telephone network.

The computer "switches" which Cellnet uses to route incoming radio phone calls into BT's telephone network are equipped with matching descramblers. So when the call leaves the switch to go to its destination in an office or home phone, it is "clear". The called phone thus needs no extra electronics, unless it too is a cellphone.

Scrambling is by Variable Split Band Inversion. The sound spectrum is split into two bands (as with existing systems) but the frequency at which the split occurs continually changes, several times a second, between 32 different values, and with no regular time pattern for the changes. If the radio signal is picked up by a scanner it just warbles like a fax machine or electronic mail modem.

DESCRAMBLE

The descrambler in the network switch must change its band-splitting circuits in synchronism with the circuits in the cellphone scrambler. This is done by making the cellphone send digital control signals along with the scrambled speech. The control signals are encrypted to stop an eavesdropper using them to switch a pirate descrambler.

Encryption is according to the Diffie-Hellman technique whereby the two ends of the link generate 64 bit random numbers which are exchanged and used as the basis of mathematical calculations which involve 100-digit codes and logarithms.

TESTING

Early this year Cellnet was quietly testing the system with a large company, whose employees need to make secure calls, and is now widening the trials. Fishermen who use cellphones for ship-to-shore communiation are interested because they do not want rivals to know when and where they have found schools.

A commerical launch is planned for the spring. The scrambler will cost around £600 and users will pay extra for calls that need descrambling, probably around twice the current cellphone premium rate of 33p per minute. The caller will key in a code with the called number to activate the network descrambler.

Although GEC Marconi acknowledges that no scrambling system can ever be 100 per cent secure, the codes used by the CPU-100 would take months to crack with a ganged array of advanced computers.

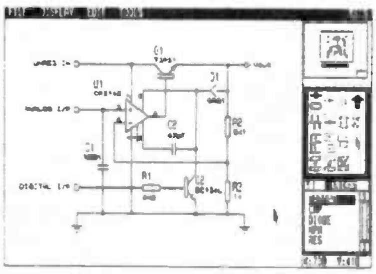
TALE

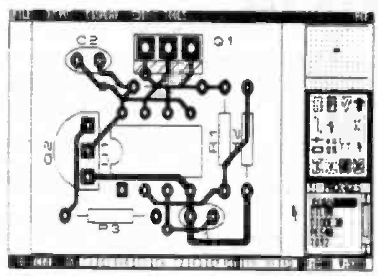
And hereby hangs quite a tale which I will tell another time. To give you a teaser, Cellnet's rival, Vodafone, has no plans to offer a system like the CPU. Vodafone sees the long term answer as GSM the pan European cellphone system which converts speech into digital code and then encrypts it with such strength that cracking becomes even more difficult that for GEC-Marconi's analogue system.

Although work on the Europe's GSM network is behind schedule, Vodafone will soon offer its MCN service. This uses GSM digital technology in micro cells inside the existing analogue network. And Mercury is publicising the security of its promised PCN, Personal Communications Network, which uses GSM technology at higher frequencies (1800MHz instead of 900MHz).

European electronics firms have been hard-selling GSM technology round the world.

Stop for a moment and think what this means. All round the world, criminals and hostile armies are being offered a low cost method of communicating with such strong encryption that even the police and security services cannot listen in.





Constructional Project

IMMERSION HEATER CONTROLLER

T. R. de VAUX-BALBIRNIE

Automatic control for your water heater.

THE TIMER described here 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 given later.

The IEE wiring regulations prohibit an immersion heater being connected by a plug and socket. This in practice means that the normal type of plug-in time switch cannot be used.

Commercial fixed-wiring time switches for immersion heaters are available but appear to cost around £40. It is true that these are more versatile than the present device but where simple once-a-day switching with manual override is required, this project turns out to much less expensive.

TIME OUT

The Immersion Heater Controller provides a choice of four operating times, using a six-position rotary switch on the front panel. These are nominally 30mins., 60mins., 90mins. and 120mins. (although the times are freely adjustable at the setting-up stage up to a maximum of four hours). There are also *continuous* and *off* positions.

The *off* setting inhibits operation and may also be used to cut the timing period short if required. A manual trigger switch is also provided – this can begin a timing cycle at any time of day.

For those needing the simplest control, the additional facilities need not be used. The operating time could be left preset and the Immersion Heater Controller will switch on and off each day indefinitely.

The daily timing is highly accurate – to within minutes per year. This means that, once set for the correct time of day, the controller will continue to operate without attention. This may be an advantage for an elderly person. Continuous current consumption from the mains is negligible whether the controller is in the process of timing or not.

FRONT PANEL

The front panel of the Immersion Heater Controller shows a small analogue clock face through a transparent panel (see photograph). There is also the control knob for the six-position rotary switch and the manual trigger switch previously mentioned.

A green l.e.d. indicator shows when the immersion heater is on. Pushbutton, *set time* and *cancel*, switches are also provided on top of the unit – these are used for initial setting purposes and will be described later.

SAFETY AND REGULATIONS

Readers are warned that constructing this project involves making high-current mains connections. Anyone who is unsure of being able to do the job safely MUST consult a qualified electrician.

Special regulations apply to immersion heaters installed in "rooms containing a fixed bath". *The Immersion Heater Controller MUST NOT be installed in a bathroom (whether or not in a separate airing cupboard) or, indeed, anywhere where moisture exists. It is designed to be fixed to the wall, out of the reach of children, in an airing cupboard sited outside the bathroom and close to the immersion heater which it controls.*

ECONOMY-7

The Economy-7 system provides cheap electricity at night and in the morning between specific times. This is the *off-peak* period during which there is normally a low power demand.

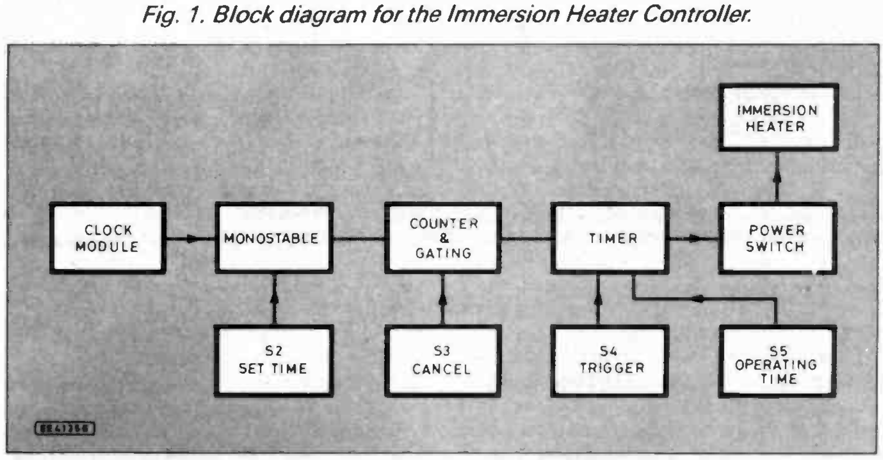
It makes sense for the generating companies to encourage people to use this electricity to offset the high costs incurred even during off-peak times. Presently, Economy-7 spans the period 11.30 p.m. (12.30 a.m. in the summer) to 6.30 a.m. (7.30 a.m. in the summer) i.e. a period of seven hours hence the name *Economy-7*.

This period is subject to change and could possibly vary from one electricity region to another. If in doubt, check with your local electricity board.

There is *no* charge to the consumer for an Economy-7 system to be installed. The old meter is simply replaced by a *dual* one which gives separate readings for on-peak and off-peak usage. Each charge is calculated separately and the results added together for the total bill.

Once placed on the Economy-7 tariff, you will have to *pay* a little *more* for each *on-peak* unit (kWh) used. It therefore needs some calculation to decide whether it is worth going on to Economy-7 or to leave things as they are.

Fig. 1. Block diagram for the Immersion Heater Controller.



If you have electric storage heaters, the whole point of using these is to take advantage of off-peak electricity so you will presumably already be on Economy-7. However, even if you do not have storage heaters it may still be worthwhile to opt for Economy-7 since such appliances as the immersion heater, washing machine, tumble dryer and dishwasher can all be used during the off-peak period although it may need a little forward planning. You may have to put up with a certain amount of noise from the appliances – shallow sleepers beware!

It is possible to cook the following day's meal with an electric cooker having a timer using off-peak power. Remember also that some electricity is already used at off-peak times such as that for the fridge, freezer, perhaps some lighting, etc.

TACKY TUNES

The device chosen as a basis for daily timing is a ready-made quartz clock module. Constructional cost was thought to be important and this is the cheapest way of doing the job combined with the necessary high accuracy. The clock operates from a crystal controlled oscillator and is accurate to within 15 seconds per month.

Home-constructed devices based on timer i.c.'s – even the so-called *precision* variety – are not accurate enough. At best, their timings tend to drift by a minute or two per day due to changes in temperature and other factors. This would mean that in a period of a few weeks, the controller would need to be re-adjusted or it could fall out of step with the Economy-7 period. Although a timer module having a digital rather than an analogue display could be used – and would involve less work – the cost would be much higher.

The specified quartz clock movement (see *ShopTalk*) gives an output pulse each hour (by means of a pair of internal contacts closing momentarily) and it is this signal which is counted 24 times and used to control the rest of the circuit. These pulses are really intended to operate a set of chimes on the hour but, of course, this is not needed in the present design.

The supplier may provide the "chimes" – free of charge – these take the form of a set of tacky tunes ranging from *I'm Popeye the Sailor Man* to *The Yellow Rose of Texas* supplied on a small circuit panel together with a miniature loudspeaker and battery holder. This section is completely separate from the clock movement and since the cost of the whole package is very low anyway, this part could be simply thrown away.

On the other hand, if the user is fond of the medley of British, American and various other tunes, it could be used for some other project! At least the miniature loudspeaker and battery holder will be worth keeping.

The clock movement is battery-operated using a single AA size cell. Battery life is at least one year.

CIRCUIT DESCRIPTION

A block diagram of the Immersion Heater Controller is shown for Fig. 1. This comprises five main parts: the clock module (daily timing section) itself; a monostable; a counter and gating circuit; a short-period timer (immersion heater *on* time) and a power switching (relay) section.

The complete circuit diagram for the Immersion Heater Controller is shown in Fig. 2. The power supply for all sections except the clock module is derived from the mains using transformer, T1, in a conventional arrangement of twin rectifier diodes D3 and D4, smoothing capacitor C6 and fuses FS1 and FS2. This provides a nominal 12V smooth d.c. supply.

Ignore IC1 and associated components for the moment. Hourly counting is carried out by a 7-bit binary counter, IC2. On the arrival of *high* pulses applied to the clock input, pin 1, the seven binary coded outputs – pin 12 (units), pin 11 (twos), pin 9 (fours), pin 6 (eights), pin 5 (sixteens), pin 4 (thirty-twos) and pin 3 (sixty-fours) increment accordingly.

Assuming that the device is reset, i.e. begins at 0000000, after the first hour the count will be 0000001, on the second one it will be 0000010, on the third, 0000011 and so on. Since twenty-four is 16 + 8 i.e. 11000 in binary, it can be seen that a daily signal may be derived when the sixteens (pin 5) and eights (pin 6) are high (supply positive voltage) simultaneously.

The required outputs are applied to NAND gate, IC3 inputs (pins 8 and 9) so that when they are both high, the output, pin 10, goes low (since the output of a NAND gate is low only when both inputs are high). This *low* state is applied momentarily via capacitor, C3, to the trigger input, pin 1, of precision timer, IC4.

The precision timer IC4 is a digital device which operates as follows. After triggering, pin 3 will be high and pin 2 low. Capacitor C5 will then charge up through some or all of the preset potentiometers in the chain VR1 to VR4; as selected by rotary switch S5a, pole A positions 1 to 5, and connected between pins 13 and 14 (ignore resistor R9 for the moment).

After a certain time, C5 is discharged and a count of *one* is registered by an on-chip binary counter. This cycle repeats until the 4095th one, whereupon the twin outputs, pin 2 and pin 3 change state – that is, pin 3 which was previously high goes low and pin 2 which was previously low goes high.

The time during which pin 3 remains high is determined by the value of capacitor C5 in conjunction with the adjustments of the presets as selected by S5a pole. While IC4 output pin 3 is high, current is supplied to the base of the Darlington transistor TR2, through current-limiting resistor R11.

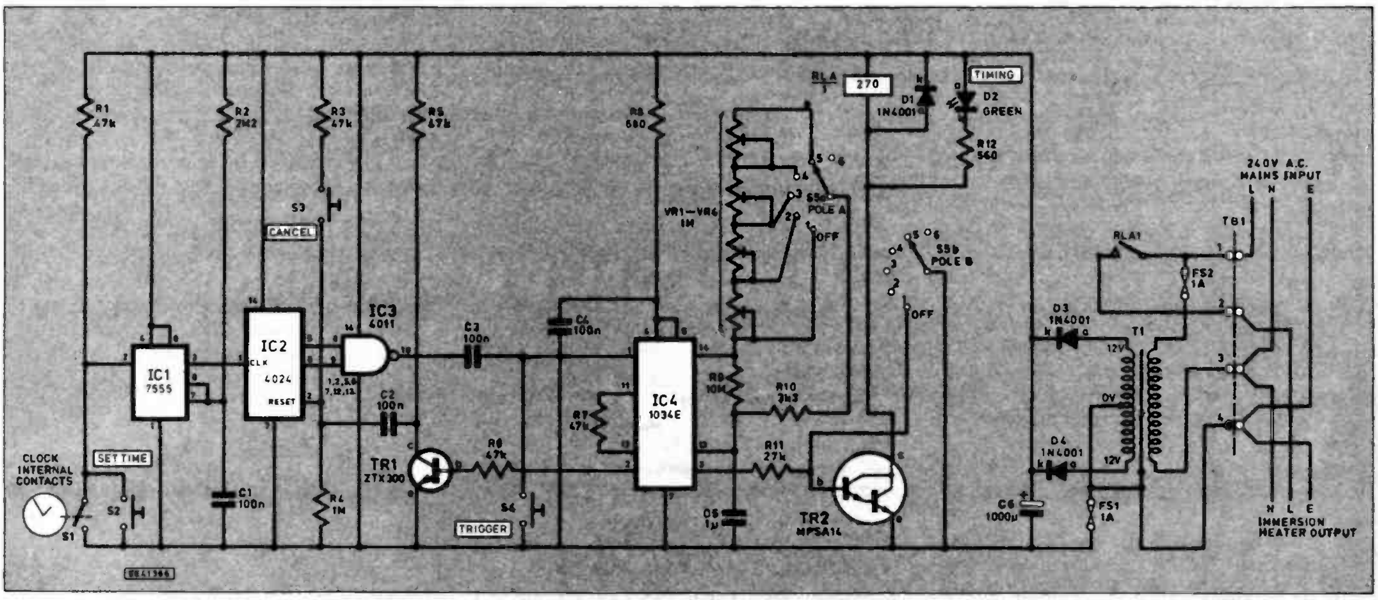


Fig. 2. Complete circuit diagram for the Immersion Heater Controller. Note that switch S1 is part of the clock mechanism.

