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AUGUST 1994

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SEALED LEAD ACID Battery, 6v 80/100 AH made for BT, ex equipment but ok £45 each ref APR47. Ideal electric vehicle etc.
ASTEC SWITCHED MODE PSU Gives +5 @ 3.75A, +12@1.5A, -12@.4A. 230/110, cased, BM41012. £9.99 ref APR10P3.
TORRODIAL TX 30-0-30 480VA. Perfect for Mosfet amplifiers etc. 120mm dia 55mm thick. £18.99 ref APR19.
MOD WIRE Perfect for repairing PCB's, wire wrap etc. Thin insulated wire on 500m reels. Our price just £9.99 ref APR10P8.
12v MOVING LIGHT Controller. Made by Hella, 6 channels rated at 90watts each. Speed control, cased. £34.99 ref APR35.
ELACTRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £9.99 ref APR10P5.
24v 96WATT Cased power supply. New. £13.99 ref APR14.
STETHOSCOPE Fully functioning stethoscope, ideal for listening to hearts, pipes, motors etc. £6 ref MAR6P6.
OUTDOOR SOLAR PATH LIGHT Captures sunlight during the day and automatically switches on a built in lamp at dusk. Complete with seales lead add battery etc.£19.99 ref MAR20P1.
ALARM VERSION Of above unit comes with built in alarm and pir to deter intruders. £24.99 ref MAR25P4.
CLOCKMAKER KIT Hours of fun making your own clock, complete instructions and everything you need. £7.99 ref MAR8P2.
CARETAKER VOLUMETRIC Alarm, will cover the whole of the ground floor against forcred entry. Includes mains power supply and integral battery backup. Powerful internal sounder, will take external bell if req'd. Retail £150+, ours? £49.99 ref MAR50P1.
TELEPHONE CABLE White 6 core 100m reel complete with a pack of 100 clips. Ideal 'phone extns etc. £7.99 ref MAR8P3.
VIEWDATA RETURNS £6 made by Tandata, includes 1200.75 modem, k/bd, RGB and comp o/p, printer port. No PSU.£6 MAG6P7
IBM PC CASE AND PSU Ideal base for building your own PC. Ex equipment but OK. £14.00 each REF: MAG14P2
SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor.Superb value kit just £5.99 REF: MAG6P8
SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26v DC 57x43x21mm with terminal screws £3.99 REF MAG4P10
300DPI A4 DTP MONITOR Brand new, TTL/ECL inputs, 15" landscape, 1200x1664 pixel complete with circuit diag to help you interface with your projects. JUST £24.99. REF MAG25P1
ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, .5-12v electret condenser. Cost£12 ea, Our? four for£9.99 REF MAG10P2
RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £99 each REF MAG99P1
GX4000 GAMES MACHINES returns so ok for spares or repair £9 each (no games). REF MAG9P1
C64 COMPUTERS Returns, so ok for spares etc £9 ref MAG9P2
FUSELAGE LIGHTS 3 foot by 4" panel 1/8" thick with 3 panels that glow green when a voltage is applied. Good for night lights,front panels, signs,disco etc. 50-100v per strip. £25 ref MAG25P2
ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF MAG18P1. PSU £5 ref MAG5P12.
SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@.5A, +12v@2A,-12v@.5A 120/220v cased 245x88x55mm IECinput socket £6.99 REF MAG7P1
PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9
PLUG IN ACORN PSU 19v AC 14w , £2.99 REF MAG3P10
POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9
ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2
GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. £29 REF MAG29P1
SINCLAIR C5 13" wheels complete with tube, tyre and cycle style bearing £6 ea REF MAG6P10
AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip, 55x32x32mm. £3 a pack. REF MAG3P11
13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3
360K 5.25 brand new half height floppy drives IBMcompatible industry standard. Just £6.99 REF MAG7P3
PPC MODEM CARDS. These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 REF: MAG5P1
INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2
TOWERS INTERNATIONAL TRANSISTOR GUIDE. A very useful book for finding equivalent transistors, leadouts, specs etc. £20 REF: MAG20P1
SINCLAIR C5 MOTORS We have a few left without gearboxes. These are 12v DC 3,300 rpm 6"x4", 1/4" OP shaft. £25 REF: MAG25
UNIVERSAL SPEED CONTROLLER KIT Designed by us for the above motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17
VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2
***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1
LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair REF: MAG 8P1 2 x PP3 req'd.
***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2 kilometres in open country. Units measure 22x52x155mm. Complete with cases and earpieces. 2xPP3 req'd. £30.00 pair REF: MAG30.
COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.
LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc In fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

NEW BULL ELECTRICAL STORE
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NOW OPEN AT 55A WORCESTER ST TEL 0902 22039

100MHZ OSCILLOSCOPES now in stock, 12x10cm screen, delayed sweep, 1Mohm/25pf inputs, modes-ch1, ch2, add, chop, alt, dual. 460 x 305 x 200mm, 17kgs, £267+Vat includes insurance and carriage.

INFRARED LASER NIGHT SCOPES
Second generation image intensifier complete with hand grip attachment with built in laser lamp for zero light conditions. Supplied with Pentax 42mm camera mount, 1.6kg, uses 1xPP3,3xAA's (all supplied)£245+Vat

NEW HIGH POWER LASERS
15mW, Helium neon, 3 switchable wave lengths .63um,1.15um,3.39um (2 of them are infrared) 500:1 polarizer built in so good for holography. Supplied complete with mains power supply.790x65mm. Use with EXTREME CAUTION AND UNDER QUALIFIED GUIDANCE. £349+Vat.

'PC PAL' VGA TO TV CONVERTER
Just plug in and it coverts your colour television into a basic VGA screen, perfect for laptops, saves lugging monitors about or just as acheap upgrade. Intro price £49.99 +Vat.

AMSTRAD 1512DD
1512 BASE UNIT AND KEYBOARD AND TWO 5.25" 360K DRIVES . ALL YOU NEED IS A MONITOR AND POWER SUPPLY WAS £59.00
NOW ONLY **£39.00**
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3FT X 1FT 10WATT SOLAR PANELS
14.5v/700mA
NOW AVAILABLE BY MAIL ORDER
£33.95
(PLUS £2.00 SPECIAL PACKAGING CHARGE)
TOP QUALITY AMORPHOUS SILICON CELLS HAVE ALMOST A TIMELESS LIFESPAN WITH AN INFINITE NUMBER OF POSSIBLE APPLICATIONS, SOME OF WHICH MAY BE CAR BATTERY CHARGING, FOR USE ON BOATS OR CARAVANS, OR ANYWHERE A PORTABLE 12V SUPPLY IS REQUIRED. REF: MAG34

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TURN YOUR SURPLUS STOCK INTO CASH. IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR COMPLETE FACTORY CLEARANCE.

1994 CATALOGUE.
PLEASE SEND 45P , A4 SIZED SAE FOR YOUR FREE COPY.
MINIMUM GOODS ORDER £5.00 TRADE ORDERS FROM GOVERNMENT, SCHOOLS, UNIVERSITIES, & LOCAL AUTHORITIES WELCOME. ALL GOODS SUPPLIED SUBJECT TO OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30 DAYS. RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR NOTICE. ORDERS SUBJECT TO STOCK. QUOTATIONS WILLINGLY GIVEN FOR QUANTITIES HIGHER THAN THOSE STATED.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.
PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY
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VISA

SPEAKER WIRE Brown 2 core 100 foot hank £2 REF: MAG2P1
LED PACK of 100 standard red 5m leds £5 REF **MAG5P4**
UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF:MAG15P (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)
***FM TRANSMITTER** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £26 REF: MAG26 Transmits to any FM radio.
***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5
***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14
TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert and ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: **MAG3P1**
100 WATT MOSFET PAIR Same spec as 2SK343 and 2SJ413 (8A,140v,100w) 1 N channel, 1 P channel, £3 a pair REF: **MAG3P2**
TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality. £2 each REF: **MAG2P4** or 4 for £6 REF: **MAG8P2**
TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: **MAG2P5** or 4 for £3 REF: **MAG3P4**
AT KEYBOARDS Made by Apricot these quality keyboards need just a small mod to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: **MAG6P3**
PC CASES Again mixed types so you take a chance next one off the pile £12 REF:**MAG12** or two the same for £20 REF: **MAG20P4**
COMMODORE MICRODRIVE SYSTEM mini storage device for C64's 4 times faster than disc drives, 10 times faster than tapes. Complete unit just £12 REF:**MAG12P1**
SCHOOL STRIPPERS We have quite a few of the above units which are 'returns' as they are quite comprehensive units they could be used for other projects etc. Let us know how many you need at just 50p a unit (minimum 10).
HEADPHONES Ex Virgin Atlantic. 8 pairs for £2 REF: **MAG2P8**
PROXIMITY SENSORS These are small PCB's with what look like a source and sensor LED on one end and lots of components on the rest of the PCB. Complete with fly leads. Pack of 5 £3 REF: MAG: 3P5 or 20 for £8 REF: **MAG8P4**
SNOOPERS EAR? Original made to clip over the earpiece of telephone to amplify the sound-it also works quite well on the cable running along the wall! Price is £5 REF: **MAG5P7**
DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: **MAG5P8** Worth it just for the very comprehensive manual! 5.25" only.
DOS PACK Microsoft version 5 Original software but no manuals hence only £3 REF: **MAG3P8** 5.25" only.
CTM644 COLOUR MONITOR Made to work with the CPC464 home computer. Standard RGB input so will work with other machines. Refurbished £59.00 REF:**MAG59**
PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec, long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 REF: **MAG8P5**
WINDUP SOLAR POWERED RADIO AM/FM radio complete with hand charger and solar panel! £14 REF: MAG14P1
COMMODORE 64 TAPE DRIVES Customer returns at £4 REF: MAG4P9 Fully tested units are £12 REF: MAG12P5.
MAINS CABLES These are 2 core standard black 2 metre mains cables fitted with a 13A plug on one end, cable the other. Ideal for projects, low cost manufacturing etc. Pack of 10 for £3 REF: MAG3P8 Pack of 100 £20 REF: MAG20P5
MICROWAVE TIMER Electronic timer with relay output suitable to make enlarger timer etc £4 REF: MAG4P4
MOBILE CAR PHONE £5.99 Well almost! complete in car phone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6
ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5 REF: MAG5P11
FIRE ALARM CONTROL PANEL High quality metal cased alarm panel 350x165x80mm.With key. Comes with electronics but no information. sale price 7.99 REF: MAG8P6
REMOTE CONTROL PCB These are receiver boards for garage door opening systems. Another use? £4 ea REF: MAG4P5
6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.
FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1
LOPTX Line output transformers believed to be for hi res colour monitors but useful for getting high voltages from low ones! £2 each REF: MAG2P12 bumper pack of 10 for £12 REF: MAG12P3.

BOTH SHOPS OPEN 9-5.30 SIX DAYS A WEEK

PORTABLE RADIATION DETECTOR
£49.99
A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook.
REF: MAG50

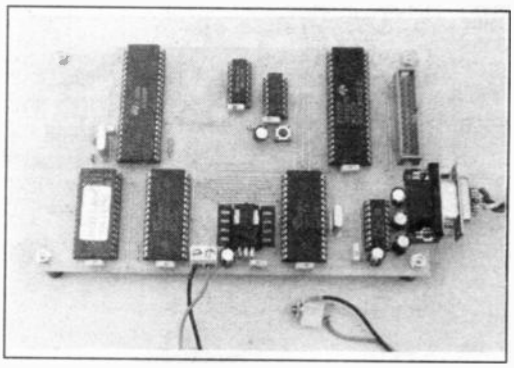
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

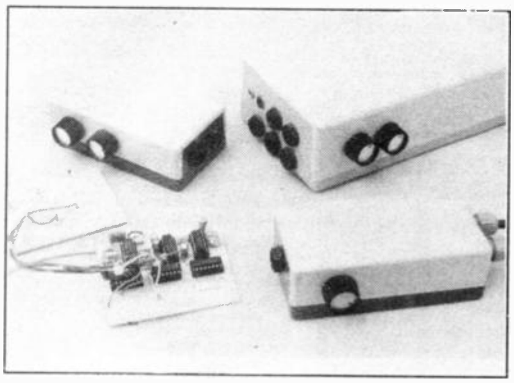
VOL. 23 No. 8 AUGUST 1994

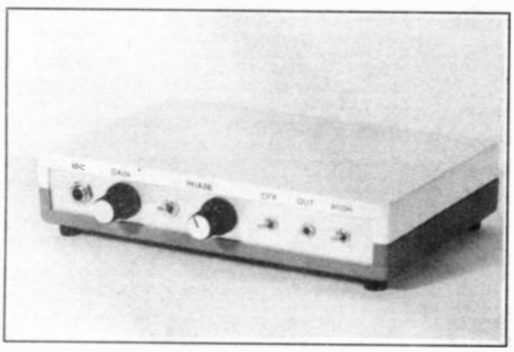
EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

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







Projects

Series

Features

Our September '94 issue will be published on Friday, 5 August 1994. See page 563 for details.

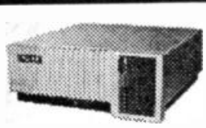
Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

LOW COST PC's - ALL EXPANDABLE - ALL PC COMPATIBLE



SPECIAL BUY AT 286

40Mb HD + 3Mb Ram

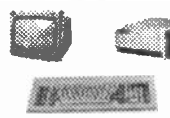
LIMITED QUANTITY only of these 12Mhz **HI GRADE 286** systems Made in the USA to an industrial specification, the system was designed for reliability. The compact case houses the motherboard, PSU and EGA video card with single 5¼" 1.2 Mb floppy disk drive & integral 40Mb hard disk drive to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with **enhanced keyboard**, 640k + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee. *Ready to Run !*

Order as HIGRADE 286 **ONLY £169.00** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£32.95
NE2000 Ethernet (thick, thin or twisted) network card	£49.00

PC SCOOP COMPLETE COLOUR SYSTEM

ONLY £99.00



A massive bulk purchase enables us to bring you a **COMPLETE** ready to run colour PC system at an unheard of price! The **Display Electronics PC99 system** comprises of fully compatible and expandable XT PC with 256k of RAM, 5¼" 360k floppy disk drive, 12" CGA colour monitor, standard 84 key keyboard, MS DOS and all connecting cables - **just plug in and go !! Ideal** students, schools or anybody wishing to learn the world of PC's on an ultra low budget. **Don't miss this opportunity.** Fully guaranteed for 90 Days.

Order as PC99COL **£99.00** (E)

Optional Fitted extras: 640k RAM	£29.00
2nd floppy drive, specify 5¼" 360k or 3½" 720k	£29.95
Above prices for PC99 offer ONLY.	

THE OFFER OF 1994 !

Computer Controlled Laser Video Disk Player

One of the most amazing surplus deals that we ever been able to offer you! The **Philips** VP410 LaserVision player, in as new condition, unit features full computer control. Plays standard 12" LaserVision disks with **startling visual and audio quality** in two channel **stereo** or mono. When controlled by a computer, it may also be used as a versatile high quality storage / retrieval medium. It will play back either LaserVision CAV (active play) or CLV (Long Play) discs (which covers most types of commercially available video discs). Some of the many features of this incredible machine are:

RS-232 INTERFACE	RGB / COMPOSITE VIDEO OUTPUT
BNC+SCART INTERFACE	PAL / RGB DECODER
IR+WIRED REMOTE CONTROL	FAST RANDOM ACCESS

SPECIAL PURCHASE Only **£399.00** (F)

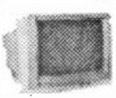
FLOPPY DISK DRIVES 3.5"- 8"

5.25" from £22.95 - 3.5" from £24.95

Massive purchases of standard 5.25" and 3.5" drives enables us to present prime product at industry beating low prices! All units (unless stated) are *BRAND NEW* or removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3.5" supported on your PC).

3.5" **Panasonic** JU363/4 720K or equivalent	£24.95(B)
3.5" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only *	£36.95(B)
3.5" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£29.95(B)
5.25" **Teac** FD-55GFR 1.2 Meg	£29.95(B)
5.25" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
* Data cable included in price.	
Shugart 800/801 8" SS refurbished & tested	£195.00(E)
Shugart 851 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" sided switchable *NEW*	£250.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply. Ideal as exterior drives!	£499.00(F)

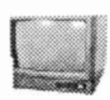
VIDEO MONITOR SPECIALS



Superb quality 14" **FOREFRONT MTS-9600 SVGA** Multisync - Multimode monitor 0.28" dot pitch with resolution of **1024 x 768**. The multi mode input allows direct connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** etc. The H version will also function with the **ATARI** in all modes inc **HI RES** monochrome. Complete with 'text' switching for WP use. Syncs down to 15 kHz. Supplied in EXCELLENT little used condition with full 90 day guarantee.

Order as MTS-9600 / H for ATARI	£159.00 (E)
All modes as above Order as MTS-9600 / S	£139.00 (E)

ELECTROHOME ECM-1211SBU 12" VGA multisync monitor with resolution 640 x 480. Multi input selection; 9pin CGA/ EGA ; 15 pin VGA or 5 BNC connectors. 0.31 pitch. Compatible with PCs, Amiga, Atari and others. In good used condition (possible minor screen burns). 90 day guarantee. ..... £99.00 (E)



KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". **Only £125** (E)

Good used condition. 90 day guarantee.

KME 10" as above for PC EGA standard £145.00 (E)

NEC CGA 12" colour IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for cosmetic reasons. **Only £49.00**(E)

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRABLE APPLICATION

BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O's to 'D' and BNC type connectors - all you have to do is provide +5 and +12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502 / 6512 CPU, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data. On application of DC power the system boots and provides diagnostic information to the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95

2 for £53 (B)

HARD DISK DRIVES

End of line purchase scoop! Brand new **NEC D2246** 8" 85 Mbyte of hard disk storage! Full **industry standard SMD interface.** Ultra hi speed data transfer and access time, replaces Fujitsu equivalent model. complete with manual. Only £299.00(E)

3.5" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3.5" **CONNER** CP3024 20 mb IDE I/F (or equiv)RFE	£69.95(C)
3.5" **CONNER** CP3044 40mb IDE I/F (or equiv.)RFE	£99.00(C)
3.5" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£99.00(C)
5.25" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5.25" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5.25" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£89.95(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)
Hard disc controllers for MFM , IDE, SCSI, RLL etc. from £16.95	

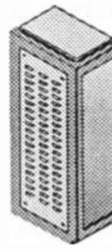
20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & optional sound inputs. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

9" Mono cased, Black & White for CCTV Used /Tested £49.00 (C)

19" RACK CABINETS



Superb quality 6 foot 40u Virtually New, Ultra Smart *Less than Half Price!*

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Overall dimensions are: 77-1/2" H x 32-1/2" D x 22" W. **Order as:**

Rack 1 Complete with removable side panels.	£295.00 (G)
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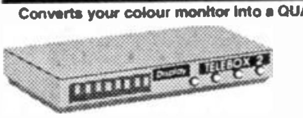

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The **TELEBOX** consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers* (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. TELEBOX MB covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

TELEBOX ST for composite video input type monitors	£32.95
TELEBOX STL as ST but with integral speaker	£36.50
TELEBOX MB Multiband VHF-UHF-Cable- Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6mhz sound specification.
*For cable / hyperband reception Telebox MB should be connected to cable type socket. Shipping code on all Teleboxes is (B)

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Order as: MUD 1 **£575.00**(G)

EMERSON ACCUCARD UPS, brand new 8 Bit half length PC compatible card for all IBM XT/AT compatibles. Card provides DC power to all internal system components in the event of power supply failure. The Accusaver software provided uses only 6k of base RAM and automatically copies all system, expanded and video memory to the hard disk in the event of loss of power. When power is returned the machine is returned to the exact status when the power failed ! The unit features full self diagnostics on boot and is supplied with full fitting instructions and manual. Normal **price £189.00**

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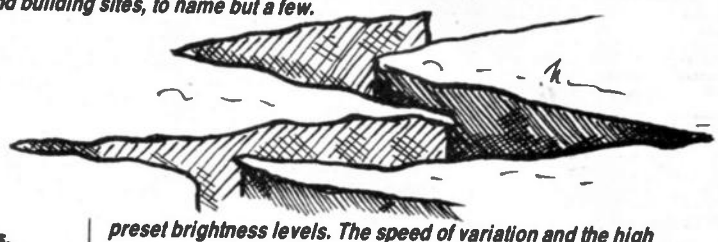
EXPERIMENTAL SEISMOGRAPH

Tune in your computer to the seismic singing of intra-planetary rock and roll.

Back in '89 we published a design for a single seismographic sensor whose output was monitored by a pen recorder. The authors commented on the possible difficulty of recording data on a computer and speculated about the use of Hall effect sensors instead of tuned coils. Reference was also made to the wide range of frequencies generated by earthquakes and other land movements, both natural and man-made.

Inspired by their article, John Becker designed the seismograph described next month to explore the earth movements referred to and the implications of the authors' comments. Throughout the design, much emphasis has been placed on versatility and adaptability.

Although the term seismograph literally refers to the recording of earthquake activity, the scope of this design allows the recording and examination of a whole range or ground vibrations, including those generated by nuclear and volcanic explosions, avalanches and landslides, tidal movements, traffic and trains, quarrying and building sites, to name but a few.



AUTOMATIC GREENHOUSE WATERING

Maintains the best growing moisture for your plants.

This automatic watering system monitors the compost moisture content and when this falls to a user preset level opens a water solenoid valve for a preset time. The valve lets water pass to a mist irrigation system set up in the greenhouse over the seed trays and plants. Such a mist irrigation system is widely, and cheaply available.

To provide some protection for your plants certain safety features have been built in to prevent over watering if the spray head over the moisture detector were to block or fail.

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This controller can drive up to three lamps, or sets of lamps, continuously varying their brilliance up and down between two preset brightness levels. The speed of variation and the high and low brilliance levels are independently adjustable for each channel, allowing many different and interesting effects to be achieved.

Although originally intended to drive the lights on the author's Christmas tree, it can easily handle over 100W per channel, making it suitable for home discos, parties, advertising displays and a host of other applications where a colourful light display is required.

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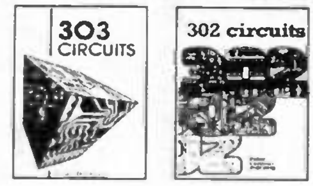

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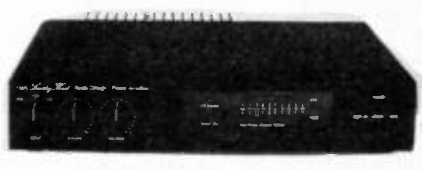

This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hifi system. This kit is your way to get £K performance for a few tenths of the cost!. Featured on the front cover of 'Electronics Today International' this complete stereo power amplifier offers World Class performance allied to the famous HART quality and ease of construction. John Linsley Hood's comments on seeing a complete unit were enthusiastic:- "The external view is that of a thoroughly professional piece of audio gear, neat elegant and functional. This impression is greatly reinforced by the internal appearance, which is redolent of quality, both in components and in layout." Options include a stereo LED power meter and a versatile passive front end giving switched inputs using ALPS precision, low-noise volume and balance controls. A new relay switched front end option also gives a tape input and output facility so that for use with tuners, tape and CD players, or indeed any other 'flat' inputs the power amplifier may be used on its own, without the need for any external signal handling stages. 'Slave' and 'monobloc' versions without the passive input stage and power meter are also available. All versions fit within our standard 420 x 260 x 75mm case to match our 400 Series Tuner range. ALL six power supply rails are fully stabilised, and the complete power supply, using a toroidal transformer, is contained within a heavy gauge aluminium chassis/heatsink fitted with IEC mains input and output sockets. All the circuitry is on professional grade printed circuit boards with roller tinned finish and green solder resist on the component ident side, the power amplifiers feature an advanced double sided layout for maximum performance. All wiring in this kit is pre-terminated, ready for instant use!

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Just Out! Hot Off the Press, the definitive electronics and audio book by the renowned John Linsley Hood. This 300+ page book will give you an unparalleled insight into the workings of all types of audio circuits. Learn how to read circuit diagrams and understand amplifiers and how they are designed to give the best sound. The virtues and vices of passive and active components are examined and there are separate sections covering power supplies and the sources of noise and hum. As one would expect from this writer the history and derivation of audio amplifier circuitry have an entire chapter, as does test and measurement equipment.
Copiously illustrated this book is incredible value for the amount of information it contains on the much neglected field of linear, as opposed to digital, electronics. Indeed it must be destined to become the standard reference for all who work, or are interested in, this field.
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1992/94 248 Pages. 247 x 190.
0-7506-0614-2 .... £17.95

"THE ART OF SOLDERING", R. Brewster.
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MICROPROCESSORS

A number of readers have been intrigued by our recent microprocessor based projects and have asked for information on programming and using these devices. The *6802 Development Board* article in this issue provides an inexpensive way to get into this. The software necessary to use a PC to develop 6802 based projects is available very cheaply and the development board is relatively easy to build.

Of course it is impossible to carry a full tutorial on programming the 6802 but this information is available both from Motorola and in various books. We also hope to publish further material on programming and using other types of microprocessor in the future.

EXPERIMENTING

While many readers will be fascinated by working out and writing control software for projects there will also be many who are left cold by this growing aspect of our hobby. Such readers can, of course, simply treat programmed chips in the same was as they would any other dedicated chip, but there are also plenty of fascinating areas where hobbyists can still experiment with "basic circuitry".

One such area is covered by Robert Penfold's informative *Experimental Sound Cancelling Unit* article in this issue. As Robert points out, there is far more to this subject than meets the eye. With more and more interest being focused on pollution in various forms and with modern life generating increasing levels of noise pollution this is also a very worthwhile area of investigation, with plenty of avenues for experimentation open to the hobbyist.

WELCOME

Finally we would like to welcome John Becker to the EPE staff. John will be well known to many readers both as a contributor (this issue carries two articles written by him) and as the editor of *Practical Electronics* in the late 80's. With the continual development of our various technological publications the experience and expertise that John brings to our editorial team will benefit everyone.

Mike Kenward

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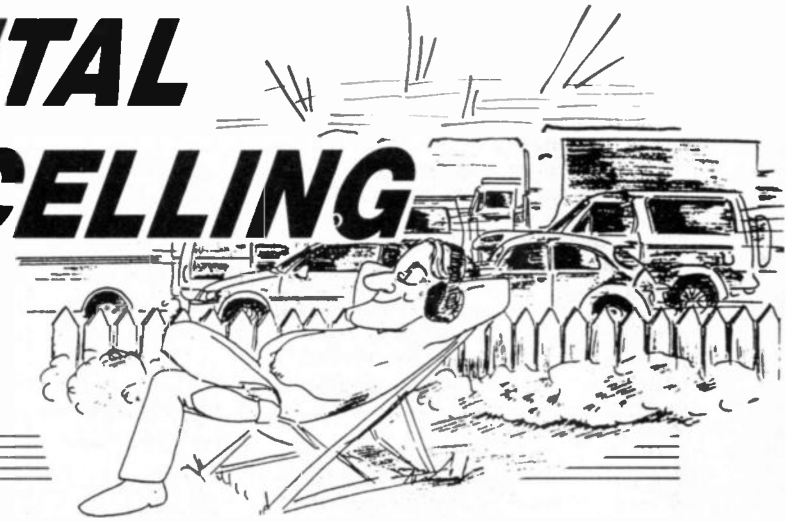
EXPERIMENTAL NOISE CANCELLING UNIT



ROBERT PENFOLD

An experimental approach to controlling the ever increasing problem of "noise pollution", and how to combat it!

MODERN life undoubtedly has its advantages, but it is not without its drawbacks as well. One of these is the ever increasing amount of "noise pollution". As I sit writing this piece in tranquil suburbia, I can just about hear the odd "chirp" of spring birdsong above the drone of the hard disk in the computer, various noises from the central heating system, and the noise from air compressors, etc. as the gas board lay new pipes in the street outside!

It is not surprising that there has been a lot of interest recently in devices for combatting noise pollution. A number of readers have expressed an interest in electronic noise cancelling devices.

This is one of those things where it is easy to end up with a "sledgehammer to crack a nut" solution. If you simply need to cut out noise, mechanical solutions such as ear defenders, and ear plugs, are likely to be more effective than electronic solutions, and a lot cheaper.

The potential advantage of an electronic noise cancelling unit is that it enables unwanted sounds to be reduced while leaving other sounds intact. In particular, you could listen to your personal stereo, television set, etc. with the sound unaffected, while background noises could be greatly reduced. You could have music while you work via a personal stereo without having to put up with the whining sound of the laser printer in the background.

Noise cancelling systems are very simple in principle, and they use a basic phase cancelling technique. Although simple in principle, phase cancelling is something less than straightforward when applied to sounds. When systems are demonstrated on television programs it is all made to seem delightfully simple, but there are numerous factors which make life difficult when trying to produce a system that will work well in the real world.

The circuits provided in this article will certainly provide noise cancelling, but how well (or otherwise) they function is dependent on a number of factors. These include such things as the type of sound that is to be combatted, how meticulously everything is set up, and the quality of the microphones used.

They provide a good basis for anyone wishing to experiment with noise cancelling techniques, and should be usable in practical noise cancelling systems. However, this article is primarily aimed at electronics experimenters who are prepared to spend some time getting to grips with the problems involved.

BIG NOISE

Phase cancelling is something that is used routinely in electronics circuits, and in a purely electronic context it normally works extremely well. The waveforms of Fig.1 show the effect of adding together in-phase and out-of-phase signals.

In the left hand set of waveforms two identical sinewave signals (*a* and *b*) are combined. This gives the end result that one would expect, with and output signal that is the same as the input signal, but at double the amplitude.

In the right hand waveforms two identical signals are again added together, but waveform (b) has been inverted. When waveform (a) is positive, waveform (b) is negative by an identical amount. When signal (a) is negative, signal (b) is positive by an identical amount.

Combining the two signals gives waveform (c), which is a steady 0 volts. Each signal precisely cancels out the other signal so that there is zero output.

It does not matter how simple or complex the two signals happen to be. Equal and opposite signals will always provide precise cancelling, resulting in no output signal.

PHASED OUT

In order to obtain a high degree of cancelling it is essential that the signals are accurately matched in amplitude, and that

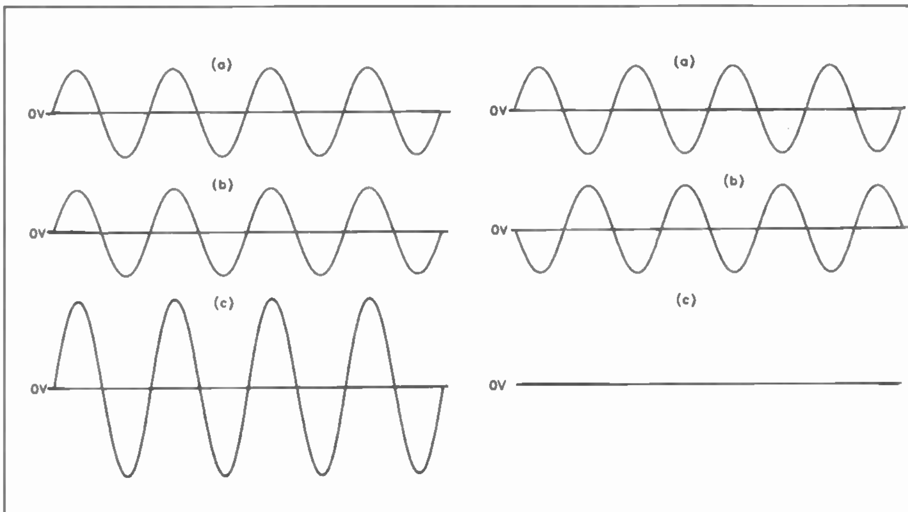


Fig. 1. In-phase mixing (left) produces a stronger output signal. Out-of-phase mixing (right) produces a cancelling effect.

they are precisely *180 degrees out-of-phase*. The waveforms of Fig. 2 show the effects of poor amplitude matching and incorrect phasing.

In the left hand waveforms two input signals are precisely out-of-phase, but signal (b) is at only half the amplitude of signal (a). As a result of this it only cancels signal (a) by 50 per cent, giving the output waveform of (c).

The right hand waveform shows the effect of inaccurate phasing. Signal (a) has precisely the same *amplitude* as waveform (b), but it is *phase* shifted by 90 degrees. In other words, it is exactly half way between being in-phase and out-of-phase.

One might expect that this would give a similar result to the mismatch in amplitude, with an output signal that is a somewhat reduced version of signal (a). In reality it produces an output waveform (c) that is phase shifted by about 45 degrees relative to signal (a), and which is also about 1·5 times greater in amplitude.

The implications of this are clear. Mixing a signal with an identical but inverted copy of itself will result in precise cancellation, and a high degree of attenuation. A mismatch in the amplitudes of the two signals will still give a certain amount of attenuation, but quite a small mismatch will severely limit the effectiveness of the system. Even a mismatch of just 10 per cent will limit the attenuation to 20dB.

Errors in the phasing of the two signals are more serious. Quite small errors will severely limit the attenuation obtained, and large errors will result in the signal being boosted. In a noise cancelling application a high degree of attenuation can be achieved if everything is just right, but with incorrect matching of the two signals you could end up with more noise rather than less!

SOUND ADVICE

Accurately phasing out an electrical signal does not usually present any major problems. A simple inverting amplifier is all that is needed in order to produce an out-of-phase copy of the input signal, and a variable attenuator enables the copy to be accurately matched to the amplitude of the original.

Very minor phase and amplitude variations may occur over the audio range, but it is generally only with wide bandwidth signals that it becomes difficult to obtain a high degree of attenuation over the full frequency range of the system. Over the audio range it is usually possible to achieve 60dB or even 80dB of attenuation without too much difficulty.

Phase cancelling can be applied to sounds, and many pieces of machinery use a balancing technique to keep noise and vibration down to acceptable levels. In theory, in order to remove a sound you simply have to generate an identical out-of-phase sound.

Any change in air pressure produced by the original sound is then balanced by an equal and opposite change in air pressure by the out-of-phase sound, producing silence. However, there are practical difficulties with real world noise cancelling systems.

My experiments with systems using a loudspeaker to generate the "anti-sound" were totally unsuccessful. Acoustic feedback and "howl-around" were constant problems, and changes in the position of the listener relative to the sound source and the loudspeaker seem to substantially affect results.

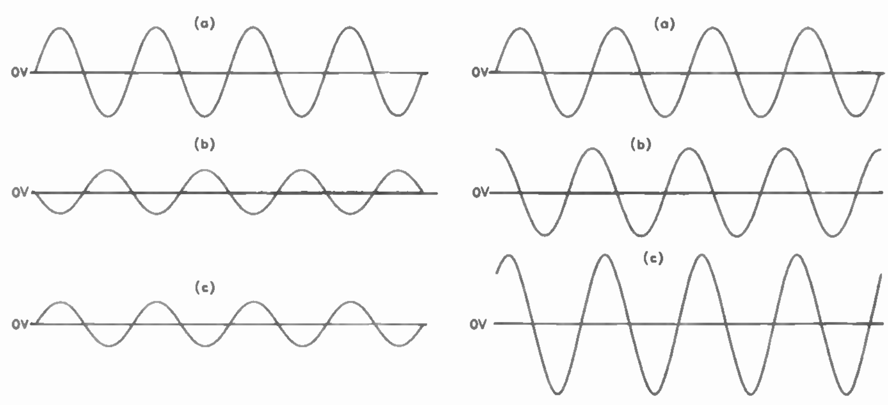


Fig. 2. Mismatched amplitudes (left) produce only partial cancelling. A lack of phasing accuracy (right) can result in a boosted output signal.

It is no doubt possible to obtain a worthwhile degree of noise cancelling using a loudspeaker based system, but it does not seem to represent a good starting point. Experiments with systems based on headphones were more simple, and provided much better results.

SOUND TRACK

An important point that must always be kept in mind when dealing with noise cancelling systems is that sound does not travel instantly from its source to your ears. Sound travels at about 0·3 metres (1ft.) per millisecond.

If you position a microphone close by one of your ears, what you hear and the microphone "hears" will be very much the same. If you move the microphone away from you ear, the sounds it picks up will be slightly different to those that you hear.

In particular, there will be a phase difference between the two sounds. At low frequencies the wavelengths are relatively long, and the positioning of the microphone is less critical. At high frequencies the wavelengths are much shorter, and even moving the microphone slightly away from your ear could produce an in-phase signal instead of an anti-phase type.

The most simple form of noise cancelling system that will work reasonably well is two microphones driving a pair of stereo headphones via a preamplifier. The microphones must be mounted one on each earphone, and as close to their respective earphones as possible. The earphones only produce very low sound levels, so acoustic feedback is not a major problem, although it is still necessary to have a small gap between each earphone and microphone.

With this method it is essential to use two microphones, since a single microphone would have to be well separated from one or both earphones. This would introduce phase shifts which would render the system ineffective.

MICROPHONE PREAMPLIFIER

A circuit diagram for a simple low noise Microphone Preamplifier which is suitable for use in a noise cancelling system is shown in Fig. 3. The circuit will work well with any normal type of low impedance microphone. A very low noise operational amplifier (op.amp) IC1 is used here as an inverting amplifier having a voltage gain of about 47 times (34dB).

The circuit will work using a cheaper op.amp for IC1, but using a device such

The completed Experimental Noise Cancelling Unit showing front panel lettering, using the Phase Shifter board.

as the 741C or LF351N will degrade the signal-to-noise ratio by about 26dB or more. This could result in sounds being drowned by the system noise rather than being cancelled out!

The output of IC1 is coupled into a volume control style variable attenuator which is used to balance the output of the earphone with the direct sounds. IC2 provides further amplification, and it is used in a non-inverting amplifier having a voltage gain of 11 times (just over 20dB).

It is not necessary to use a very high quality operational amplifier in the IC2 position as this stage is operating at a much higher signal level than IC1. An LF351N or similar Bifet device (TL081CP, etc.) is perfectly adequate.