A Darlington device consists of two transistors connected together internally to give the equivalent of a single transistor having an exceptionally high current gain. Thus, the very small base current supplied by IC4 pin 3 causes sufficient collector current to flow to energize the relay coil, RLA. The "make" contacts of the relay, RLA1, then close and switch the mains live feed to the immersion heater.

When IC4 outputs change state at the end of the timing period, the high state of pin 2 is applied through resistor R6 to transistor TR1 base. The collector goes low and this resets IC2 at reset input pin 2, via C2. Thus, the binary count is again 0000000 and the cycle repeats indefinitely.

Suppose switch S5 is set to position 1 (OFF). Now, the relatively low-value fixed resistor, R10, is connected between pins 13 and 14. This produces a complete timing cycle in 15 seconds or so. Also, S5b pole connects TR2 base directly to supply negative – the relay therefore switches off immediately.

If S5 is set to position six (Continuous), IC4 pin 13 is disconnected from the VR1 to VR4 chain, via S5a pole (moving contact).

The only timing resistor left in the circuit is now the high-value fixed resistor R9, and so timing takes place over a long period – 12 hours approximately in the case of the prototype unit.

With such a high resistor value the timing is rather unpredictable but this is included as a precaution in case the *continuous* setting has been forgotten. Diode D1 prevents the potentially destructive

COMPONENTS

Resistors

R1, R3, R5, R6, R7	47k (5 off)
R2	2M2
R4	1M
R8	680
R9	10M
R10	3k3
R11	27k
R12	560

All 0·6W 1% metal film.

Potentiometers

VR1 to VR4	1M miniature presets, vertical (4 off)

Capacitors

C1, C2, C3, C4	100n disc ceramic (4 off)
C5	1µ polyester
C6	1000µ radial elect., 16V

Semiconductors

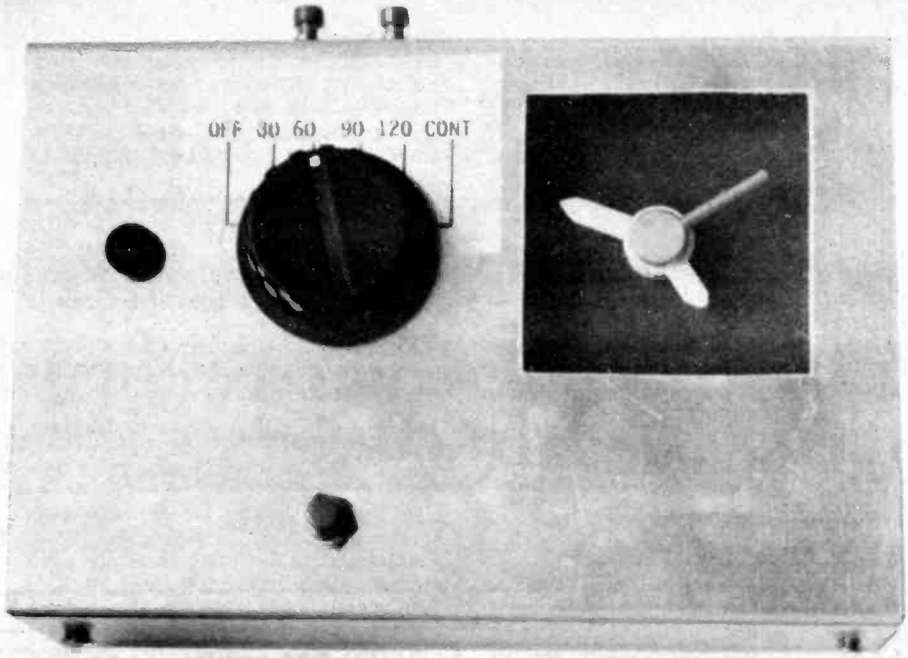
D1, D3, D4	1N4001 1A 50V rect. diode (3 off)
D2	5mm green l.e.d. indicator
TR1	ZTX300 npn silicon transistor
TR2	MPSA14 npn Darlington transistor
IC1	7555 low-power CMOS timer
IC2	4024 7-bit counter
IC3	4011 quad NAND gate
IC4	ZN1034E precision counter timer

Miscellaneous

T1	Mains transofmer, 12V-0V-12V 100mA secondary – or twin 12V secondaires
FS1, FS2	20mm panel fuseholder and 20mm 1A fuse to fit (2 off)
TB1	15A screw terminal block – 4 sections required
S1	Part of clock – see text
S2, S3, S4	Miniature push-to-make siwtch (3 off)
S5	2-pole 6-way rotary switch 35mm diameter control knob
RLA	Relay with 270 ohm 12V coil, and *mains* make contacts rated at 240V 16A minimum

Stripboard 0·1in. matrix, size 15 strips x 54 holes; 8-pin d.i.l. socket; 14-pin d.i.l. socket (3 off); Melody clock and plastic hands – see text; self-adhesive releasable cable clips (or strain relief bushes) (2 off); rubber grommets (2 off); connecting wire. 2·5mm 13A 3-core butyl rubber flexible immersion heater wire; solder, etc. aluminium box, size 152mm x 102mm x 51mm.

Approx cost guidance only **£28**



effect on the semiconductors from the reverse high-voltage pulse which occurs when the magnetic field in the relay core collapses on switching off.

COMING CLEAN

The CMOS timer IC1 and associated components are connected as a *monstable*. Its purpose is to provide *clean* pulses for IC2 to count. This is necessary because the original signal derived from the quartz clock module is provided by the mechanical closure of an internal switch, S1.

All mechanical contacts tend to "bounce" when they touch and this would result in the delivery of several pulses on each closure instead of only one. IC2 would therefore count unpredictably.

To overcome this, the signal obtained from S1 provides *low* pulses which are applied to trigger input, pin 2, of IC1. The effect is to deliver a *high* output from pin 3 for a certain time which depends on the values of resistor R2 and capacitor C1.

With the values specified, the output remains high for approximately 0·2 sec. and this allows time for all the contact bouncing at S1 to stop. Since it does not matter much what the exact timing is, there is no adjustment provided.

The first "make" of the clock contacts triggers IC1 and successive bounces have no effect. Pin 3 therefore delivers a totally *clean* signal which is applied direct to IC2 trigger input, pin 1, and the pulses are counted in the manner already described.

The trigger input to IC1 pin 2 is kept normally high by pull-up resistor R1. Note that it is a characteristic of this type of timer (and of IC4) that triggering takes place on the arrival of a *low* pulse rather than a high one.

Push-to-make switch S2 (Set Time), connected in parallel with clock switch S1, is used to inject dummy clock pulses into IC1 and this will be used to set the operating time of day at the end of construction. Switch S4 (Trigger) initiates a timing cycle at any time of day by making IC4 pin 1 (trigger input) low momentarily. Push-to-make switch S3 (Cancel) resets IC2 by applying a high pulse, via fixed resistor R3, to the reset input, pin 2.

RELAY

The relay used in this project MUST be adequately rated. A 3kW immersion heater requires a current of 12·5A on 240V mains and it is essential that the relay contacts can handle this load repeatedly and over a *long* period of time.

The specified component has *silver cadmium oxide contacts* and a rated life of 100,000 operations minimum at 20A. This should ensure a very long life. Beware of using small, cheap relays which seem only just adequate – they may overheat and fail quickly in service.

CONSTRUCTION

Construction of the Immersion Heater Controller is based on a main circuit panel made from a piece of 0·1in. matrix stripboard, size 54 holes by 15 strips. The topside component layout and details of the underside breaks required in the copper strips is shown in Fig. 3.

Begin construction by cutting the material to size, drilling the three mounting holes and making all track breaks and inter-strip links as indicated. Note the *intact* copper strip linking IC3 pin 2 to pin 13. *The double breaks around the relay contact connections must be checked carefully since these isolate the mains from the low-voltage control section.*

Solder the on-board components into position noting the polarity of capacitor C6 and of all diodes. After a careful check for errors, solder 20cm pieces of light-duty stranded connecting wire to copper strips *E, G, H* and *I* on the left-hand side of the panel as shown also to strips *A, D* . and *F* at hole position 30 and to strip *A* at hole position 31.

Solder similar pieces of wire to strips *A, B, C, D* and *F* to the right. Using different colours e.g. *rainbow* ribbon cable, will help in avoiding errors. There is quite a lot of wiring to do so take care to avoid mistakes. Proceed slowly and carefully because any such mistakes could be difficult to find later.

Solder the presets VR1 to VR4 around rotary switch, S5 pole A, contacts one to five as shown in Fig. 4. This is a fiddly job and needs to be done with care. A short link wire is needed between each sliding contact (centre) tag and the corresponding outer one – *do not rely on a blob of solder.*

THAT'S THE DRILL

Prepare the box by making the large hole in the front for the clock hands to be seen. It is worth taking time over marking this out, cutting it and smoothing the edges.

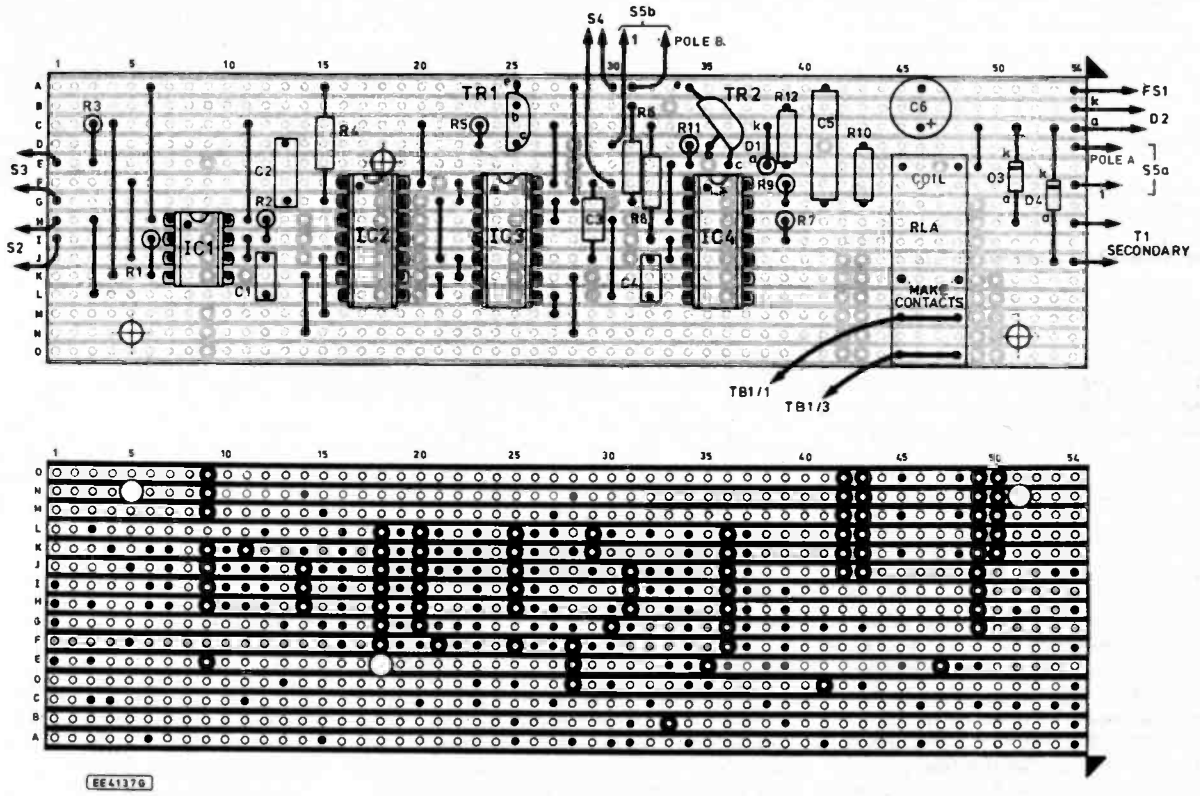


*Fig. 3. Stripboard topside component layout and details of breaks required in the underside copper strips. Double breaks **must** be made around the relay to isolate the mains.*

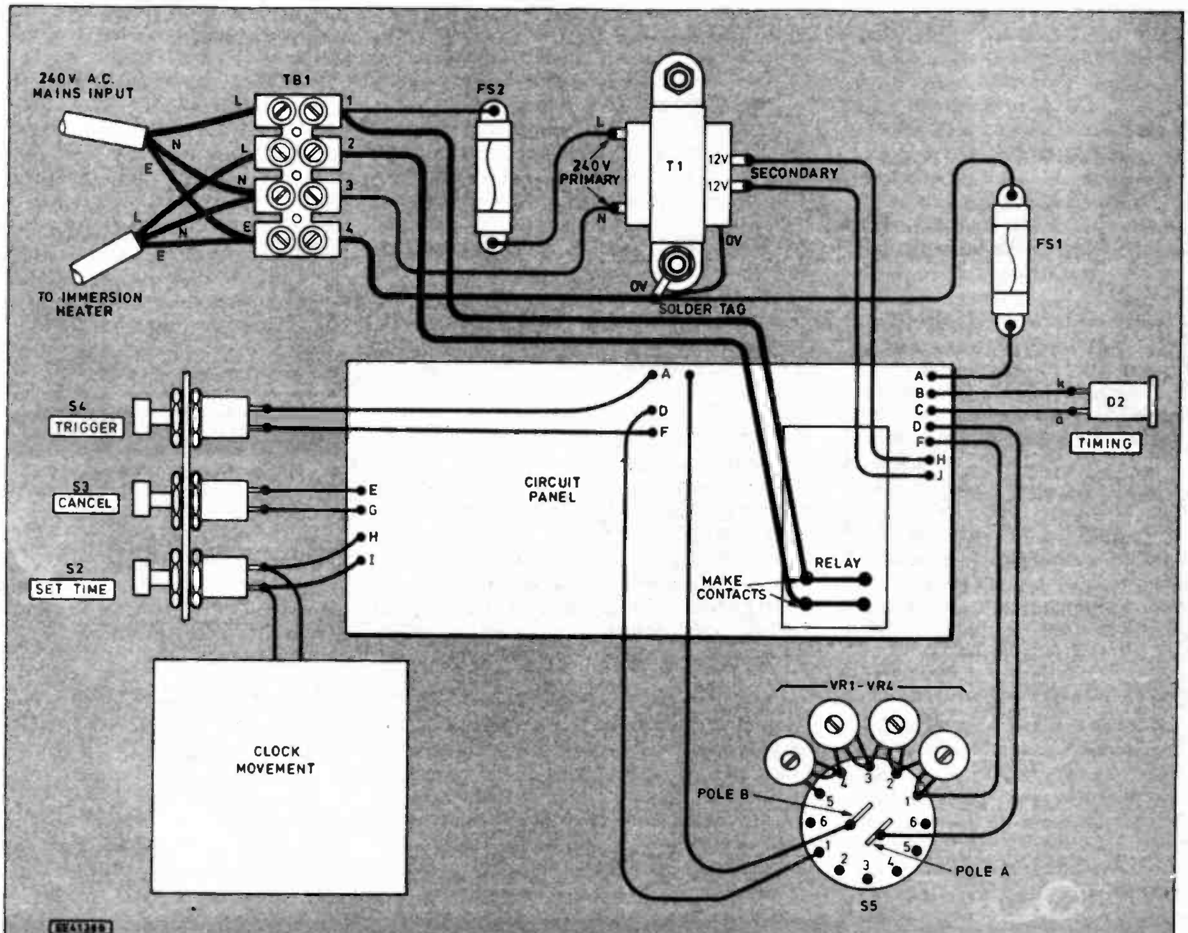


Fig. 4. Interwiring from the circuit panel to all off-board components. Use mains cable to make connections directly to the relay contacts. Note the relay leads pass under the circuit board.

The appearance of the finished project depends largely on the appearance of this.

Drill the holes in the front panel for rotary switch S5, l.e.d. indicator D2 (Timing) and also for pushbutton switch S4 (Trigger). Drill holes in the top for switches S2 (Set Time) and S3 (Cancel).

Examine the holes which exist in the flanges of lower section of the case and which are used with the self-tapping screws to hold the two parts together. Mark out and drill new holes in the flanges 5mm higher than the existing ones. This will enable the case to be assembled with the lid section slightly higher – check this point. This is necessary to allow clearance for the clock movement inside.

Referring to Fig. 5, cut out the aluminium /clock panel. Bend the material as shown and drill the clock movement mounting hole and the two smaller ones which will be used to secure the bracket to the top section of the box later.

In the prototype unit, the panel was sprayed with matt (car-type) black paint and the hour and minute hands painted white (see photograph). Allow the paint to dry thoroughly before proceeding.

Mount the clock movement on the bracket. It may be necessary to provide some padding between the clock itself and the metalwork – e.g. a piece of cardboard. Cut the plastic hands short using sharp scissors and file the edges smooth.

Before fitting the hands, it will be necessary to line them up so that the internal contacts, S1, close on the hour. By turning the movement using the time setting knob on the side, the click of the switch contacts will be heard. The minutes hand may then be attached at the top.

Cut a piece of transparent plastic 1cm longer and wider than the hole made for the clock and stick this on the inside using strong fabric-backed adhesive tape ("gaffer tape" was used in the prototype). Drill the holes and attach the bracket to the box using two small fixings. Check for adequate clearance between the clock hands and the plastic window. Note that it is necessary to mount the movement to the lid section of the box so that the battery can be easily changed.

Drill holes in the bottom of the base section to correspond with those already made in the circuit panel. Drill holes also for transformer T1, for terminal block TB1 and for the fuseholders.

Check the size and drill the two large-diameter holes in the side of the box for the grommets to be used on the input and output wires. Note that in the prototype, separate strain relief clamps were used but large strain-relief bushes could be used in place of the grommets. Noting the position of the internal components so that these may be avoided, drill two holes in the back of the box to attach the unit to the wall later.

INTERWIRING

Cut off a 10cm piece of the specified heat-resistant mains cable (see Components List) and remove the thick outer insulation. Use the brown and the blue piece to make ***direct*** connections to the relay ***make*** contacts – note the essential re-inforcement of the copper strips as shown. ***Make certain that these wires are secure***. Keep the piece of green/yellow wire – this will be needed later.

These wires are shown as much thicker leads in Fig. 4. Note that they pass ***under*** the circuit panel on their way to terminal block TB1.

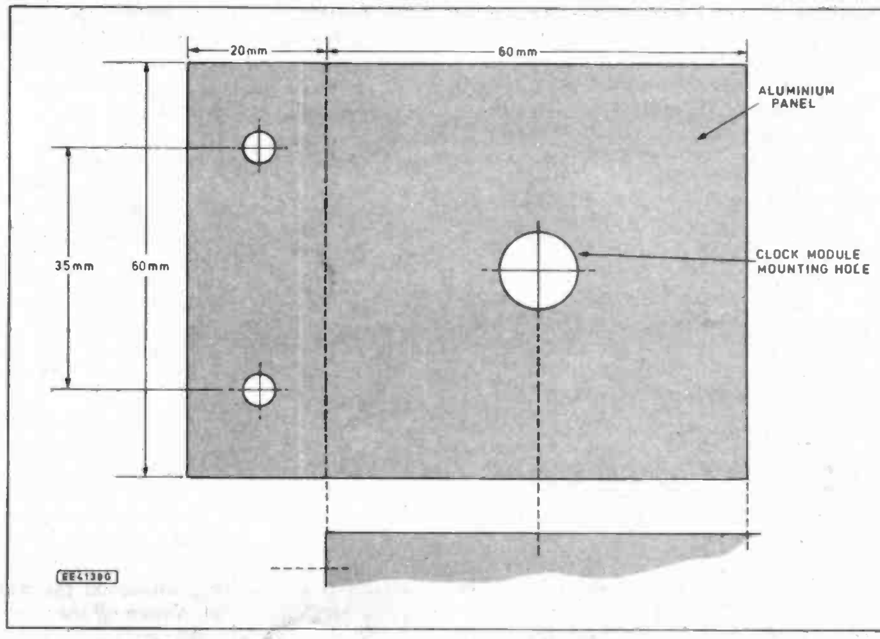


Fig. 5. Drilling details and dimensions for the clock mounting bracket.

Connnect the clock movement wires to switch S2 terminals and mount all remaining components. Connect the solder tag on one of transformer T1 fixings to the piece of green/yellow mains wire left over earlier.

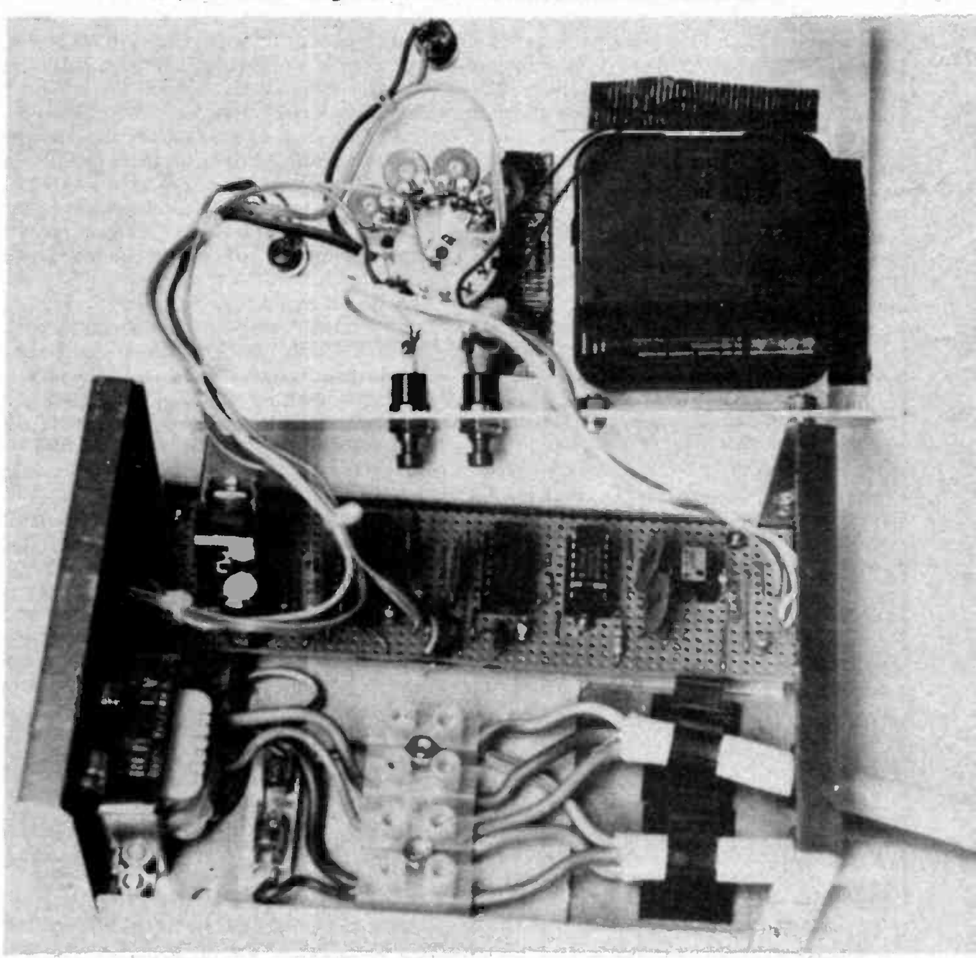
When mounting the circuit panel use *nylon* fixings because this will eliminate the possibility of short circuits occurring to the metalwork. Short plastic stand-off insulators must be used on the fixings to keep all connections on the copper strip side at least 3mm clear of the base of the box. Check this point carefully ***especially at the relay contact connections.***

Make certain no sharp connections can puncture the mains wires leading to the relay contacts. Place a piece of thick cardboard on the base of the box as an additional precaution. This should cover the area of the circuit panel and terminal block but should avoid the mains transformer position – see photograph.

Refer to Fig. 4 and complete the internal wiring. Note the Earth wire already attached to the solder tag at T1 is connected to terminal block TB1/4.

Insert the i.c.s into their sockets with the correct orientation. The i.c.s are CMOS

Layout and wiring inside the two halves of the metal case.



devices and, as such, could be damaged by any static charge which may exist on the body. Although they are internally protected, it would be a wise precaution to avoid touching the pins or to touch something – such as a water tap – which is earthed just before handling them.

Fit rotary switch S5 control knob. Set presets VR1 to VR4 sliding contacts all to mid-track position – this will provide nominal timings of 30, 60, 90 and 120 minutes.

The internal wiring can be tidied up by arranging the individual wires into groups and using spiral wire-wrap or self-locking cable ties as shown in the photograph. Insert the fuses into their holders.

TESTING

Make up a temporary input wire with a mains plug on the end. Pass the other end through one of the grommets and connect it up to the terminal block TB1 as follows: brown to TB1/1 (Live in); blue to TB1/3 (Neutral) and green/yellow to TB1/4 (Earth). Fit the lid of the case using the self-tapping screws in the new holes and plug in the unit.

Set the rotary switch S5 to position 2 (30 mins.) and press switch S4 (Trigger). The relay should click and the l.e.d. indicator (Timing) light. Move S5 to position 1 (Off) – it should switch off immediately.

Wait for 20 seconds (for IC4 to time out) and move S5 to 30 mins. once again. The l.e.d. should remain off – if it comes on wait longer with S5 in the off position.

Trigger once again and check the timing. Check the other timings – 60mins., 90mins., 120mins. – in the same way. Adjust the operating times if necessary using presets VR1 to VR4 respectively. Remember to unplug the unit from the mains before removing the lid of the case.

Maximum clockwise movement of any given preset, VR1 to VR4, will provide approximately one hour, these timings being cumulative. However, there is little point in trying to set timings up with great accuracy.

Set S5 to position 2 (30 minutes) again. Press pushbutton switch S3 (Cancel) and press S2 (Set Time) 24 times. Do this deliberately with a short pause between each operation. On the last one, the l.e.d. should come on. If this does not work properly, repeat more carefully.

If this works, it may be assumed that the circuit will operate correctly when triggered by the clock. Any problems are almost certainly due to simple faults such as incorrect connections, "bridging" of copper strips with solder, omitted link wires or track breaks, faulty wiring, etc.

INSTALLATION

It is essential to use the correct type of mains cable and pay respect to the appropriate regulations regarding immersion heater installations.

The correct type of wire to use is 2·5mm twin and earth butyl rubber sheathed (heat resistant) flexible cable. This type of wire may be obtained from electrical contractors – it may not be available from all DIY outlets.

A mains isolating switch and a separate fuse at the main fuse box should already exist. If there is no such switch or fuse or if the existing wiring is of an incorrect type, *do not proceed until you have asked a qualified electrical contractor to check the installation.*

Choose a suitable position on the wall for mounting the unit. *Switch off the supply at the main fusebox and remove the immersion heater feed fuse.* Drill and plug the wall and attach the unit using two screws through the holes in the back already drilled for the purpose.

Remove the cover from the immersion heater isolating switch and disconnect the feed wire leading to the immersion heater itself noting how it is connected. Shortening the wire as required, pass it through one of the grommets. Connect the wires to TB1 as follows: TB1/2 (Live output: brown); TB1/3 (Neutral: blue) and TB1/4 (Earth: green/yellow). Leave the terminal screws loose for the moment.

Now, cut off a new piece of wire long enough to reach the switch, pass it through the other grommet. Connect it to TB1 in the following way: TB1/1 (Live in: brown); TB1/3 (Neutral: blue) and TB1/4 (Earth: green/yellow). Tighten all terminals and check the work carefully.

Clamp both input and output wires. Connect the free end of the wire to the isolating switch. Set the clock hands to read the correct time of day.

Replace the lid of the box looking out for possible trapped wires and for short-circuits being formed with the metalwork. Check also that the self-tapping screws holding the case together do not puncture any wiring. Connect the supply and switch on. Check the system for correct operation.

If the lid needs to be removed for adjustment to preset VR1 to VR4 or for battery replacement, then the timer must first be isolated from the mains by switching off at the main fusebox and removing the fuse.