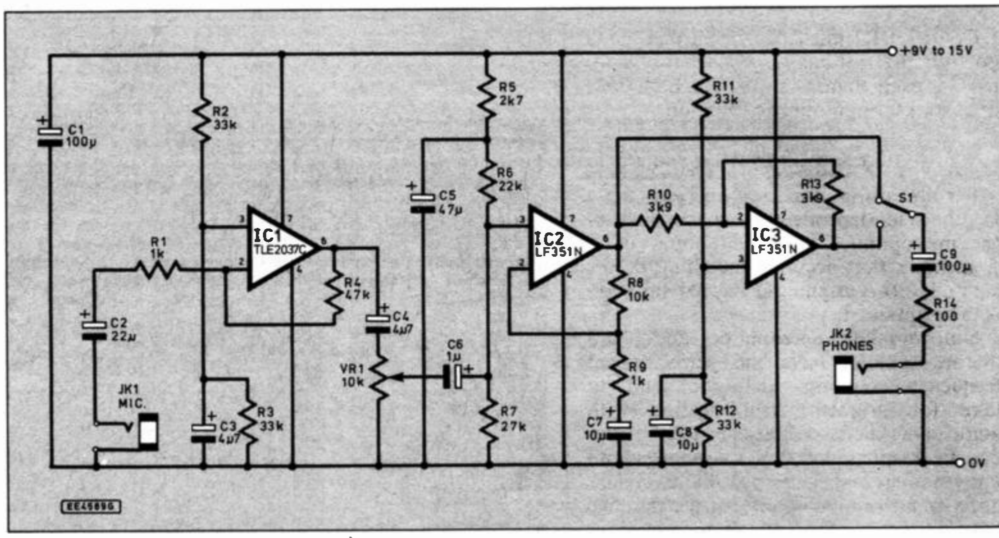


Fig. 3. Circuit diagram for the low noise Microphone Preamplifier.

The output of IC2 is coupled to the input of a unity voltage gain inverting amplifier based on IC3. Switch S1 enables the headphone socket to be switched between the outputs of IC2 and IC3, giving the choice of *inverted* or *non-inverted* signals.

This may seem to be unnecessary, since it is only an inverted signal that is needed. However, the phasing of the microphones and the headphones is an unknown factor. The only way to determine the correct phasing for the output signal is to use the "suck it and see" method. Switch S1 and the inverter stage make it easy to alter the polarity of the output signal, and quickly determine which is the correct one.

CONSTRUCTION

The stripboard component layout for the microphone preamplifier and breaks required in the copper tracks are illustrated in Fig. 4. This layout is based on a board which has 50 holes by 22 copper strips. Of course, two boards are required, one for each channel.

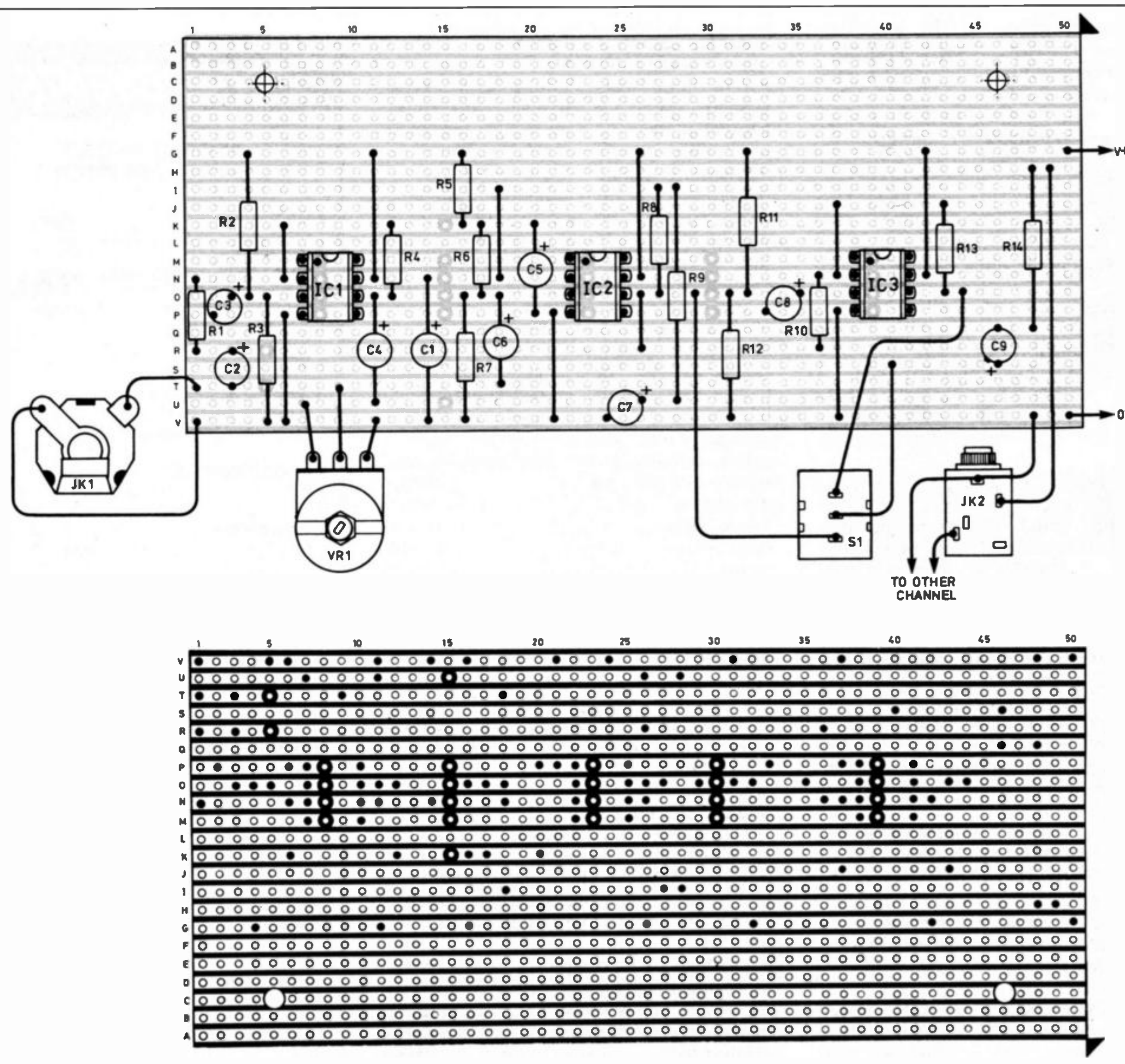


Fig. 4. Microphone Preamplifier stripboard component layout and details of breaks required in the underside copper tracks.

Control VR1 must *NOT* be a dual gang potentiometer; it has to be a separate control for each channel so that each channel can be set for optimum attenuation.

FLAT RESPONSE

Results using this system are to a large extent dependent on the quality of the microphones and headphones used. Remember that accurate matching of the sound levels is essential if high attenuation is to be obtained.

Unfortunately, microphones and headphones do not have the perfectly flat frequency responses that we tend to take for granted when dealing with audio amplifiers. Variations in the frequency response of the headphones and microphones make it impossible to obtain good matching at all frequencies. The flatter the responses of the microphones and headphones, the better the system should work.

Headphones have improved a great deal over recent years, and even quite inexpensive stereo headphones of the "inner-ear" variety were found to give quite good results. Higher quality types work that much better though.

For some reason results using anything other than "inner-ear" headphones were not particularly good. Possibly other types have a larger effect on the frequency response of the user's hearing, making it difficult to get good cancelling over a wide frequency range.

MICROPHONES

The microphones are likely to be the weakest link in the system, and various inexpensive dynamic microphones were found to give very poor results. In some cases no sound cancelling at all could be perceived.

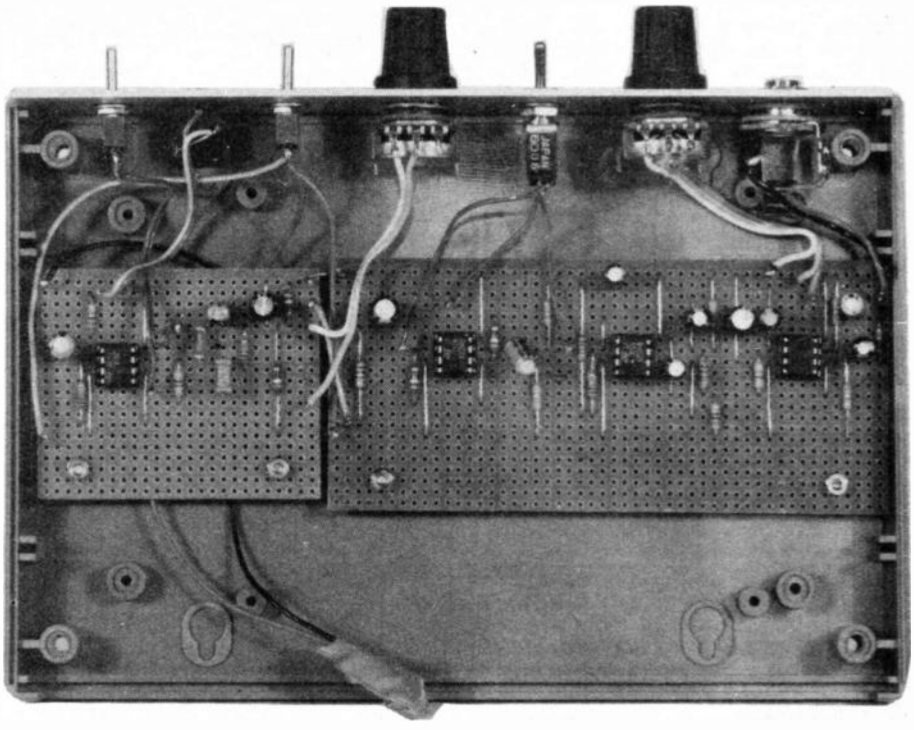
The large size of most dynamic microphones makes them a dubious choice anyway. Presumably few users would be prepared to look like something from an episode of *Doctor Who* with one of these perched on each ear! The fact that they are unidirectional also limits their overall effectiveness.

Human hearing is more or less equally sensitive in every direction, and the microphones should therefore be omnidirectional types that will match this response as closely as possible. The microphones therefore need to be reasonably small and light, and should also be an omnidirectional type.

Experiments using inexpensive electret microphone inserts were not very successful, but electret tie clip microphones were found to give quite good results. I used inexpensive microphones of this type, but if you have access to broadcast quality microphones they will presumably provide rather better results.

I would not recommend the use of any other type of microphone, but it would obviously be quite interesting to try other types if you have them to hand. Bear in mind though, that the microphone preamplifier featured here is only intended for use with low impedance microphones.

The microphones can simply be clipped onto the earphone leads, but ideally there should be some way of adjusting their position slightly. I tried mounting them in various positions on a headband removed from an old pair of headphones, and this proved quite successful.



The completed Experimental Noise Cancelling Unit showing the wiring to the preamplifier board and the small Phase Shifter board.

TUNING IN

When initially trying out the system it is a good idea to use an F.M. radio tuned between stations to provide a white noise source. With the gain controls well backed-off the noise will be heard to emanate from the radio set. If the gain controls are well advanced the apparent source of the noise will be the earphones. The correct settings are somewhere between these two extremes.

When a "null" is achieved there is a very obvious drop in the level of the noise signal, and its pitch will probably seem to change as well. The change in pitch is due to the fact that better cancelling is obtained over some frequency bands than is obtained over others.

If no attenuation can be obtained at any settings of the gain controls, try altering the settings of the phase switches. These switches will probably need the same settings, but it is possible that the microphones will not be connected with the same phase, and that these switches will need to be set for anti-phase outputs.

Do not expect to totally eliminate the noise. I found that is was possible to obtain a very useful degree of attenuation over the low and middle frequency range. It is not really possible to make accurate measurements with this type of thing, but I would estimate that there was a reduction of around 20dB to 30dB over this frequency range.

The higher frequencies proved to be more difficult. By adjusting the gain potentiometers it is possible to improve the high frequency attenuation, but at the expense of the low and middle frequency attenuation.

The high frequency performance seemed to be much better on some occasions than on others. It is likely that the precise positioning of the microphones is an important factor at higher frequencies where the wavelengths are short.

It is certainly worthwhile experimenting a little with the positioning of the microphones in an attempt to optimise the

COMPONENTS

MICROPHONE PREAMPLIFIER

See SHOP TALK Page

Resistors

R1, R9	1k (2 off)
R2, R3, R11, R12	33k (4 off)
R4	47k
R5	2k7
R6	22k
R7	27k
R8	10k
R10, R13	3k9 (2 off)
R14	100

All 0·25W 5% carbon film

Potentiometer

VR1	10k rotary carbon, log.

Capacitors

C1, C9	100µ radial elect. 16V (2 off)
C2	22µ radial elect. 16V
C3, C4	4µ7 radial elect. 63V (2 off)
C5	47µ radial elect. 16V
C6	1µ radial elect. 63V
C7, C8	10µ radial elect. 25V (2 off)

Semiconductors

IC1	TLE2037C ultra low noise op.amp
IC2, IC3	LF351N bifet op.amp (2 off)

Miscellaneous

JK1	standard 6·35mm jack socket
JK2	3·5mm stereo jack socket
S1	s.p.d.t. min toggle switch

Stripboard 0·1in. matrix, size 50 holes by 22 strips; 8-pin d.i.l. i.c. holder (3 off); control knob; connecting wire, solder; etc.

Approx cost guidance only **£10**

overall performance of the system. To obtain consistent results it would probably be necessary to mount the microphones in a way which would guarantee that their positioning remained constant relative to the earphones.

The obvious way of improving the performance over the full audio bandwidth is to use some tailoring of the frequency response. Experiments with simple tone controls were not very successful.

A point that should not be overlooked is that circuits which tamper with the frequency response are likely to produce phase shifts. Unfortunately, this means that corrections to the frequency response of the system could easily produce phase shifts that would leave the performance of the system worse rather than better.

It would probably be worthwhile experimenting with simple graphic equalisers, or a parametric equaliser perhaps, and I will certainly try both of these in due course. Even without any broadening of its frequency response, the system is quite effective if the unwanted sounds are predominantly in the lower and middle audio ranges.

PHASE COMPENSATION

Having a microphone close to each earphone is probably the only practical system if the user will be moving around. The microphones and the headphones move around with the user, ensuring that once the system is set up correctly, it should work properly wherever the user goes.

If the user is going to remain more or less in the same place (sitting in the same chair for example), it is possible to separate the microphones from the headphones. In fact it is possible to use just a single microphone and still get quite good results. This saves the expense of a second high quality microphone, and it makes the mechanical side of construction much more straightforward.

The problem in moving the microphone away from the headphones is that, as explained previously, it introduces a phase shift that prevents the system from operating properly. This problem is not insurmountable, and all that is required is a circuit to correct the phase shift.

Basically all that is needed is a delay-line to compensate for the fact that the microphone is nearer to the sound than the user's ears. Sound travels at about 300 millimetres per millisecond, so a delay of a little over three milliseconds is needed if the microphone is one metre closer to noise source than the user.

Delays of a few milliseconds are easily produced using a small CCD (bucket brigade) delay-line. If the noise is at a single frequency, or predominantly over a narrow range of frequencies, a simple phase shifter circuit is all that is needed.

There is a potential drawback to any system which has the microphone well separated from the headphones. In most

COMPONENTS

PHASE SHIFTER

Resistors

R1, R2	3k9 (2 off)
R3, R5	10k (2 off)
R4	4k7
R6	100

All 0.25W 5% carbon film

See SHOP TALK Page

Potentiometer

VR1	100k rotary carbon, lin.

Capacitors

C1	10µ radial elect. 25V
C2, C6	100µ radial elect. 16V (2 off)
C3	2µ2 radial elect. 63V
C4	100n polyester
C5	10n polyester

Semiconductors

IC1	LF351N bifet op.amp

Miscellaneous

JK1	3·5mm stereo jack socket
S1	s.p.s.t. min toggle switch

Stripboard 0·1in. matrix, size 25 holes by 20 copper strips; 8-pin d.i.l. i.c. holder; control knob, connecting wire; solder, etc.

Approx cost guidance only **£6**

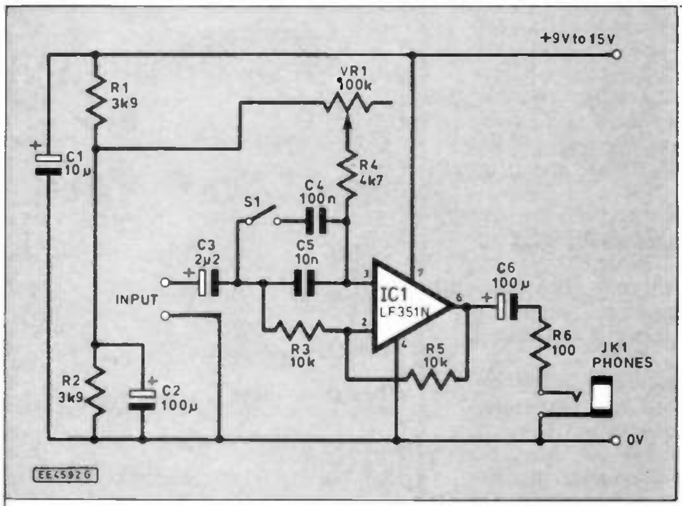
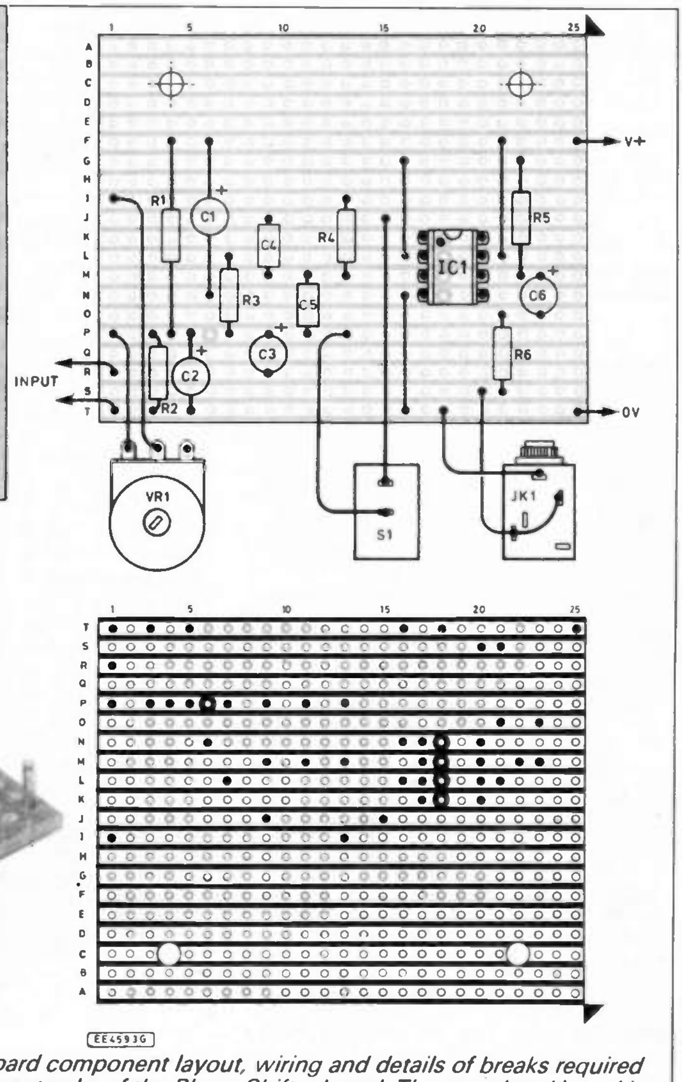


Fig. 5. Circuit diagram for the Phase Shifter.