SETTING START TIME

Suppose the timer is to begin a timing cycle at 6a.m. and the present time is 5.30p.m. It will be necessary to use the Set Time pushbutton to provide the correct number of "missing" pulses i.e. those which would have normally been provided by the clock since the last operation.

There would have been pulses provided by the clock at 7, 8, 9a.m. and so on. The last one would have been given at 5p.m. i.e. eleven pulses altogether.

Press the Cancel switch S3 to make sure the counter begins at zero then press S2 eleven times. The twelfth will be given automatically at 6p.m. the thirteenth at 7p.m. and so on. The twenty-fourth one will then arrive at 6a.m. as required.

If a mistake is made, press S3 (Cancel) to reset the counter and repeat the procedure. An alternative method is to wait for the required operating time (or up to one hour later) and simply press S3 (Cancel).

If there is a power failure or the mains supply is interrupted for any reason, the counter will auto-reset when the supply is re-established. It will then be necessary to set the starting time again.

There is no need to reset the clock for British Summer Time. This is because Economy-7 operates at the same absolute time each day. Thus, it will continue to provide the correct times but, of course, the clock will be one hour "out".

Try to avoid moving the control knob to a different time setting when the device is already in the middle of a timing cycle. If you do, the timing will be unpredictable. It would be better to cancel before selecting a new time.

Note that if S5 is moved to the *off* position during operation, it will be necessary to wait for 20 seconds minimum before moving it to another position. This will allow the precision timer IC4 to time out.

It only remains to label the switches and put the Immersion Heater Controller into service. Some users may wish to make a small cover for the Set Time and Cancel switches to that they cannot be pressed accidentally. □

READOUT

MISSING A LOT

Dear Ed. and Tony,

Having read the letter by Philip Hall of Chichester – April issue, I had to write, expressing my views.

I thought I had seen and heard all the arguments for scrapping the Morse exam, but the remarks by P. Hall, were I feel a bit below the belt.

Whilst I would agree – after 46 years "hamming", we have our share of "snobs" – cliques – and of course the cowboys – I've heard them all – his remarks regarding the CW fraternity were totally uncalled for.

He gets the impression – he says "that the majority of the CW users are ex-military who have learned their Morse at the taxpayer's expense!"

Those same "ex-military types" that you decry in your self-opinionated way, were trained to do a job as wireless ops, and did a highly important job too.

Quite a large number of them died doing it – of course, "at the taxpayers expense!"

In passing, I learned my CW when I was 14 years of age – self taught!

He, Mr Hall, goes on to say he has the competence and the means to become a creditable radio ham. Then stop whining and get on with it, Morse and all.

For those young and old enthusiasts who have made the effort, and indeed have proved their competence and hold a license, it would be a betrayal to allow these "whingers" to have everything "on a plate".

Whether or not people who have qualified use Morse or not is entirely their prerogative. In a given emergency I know who I would rather have with me.

In these days of digital electronics and expensive off-the-shelf gear, Amateur radio – as such, is most surely in decline.

I don't consider myself an elitist; most certainly not a "cowboy", but old fashioned I may be, will always believe there is a place, however small, for the basic needs of radio communication, i.e. the Morse code. If as P. Hall says he is, a keen HF listener, then he is missing an awful lot of the ham bands.

Jim Roberts
Stoke-on-Trent

LIFE SAVER

Dear Ed.,

Just a quick reply to the letter in *Readout* by Mr Lui Giacomello. he cannot be greatly interested in amateur radio if the Morse exam puts him off becoming a ham.

I wonder if he realises the number of lives that have been saved by the use of Morse code over the years when all else has failed? Also the Morse exam does keep out the people that have brought CB into illrepute; has he listened to any conversations on CB of late, just filth most of the time.

If Lui cannot be bothered to take the Morse exam and becomes a qualified operator, we don't need Lui on the air.

As a subscriber on an annual basis, please don't let this great magazine turn into an amateur radio magazine. We have plenty devoted to the ham subjects. Thanks.

Keith J. Marshall, G0FTQ
Wraysbury

EXPERIMENTATION

Dear Ed.,

In reply to mr Giacommello (March and April 1993) I wish to clarify a few points. Firstly, the Amateur radio licence is issued for the express purpose of "self training in communication by wireless telegraphy, which use (without limiting the generality of the foregoing) includes technical investigations". This is the first paragraph from yer actual licence!

The intention is obviously to encourage experimentation with "hardware" and not purely as a "chat band". If people wish to simply talk to others may I suggest they obtain a CB which would probably satisfy their needs for all of about 10 minutes, until they get fed up with all the swearing and music players!

In response to the Morse debate, I am currently under going the "torture" myself, but I don't see it has a necessary evil, rather as another aspect to the hobby. And weren't hobbies invented to consume time anyway?

If people really want "something for nothing" then please look elsewhere, as a licence ham I am constantly bombarded with the "I want a ham licence out of a cornflake box" people, and my answer is usually "yer gets what you pay for!" Isn't something that will last for a life worth a bit of effort?

P. Ryder, G1XUL
Nottingham

SKILL

Dear Ed.,

With reference to your letter *Ham Fisted* from a reader in Edinburgh in the April issue, who cannot understand why he has to learn Morse. He doesn't know what he's missing.

Okay I agree it takes a while to learn, but once mastered there is nothing to describe the joy one gets after tuning up your gear and QSO'ing (communicating) with someone across the world.

I am a radio amateur, I trained in Morse as a R/O for the Merchant Navy and I can assure your reader it's far more exciting than communicating with radio telephone. If your Edinburgh reader just wants to "speak" with people around the world why doesn't he just ring them on ordinary landline telephones?

Just picture this if you can, sitting at your Morse transmitter and receive with your fingers by the key receiving Morse at 30 words a minute, without using pen or paper, the signal being the weakest of three on the same frequency, stirring and drinking a cup of coffee, and thinking up your reply – all at the same time. That's skill and its well worth the effort of learning Morse.

When I get a chance I'll be going for my amateur licence. long live Morse.

Alan Campbell
Mid Glamorgan

RICH MAN'S HOBBY

Dear Ed.,

I refer to the Rich Man's Hobby letter in the April edition and wish to table a counter view regarding the cost of the RAE course.

At Brighton College of Technology our course fee for this current session (September to May) has been £69. A one third reduction is made if you are unemployed or under 18. When you consider that this equates to £2.30 per evening or 92p per hour I regard it as excellent value for money for tuition from a professional radio lecturer. The cost, incidentally, includes all course notes and 500 typical exam questions. These alone equate to the two standard tests used by home study students.

I have had no complaints that the charge is excessive and our well-above national pass rate must support the case that attending college is a beneficial method of tackling the RAE,

The cost of the examination, however, is outside our control and set by City & Guilds, but is roughly £30. This approximates to £10 per hour for accommodation, invigilation, paper setting/marking and associated administration incurred.

Are the above charges really unrealistic? A plumber charges £10 per hour which makes 92p an hour including all notes a very moderate cost.

T. F. Strickland (G4EOA)
Head of School of Electrical Technology
Brighton College of Technology

SOLDERABILITY

Dear Ed.,

I'm writing in the hope that certain suppliers of kit-form equipment may be swayed into giving due consideration to solerability in the context of p.c.b.'s (inc. items of seeming professional quality). The problem as I see it, relates to two factors: a) extensive storage in less than ideal conditions prior to despatch, and b) the bizarre practice of using 1mm diam. holes for 0.5mm component wires – there are such things as 0.7mm drills, sealable plastic bags, and flux/preservative. I'm sure that anyone intent on doing a first class job in this particular field is only too aware of the problem.

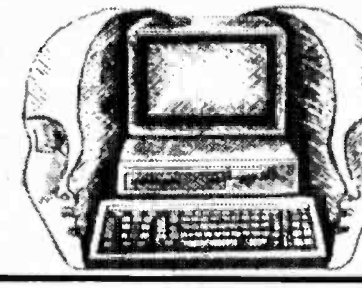
Of the reference to "plenty of heat" within the instructions provided by some suppliers of kit-form audio equipment, viz. in the context of p.c.b. assembly typically, heavy items that really have no place on a p.c.b. at all! I can only inform all concerned that the "plenty of heat" aspect simply serves to reduce solderability courtesy of oxidization of the relevant connection. Clearly, the correct technique involves using the solder itself as the heat carrier – allied with an iron of adequate heat capacity.

Whilst I appreciate that solderability can be improved via washing in a weak hydrochloric acid solution – followed by hot and cold water rinsing, drying (gentle electric heat), and solvent cleaning prior to soldering (with variable success), the associated process is hardly in-line with either the buyer's expectations, or the claims of the average supplier – "a few evenings satisfying/relaxing/rewarding/profitable work!"

Even boards of professional appearance have proved wholly unpredictable – despite a bright appearance.

M. J. Evans
Worcester

INTERFACE



Robert Penfold

I FIRST read about single bit speech synthesis many years ago, and I was more than a little sceptical about the efficacy of such systems. Speech synthesisers using much higher resolutions often produce results which are far from perfect, so a simple single bit system could reasonably be expected to produce an output that was so distorted as to be totally unintelligible.

However, I must admit to being quite impressed by the effectiveness of the speech produced via the integral sound generator by various pieces of PC software. These programs clearly demonstrate that single bit speech synthesis can provide worthwhile results.

For PC users there is a shareware package called the *Digitised Voice Programmer's Toolkit* which makes it easy to experiment with single bit speech recording and playback. Using this to playback one of the demonstration speech samples gives a good idea of what can be achieved.

Playback is via the PC's internal sound generator, and the distortion on the recorded speech is massive. However, despite this high level of distortion, every word of quite long speech samples is perfectly understandable.

Natural Flow

The main problem with speech synthesis systems that use high levels of resolution is that even a few brief messages tend to take large amounts of storage space. If the host computer has the wherewithal, something like an 8-bit system with a sampling rate of around 18kHz will provide very natural sounding results. However, some relatively complex hardware is needed in order to record speech samples and play them back again.

Most high resolution speech synthesisers use systems which do not require large amounts of memory or disk space to hold long samples. This usually means having a library of words, or even parts of words (allophones), with the reproduced speech being put together from these constituent parts. Such systems work, but with the allophone system it can take a lot of effort to put together some reasonably convincing words.

With both systems there is a major problem in that the natural modulations in real speech are absent. These changes in pitch and speed, plus more subtle changes, are something that we all use whenever we speak. They are important to the listener, since the same phrases can have different meanings depending on the way in which they are spoken.

Single bit speech synthesis systems do not need to use any form of data compression. Complete messages are recorded and played-back as and when necessary. Provided the recorded phrases are spoken clearly and in a natural fashion, the played-back samples should also have a natural flow and be easily understood.

A sample rate of about 16kHz is adequate, but only one bit (not one byte) is needed to store each sample. This gives about 2K of data per second of recorded speech. On an 8-bit system it might be necessary to keep the messages quite short, but with most 16/32-bit systems there would probably be no difficulty in using a few minutes of recorded speech.

A big advantage of single bit systems is that a very simple interface is all that is needed in order to record the speech samples. Playback is often possible via the computer's built-in sound generator unit, and in other cases the addition of some very simple hardware is all that is required.

How It Works

For those who are not familiar with single bit speech synthesis it would perhaps be as well to explain the basic way in which such a system operates. The hardware interface used when recording is basically just a microphone feeding into a clipping amplifier. The distortion on the clipped output signal is obviously very high indeed. Surprisingly though, with a speech input the clipped output signal is still perfectly understandable. It has to be emphasised here that such a system is only suitable for speech, and will not give usable results with music.

The clipped output signal is a digital signal, which is high for one set of audio half cycles, and low for the other set. This signal is coupled to a digital input of the computer.

During the recording process a software routine checks the state of the input line at regular intervals, and stores the results in a block of memory. As with any digital recording system, the sampling rate must be high enough to ensure that the played-back signal is a sufficiently accurate copy of the original. In this case a sampling rate as low as 16kHz seems to be adequate.

During playback the stored data is fed to a digital output, bit-by-bit, at the same rate that it was recorded. The output line is used to drive a loudspeaker via a suitable amplifier stage. With some computers it is possible to send the signal to the internal sound generator circuit, although in most cases this will require some imaginative programming.

Hardware

The hardware needed for recording single bit audio is quite simple, as can be seen from the block diagram of Fig.1. The low level microphone signal is fed to a preamplifier stage. From here the signal is coupled via a gain control to a highpass filter. The high-

Fig. 1. Block diagram for a single bit speech synthesiser recording circuit.

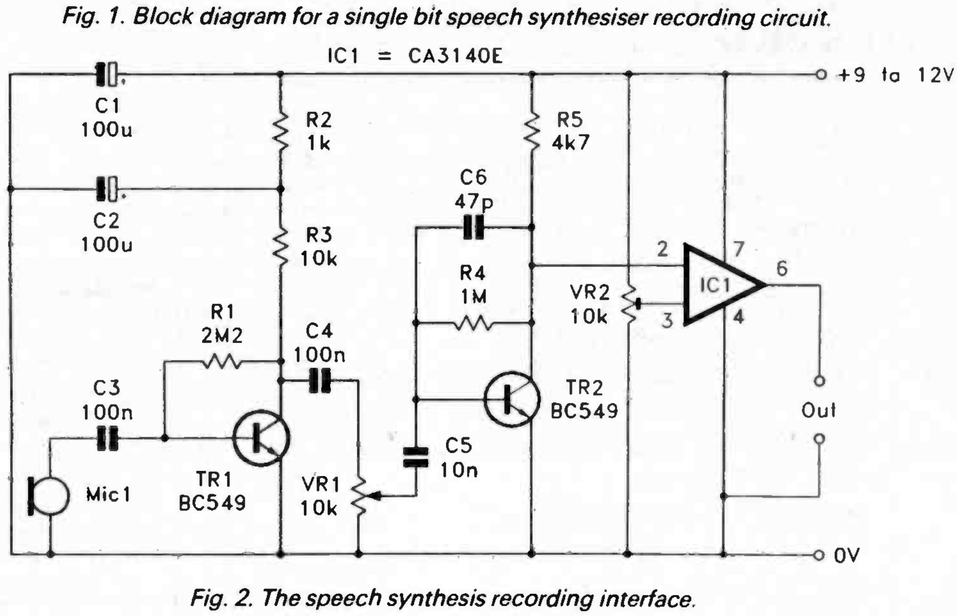


Fig. 2. The speech synthesis recording interface.

pass filter might seem to be superfluous, but in practice it is essential.