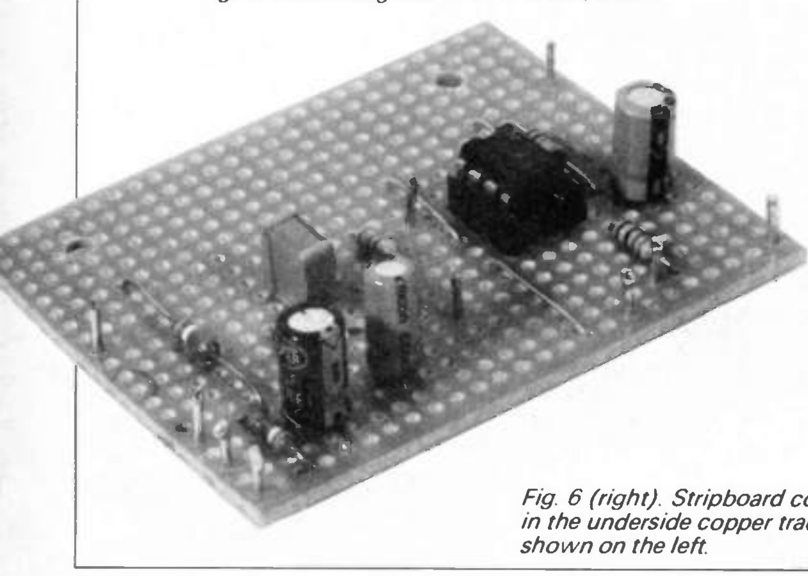


Fig. 6 (right). Stripboard component layout, wiring and details of breaks required in the underside copper tracks of the Phase Shifter board. The completed board is shown on the left.

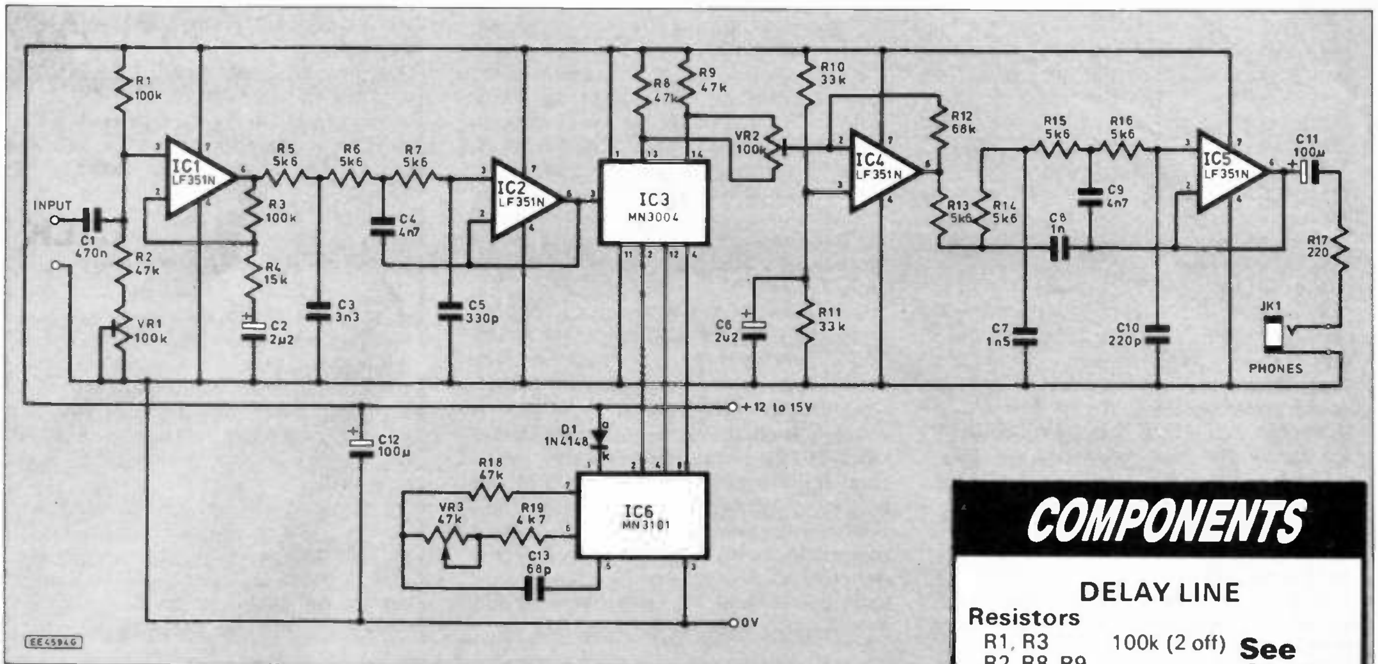


Fig. 7. Circuit diagram for the Delay-Line using MN3004 c.c.d. delay i.c.

cases the sound we hear is mainly received direct from the sound source. There is also a certain amount of sound which comes indirectly via reflections from the ceiling, etc., and it is this sound that is the source of the potential problem.

Because this "indirect" sound does not approach the user from the same direction as the main sound, it will often need a different delay or phase shift to the main sound. This is not practical, which means indirect sounds will not be properly cancelled out.

Just how much this factor compromises performance depends on the strengths of the reflected signals. In many cases they will not be strong enough to be of significance, particularly if the user is close to the sound source.

PHASE SHIFTER

The circuit diagram for a Phase Shifter is provided in Fig. 5. This is fed from the output of the microphone preamplifier. It can be used to drive both earphones, but for optimum attenuation a separate phase shifter should be used for each earphone.

The circuit is a conventional design which can be adjusted for a phase shift of between about 0 and 180 degrees over a large part of the audio range. With the phase inversion available from the preamplifier, this permits virtually a full 0 to 360 degree range to be covered. Switch S1 should be used to switch capacitor C4 into circuit when trying to null a low frequency sound.

Details of the stripboard and wiring for the Phase Shifter are provided in Fig. 6. The board measures 25 holes by 20 copper strips.

DELAY-LINE

The circuit diagram for a Delay-Line, based on an MN3004 512 stage c.c.d. chip (IC3), is shown in Fig. 7. IC1 acts as an input buffer stage, and it also provides a small amount of voltage amplification so that the circuit operates at a signal level which gives a good signal to noise ratio.

A three stage anti-aliasing filter ahead of the delay-line is provided by IC2. IC4 acts as a mixer which combines the outputs of the last two stages of the delay-line chip IC3. Output filtering is provided by a fourth order active filter based on IC5. IC6 is the matching clock and bias chip for IC3.

Potentiometer VR3 permits the clock frequency (and the delay time) to be varied. The clock frequency can be varied from about 50kHz to 200kHz. This provides a delay time that is variable from about 1·28 to 5·12 milliseconds, which represents a headphone to microphone distance of between about 384 millimetres and a little over 1·5 metres.

CIRCUIT BOARD

Details of the Delay-Line stripboard component layout and wiring are shown in Fig. 8. The board has 68 holes by 29 copper strips. IC3 and IC6 are MOS devices which therefore require the standard anti-static handling precautions.

Potentiometer VR1 is simply adjusted to give symmetrical clipping. If you do not have the appropriate test equipment, just use any setting that gives a low distortion output signal.

Preset VR2 must be adjusted to minimise the clock breakthrough at the output. If you do not have an oscilloscope to monitor the output of IC4, temporarily connect a capacitor of about 2n2 in parallel with C13. This will bring the clock frequency into the audio range so that it becomes

COMPONENTS

DELAY LINE

See SHOP TALK Page

Resistors

R1, R3	100k (2 off)
R2, R8, R9, R18	47k (4 off)
R4	15k
R5, R6, R7, R13, R14, R15, R16	5k6 (7 off)
R10, R11	33k (2 off)
R12	68k
R17	220
R19	4k7

All 0·25W 5% carbon film

Potentiometers

VR1, VR2	100k min. carbon preset, horizontal (2 off)
VR3	47k rotary carbon, lin.

Capacitors

C1	470n polyester
C2, C6	2μ2 radial elect. 63V (2 off)
C3	3n3 polyester
C4, C9	4n7 polyester (2 off)
C5	330p ceramic plate
C7	1n5 polyester
C8	1n polyester
C10	220p ceramic plate
C11, C12	100μ radial elect. 16V (2 off)
C13	68p ceramic plate

Semiconductors

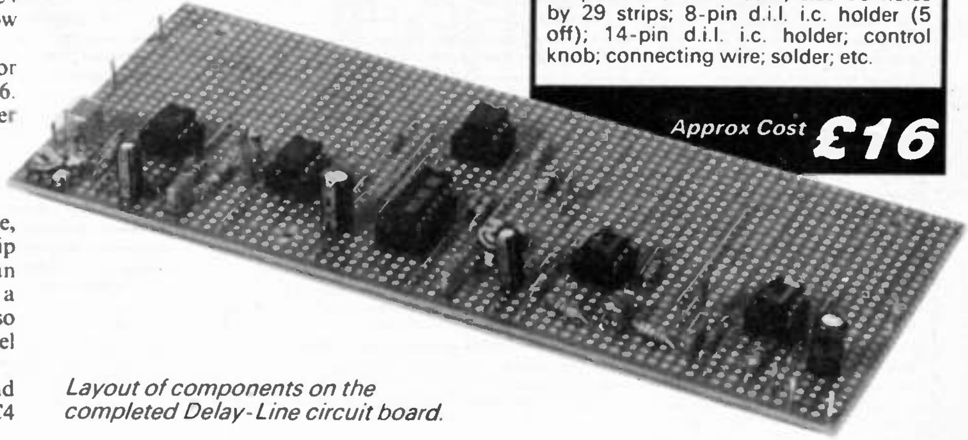
D1	1N4148 silicon signal diode
IC1, IC2, IC4, IC5	LF351N bifet op.amp (4 off)
IC3	MN3004 c.c.d. delay line
IC6	MN3101 clock generator

Miscellaneous

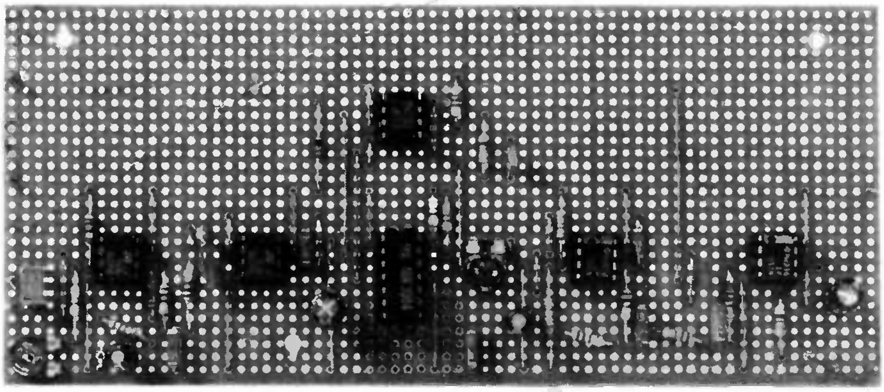
JK1	3·5mm stereo jack socket

Stripboard 0·1in. matrix, size 68 holes by 29 strips; 8-pin d.i.l. i.c. holder (5 off); 14-pin d.i.l. i.c. holder; control knob; connecting wire; solder; etc.

Approx Cost **£16**



Layout of components on the completed Delay-Line circuit board.



audible. VR2 is then adjusted "by ear" for the lowest clock breakthrough. Like the phase shifter, the delay-line should be fed from the output of the microphone preamplifier.

IN USE

When using either the Phase Shifter or the Delay-Line it is advisable not to use a headphone to microphone separation which is any greater than is really necessary. Results using the Phase Shifter on pure test tones were quite impressive.

Even using a single phase shifter to drive both earphones it was possible to obtain a degree of attenuation that I would estimate to be at least 30dB. However, the phase and gain controls must be adjusted very carefully if a high degree of attenuation is to be achieved.

Because the system is only operating over a narrow frequency range it is not essential to use high quality microphones. When tested on a real world sound the unit was quite effective at combatting the annoying whining sound from a laser printer, but it did little to reduce the quieter "whooshing" sound of the fan which contains a wide range of frequencies.

With the Delay-Line set for the correct delay time I found that quite good attenuation was obtained over the low to middle audio range. It is necessary to experiment a little with the delay time, since the wrong delay will provide good attenuation at certain frequencies where it just happens to provide the correct anti-phase signal.

In common with the system which has a microphone near each ear, this system, even using good quality microphones, failed to give a high degree of attenuation over the full audio range. Adjusting the controls to improve the high frequency

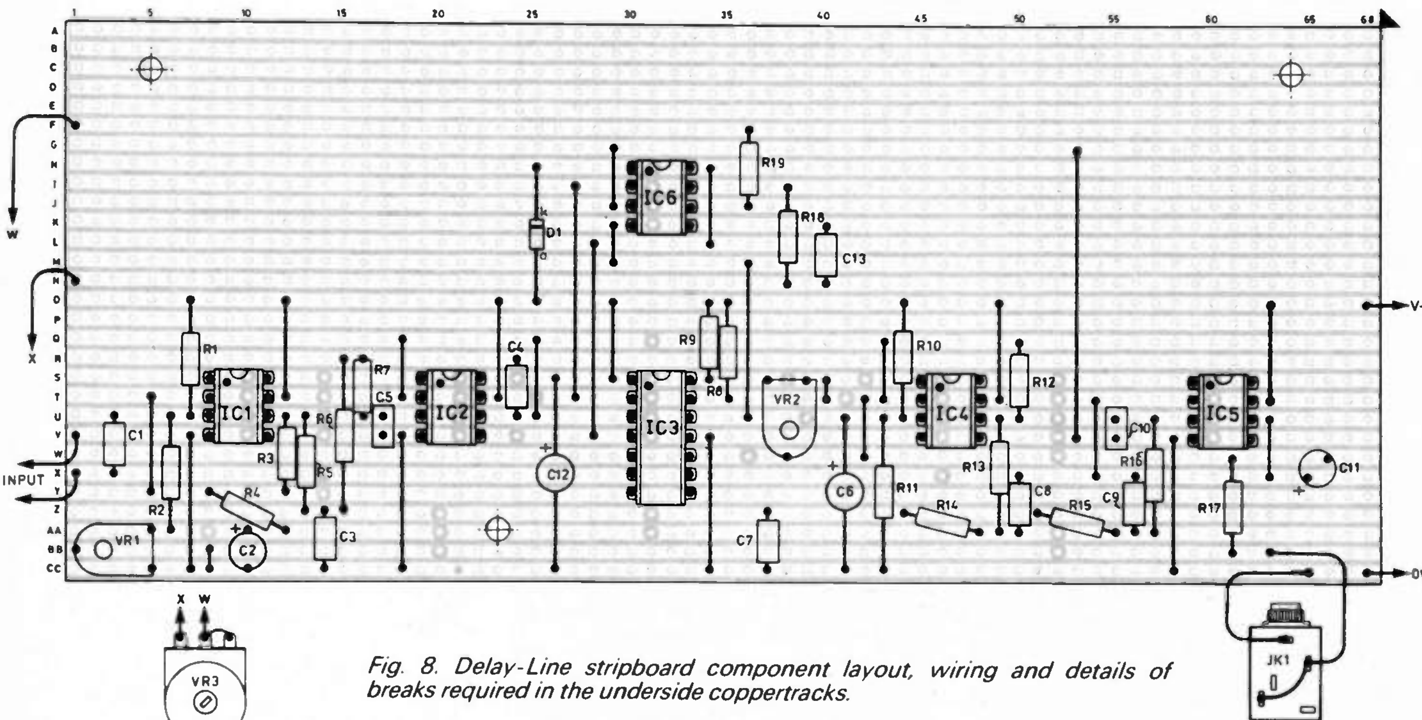
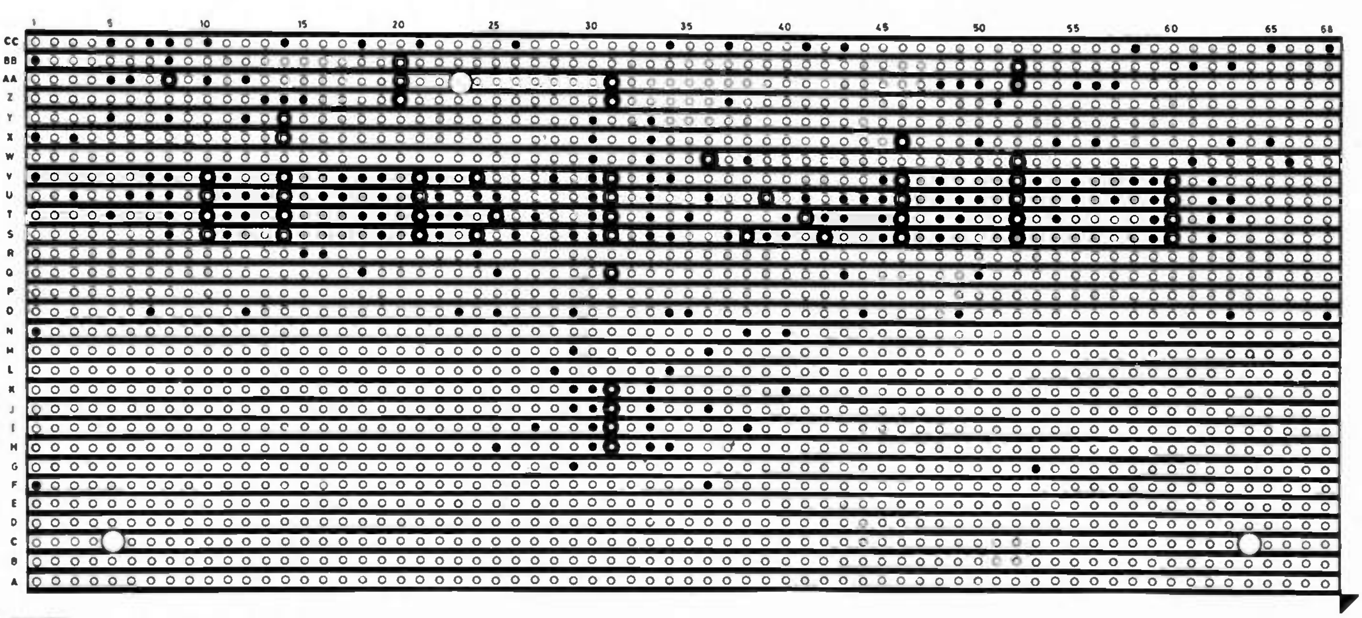


Fig. 8. Delay-Line stripboard component layout, wiring and details of breaks required in the underside coppertracks.



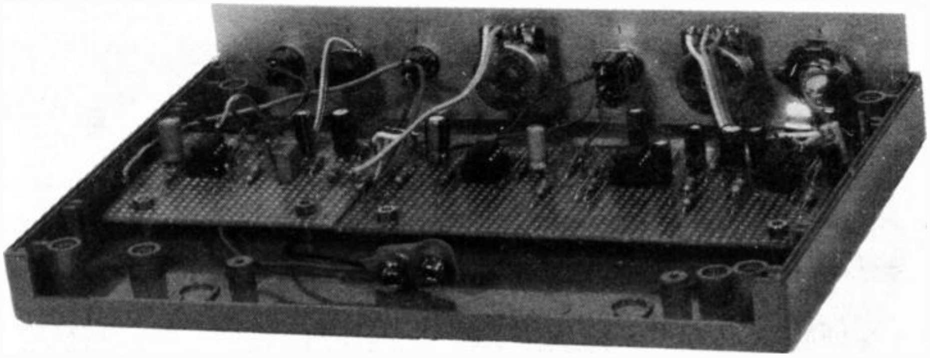
EE 4591G

attenuation resulted in a loss of low and middle frequency performance.

FINALLY

If you wish to mix the output from a piece of audio equipment with the noise cancelling signals, the best method is to use a simple mixer circuit at the output of the noise cancelling circuit. Alternatively, the output from the audio device can be fed to pin 2 of IC1 in the Microphone Preamplifier via a one megohm resistor and a 22n capacitor. IC1 will then provide a simple summing mode mixer action. Of course, this will only work properly with a stereo signal if totally separate processing is used for each ear.