Without this filtering the low frequencies in the voice signal tend to result in the clipped output signal staying at one logic level or the other for relatively long periods of time. This gives an output signal that is little more than a random "clicking" and "buzzing" sound. The low frequencies do not significantly aid the intelligibility of speech, and in the current context they actually seem to hinder it. The practical result of removing these frequencies is certainly a digital output signal that has a far higher degree of intelligibility.

The next stage is another amplifier, and this is needed in order to bring the signal up to a level that will drive the final stage. This is just a basic trigger circuit which provides a logic 1 output on positive half cycles, and a logic 0 level on negative half cycles.

The toolkit package includes a circuit diagram for a recording interface, plus a printed circuit design, all of which can be printed out to a HP Laserjet or Laserjet compatible printer. However, I made up my own interface using the circuit of Fig.2. This is simpler and cheaper than the circuit provided with the toolkit package, but it seems to work quite well. It is easily accommodated on a small piece of stripboard.

Circuit Description

The circuit uses two common emitter amplifiers to provide the voltage gain, with lower than normal values for the coupling capacitors to provide the highpass filtering. VR1 is the gain control, and results seem to be best if this is advanced just far enough to give strong clipping at the output.

I used a low impedance dynamic microphone of the type sold as replacements for cassette recorders. However, the circuit should work well with any normal low or medium impedance microphone, and would probably even give good results with a crystal type.

Integrated circuit IC1 is the trigger circuit, and this is really just an operational amplifier used in the voltage comparator mode. VR2 is adjusted very close to the point where the output of IC1 changes state. It does not matter whether the output is normally high or normally low. The CA3140E used for IC1 is a static sensitive device incidentally.

The output of the unit is connected to one of the PC's serial ports. Note that it drives the CTS handshake input and not the data input. Connection details for 9- and 25-pin PC serial port connectors are provided in Fig.3.

In my original circuit IC1 was equipped with a negative supply, so that the unit provided suitable positive and negative voltage levels to drive an RS232C input. In practice the circuit seems to drive an RS232C port properly without using a negative supply for IC1, so this was omitted from the final design.

Testing

A good way of testing the circuit is to feed the output to a crystal earphone. If the interface is working properly the distorted

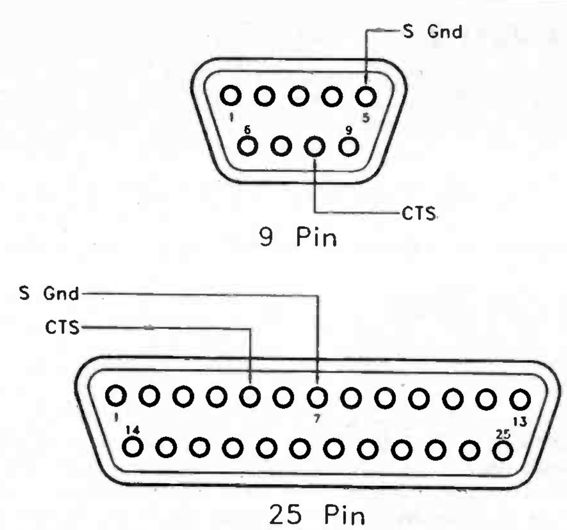


Fig. 3. Connection details for 9- and 25-pin serial ports

audio output should be clearly audible. Monitoring the output using a crystal earphone makes it easy to find an effective setting for VR1.

The toolkit package includes stand- alone recording and playback programs which can be used to check that the overall system is operating properly, and when experimenting with the system.

The Software

The toolkit is provided with all the software that is needed in order to use the recorder device. The main parts of this are two modules, one for recording and one for playback, which are supplied both as source code (assembler) and as compiled object (.OBJ) files. These are linked into your programs to provide recording and playback facilities. They can both be used in the same program if required (though this would perhaps be unusual) but they cannot be used simultaneously because of hardware conflicts.

The modules are written to use the Far Pascal calling convention. They should therefore be usable from most versions of Pascal, provided .OBJ modules can be linked, and also from Modula-2, which uses the same convention. Most C compilers can also use Pascal calling conventions. Not surprising, this, as it is the convention used in Microsoft Windows. C header files for the two modules are included in the kit.

Playback of sound is done in "background" mode. The routines return immediately, so there is no waiting while the sound plays. This is a good feature, as there is nothing more frustrating than being stuck with an unresponsive computer, especially if you don't want to hear the sound!

Programs which play back sound can either use files external to the program, or the recording data can be 'embedded' into the .EXE file. This is an interesting process. First, the binary data file is converted to assembly language, in fact to a long list of DB statements. The kit includes a program for this purpose. This is then assembled into an .OBJ file which is linked into the program. Obviously, you need an assembler to do this.

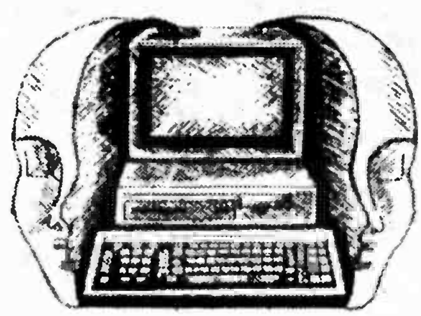
An example of an 'embedded' program is included, and again, you get both source code and complied .EXE file. There is even and embedded TSR which says 'left shift pressed' every time you press left shift. Scope for practical jokers here! Again, this comes also as source (assembly language) code.

By looking at these examples, you should be able to see how to use the modules. You do, however, need to be familiar with the concepts of object files and linking. It takes a bit more than just selecting 'compile' from a menu.

Editor

Finally, an editor program is included. This allows recording, mixing, merging, and general editing of voice files, rather like using a tape recorder. Using this, it is possible to tidy up recordings to any necessary degree. However, in the current version, memory requirements limit the length of recording which can be edited in one piece to about 3 minutes 45 seconds. Since voice recordings are simply binary data, however, files can simply be concatenated to give longer periods of sound.

The software will run on any PC which has a least an 80286 processor. Note that this software is shareware and not of the public domain variety. If you use the software in earnest the registration fee of this American package is $50. The *Digitised Voice Programmer's Toolkit* is on disk 2126 from the P.D.S.L., Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL (Tel. 0892 667473). It might be available from other sources under a different catalogue number.



Home Base

Jottings of an electronics hobbyist – Terry Pinnell

Fiddler on the Roof

Although no great technical heights had to be scaled when I built my Weather Centre, installing the wind speed and direction sensors on the roof was decidely hazardous. To ensure reliable operation they had to be mounted as high as possible, which in practice meant sharing the chimney stack with the TV antenna. Given the lofty location of the finished units, plus my low pain threshold, safe access was my paramount objective when it came to installation.

The obvious approach was to use my extendable ladder, which was just high enough. But I quickly concluded that there was no way I was going to risk the very real danger of falling off onto the patio and crippling or killing myself. I recall muttering to myself something inarticulate like "Blow that for a game of conkers" as I reached the quite modest altitude at which terror overtook enthusiasm.

Only about half way up I felt decidely insecure, even carrying nothing and with both hands dedicated to the rungs. I reckon the ladder was extended to about twice the height of previous occasions, such as when using it for painting windows. That in itself made one mighty difference to apparent stability. But the chief problem was that the adjacent wall was just featureless brick, going up two stories and then straight up the chimney stack itself, with no anchor points of any sort.

I was reluctant to give up so soon though, especially as I remembered the TV aerial chap shinning up there confidently a few years earlier. So I thought I'd try getting a rope over the roof, which I could then tie to the top of the ladder, securing the other end so that it couldn't slip. I could then contrive some way of hooking myself successively onto higher rungs of the ladder as I climbed, probably even with two hooks so that it was physically impossible to fall off.

But the first stage of all this meant casting a small lead weight right over the house, from front to back garden, using one of my fishing rods, so that I could then use the nylon line to pull over a string and then the rope. Like most of my bright ideas however, this proved much trickier than I had thought.

Unlike casting across water, where there is plenty of scope for trial and error, I needed to get it just right first time. If I should accidentally cast much too short, I could put the lead straight through my front window. More likely, if I got it over the house but was still too short, there was a serious risk that the lead would swing sharply in over the guttering and smash a rear window. Anything light enough to present no risk to the windows proved impossible to cast high enough. So reluctantly I abandoned the ladder approach and started looking for an alternative way of reaching my roof-top destination.

Up the North Face

The eventual route was still fairly hairy. I started by standing on the side of the bath, climbing backwards out of the window and edging slowly along the outside of the house gripping the flat, gravel-strewn bathroom rooftop. Then came probably the most awkward part, where I had to sort of swing round the corner and onto the tiles. I could then scramble up the roof on all fours, initially in the fairly safe "valley" formed between two differently sloping sections and then finally up the exposed part to the top.

One vital pre-requisite was warm, dry weather conditions. Another, as I learned the hard way, was to plan each expedition painstakingly to ensure I took everything I needed. I never did manage to get it completely right though. Standing upright, straddling the parapet, one hand grasping a chimney pot, the other holding a pair of scissors, with a roll of insulating tape temporarily lodged between my lips – that was not the best time to realise that I hadn't brought the right connecting wire with me.

As shown roughly in Fig.1, I attached the units on the horizontal top section of a T-shaped arrangement of square section tubing, and then secured this to the chimney with an antenna bracket. It needed four holes in the chimney stack, so my electric drill and a mains extension cable had to make that trip with me. Those few square inches of brickwork naturally proved to be the hardest in the entire building, and of course my meticulously-prepared checklist hadn't envisaged the need for a new drill-bit.

I routed the wires down across the roof tiles, along the fascia boards, through a window frame and finally to the Weather Centre unit in my bedrooom. Altogether there were a dozen wires: eight for the wind direction unit, one for the anemometer output signal, 0V and +V (powering both units) and a token spare for one of several options I had in mind for the future.

Magnetic Compass

The Wind Direction unit was constructed by gluing eight small reed switches at 45 degree intervals inside a strong, cylindrical case (a tin of drinking chocolate in a previous existence) representing all main and intermediate points of the compass: N, NE, E, SE, S, SW, W and NW.

A magnet was mounted on the spindle so that it closed the contacts of the adjacent reed switch when the wind came from that direction, and this illuminated the corresponding l.e.d. in the circular arrangement on the display panel. I clearly didn't concentrate hard enough when I first installed this, and ended up with southerly winds apparently coming in to my Surrey home from the general direction of Scotland.

After some nine years' use, it has been as reliable as you'd expect from such a simple arrangement, although there is one very narrow arc within which no l.e.d. lights, and another when two adjacent ones come on simultaneously. These would be trivial to correct if it was installed inside the house of course. But the reality would be standing on the roof to undo well-weathered nuts and bolts to remove it from the T-bracket, disconnecting ten wires from screw-connectors (which from the experience of previous maintenance expeditions will probably be rusty, despite the heavy use of insulating tape), dismantling the vane and getting the tin case back intact down the North Face.

Anemometer's Demise

While that fault alone isn't serious enough to get me up there on a maintenance mission, I really must attend soon to the Wind Speed Unit. Sadly, some eight years into its life, it seems that a large crow or the like took a fancy to it as a resting perch. It wasn't for some time that I discovered this, but lying in bed one stormy night I realised that I wasn't getting the usual pyrotechnic display from the line of wind speed l.e.d.s. Now and again one or two of them would come on, but no more.

Checking with the binoculars the following morning, I found that one of the three arms had vanished, so reliable rotation was now impossible. In the cause of ensuring easy spinning, I had done everything possible to reduce weight and thus friction. Hence the flimsy arrangement of rather thin wire and ping-pong hemispheres. This came successfully through my rigorous wind tests (wife's hair-dryer) but I must say I hadn't bargained with brainless crows!

Steady State

One unusual feature of the otherwise very simple Wind Direction circuit is its "Steady" indicator. At the centre of the circle of eight red direction l.e.d.s is a single green one, which comes on if the wind has not changed direction within about ten minutes. No doubt there are simpler ways of implementing this but I settled on adding 47 ohms in series with the supply to the direction l.e.d.s, so that at its lower end there would be small voltage pulses generated whenever any l.e.d. went on or off.

I first filtered the pulses (because mains noise was occasionally causing spurious triggering), amplified them using a 741 amplifier, then added a single transistor signal-shaper stage, and finally a re-triggerable 555 monostable whose output was high (disabliing the Steady l.e.d.) if it had been triggered within approximately ten minutes.

So when I wake up, if the Weather Centre tells me it is not only warm and sunny but also that there is a bonus of no wind, then I could just be tempted to get up and go out. Or at least open the curtains for a bit more input!

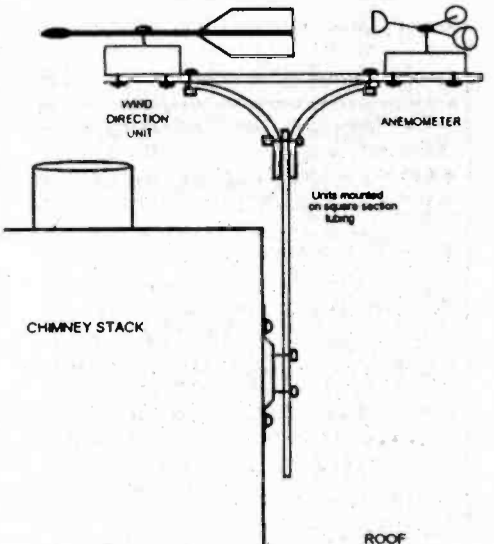
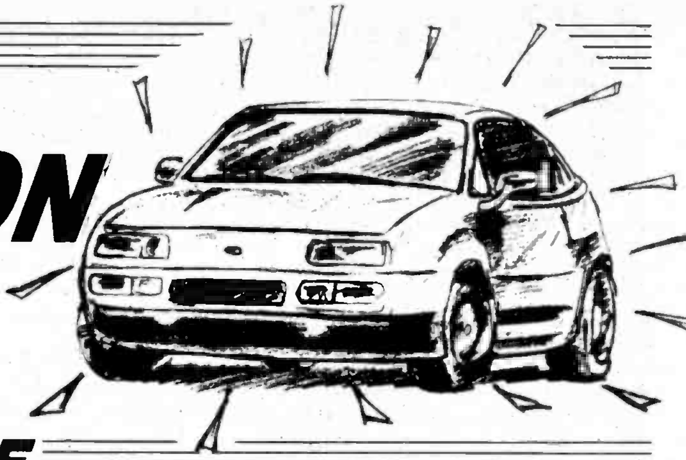


Fig. 1. General arrangement of units mounted on the chimney.