Noise cancelling certainly represents an interesting field for the experimenter. Obtaining reasonable performance over a narrow range of frequencies seems to be reasonably easy. Combatting noise that is predominantly at low and middle frequencies is more difficult but possible provided due care is taken to get everything just right.



The completed unit using the Phase Shifter board in combination with the microphone pre-amp. If the larger Delay-Line board is used, in place of the Phase-Shifter, an alternative method of mounting it in the case will need to be found; it could possibly be "stacked" above/below the pre-amp.

Obtaining a high degree of attenuation over the full audio range is a much more difficult prospect, and something I have yet to achieve. In order to accomplish this it is probably necessary to have a circuit that permits the amplitude and phase of high frequency signals to be trimmed, and accurately matched with the sounds reaching the user's ears.

There may be a reasonably simple but effective way of achieving this, but if there is I have yet to discover it. It is a goal I will continue to pursue though.

SHOP TALK
with David Barrington

6802 Development Board

The most obvious item that stands out from the components list for the 6802 Development Board project, and one that readers will automatically ask "where do I get that?" is the pre-programmed 27C64 EPROM. A ready programmed EPROM, together with all relevant software is being made available by the author Richard Stone for the sum of £15 inclusive. This is by *Mail Order only* and orders should be sent to: **Mr. Richard Stone, Dept EPE, 19 Cheryfields, Poplars Farm, Bradford, BD2 1LB.**

Most of our components advertisers now stock fairly extensive ranges of computer-based i.c.s and should be able to supply the rest of the i.c.s "of-the-shelf". This comment also applies to the plugs and stockets.

The crystals should not prove too difficult to find and suitable types should be stocked by **Cirkit, Electromail, Cricklewood, Maplin** and many others. The small clip-on TO220 heatsink for the voltage regulator was obtained from Maplin, code KU50E.

The printed circuit board is available from the *EPE PCB Service*, code 894.

Stereo HiFi Controller

The "snap action" p.c.b. mounting connectors called for in the *Stereo HiFi Controller* should be widely available, but some readers may have problems sourcing them locally. The ones used in the model came from **Maplin**. These come in three parts consisting of the plug assembly, socket housing and terminal strip: 2-way assembly – RK65V/HB59P/YW25C; 3-way – BX9E/BX97F/YW25C; 4-way – YW11NY/HB58N/YW25; 5-way – FY93B/BH66W/YW25C; 17-way – BH61R/RK69A/YW25C. The 0·1 inch spacing socket strip also came from the same source, order code KP51F.

The semiconductor devices should be generally available. However, it is suggested you stick with the **BC109C** if you can, the other 109's tend to be of lower gain and will restrict overall performance. The double-digit, common cathode display came from Maplin, code BY68Y. Most component advertisers should be able to offer a similar device, but check the pinout arrangement before you purchase.

If you wish to use the same steel instrument case and the Paxolin based phono socket set, these were purchased from the above mentioned company, codes XJ27E (case) and BW74R (phono Skt.). You will need two socket panels and one will have to be trimmed down for the three-way version.

The printed circuit boards for the Controller are available from the *EPE PCB Service*, codes 887 (Main) and 888 (Exp/Display) boards. See page 639.

Dancing Fountains

The opto-isolators, used in the Pump Controller board of the *Dancing Fountains* project, are the only items that may be hard to track down. These appear to be RS devices and were purchased through Electromail (☎ *0536 204555*), codes 585-258 (transistor output) and 308-196 (triac output). The 4A 600V triac types BT134 or BT136 should be stock items or suitable alternatives may be offered.

The printed circuit boards for the Preamp, Pump Controller and Filter are obtainable from the *EPE PCB Service*, codes 889 (preamp), 890 (pump) and 891 (filter) – see Page 639. The choice of water pump is obviously left to the individual.

Experimental Noise Cancelling Unit

Most of the items needed to build the *Experimental Noise Cancelling Unit* project should be "over the counter" items and should not be too troublesome locating. But if readers do have problems with the i.c.s, particularly the TLE2037C low noise op.amp, MN3004 delay line and the MN3101 clock generator these were ordered from **Maplin**, codes CP87U, UM64U and UM66W respectively.

Circuit Surgery

The ICL7673 automatic battery change-over i.c. used in the Marine Battery Back-up circuit, described in this month's *Circuit Surgery*, is currently listed by Electromail (☎ *0536 204555*) part No. 632-966, Maplin Code No. UH36P and Farnell (☎ *0532 636311*) Part Ref ICL7673 CPA where the "P" stands for the 8-pin dual-in-line type. Also, shop around for nickel-cadmium cells suitable for your own specific needs.

PLEASE TAKE NOTE

EPE Micontroller P.I. Treasure Hunter (June '94)

Since publication of the *EPE Micontroller P.I. Treasure Hunter* project, a number of minor modifications and improvements have been made and a small number of errors in the parts list have been discovered. These are all listed below.

The table below clarifies the component references and values – these are the correct ones for the modified p.c.b. supplied not those shown in the magazine parts list.

Circuit Ref.	Total Quantity	Description
C1, C13 C14, C17	4	10µF 16V min. radial elect. capacitor
C4, C15	2	47µ 16V min. radial elect. capacitor
R26	1	220 ohm 0·6 Watt 5% metal film resistor
R27	1	470 ohm 0·6 Watt 5% metal film resistor
R28*A	1	56 ohm 0·25 Watt resistor (between TR3 and TR4 on p.c.b.)
R28*B	1	100 ohm 0·25 Watt resistor (next to R18 on p.c.b.). (R28 was used twice on p.c.b. component layout print).

The magazine components list has a quantity of "5 off" listed against C7. There is only one.

Circuit changes: Resistor R28B and capacitor C17 have been added to give additional smoothing to the +16 volt supply.

The printed circuit board shown in the magazine has an error. (VR1 is connected to +9V and not +16V). This was corrected before any boards were made, and so all *PCB Service* boards and Magenta kits are correct.

Many circuits have been built and are working well.

250/600W Mains Inverter (Dec '93)

The voltage dependent resistors VDRs should be types: VDR1 = V18ZA1; VDR2, 3 = V275LA15. The mains transformer is RS part no. 210-780 (supersedes 207-835).

Note, VDR3 (*next to VDR2*) is incorrectly labelled as VDR1 on the p.c.b. layout (Fig. 10). PL1 on the same diagram is not required and should be omitted.

Innovations

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

COMBATING ASTHMA AND ALLERGIES

Southampton promotes the electret as a medical aid – *by Hazel Cavendish*

ELECTROSTATIC technology is the basis of new methods to combat asthma and allergies in Southern England, where the Wessex area records the highest figures in Britain in these twin problems. Appropriately research is centering on Southampton University where over 70 researchers in its Medical School have been working to find out why people in this part of Britain are statistically more likely to develop these allergies than those in other areas.

The department of Electrical Engineering at the University is investigating ways of controlling the mites and parasites that are responsible for these afflictions. Electrets are the name of the game.

The value of their research is immense, with a quarter of the adult population of Great Britain known to suffer from asthma, eczema, rhinitis or the allergy known to be caused by dust mites. In the Wessex area one third of children in the 7/9 age group develop "episodic wheezing" which may be early asthma. Professor Stephen Holgate, who returned from Harvard University in the States to Southampton University, was one of the instigators of the charity known as AIR set up by the Allergy and Inflammation Research Trust to raise £100,000 to carry out research in homes in the area, where he claimed the South's high standard of living contributed largely to its allergy record.

"It is a mixture of the South's warm climate and humidity, together with the fact that so many homes down here are centrally heated with double glazing and wall-to-wall carpets, that provide an ideal breeding-ground for the house mite, one of the principal causes of allergy," he said.

Meanwhile Professor John Hughes was busy working with his team in the Electrical Engineering faculty, utilising electrets as a valuable weapon against the dust mite. Although electrets had been around for 15 to 20 years he realised they had many more applications than had been investigated in the past two decades.

An electret is the electrical analogue of a permanent magnet. Where a magnet is magnetically polarised north and south, an electret is electrically polarised plus and minus, and can be summarised as a piece of plastic with its positive and negative charges permanently separated. They are manufactured in a number of ways, but the most common method is to bring the plastic up to a temperature where it becomes liquid and then subject it to an electric field, so the positive and negative are correctly set. While still under the electric field the temperature is brought down to room temperature so that is solidifies again, ensuring the separated charge is "frozen in."

In developing the electret it was found necessary to manufacture the plastic material in very fine fibre form – finer than a human hair – to form a filter which looked like felt or a sheet of material. It was this which proved to have the property of being able to trap very small particles efficiently, including minute insects and pests so small as to be invisible to the human eye – as for example, the dust mite. The electret filter first saw the light of day in domestic vacuum cleaners, and its success was the green light for future research.

Possibilities

Professor Hughes is more excited by some of the possibilities now emerging from the latest research into the potential of the electret. "Our interest has been directed towards the control of all particles from car emissions, as well as the air pollution connected with occupations such as painting and photo-copying. We try and ensure that those particles do not become airborne, for if you can do that the problem is solved because you won't inhale them. We need to anchor those particles in some way."

Because carpets are known to be the most popular habitat for dust mites after bedding, electrets have been considered for an interweave to be incorporated in carpet manufacture which would prevent dust being kicked up into the air. "This is where our discovery is important to child care", says Hughes, "Young children crawl on carpets, and put their faces into the pile." Cleaning with wet shampoos and the possibility of liquid spillage on a carpet does not affect the electret adversely as he describes it as "quite a rugged element."

A more recent development in the carpet field, which has aroused considerable interest in the trade, is an invisible film containing the electret which is both permeable and flexible, and able to be attached to the underside of a carpet like an adhesive coating, or to a mattress.

With the co-operation of entomologist Dr Howse with his expertise in insect-trapping, a new range of Pet Care products is presently invisaged. The Professor believes a disposable collar with electrets would be more environmentally friendly than the insecticide-treated collars which have been around for some time. Some animals are known to have had adverse reactions to the latter, and instecticides are increasingly unpopular in public concern for a healthy environment. The new collar would trap all the parasites in it ensuring the animal is kept completely clear of pests.

Electret Gel

The latest extension of the technology is to produce it in a non-solid property such as a cream or gel. "This opens up a whole new area of application," says Hughes, adding that such gels could be used as an instant treatment for carpets which had not been treated in the manufacturing process, for the grooming of pets, and also as a cosmetic application. The Professor is well aware of public concern at the level of pollution in the atmosphere, and envisages an invisible cream or gel which could be smeared inside the human nose, coating the nasal hairs so that these assumed electret properties themselves – "improving on Nature's filter, in fact."

"This may sound like science fiction, but we already know that there are some naturally occurring products which actually display electret properties, so we believe a significant product might be developed in the next five years."

SINCLAIR ZETA

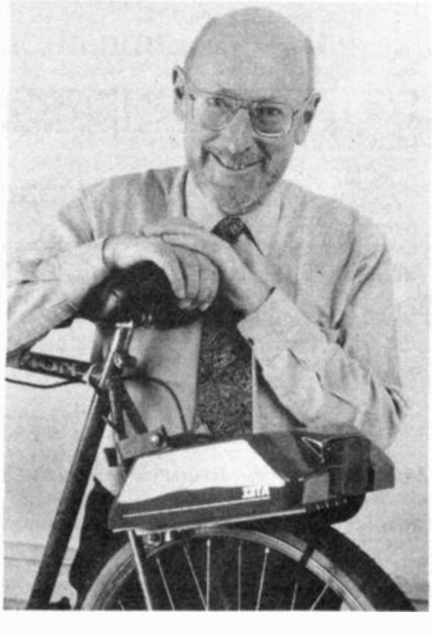
Following "hard on the wheels" of their *Zike* electric cycle, Sinclair Research launched what is claimed to be the "next major breakthrough in the growing electric bicycle market" in the form of ZETA – the ZeroEmission Transport Accessory. This bolt-on accessory for bicycles provides electric motor drive to the rear wheel at the press of a button. The power-assistance means less effort for cyclists, enabling them to tackle steeper gradients or head winds by switching in the motor boost when required. It can be used on any tyre or wheel size including MTB's. The complete unit weighs just under 5 kilos and sits over the rear wheel, explained Sir Clive.

ZETA transmits power using a novel toothed belt arrangement which provides a friction drive directly onto the tyre tread, and is operated with a handlebar switch. Designed more for supplementing the cyclists' own efforts rather than providing full-time propulsion, ZETA utilises a standard sealed 12V 7Ah lead acid Yuasa battery coupled to a 174W maximum power (0.25 horsepower) compact d.c. motor of Japanese manufacture.

Top speed is 15 m.p.h., being the maximum permissible by law for this class of transport. Range is anywhere between 10 and 30 miles depending on usage and the drive can be adjusted for wet weather to provide extra traction. The UK designed ZETA includes a mains recharger which enables a completely discharged battery to be replenished in approximately 14 hours at a cost of under one penny, claims Sinclair. The battery can also be trickle charged on the move, to a limited extent.

Retail price is £144.95 with spare batteries available for £29.95. ZETA is currently being distributed by mail order; expect it to be in the shops in the autumn.

Contact Sinclair Research Ltd., 15-16 Margaret Street, London, W1N 7LE. – *Alan Winstanley*.



New Technology Update

Ian Poole investigates the latest research developments in digital picture correction for c.r.t.s and 50V CMOS semiconductors.

CATHODE ray tubes are still the most widely used form of display in the electronics industry today. They find uses in a variety of applications from television sets to computer monitors, and are manufactured in their millions each year.

Despite the fact that many other forms of display have been tipped to overtake the c.r.t., no other type has yet been able to displace them from their number one position. The reason for this is that c.r.t.s offer better performance for cost when compared to any other type. Having been in use for many years now, they have undergone a vast amount of development and improvement, and this has resulted in a high level of performance for a relatively low price.

C.R.T. Drawbacks

Despite this c.r.t.s still have some drawbacks. Some, like their size, weight, and the voltages and power required are almost fundamental limitations about which little can be done. However there are problems which can be addressed. One of these is that the picture quality deteriorates towards the edge of the screen. This arises because the electron beam has to undergo much larger degrees of deflection for these areas.

It is found that the images become distorted as a result of non-linearities which occur as the beam angles change. This results in the convergence for the colours as well as the focus not being as good as it is at the centre of the screen. A number of methods have been devised to help overcome this, and many of these are in current tubes in use today. However a new and rather interesting scheme to solve the problem involves digital techniques and is being developed by Philips Consumer Electronics at Knoxville, Tennessee.

Automatic Compensation

The new system uses some additional circuitry over that normally employed to drive a c.r.t. In conjunction with a magnetic sensor to detect the levels of external fields, the new circuitry automatically compensates for any non-linearities and changes which would cause the image to become distorted. Using this circuitry the system is able to cater for any non-linearities within the tube, as well as any external ones; these often occur when a monitor is moved from one place to another.

The new circuitry is designed to be included in the monitor itself. The system has been designed so that any adjustments which need to be made can be effected quickly and accurately. Then they are stored within the monitor in a digital format. These adjustments are implemented at the final stage in the production of the monitor. In this way it is possible to remove the effects of any tolerances in the electronic components as well as those introduced by the distortion of fields from any mechanical components.

The system has been shown to be very successful. The brightness level can be maintained to within 90 per cent over the whole area of the screen against 75 per cent for a traditional monitor. In addition to this the colour information can be controlled more accurately.

Apart from maintaining the uniformity of brightness and colour, the circuitry also enables other functions to be controlled more easily. One specific example is that it enables the colour temperature to be set to a user defined level. Normally this is preset in monitors, but in some specialised applications it is very useful to be able to control it.

Although today's monitors perform very well by comparison with those produced even a few years ago, new software which is reaching the market is pushing the requirements for monitors to the limits. These new developments should enable monitor technology to keep a few steps ahead of the software.

50V CMOS Structure

In most areas of electronics it seems as if there is a growing trend for lower voltage i.c.s (3·3V looks set to become the new standard quite soon) to fill the expanding requirement for battery operated equipment. However there are many other areas where high voltage chips are needed. In fact there is increased use of electronics in a wide variety of machines which previously used purely electrical or electro-mechanical devices. This has brought about a need for high voltage chips which can be used as controllers.

With this demand comes a great challenge for i.c. designers because conventional i.c technology running from standard five or 3·3 volt rails needs to be contained on the same chip as much higher voltage and current control devices.

To meet this demand a company called Austria Mikro Systeme has produced a new CMOS structure which is capable or running at 50V and switching relatively large currents. Being CMOS it allows standard microprocessor logic to be contained on the same chip. This enables less chips to be used in any given circuit, thereby reducing the cost and size whilst increasing the reliability. This last factor is particularly important because many of these circuits have to operate in environments which are not ideal for electronic circuits.

New Structure

The new structure uses a new "2µm CBK" process. This has a *p*-type substrate and uses two levels of metallisation together with one of polysilicon (a layer of silicon deposited onto the substrate during manufacture). This gives the basic CMOS structure. *N* channel FETs are also used as well as a number of bipolar transistors, some of which are totally isolated from the rest of the chip by using an insulating oxide layer.

The new chip will handle much higher voltages than standard CMOS because of small but crucial changes to the structure. Normally the gate is placed on an insulating oxide layer between the drain and source. When a high voltage is placed across the channel, breakdown can occur across the channel electrodes via the gate, destroying the device.

In the new structure (Fig. 1) a thick oxide layer is used to enlarge the gap between channel electrodes and the gate. Furthermore the drain is placed into a well of *n*-type material which extends into the substrate.

This has two effects. Firstly it increases the distance between the gate and the drain, and secondly it enables the depth of the channel to be increased, allowing the "on" resistance to be reduced. This is very important when considering the higher currents which are also used in control applications.

The new process is particularly good because it makes only small modifications to an existing and well established one. As a result it will be relatively cheap and easy to introduce into full scale production.

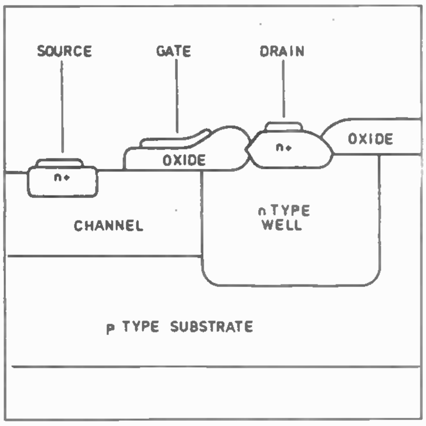


Fig. 1. The new 50V CMOS semiconductor structure.

Special Feature

I'LL BE SEEING YOU

ALAN W. RUDGE OBE, PhD, F.Eng, FRS

The face of telecoms services for the future is taking shape now. What can we tell about the future world of infinite bandwidth?

THE world's telecoms network is the largest human construction of all time. It is also the most complex, handling in excess of 1000 billion calls every year plus an immense amount of data. It allows communications to be sent and received almost anywhere, virtually without censorship or control. Its very existence is an important element of our personal freedom.

Although the concept of telephonic communication existed at least 300 years ago, the practical realisation is not yet 120 years old. The progressive penetration of telephony into everyday life has continued steadily ever since.

While telephony flourished in the USA, development was much slower in Europe, where telecoms were provided by government agencies, which failed to appreciate the scale of the opportunity and its potential impact on commerce and society. This lack of vision contributed to a critical early lead by the USA, which continues to retain an edge.

SATELLITE COMMUNICATIONS

In the 1960s, a major step forward occurred with the onset of satellite communications. The *Intelsat* programme, which commenced in 1965 provided at first for 240 telephone circuits or one TV channel per satellite. Succeeding generations have grown in size, complexity and capability; the latest *Intelsat VI* satellite offers simultaneous capacity for 24,000 telephone circuits and three TV channels.

Cable technology was far from dormant during this period. In 1965, Kao and Hockam at STC Laboratories in the UK published their paper on optical fibre and laid the theoretical basis for a revolution in cable technology. Photons of light rather than electrons were to be the transmission medium, and if technological challenges could be overcome, each hair-like fibre strand could convey virtually limitless bandwidths.

The GPO, later BT, in conjunction with UK industry and academia, played a major role in establishing the UK as a world leader in this new technology The BT network now contains more than two million kilometres of optical fibre. BT also played a major role in the development of the first fibre-optic cables, linking the UK and Europe in 1985 and the UK and USA in 1988.

With optical fibre providing significantly higher transmission quality than satellite, optical technology is progressively replacing satellite communications on high-capacity international routes (Fig.1). The combined effect of these technological advances has been a logarithmic improvement in capacity and corresponding decrease in cost. For instance, a three-minute direct-dialled call from Britain to the USA costs less than £1.50 today. A call of similar duration, but inferior quality, in 1946 would have required the assistance of an operator, a three-hour wait, and cost the equivalent of £440 in today's money.

TECHNOLOGY ADVANCES

In parallel with advances in transmission technology, equally momentous advances were occurring in electronics, computing and radio technology The advent of integrated-circuit electronics, software engineering and new digital technologies has initiated a transformation of telecoms services. Since privatisation in 1985, BT has invested over £19 billion to modernise its networks with digital switches, computerised network management, new billing and customer service systems and optical-fibre transmission. Over this period, a new competitive regime has been established in the UK: Mercury has built a second national long-distance network, while Cellnet and Vodafone have established major cellular-radio telephony networks.

The first "intelligent" network services have also appeared, using the software controlled potential of exchange switches and network-based computers to provide advanced services such as 0800, 0345, voice-bank, voice-messaging and "star services" including call forwarding, call waiting and three-way calling. Intelligent-network technology will make available a plethora of new services, capable of being tailored to suit individual needs.

DATA TRANSMISSION

It is not only in telephony that these technological advances have been felt. The rapid growth of computing has led to a growing need for data transmission. Driven by the exponential growth of computing, the growth rate of data transmission over the past decade has exceeded that of telephony by a substantial margin.

Today there are more than 800 million telephones in use in some 230 countries around the world, most of which can be dialled direct for voice or fax transmission. Data networks wrap around the globe, and electronic mail and electronic data interchange are becoming common-place.

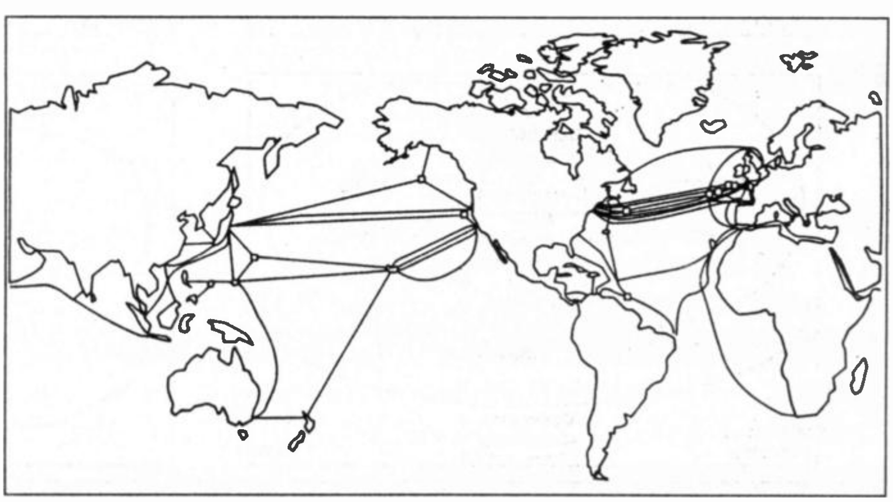


Fig. 1. Undersea fibre-optic lines now span most of the busiest international circuits.

Country	Lines per 100 population
Sweden	68.8
Canada	58.6
Denmark	57.7
United States	51.6
France	51.0
Australia	46.4
Hong Kong	45.2
Japan	45.1
United Kingdom	44.6
Germany	40.4
Latvia	24.1
Slovenia	23.5
Lithuania	21.8
Armenia	17.7
Ukraine	15.6
Russia	15.0
Rumania	10.5
Georgia	10.3
South Africa	9.5
China	0.7

Fig. 2. Telephony penetration in world markets.

The impact on the world of this capability to communicate at the personal level cannot be over-estimated. There is little doubt that telecoms is a fundamental requirement for sustaining and developing modern civilisation. Every nation's defence, trade, commerce, industry and social practices are all inextricably dependent on the reach and quality of their communications.

The recent collapse of the totalitarian regimes in the USSR and Eastern Europe cannot be attributed to a single cause, but the growing ability of their people to communicate was certainly a factor. It is interesting to note that at the time of their collapse, most of the Eastern Bloc states had achieved a telephone penetration of between 10 and 20 lines per 100 population, whereas China, which has resisted such change, has a penetration rate of less than 1 per 100 (Fig. 2).

RATE OF CHANGE

It would be easy to dismiss the progress of telecoms as merely following a natural course of evolution. However, this would show a lack of vision even greater than that which held back many European nations in the early days of telephony. Let us consider some of the key points.

The rate of technological change is accelerating rather than declining. Computer memory and signal-processing power are doubling every two years, while costs are halving in the same timescale. Digital signal-processing techniques and video compression are transforming the prospects for widespread use of image and video over cable or radio systems.

Transmission and switching capabilities are being transformed. New digital transmission techniques, such as synchronous digital hierarchy and asynchronous transfer mode, will offer higher transmission rates, lower unit costs and improved network quality. Optical networks offer the potential for gigabit switched bandwidths, while optical amplifiers, now becoming available, will provide another enormous step forward in transmission and processing, lowering the cost of both terrestrial and submarine transmission.

The appearance of intelligent-network architectures will in essence, convert the networks into giant distributed computing platforms to run a wide range of software-controllable applications. The high degree of software control will allow both the rapid deployment of new services and an increasing degree of control to be placed with the end user.

Driven by the highly competitive consumer-electronics market, dramatically lower costs for complex equipment are already becoming apparent, a trend that will certainly continue under the twin pressures of technological progress and competition. Systems and software engineering are emerging as critical skills in managing complex equipment and networks, and in implementing the services of the future, although much remains to be done to establish software engineering on a finer scientific base.

In summary, as far as technology is concerned, the issue is not "can it be done?" but rather, "what needs to be done?". It is noteworthy that these key technologies underpin not only the telecoms industry, but also computing, broadcasting, consumer electronics, and a diverse range of activities broadly defined as the information-technology sector.

CONVERGENCE

Major companies, which formerly operated in relatively independent sectors, increasingly find themselves in direct competition with organisations from adjacent sectors (Fig.3). The net effect of this dual convergence – of technology on the one hand and markets on the other – will be both a dramatic increase in competition on a global scale and a further acceleration in the rate of technological change.

In the past, the separate identity and licensing of telephony and data and broadcast services reflected basic dif-

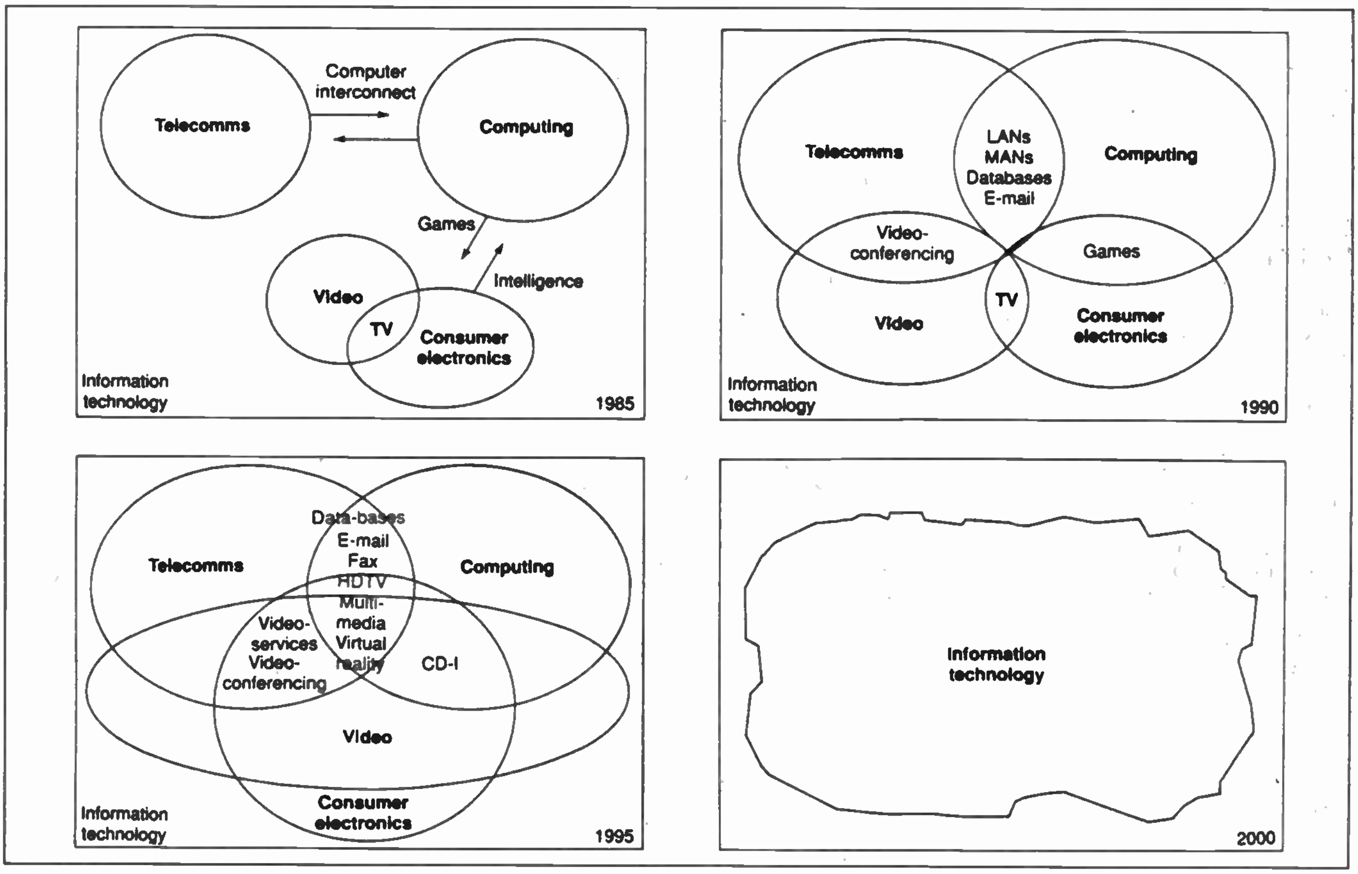


Fig. 3. Previously quite distinct markets are moving together; companies now find themselves competing with others from sectors that were once completely separate.

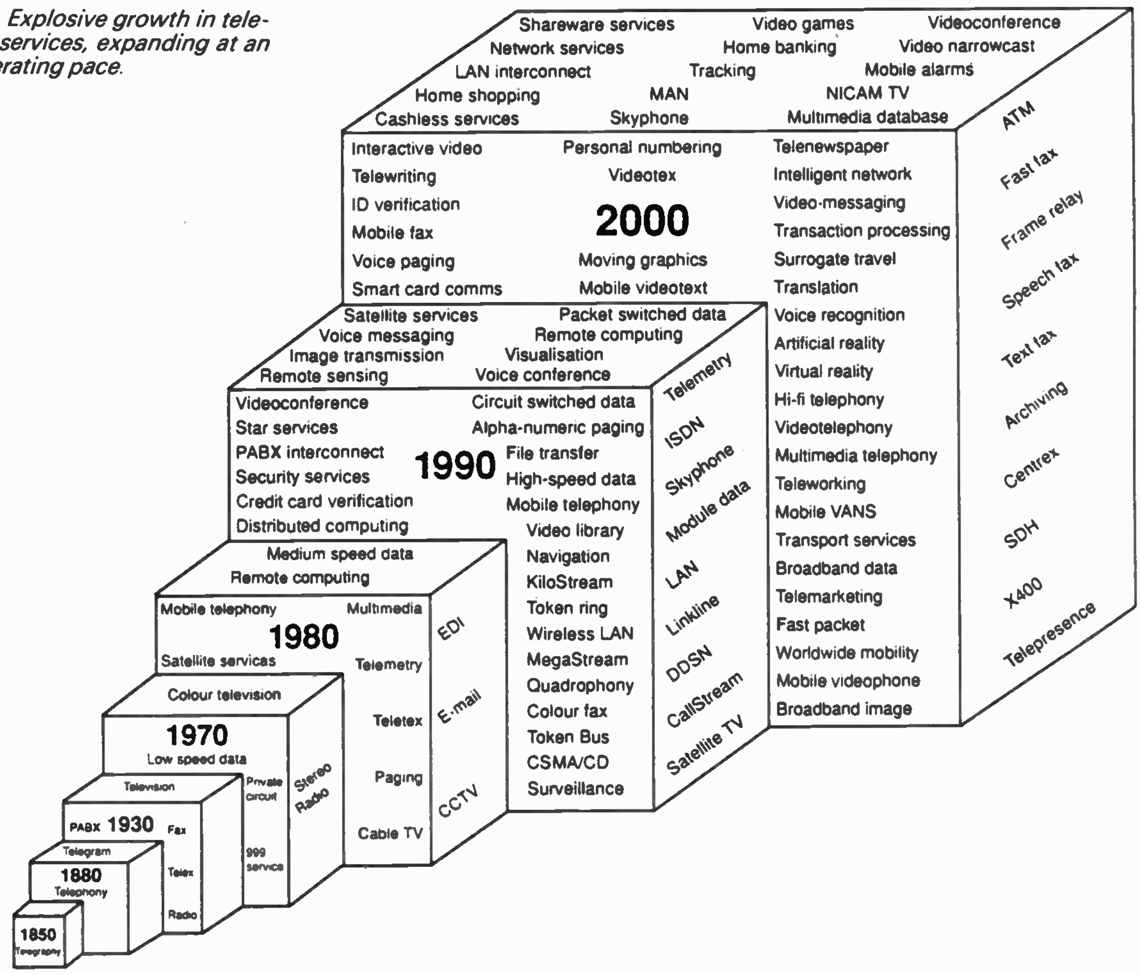


Fig. 4. Explosive growth in telecoms services, expanding at an accelerating pace.

ferences in the transmission. With the advent of digital technology, distinctions between the processing and convenience of these services have become arbitrary. More importantly, advances in digital technology have given a glimpse of the enormous potential of integrating and processing information flows to provide a very broad range of multimedia applications.

Multimedia applications in which the terminal equipment takes the form of either a personal computer or a workstation can represent a very powerful business tool, particularly for interpretative work, where large amounts of data are required to solve complex multi-parameter problems. With combined telecoms and computing capabilities, such an application could provide for the simultaneous sharing of information with other users, as well as integrated voice and video communications or electronic-mail facilities.

MULTIMEDIA APPLICATIONS

The current capabilities of multimedia applications are limited mainly by the bandwidth constraints imposed by the network. The advent of switched broadband networks will lead to a dramatic increase in the quantities of data transmitted and displayed, and hence in the quality and scale of the video component. For example, during the past year, BT has carried out a very successful experiment with home-based directory enquiry operators in Inverness. The relief in travel congestion that could arise from widespread adoption of these teleworking practices would be a major national benefit.

Some potential multimedia applications are shown in Fig. 4, which illustrates the exponential growth in telecoms services. These include home shopping and home banking, estate agency, travel agency, market research, education and training, healthcare, security and consultancy.

On the entertainment front, the potential is equally promising. Many of these applications require large computing resources, which could be located with a service provider and connected via a broadband network. Examples are interactive games, video on demand, telepresence, video books and library facilities, video meetings and holograph.

The potential for applications of wide-bandwidth multimedia technology is almost unbounded and is constrained only by the limits of imagination. Some of the applications may seem frivolous, but the impact on many aspects of business and social life will be enormous.

With the use of digital compression, the current narrowband networks can support early multimedia applications over the existing copper network. However, a

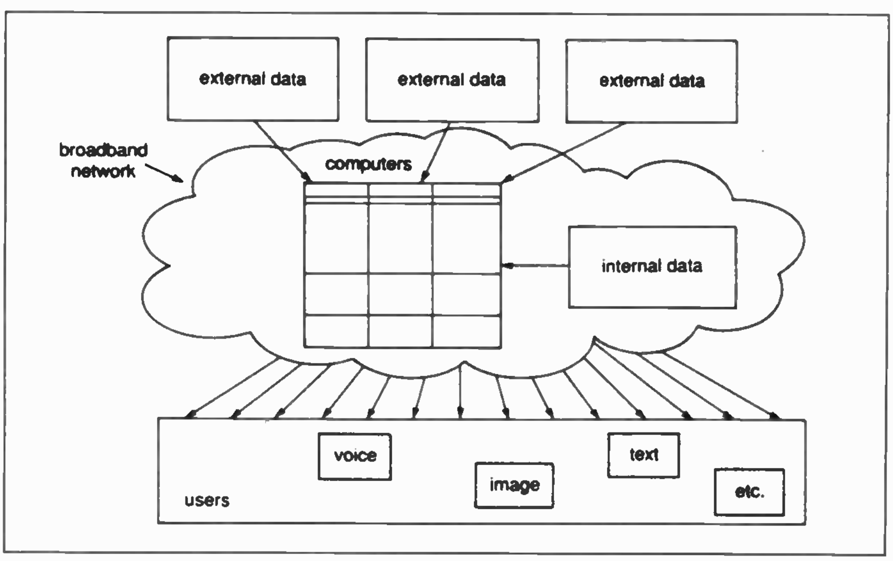


Fig. 5. The integrated broadband network will give users access to data in many forms, from many sources.

A BT directory enquiry operator working at home as part of the Inverness teleworking experiment (BT Pictures).

ubiquitous, intelligent, switched broadband network will be an essential requirement for any nation with ambitions to establish a strong position in the "information age". In economic terms, this will be the 21st-century equivalent of today's motorway network (Fig.5).

The intelligent broadband network will allow service providers to offer myriad new services and applications. It will not only simulate the telecoms industry, but also encourage the growth of a whole new sector of the IT industry engaged in the provision and development of such services.

Early implementation of a national broadband network will provide a significant strategic advantage. However, in the UK regulatory constraints on the major network operators are discouraging this development. This warrants urgent review by the Department of Trade & Industry.

REVOLUTION

Although the development of telecoms has not been slow, the rapid advance of key technologies, along with increasing competition, will produce conditions in future years closer to revolution than evolution. Market opportunities will be huge and the impact all-pervasive. Besides the obvious benefits for the IT industry, an intelligent broadband network could bring major benefits to all aspects of the UK economy.