SWITCHED-ON REMINDER

T. R. de VAUX-BALBIRNIE

A bleeping memory-jogger for the motorist.

THIS project is designed to remind the forgetful car driver that an electrical accessory is switched on. This it does by giving a short bleep once every three minutes or so until the accessory is switched off or the system cancelled.

It was found that an intermittent *audible* warning is more effective in attracting attention than a warning light. Up to *four* pieces of equipment may be connected to the unit simultaneously so that the warning will be given if any of them are switched on.

The Switched-On Reminder has been found particularly useful to the author as a memory-jogger when the heated rear windscreen or fog lights have been left operating unnecessarily. However, use is not restricted to these particular items – this circuit will provide a warning when used with almost any 12V car electrical accessory or accessories.

The unit is built in a small plastic case with a pushbutton Cancel switch mounted on the end panel. The box is secured under the car dashboard and is fairly unobtrusive. Connections from the accessory circuits being monitored are made to a piece of screw terminal block mounted on the side of the unit.

The "reminder" draws current from the 12V car electrical system and then only while the ignition is switched on. The continuous current requirement is less than 5mA which may be regarded as negligible. For safety reasons, the circuit is fused using a car radio-type line fuseholder.

CANCELLATION

The pushbutton Cancel switch mentioned above may be operated at any time where the warning could prove annoying – where the heated rear windscreen needs to be left switched on for a long time, for example. Normal action will return automatically when the accessory is switched off then on again.

If the accessory is controlled through the ignition switch, then normal operation will also return when the ignition is switched off then on again. Note that if the unit is to be used to monitor a fog light, the circuit may reset when the headlights are switched between dipped and main beam depending on how it is connected.

The bleep time is preset but could be easily changed if desired (details for this are given later). The time between bleeps is continuously adjustable between limits of five seconds and nine minutes approximately. This will be set at the end of construction to suit personal preference.

EXISTING CIRCUIT

Consider the heated rear windscreen circuit shown in Fig. 1a. It is usual for one terminal of an accessory such as this to be connected to the car battery negative terminal through the vehicle chassis – that is, the car bodywork acts as the return wire. The other terminal of the accessory is connected to the battery positive terminal through the on-off switch.

When the accessory is switched *on*, point *X* will assume positive supply voltage (nominally +12V and referred to as *high* in the text). This is because it is connected directly to the battery positive terminal through the switch which is virtually a zero-resistance path.

When the accessory is switched *off*, point *X* will be at 0V (car chassis voltage referred to as *low* in the text) via the accessory itself. It is this voltage change which operates the new circuit.

Note that the circuit will work incorrectly if the accessory switch is placed in the *negative* wire (the one connected to the car chassis) – see Fig. 1b, since point *X* will be high with the accessory *off* (via the accessory itself) and low when it is *on* – that is, via the switch.

Connecting a switch in this latter way is unusual and is normally restricted to devices such as courtesy lights where, for simplicity, one terminal of the switch (in this case, a door pillar switch) is connected to the car body. It is unlikely that any circuit of this type will need to be monitored.

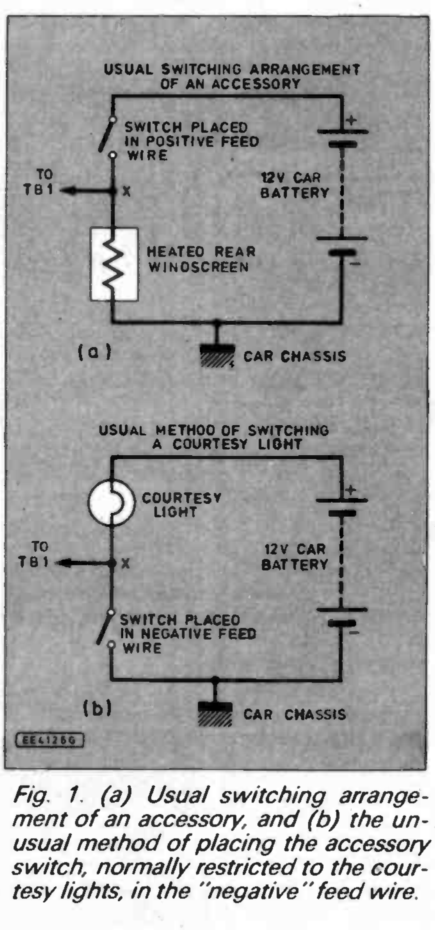


Fig. 1. (a) Usual switching arrangement of an accessory, and (b) the unusual method of placing the accessory switch, normally restricted to the courtesy lights, in the "negative" feed wire.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Switched-On Reminder is shown in Fig. 2. The principle component is IC1 – a dual CMOS integrated circuit timer i.e. one integrated circuit containing two identical sections.

In this application, one section, IC1a, is configured as an *astable* while the other, IC1b, is connected as a *monostable*. The astable section output, IC1a pin 5, switches on and off (becomes high and low repeatedly) so long as a supply exists and the reset input, pin 4, is *high*.

The rate at which pulses are produced depends on the values of fixed resistors, R4 and R5 in conjunction with preset potentiometer VR1 and capacitor C1. Preset VR1 forms the adjustment to the pulse repetition frequency.

As a pulse falls from *high* to *low*, the monostable section IC1b is actuated by making its trigger input, pin 8, low momentarily through capacitor C2. Once operating, the output, pin 9, goes high for a certain time then reverts to low.

The time period here depends on the value of fixed resistor R8 in conjunction with capacitor C3. With the values specified this time is preset to 0·2 seconds approximately. Fig. 3 shows a timing diagram of the system.

While the monostable output (IC1b) is high, it operates the audible warning device (solid-state buzzer) WD1 *direct*. While the monostable is standing by between pulses the trigger input, pin 8, is kept high through resistor R7 and this prevents false operation.

With all accessories being monitored switched off, pin 4 is kept low via resistor R6, so the astable section (IC1a) is disabled. No pulses are then produced and the monostable, hence the audible warning device, remain off. With an accessory switched on, pin 4 is made high from the accessory circuit being monitored via resistor R1 and one of the input diodes, D1 to D4, so enabling IC1a.

With preset VR1 sliding contact adjusted to provide maximum resistance, the theoretical pulse repetition frequency is one pulse every nine minutes approximately but in practice it will deviate from this figure since C1 is an *electrolytic* capacitor and so subject to a wide tolerance range and high leakage current. With VR1 adjusted for minimum resistance, the time period is five seconds approximately.

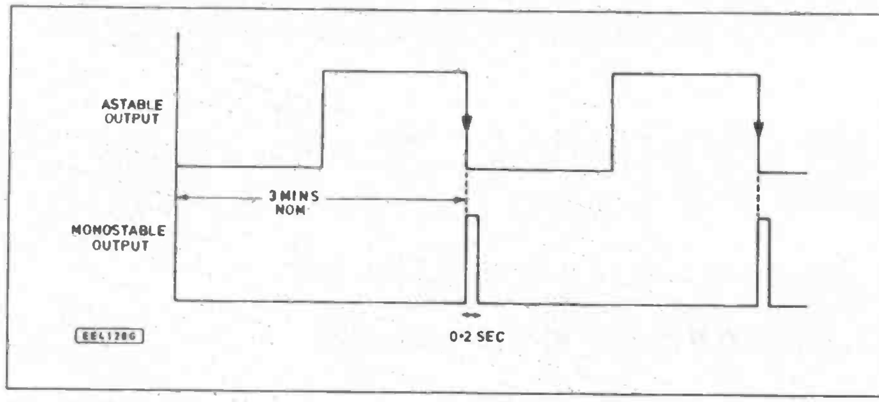


Fig. 3. Timing waveform diagram for the monostable section. The time period depends on the value of resistor R8 in conjunction with the capacitor C3. With the values shown this is approx. 0·2 seconds.

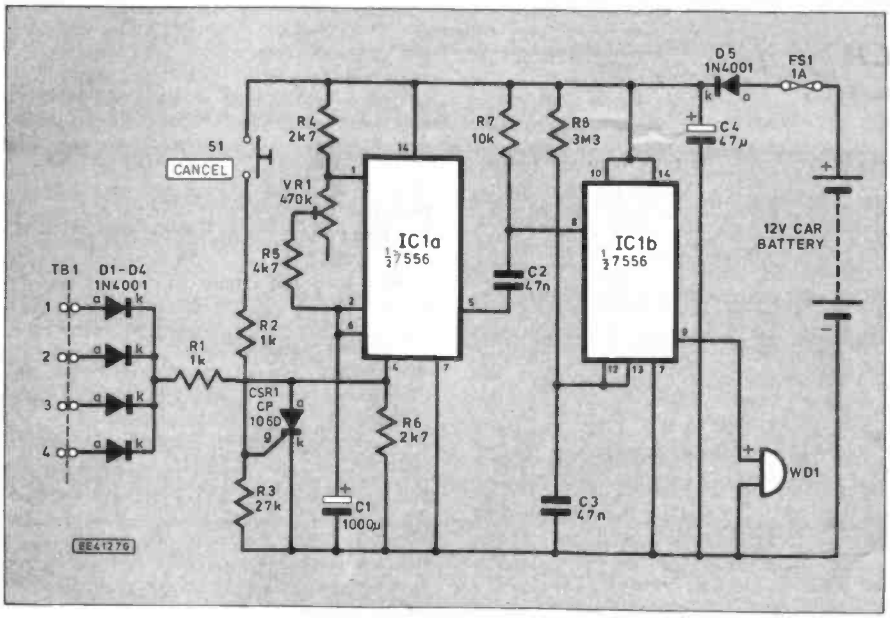


Fig. 2. Complete circuit diagram for the Switched-On Reminder.

LATCHING ACTION

If operation needs to be cancelled for any reason, thyristor CSR1 is called into play. Normally this component is *off* (that is, no current flows in its main anode-cathode circuit) and it therefore has no effect. When push-to-make Cancel switch, S1, is operated momentarily, current flows through resistor R2 to CSR1 gate (g). This triggers the device and a low-resistance path is formed between anode (a) and cathode (k).

Current flows through one of diodes, D1-D4, from the appropriate accessory circuit and through the thyristor from anode to cathode, via R1. The low voltage which exists between the thyristor anode and cathode is applied to pin 4 and effectively disables IC1a.

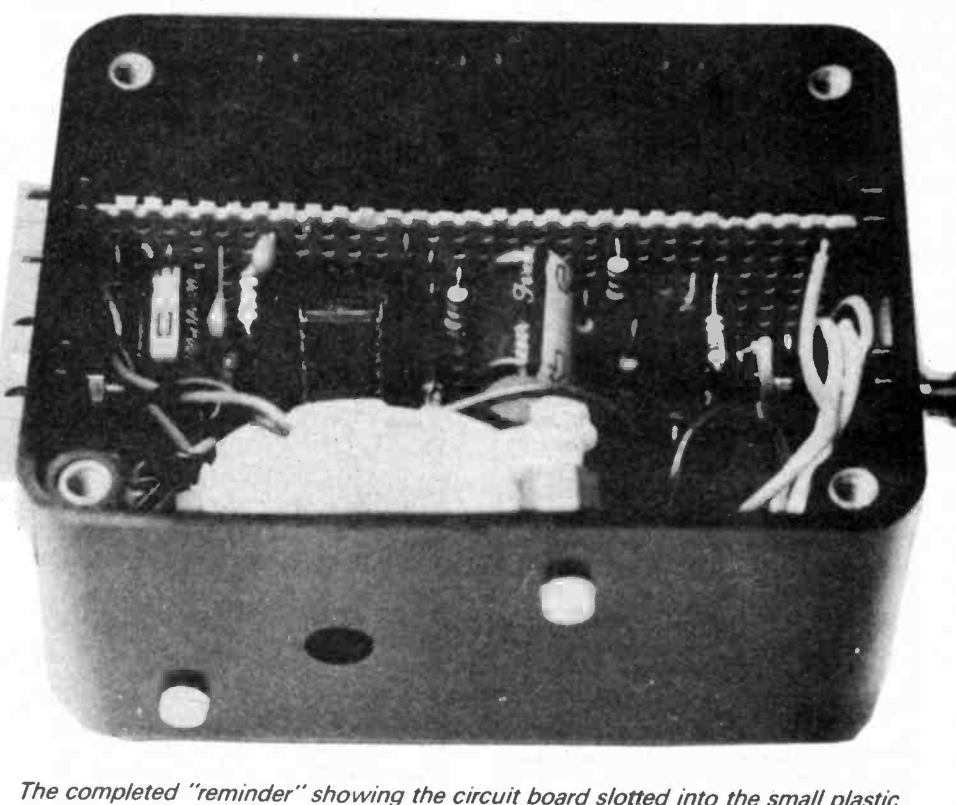
It is a characteristic of thyristors that, once triggered, anode-cathode current continues to flow when the trigger pulse is removed i.e. it *latches* (unless the anode-cathode current falls below a certain threshold value as would happen if the accessory being monitored were to be switched off). Thus, IC1a is left in a disabled state when push switch S1 is released.

Switching the ignition off then on again will also unlatch CSR1 providing the accessory receives current through the ignition switch. Resistor R3 keeps CSR1's gate normally low (that is, with S1 released) and this prevents false triggering when the supply is established.

PROTECTION

The arrangement of diode D5 and capacitor C4 serves several purposes. Firstly, it prevents possible damage to circuit components if the unit were to be connected to the supply with reversed polarity. In this case, D5 would be reverse biased and so fail to conduct.

Also, D5, in conjunction with C4, smooths the supply from the rather "noisy" car charging system. This makes for more reliable operation. A further reason for including C4 is that when the supply is switched on, it is applied fairly slowly to the circuit as the capacitor charges up and this prevents possible false triggering of the monostable and/or thyristor.



The completed "reminder" showing the circuit board slotted into the small plastic case and the warning buzzer mounted on one side wall using nylon nuts and bolts. Note also the small hole to allow the sound to pass through.

CONSTRUCTION

Construction of the Switched-On Reminder is based on a piece of 0·1in. matrix stripboard, size 11 strips x 28 holes. The circuit board component layout and details of breaks required in the underside copper tracks is shown in Fig. 4.

Begin construction by cutting the material to size and filing the short edges so that it fits the slots of the specified plastic box (see photograph). Make the track breaks and solder the inter-strip link wires into position as indicated.

Solder the i.c. socket in place and follow with all other on-board components. Take care over the polarity of capacitors C1, C4 and of all diodes. Take care also over the orientation of CSR1.

Note that only the number of diodes D1-D4 appropriate to the number of channels required need be fitted, although such a saving in cost is hardly worthwhile. Do not insert the i.c. into its socket yet. Adjust VR1 sliding contact fully clockwise as viewed from IC1 position (to provide minimum timing).

Make a thorough check for errors then complete construction of the circuit panel by soldering 10cm pieces of light-duty stranded connecting wire to strip *K* and to strips *B, C, D* and *E* (according to the number of channels required) on the left-hand side. Twist these latter wires together.

Solder a similar piece of wire to strip *B* and pieces 20cm long to strips *A* and *J* on the right-hand side. Solder the buzzer wires to strips *H* and *J* observing the polarity – the *red* wire should be connected to strip *H*. Note that the audible warning device must be of the type specified in the components list.

Prepare the box by drilling two holes in the side to secure the buzzer, WD1, and a further one of 6mm diameter between these mounting holes for the sound to pass through. Drill holes in the back of the box for terminal block TB1 mounting. Drill a 4mm diameter hole near the terminal block position to accommodate the wires passing through from the circuit panel and another hole to carry the supply positive and negative wires. Drill a hole and mount switch S1.

Refering to Fig. 5, mount remaining components and complete the internal wiring shortening any wires as necessary. When mounting the buzzer, use spacers (for example, stand-off insulators or plastic tubing) on the bolt shanks as shown in the photograph so that when in position, the front face of the buzzer is held slightly clear of the box. Knot the supply wires together and pass them through the hole drilled for the purpose – check that the knot provides strain relief.

Finally, insert IC1 into its socket observing the orientation and slide the circuit panel into position. Check that there are no short-circuits formed at the switch connections or anywhere else.

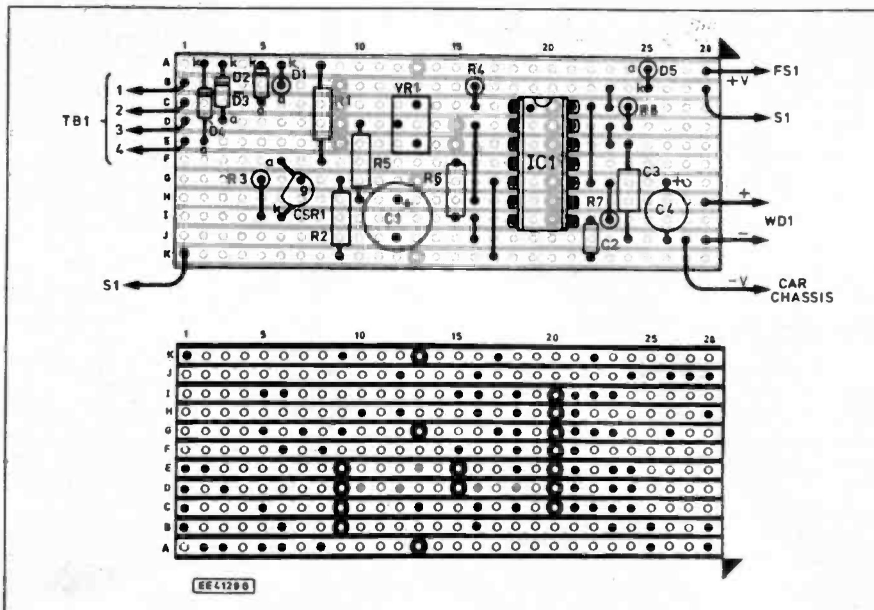


Fig. 4. Stripboard component layout and details of breaks required in the underside copper tracks.

TESTING

It is a good idea to test the system using a 9V battery. In this way, any small problems may be resolved before connecting it to the car electrical system. It is also a more convenient way to set the operating time.

Connect four short pieces of wire to the unconnected side of the terminal block TB1 (or as appropriate to the number of channels being used). Connect the positive and negative supply wires to the battery terminals. Usually the unit gives a single bleep when the supply is established – it should then remain silent.

Touch one (any one) of the wires leading to the terminal block on to the positive battery terminal (this simulates an accessory being switched on). The buzzer shold bleep and continue to do so every few seconds (but not necessarily perfectly regularly). Test the cancel facility by pressing S1 for an instant – the buzzer should now remain silent.

Disconnect then re-connect the battery so that the unit is reset. Check that the wires leading to other TB1 terminals cause the unit to sound as before.

COMPONENTS

Resistors

R1, R2 1k (2 off)
R3 27k
R4, R6 2k7 (2 off)
R5 4k7
R7 10k
R8 3M3
All resistors 0·25W 5% metal film.

See SHOP TALK Page

Potentiometer

VR1 470k sub-miniature preset, vertical

Capacitors

C1 1000µ radial elect., 16V
C2, C3 47n ceramic (2 off)
C4 47µ radial elect., 16V

Semiconductors

D1 to D5 1N4001 50V 1A rect. diode (5 off)
IC1 ICM7556 dual CMOS timer
CSR1 CP106D 400V 2A thyristor

Miscellaneous

WD1 Wire-ended d.c. operated piezo buzzer–12V operation at 10mA approx. Frequency 2·7kHz approx.
S1 Miniature push-to-make switch
TB1 4-way 2A screw-terminal block
FS1 Car radio type line fuseholder, with 1A fuse to fit

Stripboard 0·1in matrix, size 11 strips x 28 holes; plastic box, size 79mm x 61mm x 40mm (MB1 box); 14-pin d.i.l. socket; light-duty stranded wire; 3A auto-type wire; auto-type connectors (Scotchlok); solder; small fixings; plastic spacers; etc.

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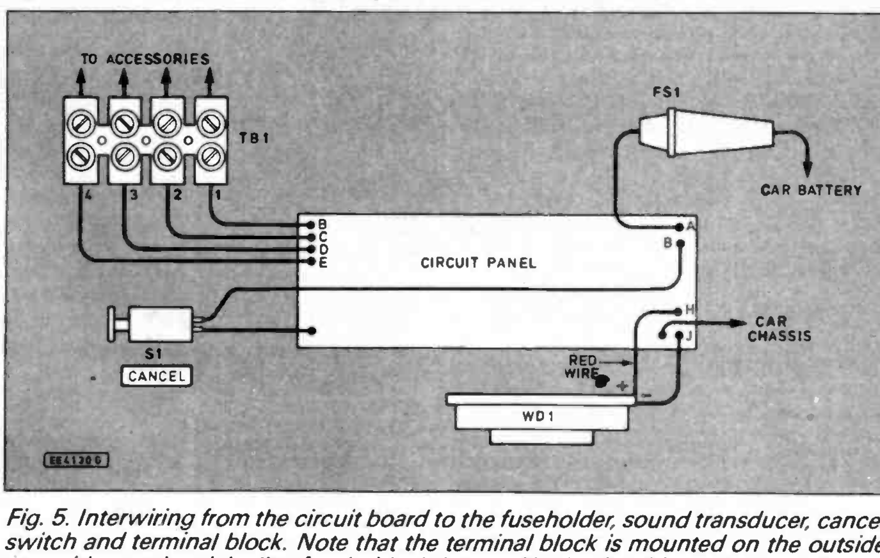


Fig. 5. Interwiring from the circuit board to the fuseholder, sound transducer, cancel switch and terminal block. Note that the terminal block is mounted on the outside case side panel and the line fuseholder is inserted in the "positive" supply lead.

Adjust preset VR1 sliding contact to provide the required operating time. In the prototype unit three minutes seemed about right. If the preset bleep time needs to be altered for any reason, this may be done by changing the value of resistor R8 – raising its value lengthens the time and vice-versa.

Fit the free end of the positive supply wire with one section of the line fuseholder. The lid of the box may now be fitted, a label made for S1 and the unit installed in the car.

INSTALLATION

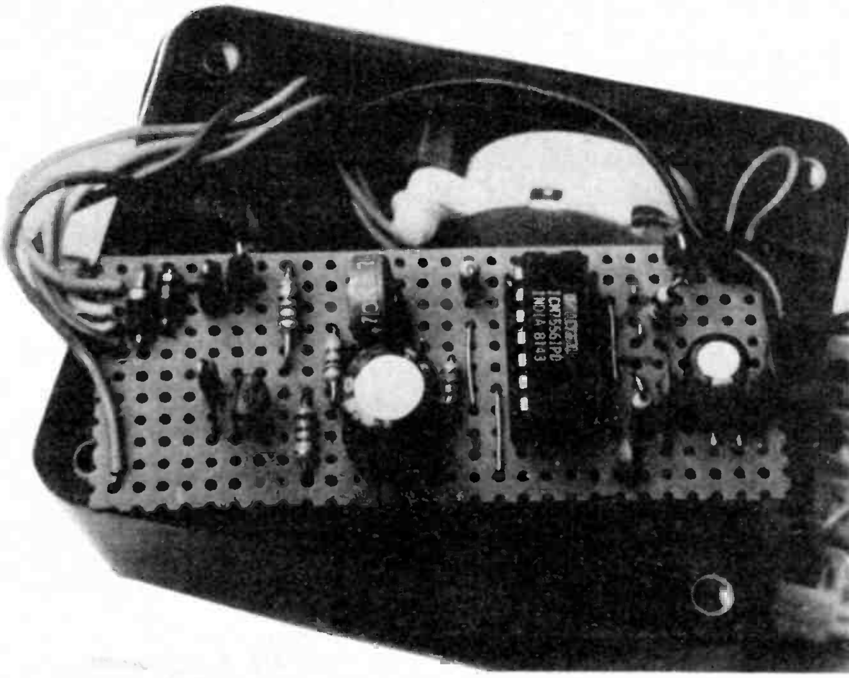
Before commencing installation work, locate an existing fuse which is live *only* while the ignition is switched on and measure the distance from here to the proposed unit position. Cut off a piece of light-duty auto-type wire of 3A rating minimum a little longer than this.

Imporant Safety Note: Before proceeding, disconnect the car battery and remove it.

Connect one end of the wire to the outlet side of the existing fuse – use a proper auto-type connector here not a twisted connection. Route the wire to the unit and fit the free end with the remaining section of the line fuseholder. Assemble the fuseholder with a 1A fuse inside.

Connect the negative supply wire to an existing Earth (chassis) point. If one cannot be found, drill a small hole in a metal part connected to the car bodywork and use a small eyelet secured with a self-tapping screw.

Make connections to the accessory circuit(s) to be monitored. These connections may be made anywhere between the switch and the accessory itself – see Fig. 1a. The best method is to use Scotchlock connectors – these are available from car accessory shops and are used to make a reliable connection to a wire without actually breaking it.



Layout of components on the completed circuit board. One of the small spacers for the sound transducer can just be seen.

Use appropriate lengths of light-duty auto-type wire of 3A rating minimum and run them to TB1 position. Connect them to TB1 terminals and check that they are secure.

Re-connect the car battery and switch on the ignition. The buzzer will probably give a single bleep – this may be ignored.

With the accessories being monitored switched *off*, nothing further should happen. Switch one of them on. The buzzer should bleep and continue to do so at intervals set previously.

Press S1 and check that the circuit cancels. Any final adjustments may be made to VR1 and the unit finally secured in position under the dashboard using a small bracket.

You will never leave accessories switched on unnecessarily with the Switched-On Reminder! □

REPORTING AMATEUR RADIO

Tony Smith G4FAI

NOVICE LICENCE DISCUSSION

I reported last month that the Radiocommunications Agency had reviewed the first year of the radio amateur Novice scheme, concluding that it had been a success. It appears, however, that a few problems were experienced during the year and that although some improvements were agreed other proposals were rejected.

Some candidates had difficulty in finding an examination centre and complaints were made that some centres were charging high administration fees. The first situation was said to be improving, but the second was outside the control of the examining body, the City & Guilds of London Institute. Some unsuccessful candidates were notified too late to enrol for the following examination but this problem was being sorted out.

It was suggested that Novice power levels were too low, and that not enough suitable equipment was available. The review felt it was too early to make any changes, and hoped that manufacturers would begin to view Novice equipment as a potential market. The power levels permitted were intended to minimise the potential for interference and one of the aims of the scheme was to encourage Novices to build their own equipment.

Another suggestion was that Novices should be allowed on 2 metres (144-146MHz); but as in many areas of the UK this band is subject to congestion and poor operating practices the review agreed that this would not assist Novices in training or offer an incentive to progress to a full licence.

It was argued that the Novice licence would be more attractive, especially to young people, if there was more emphasis on interfacing computers with radio. The review felt the Novice licence course was not the place for such study as the time constraints purposely imposed did not allow for it (a course is expected to take 30 hours in total).

It was suggested that the construction techniques taught were too simplistic. The review agreed, however, that it was essential to teach basic skills using inexpensive and readily available materials, and that Novices could be expected to progress to more advanced techniques later, depending on their ability and finances.

SPECTRUM REVIEW

The Radio Society of Great Britain's submission to the third radio spectrum review (mentioned in this column last October) contains a useful summary of the occupancy of the amateur bands within the frequency range 28-470MHz covered by the review.

According to the RSGB, approximately 30,000 UK amateur class A licensees have access to all amateur bands, including 28MHz which is covered by the review. A further 30,000 class B licensees operate on the bands above 30MHz as follows: 50MHz – 12% (increasing); 70MHz – 7% (stable); 144MHz – 66% (decreasing); 430MHz – 15% (increasing); while the new Novice licensees can operate in parts of the 28, 50 and 430MHz bands at reduced power.

The most commonly used modes are f.m. speech, s.s.b. speech, Data and CW (Morse), while groups of individuals experiment with a great variety of other modes, protocols and types of propagation.

BAND CHARACTERISTICS

Allocated to amateurs on a worldwide exclusive basis, the 28MHz band (10 metres) is available to most of the world's 2.4 million licensed amateurs, and is the most popular band below 30MHz, having both local and long distance capability. During periods of sunspot maxima, it can span the globe and there are some 60 propagation beacons, worldwide.

The 50MHz band has the characteristics of both the h.f. and v.h.f. bands and has attracted considerable research into propagation modes. There are some 45 propagation beacons worldwide and 10 packet repeaters in the UK. The 70MHz band is mainly used for local working and has some 30 UK packet repeaters.