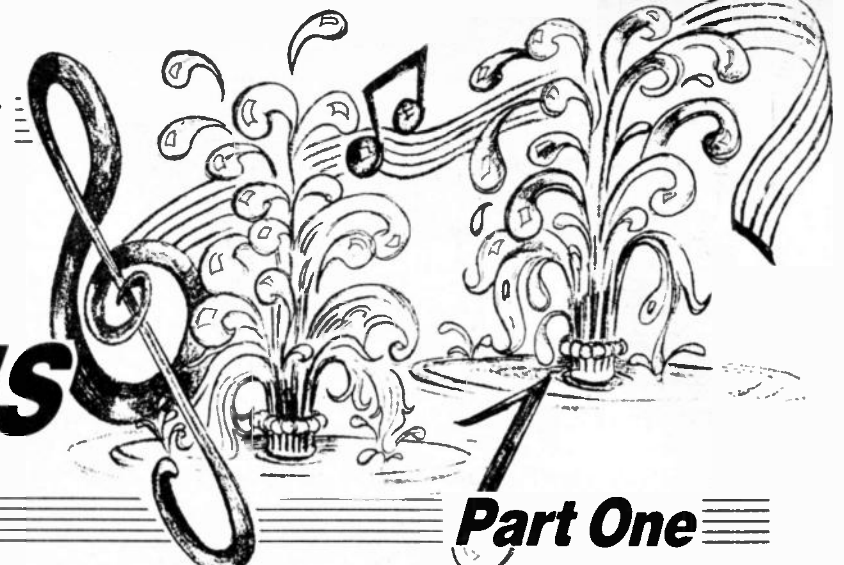
There is no shortage of critics to argue that there is little market demand and no commercial justification for multimedia services. But history is littered with the opinions of experts who underestimated either the latent demand for information or the ability of technology to deliver it economically.

It is not clear quite when the UK will have an intelligent broadband network, or how many of the new services touched on above will be available. However, I can predict that many of the video and multimedia services in their infancy today will be the norm within the next decade, along with many others not mentioned or yet conceived. Providing that my health holds out, I feel sure that "I'll be seeing you" courtesy of multimedia technology and the UK broadband network. □

Dr. Rudge is the 111th President of the IEE. This article is based on his Inaugural Address.

Constructional Project

DANCING FOUNTAINS



JOHN BECKER

Part One

Join the musical jet set at the pool and let the fountains dance the day away. Plus optional PC-Compatible Interface (next month) to let your computer call the tune.

WHILST in Jersey a couple of years ago, my wife and I became fascinated by the dancing musical fountains display at Fort Regent. By the time we had returned home, the fascination had become an obsession. I had to design a miniature version for the garden pond.

The Jersey display consisted of numerous fountain jets of varying sizes configured in regimented groups whose columns and sprays of water had been choreographed to the beat and mood of the music. The effect was enthralling.

Inquisitive examination of the outer workings revealed a vast complexity of plumbing pipes but did not show how the water was controlled. It seemed likely that it had been pre-programmed to the music, using a computer to open and close powerful pumps or solenoid valves. Though, of course, it might have been Bergerac or Charlie Hungerford pulling levers behind the scenes.

During that winter, I experimented with various design ideas for a fountain display which would respond to any music from any source, indoors or out, live or recorded. Once the winter ice had melted, electronically controlled pumps and fountains were installed amongst the back-garden fish, frogs and water plants.

They now enjoy the freshness of rhythmically cascading waters while we watch and listen as the display dances to our favourite music tracks.

MODULAR CONSTRUCTION

The system described here is in modular form and there are several ways in which the modules can be combined. There are three modules: audio preamplifier and compressor, audio filter, and garden-pump controller.

Three combinational methods of controlling garden pond fountains from the modules are shown in Fig. 1. The simplest combination requires one Preamp and one Pump Controller in the same box, controlling a single garden pump.

With this combination several fountain jets can be attached to the pump, the quantity depending on the power of the pump, all responding to the music in unison. This setup requires the music source, such as a cassette player, to be placed alongside the control box.

The second combination is similar to the first, except that the Preamp and the Controller are in separate boxes. This allows the Preamp to be treated as a "roving" unit which can be placed near an indoor audio source at the end of a lengthy cable connected to the pump controller.

The third combination allows several pumps to be controlled independently by different aspects of the same music signal. For this option one Preamp and one Filter are needed, and then one Slave Pump Controller for each pump used. The Preamp can be in the controller box, or connected as a roving unit, as above.

The systems can be used for applications other than garden fountain control, for example, control of lighting effects or the speeds of various types of a.c. motor.

PUMPS AND POWER SUPPLIES

The electronic circuits have been designed to run from a 12V d.c. supply regulated down to 9V. This may be provided from either a 12V car battery, or from an integral mains power supply, depending on the system option chosen.

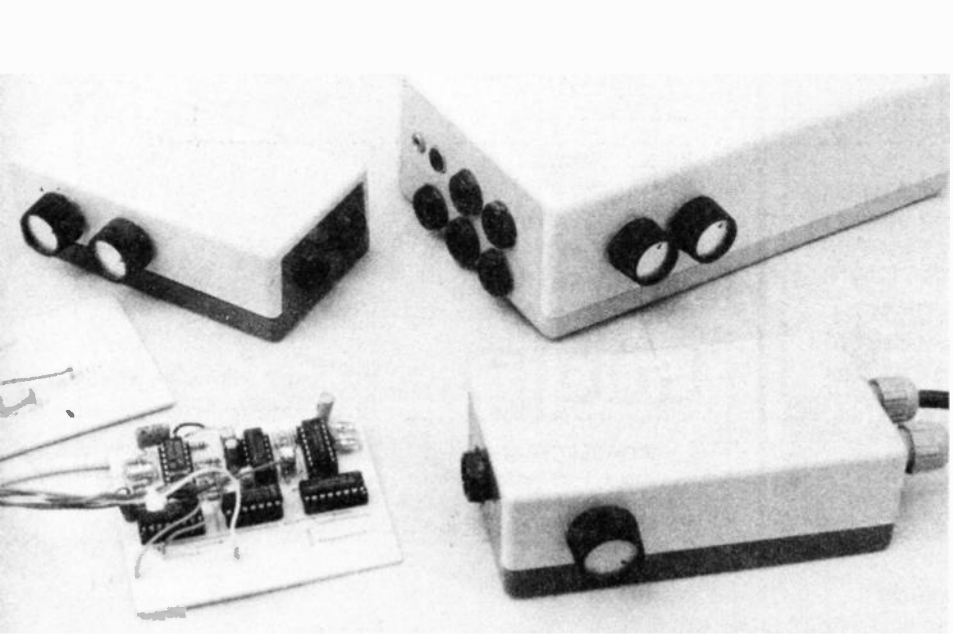
The Pump Controllers are for use with mains powered garden pond pumps. They have been used with the small Lotus Mermaid 120 pump, a medium sized Beresford Otter and the much more powerful Lotus Mermaid 1200.

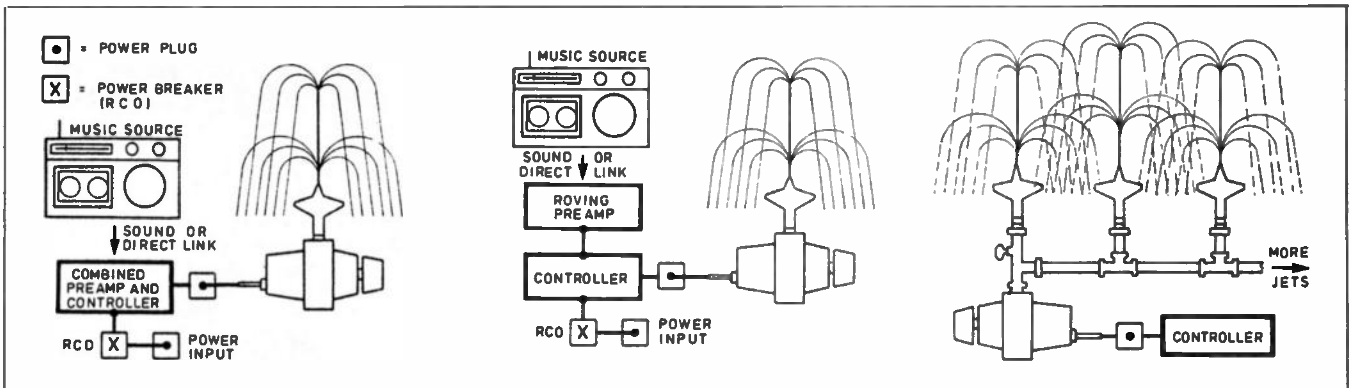
AUDIO INPUT CIRCUIT

The circuit diagram for the audio Preamp module is shown in Fig. 2. Music or other audio signals can be input to the circuit via its integral microphone, MIC1, or via a cable connected to the line output of a hifi, CD player, cassette, or similar source. A computer controlled audio signal generator Interface board will be described next month.

A sub-miniature microphone insert MIC1, having an impedance of about one kilohm, is used with my own fountain systems. Its output is amplified by the fixed gain stage consisting of IC1a and IC1b, both of which represent one half of a dual operational transconductance amplifier (TCA).

The gain is set by current flowing into the control node via resistor R1, which in turn sets the current through R2. IC1b buffers the output of IC1a.





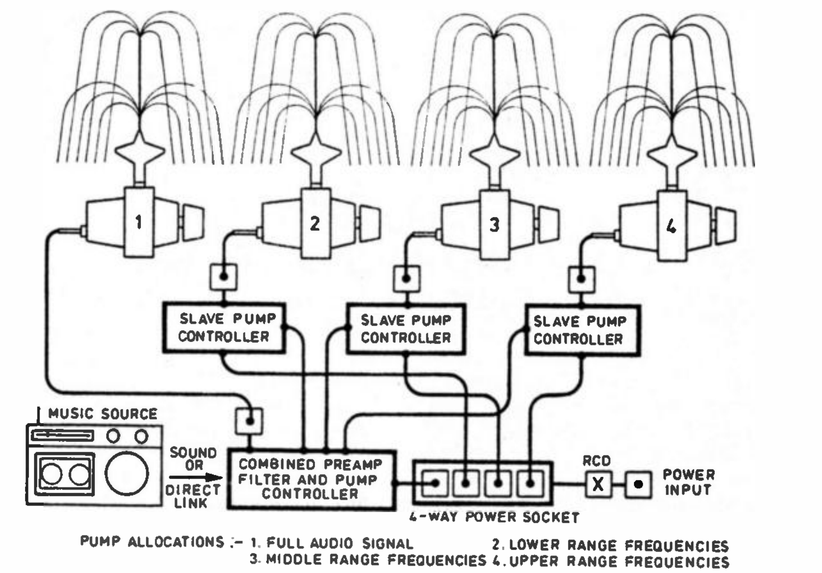
Single pump control. *Roving set-up.* *Feeding more than one jet.*

The impedances at the TCA's input pins 3 and 4 have to be balanced in order to maintain a midway d.c. level at pin 5. Preset potentiometer VR1 provides this control. If a microphone having an impedance greater than the 10k range provided by VR1 is used, the value of the preset will need increasing accordingly.

Socket SK1 is a switched input type through which either the amplified microphone signal, or an external signal source, is routed to the compressor stage via amplitude control VR2. The signal is further amplified by TCA IC1c, buffered by IC1d, and fed to the buffered output stage IC2c.

From IC1d, the signal is also fed to the compressor control circuit consisting of the network around IC2a and IC2b. Resistor R12 and diode D1 control the rate at which capacitor C3 charges up (attack rate) to match positive-going signal peaks. Resistor R13 and D2 control C3's discharge rate (decay rate) when the signal amplitude falls.

Using IC2a as a buffer, changes in the amplitude envelope level are amplified by IC2b and adjust the current flowing into



Frequency selective set-up.

Fig. 1. Some of the fountain control options.

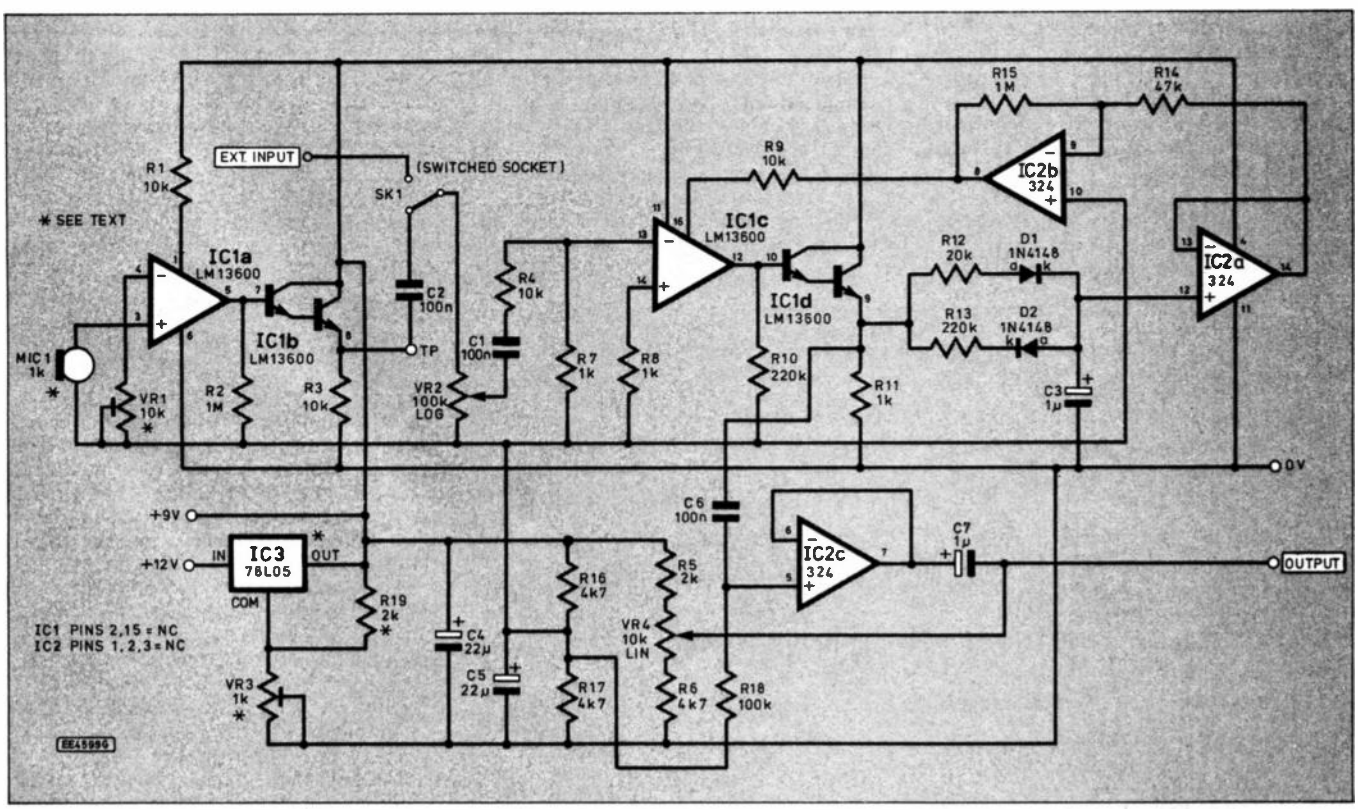


Fig. 2. Circuit diagram for the fountain Preamplifier module.

the control node of IC1c, so determining its gain value. The net result is that high amplitude signals are compressed, while low level signals are increased, so standardising the average output level.

From IC2c and via capacitor C7, the processed signal can be routed to the Pump controller circuit in Fig. 3, or to the Filter stage in Fig. 4. A d.c. bias level, which sets the range of the Pump Controller, is applied to the output side of C7 via the network consisting of VR4, R5 and R6. Resistors R16 and R17 set the midway d.c. reference level for the Preamp circuit.

When the Preamplifier is used separately in its own box, the 12V power supply is regulated down to 9V by IC3 under control of the feedback through resistor R19 as set by preset potentiometer VR3. These components are omitted when the Preamp is in the same box as a Pump Controller, the latter supplying 9V directly to the preamp.

PUMP CONTROLLER

The circuit diagram for the Pump Controller is shown in Fig. 3. It is basically a triac controller circuit of the type often used to control any a.c. motor or lamp.

The triac CSR1 controls the power flowing through the pond pump motor M1. The triac is repeatedly switched on and off by pulses applied to its gate (g) via opto-isolator IC9. The power flowing through the motor is determined by the width of the controlling trigger pulses and their synchronisation with the phases of the a.c. mains cycles.

Synchronisation pulses are generated from the 50Hz mains a.c. supply and frequency-doubled to 100Hz. The positive mains a.c. line is taken via resistor R42, preset VR6, diodes D3 and D4 to opto-isolator IC7.

Since the two l.e.d.s within IC7 are not necessarily current-matched, VR6 is used to equalise the effective balance between the two halves of the mains a.c. cycle, which are half-wave rectified through

COMPONENTS

Approx. cost from **£25** excluding pumps

PREAMP BOARD

Resistors

R1, R3, R4, R9	10k (4 off)	R10, R13	220k (2 off)
R2, R15	1M (2 off)	R12	20k
R5, R19	2k (2 off) (see text about R19)	R14	47k
R6, R16, R17	4k7 (3 off)	R18	100k
R7, R8, R11	1k (3 off)		

All 0.25W 5% carbon film or better.

Potentiometers

VR1	10k sub-min. round preset (see text)
VR2	100k log. rotary panel mounting
VR3	1k sub-min. round preset (see text)
VR4	10k lin. rotary panel mounting

See SHOP TALK Page

Capacitors

C1, C2, C6	100n polyester (3 off)
C3, C7	1µ radial elect. 63V (2 off)
C4, C5	22µ radial elect. 16V (2 off)

Semiconductors

D1, D2	1N4148 signal diode (2 off)
IC1	LM13600 dual transconductance op.amp
IC2	324 quad op.amp
IC3	78L05 +100mA voltage regulator (see text)

Miscellaneous

SK1	3·5mm mono switched jack socket
SK2, SK3	0·25 inch plastic stereo jack socket (2 off)
MIC1	Microphone insert, one kilohm (see text)

Printed circuit board available from the *EPE PCB Service*, code 889 (Preamp); 14-pin d.i.l. socket; 16-pin d.i.l. socket; knob (2 off); terminal pins; connecting wire; solder, etc.

FILTER

Resistors

R20	2k (see text)	R25 to R27, R30, R31, R34, R38 to R41	1k (10 off)
R21	20k	R32	220k
R22 to R24, R28, R29, R33, R35	100k (7 off)	R36, R37	4k7 (2 off)

All 0.25W 5% carbon film or better.