The most popular v.h.f. band is 144MHz (2 metres) which is used for most activities from international weak signal working to local f.m. simplex. There is a national network of some 70 speech repeater stations; 60 nodes for the packet data network; and some 70 propagation beacons across Europe.

Less popular, but with similar usage to 144MHz, the 430MHz band (70cms) has a national network of 150 speech repeaters and 48 packet repeaters, with 70 propagation beacons across Europe.

TYPES OF OPERATION

Both high performance systems and weak signal working achieve international and intercontinental ranges. Distances up to 1500km are common on 144 and 430MHz, and worldwide on 50MHz using CW (Morse) or s.s.b. (speech). Achieving such performance in the interference level of the domestic environment is a significant technical challenge, and temporary stations often operate on hilltop sites to achieve greater distances.

High levels of activity occur over many weekends of the year during international contests. Much use is made of anomalous propagation modes, including Sporadic E, Meteor Scatter, tropospheric ducting, Auroral reflection, and moonbounce for intercontinental operation.

Some 15 satellites are currently operational containing linear transponders, which uplink in one amateur band and downlink in another. All are funded from voluntary contributions on an international basis; and there are estimated to be 1000 UK satellite users.

Many amateurs use the v.h.f. bands for reliable short-range communication (e.g., up to 50km) from both fixed and mobile stations, usually with narrow band f.m. (NBFM) and omnidirectional vertical antennas. A variety of other modes are also used, including Data and Slow Scan TV.

The network of 220 speech repeaters is intended mainly for use by mobiles. Experiments are in progress to link some of these either on their normal frequencies or by dedicated links at higher frequencies.

The 150 digital repeaters and 220 mailboxes in the UK are part of a worldwide packet network which has evolved over 5 years with relatively little central coordination. This uses AX25 protocol and F2E modulation at 1200 baud. Most end user connections are on the 144 and 430MHz bands and messages take about a day to reach international destinations. Various data modes are used for direct links and experimentation between individual amateurs.

Television broadcast signals use the 430MHz band, with ranges varying from local to international. Slow-scan and FAX are also used for local contacts. Emergency communications support is given to various User Services and to County Emergency Planning Officers during disaster relief operations and training exercises.

FUTURE DEVELOPMENTS – AND PROBLEMS

The RSGB refers to noise pollution and breakthrough problems which inhibit weak signal operation and discourage the pursuit of technical excellence which is a conspicuous part of this aspect of amateur radio. It would like to have some protection for the weak signal parts of the bands in a similar manner to Radio-Astronomy.

Data networks are forecast to expand, providing more advanced services, needing greater capacity. High capacity trunk links will be provided on the higher frequency bands, e.g., 430MHz and above.

Geostationary satellites are apparently still envisaged although the Radio Amateur Satellite Corporation has terminated its programme leading to such satellites, as reported in this column in November 1991. Interest in unattended station operation and remote control will grow – needing careful coordination with the shared (primary) user of the 430MHz band.

Experiments with digital speech, spread spectrum and high speed data links will need wide bandwidth at reasonably low frequencies such as 430MHz.

There is concern at the proposed Europe-wide use of low power keys/car alarms around 433MHz which may result in domestic problems when amateur transmissions affect their operation. There is, says the RSGB, considerable interest in obtaining permission for aeronautical mobile operation which would be of considerable use in propagation studies.

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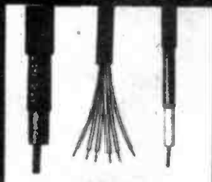
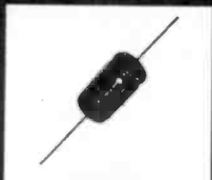
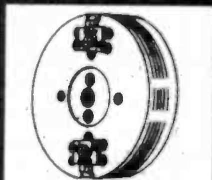


CABLES



CAPACITORS



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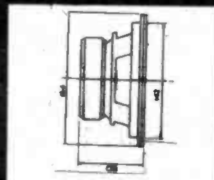

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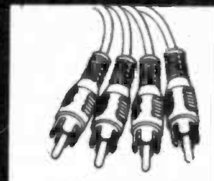

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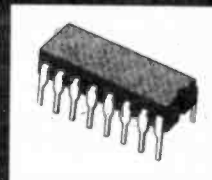

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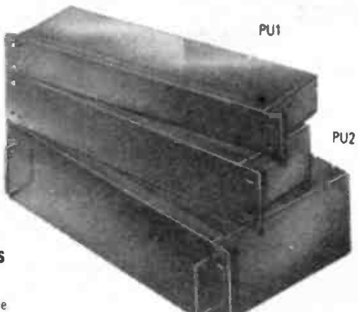

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DIRECT BOOK SERVICE

The books listed have been selected by Everyday with Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue.

EVERYDAY ELECTRONICS DATA BOOK
Mike Tooley BA
(published by EE in association with PC Publishing)
This book is an invaluable source of information of everyday relevance in the world of electronics. It contains not only sections which deal with the essential theory of electronic circuits, but also deals with a wide range of practical electronic applications.

It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic recipe book with numerous examples showing how theory can be put into practice using a range of commonly available "industry standard" components and devices.

A must for everyone involved in electronics!

256 pages **Order code DATA** **£8.95**

ELECTRONICS TEACH-IN No. 3 – EXPLORING ELECTRONICS (published by *Everyday Electronics*)
Owen Bishop
Another EE value for money publication aimed at students of electronics. The course is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. The book does not contain masses of theory or formulae but straightforward explanations and circuits to build and experiment with.

Exploring Electronics contains more than 25 useful projects, assumes no previous knowledge of electronics and is split into 28 easily digestible sections.

88 pages (A4 size) **Order code TI3** **£2.45**

Special Everyday Electronics Books

ELECTRONICS TEACH-IN No.4
INTRODUCING DIGITAL ELECTRONICS (published by *Everyday Electronics*)
Michael J. Cockcroft
Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.

Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.

The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.

112 pages (A4 size) **Order code TI4** **£2.95**

ELECTRONIC PROJECTS – BOOK 1
Published by *Everyday Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse-Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.

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ELECTRONICS TEACH-IN No.5 GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by EVERYDAY ELECTRONICS
Due to the demand from students, teachers and hobbyists we have put together a range of articles from past issues of *Everyday Electronics* that will assist those involved with the construction of electronic projects.

The book contains the complete *Project Development for GCSE* series.

Contents: Features – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Project Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; **Actually Doing It** – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.

88 pages (A4 size) **Order code TI5** **£2.95**

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.

80 pages (A4 size) **Order code TI-88/89** **£2.45**

Computers and Computing

HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM
D. Weale
This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs and how to actually make your choice as well as sections on the law, ergonomics and a glossary of common terms.

The text contains many useful tips and some warnings (which could save much effort and expense).

114 pages **Order code BP323** **£4.95**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM: RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

104 pages **Order code BP282** **£3.95**

AN INTRODUCTION TO 68000 ASSEMBLY LANGUAGE
R. A. & J. W. Penfold
Obtain a vast increase in running speed by writing programs for 6800 based micros such as the Commodore Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.

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M. James, B.Sc., M.B.C.S.
It is one thing to have learnt how to use all the Spectrum's commands and functions, but a very different one to be able to combine them into programs that do exactly what you want them to. This is just what this book is all about – teaching you the art of effective programming with your Spectrum.

144 pages **Order code BP119** **£2.50**

A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.

The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PC's. It covers both floppy disc-based systems and hard disc-based systems.

64 pages **Order code BP132** **£2.95**

A Z80 WORKSHOP MANUAL
E. A. Parr, B.Sc., DC.Eng., M.I.E.E.
This book is intended for people who wish to progress beyond the stage of BASIC programming to topics such as machine code and assembly language programming, or need hardware details of a Z80 based computer.

192 pages **Temporarily out of print**

MAKING MS-DOS WORK FOR YOU
N. Kantanis & P. R. M. Oliver

This book was written with the busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the book has also been designed to be circular, which means that you don't have to start at the beginning and go to the end.

The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.

The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meaning of some simple assembler mnemonics.

The book is relevant to all versions of both MS-DOS and PC-DOS as implemented on IBM and other IBM-compatible PCs.

182 pages **Order code BP319** **£4.95**

Audio and Music

ACOUSTIC FEEDBACK – HOW TO AVOID IT

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages Order code BP310 **£3.95**

PRACTICAL MIDI HANDBOOK
R. A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

128 pages Order code PC101 **£6.95**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

The preamplifier circuits featured include:– Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include:– Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls

92 pages Order code BP309 **£3.95**

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages Order code BP256 **£2.95**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages Order code PC107 **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

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HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. penfold

Practical constructional details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. Includes MOSFET and bipolar transistor designs.

96 pages Order code BP277 **£3.95**

Theory and Reference

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R. A. Penfold

Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular semiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.

88 pages Order code BP233 **£4.95**

NEWNES ELECTRONICS POCKET BOOK
E. A. Parr

Newnes Electronics Pocket Book has been in print for over twenty years and has covered the development of electronics from valve to semiconductor technology and from transistors to LSI integrated circuits and microprocessors. To keep up to date with the rapidly changing world of electronics, continuous revision has been necessary. This new Fifth Edition takes account of recent changes and includes material suggested by readers of previous editions. New descriptions of op.amp. applications and the design of digital circuits have been added, along with a totally new chapter on computing, plus other revisions throughout.

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Owen Bishop

This book describes over 60 modular electronic circuits – how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

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FROM ATOMS TO AMPERES
F. A. Wilson

Explains in crystal clear terms the absolute fundamentals behind electricity and electronics. Really helps you to discover and understand the subject, perhaps for the first time ever.

Have you ever: Wondered about the true link between electricity and magnetism? Felt you could never understand the work of Einstein, Newton, Boltzmann, Planck and other early scientists? Just accepted that an electron is like a little black ball? Got mixed up with e.m.f. and p.d.? Thought the idea of holes in semiconductors is a bit much?

Then help is at hand with this inexpensive book, in as simple a way as possible and without too much complex mathematics and formulae.

244 pages Order code BP254 **£3.50**

PRACTICAL DIGITAL ELECTRONICS HANDBOOK
Mike Tooley (Published in association with *Everyday Electronics*)

The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and text equipment; regulated bench power supply; logic pulser; verstaile pulse generator; digital IC tester; current tracer; audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.

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ELECTRONICS – A "MADE SIMPLE" BOOK
G. H. Olsen

This book provides excellent background reading for our *Introducing Digital Electronics Teach-In* Book and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.

330 pages Order code NE10 **£5.95**

Project Building

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R. A. Penfold

We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

96 pages Order code BP110 **£2.95**

HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s
R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

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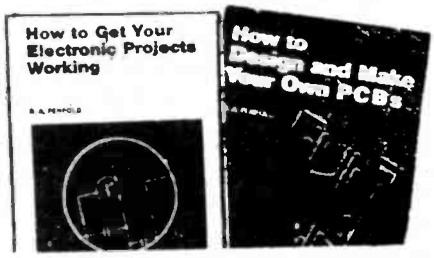

A BEGINNERS GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

166 pages Order code BP285 **£3.95**

BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS
R. A. Penfold

Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also include examples in the form of simple projects.

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ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Especially written for those who wish to participate in the intricacies of electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day one can read intelligently and handle simple tools.

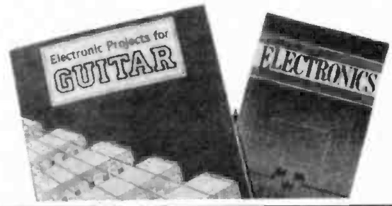
80 pages Order code BP92 **£1.75**

GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by *Everyday Electronics*

See the first page of books – ELECTRONICS TEACH-IN No.5 – for full details.

ELECTRONICS PROJECT BOOK
Published by *Everyday Electronics* in association with Magenta Electronics.

See the first page of books for full details.



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R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

104 pages Order code BP267 **£3.50**

Circuits and Design

PRACTICAL ELECTRONIC BUILDING BLOCKS – BOOK 2
R. A. Penfold
This books is designed to aid electronic enthusiasts who like to experiment with circuits and produce their own projects, rather than simply following published project designs.
Contains: Amplifiers – low level discrete and op-amp circuits, voltage and buffer amplifiers including d.c. types. Also low-noise audio and voltage controller amplifiers. Filters – high-pass, low-pass, 6, 12, and 24dB per octave types. Miscellaneous – i.c. power amplifiers, mixers, voltage and current regulators, etc.
112 pages Order code BP118 **£1.95**

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
Filters play a vital part in almost all electronic circuits, yet many people believe that they are difficult to understand. This is probably because so many of the books on this topic are extremely mathematical. By contrast, this book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ. Project descriptions include circuit diagrams, explanations of their operation, and detailed instructions for building them. A number of the projects are suitable to the beginner while others will be of interest to the more advanced constructor.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
192 pages Order code BP299 **£4.95**

ELECTRONIC ALARM CIRCUITS MANUAL
R. M. Marston
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.
Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.
124 pages Order code NE11 **£13.95**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning. This is not a constructor's book in the sense of presenting circuits to build and use, it is for the user who wants to design and troubleshoot digital circuitry with considerably more understanding of principles.
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages Order code PC106 **£8.95**

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS
Robert Penfold
Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kit and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.
92 pages Order code BP179 **£2.95**

ELECTRONIC POWER SUPPLY HANDBOOK
Ian R. Sinclair
This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.
The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.
136 pages Order code PC108 **£7.95**

HOW TO USE OP-AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages Order code BP88 **£2.95**

MICRO INTERFACING CIRCUITS – BOOK 1
MICRO INTERFACING CIRCUITS – BOOK 2
R. A. Penfold
Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.
Book 1 is mainly concerned with getting signals in and out of the computer; Book 2 deals primarily with circuits for practical applications.
BOOK 1 *112 pages* Order code BP130 **£2.75**
BOOK 2 *112 pages* Order code BP131 **£2.75**

50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages Order code BP42 **£1.95**
BOOK 2 50 more l.e.d. circuits Order code BP87 **£1.95**

CIRCUIT SOURCE BOOK 1
R. A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages Order code BP321 **£4.95**

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.
The circuits covered include:– An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap for combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.
Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and usefull circuits for short wave enthusiasts.
92 pages Order code BP304 **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.
This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
150 pages Order code BP257 **£3.50**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
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F. A. Wilson
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AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES
A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.
There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
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R. A. Penfold
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P. Shore
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