Potentiometer

VR5	1k sub-min. round preset (see text)

Capacitors

C8, C9, C11, C14, C15	1µ radial elect. 63V (5 off)
C10, C13	470p polystyrene (2 off)
C12, C16	22µ radial elect. 16V (2 off)

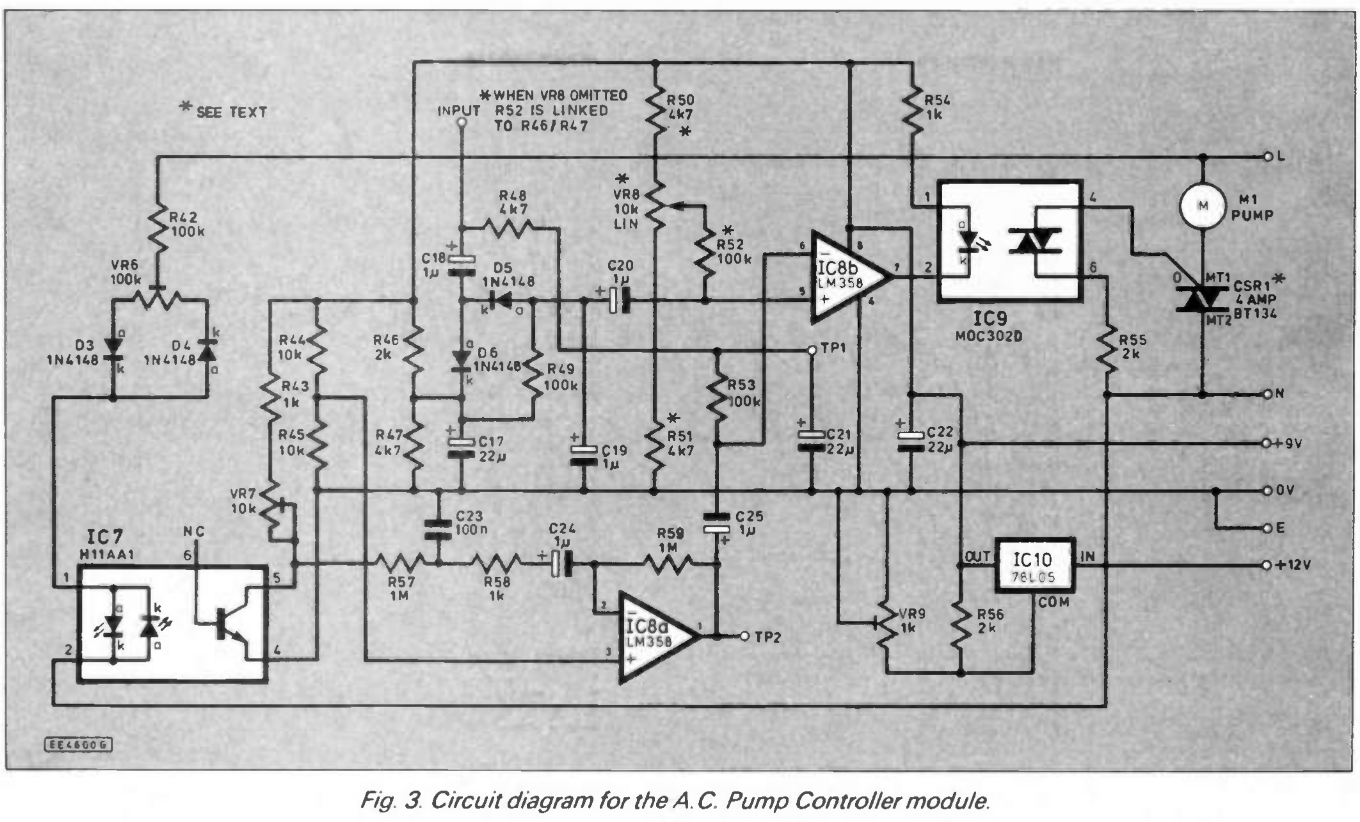


Fig. 3. Circuit diagram for the A.C. Pump Controller module.

Semiconductors

IC4	78L05 +5V 100mA voltage regulator (see text)
IC5	LM358 dual op.amp
IC6	LM13600 dual transconductance op.amp

Miscellaneous

SK5 to SK7 0·25inch plastic stereo jack socket (3 off)
Printed circuit board available from the *EPE PCB Service,* code 891; 8 pin d.i.l. socket; 16 pin d.i.l. socket; terminal pins; connecting wire; solder, wire, etc.

PUMP CONTROLLER

Resistors

R42, R49, R52, R53	100k (4 off)	R46, R55, R56	2k (3 off)
R43, R54	1k (2 off)	R47, R48	4k7 (2 off)
R44, R45	10k (2 off)	R50, R51	4k7 (2 off) (see text)

All 0·25W 5% carbon film or better.

Potentiometers

VR6	100k sub-min. round preset
VR7	10k sub-min. round preset
VR8	10k rotary panel mounting (see text)
VR9	1k sub-min round preset

Capacitors

C17, C21, C22	22µ radial elect. 16V (3 off)
C18 to C20, C24, C25	1µ radial elect. 63V (5 off)
C23	100n polyester

Semiconductors

D3 to D6	1N4148 signal diode (4 off)
IC7	H11AA1 a.c. controlled opto-isolator, transistor output
IC8	LM356 dual op.amp
IC9	MOC3020 d.c. controlled opto-isolator, triac output
IC10	78L05 +5V 100mA voltage regulator
CSR1	4A 600V triac, e.g. BT134, BT136 etc.

Miscellaneous

Printed circuit board available from *EPE PCB Service,* code 890; 6-pin d.i.l. socket (2 off); 8-pin d.i.l. socket, TB1 8-way (or 2 x 4-way) p.c.b. mounting mains rated terminal socket, 0·2 inch pitch; knob for VR8; terminal pins; connecting wire; solder, etc.

diodes D3 and D4 respectively. Both rectified signals trigger the output of IC7, resulting in a somewhat spiky 100Hz waveform whose basic amplitude is set by preset VR7. The signal is reshaped more closely to that of a sinewave by the action of R57 and C23, and is then amplified by IC8a.

From IC8a the 100Hz signal is coupled to one input of comparator IC8b via C25. The output of IC8b controls IC9 by switching its isolating l.e.d. on and off. The point in the mains a.c. cycle at which IC9 triggers the triac is determined by the relative levels on both inputs of IC8b.

The output signal from either the Preamp or the Filter is brought into the pump controller at the junction of resistor R48 and capacitor C18. The signal contains the audio waveform and a controlling d.c. bias level.

An additional bias control is provided by potentiometer VR8. When the Preamp is housed in the same box as the Pump Controller, VR8, R50 and R51 are omitted, and resistor R52 is connected to the reference line (R46/R47).

The d.c. bias level from the Preamp is added to the 100Hz signal at IC8b pin 6, via R48 and R53. Capacitor C21 removes the a.c. audio signal from the bias level.

Capacitor C18 passes the audio signal to the diode-pump circuit consisting of D5, D6, R49 and C19. This circuit removes the higher signal frequencies whilst retaining the low frequency amplitude envelope waveform. The envelope waveform at C19 is then coupled to the second input of IC8b.

It is the relationship of the three signal levels, d.c. bias, 100Hz and envelope amplitude which determines the trigger thresholds of the comparator, and thus the point at which the pump-controlling triac CSR1 is triggered. The result is that varying music levels cause water to be pumped through the fountain nozzles at correspondingly different pressures, so changing their jet spray heights.

The d.c. power for the Pump Controller is regulated down from the 12V power supply level to 9V by IC10, R56 and VR9.

FILTER

So far, the active pump controlling signal has been derived from the full frequency range of the audio signal, as set by the tone controls of the *original* audio source. The purpose of the Filter is to split that signal into three frequency ranges, *High, Middle* and *Low*, each of which can control its own pump.

The Filter circuit diagram is shown in Fig. 4. The audio signal is brought into op.amp IC5 via capacitor C8 and is processed by the complex feedback circuit around the dual TCA IC6.

The frequency range which appears at the circuit's three outputs is determined by the current flowing into the control nodes at IC6a pin 16 and IC6c pin 1, and by the value of capacitors C10 and C13. For this fountains control design, the filter's central frequency has been fixed by the value of resistor R32. An external control signal, however, could be applied via R33 (Scan

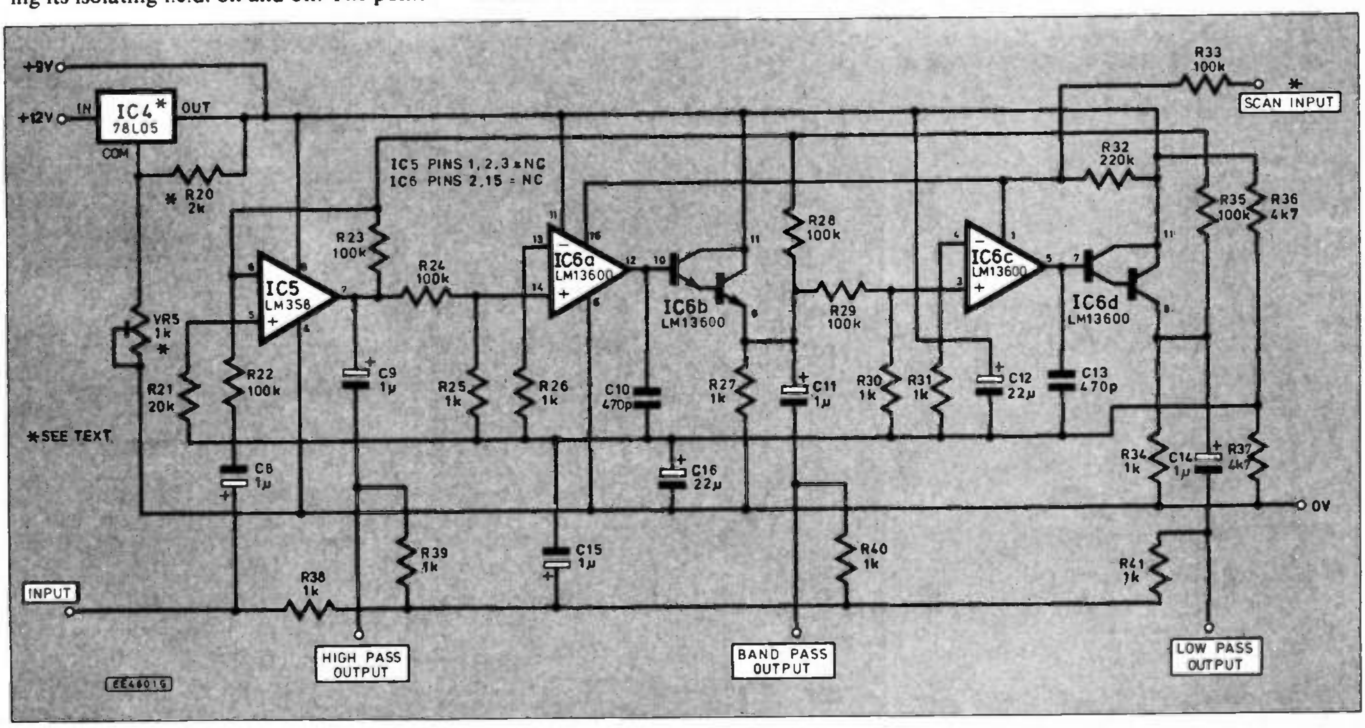


Fig. 4. Circuit diagram for the Filter module.

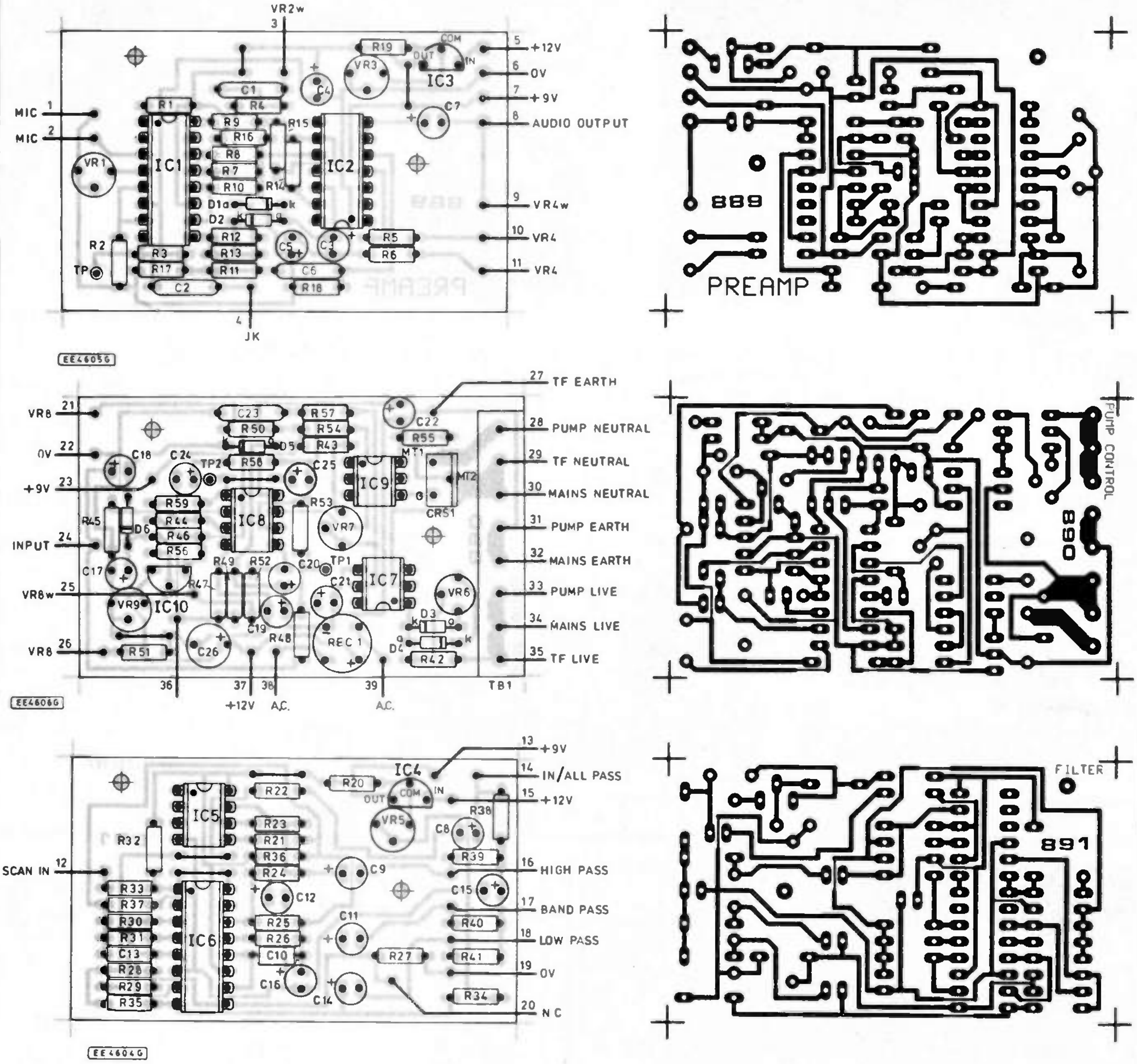
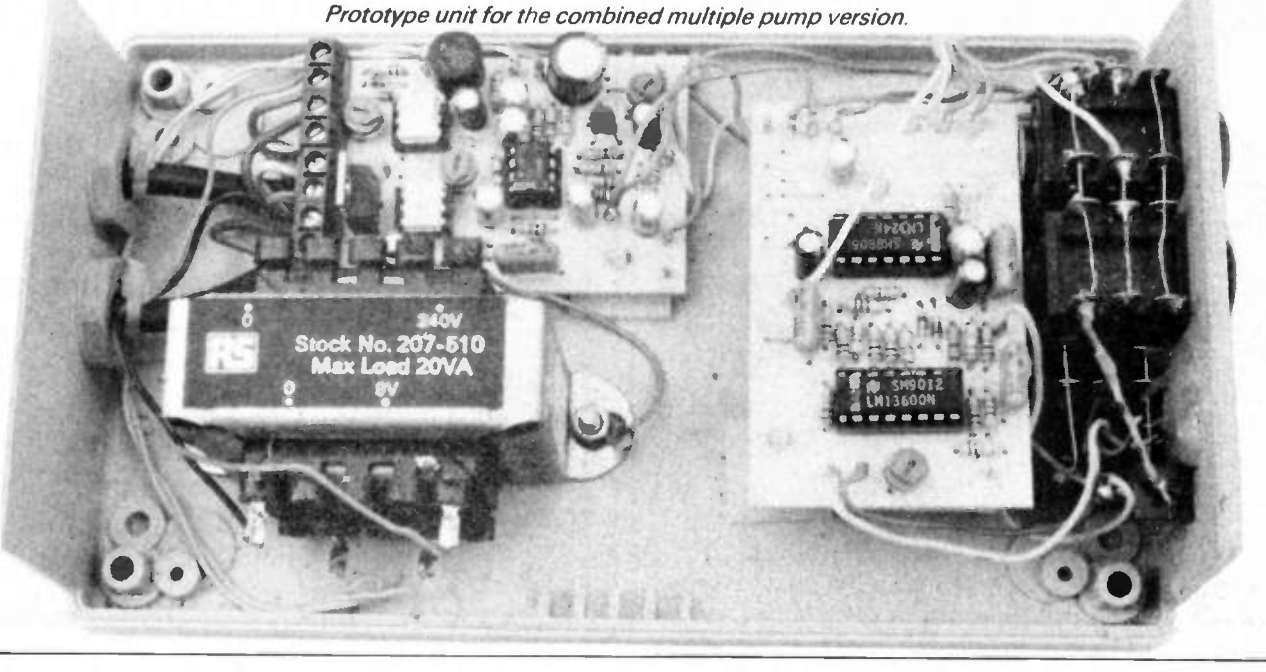
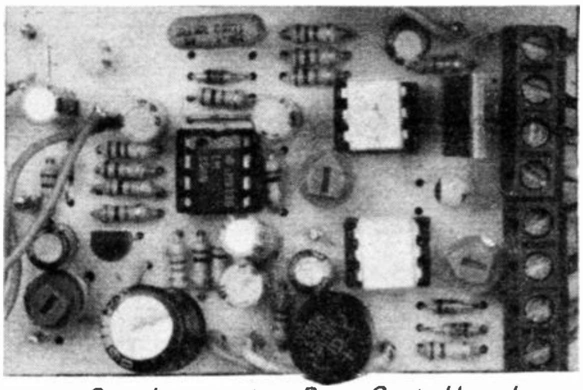


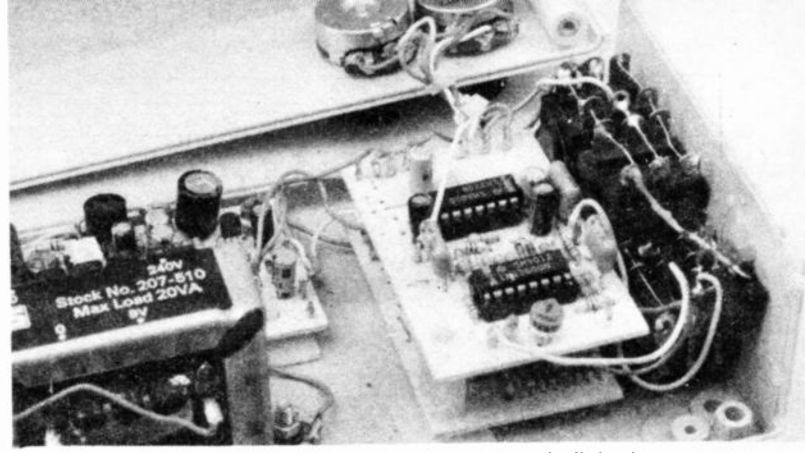
Fig. 6. Printed circuit board component layouts and full size copper foil master patterns for the Preamp, Pump Controller and Filter.

Prototype unit for the combined multiple pump version.





Complete prototype Pump Control board.



Stacking the Preamp and Filter boards so they will fit in the case.

Input), from a signal generator for example, although I shall not discuss that here.

As with the previous two circuits, the filter's power line can be regulated down from 12V to 9V, by IC4, R20 and VR5. These components are omitted when the Filter is housed in the same box as a Pump Controller, the latter supplying 9V directly to the Filter.

It is intended that the input signal to the Filter should originate from the Preamp circuit. However, if a capacitor of, say, 22µF were to be included in the input line, the Filter could be driven directly from the high level output of an ordinary audio system.

MAINS POWER SUPPLY

A suitable simple mains driven power supply which produces an output of about 12V d.c. is shown in Fig. 5. The 9V a.c. output of the transformer is full-wave bridge-rectified by REC1 and smoothed by capacitor C26. The rectifier and capacitor are mounted on the Pump Controller board.

If more than one controller board is used, only the one in the main controlling box needs the power supply components. The d.c. output from that board supplies power to *all* other function boards, except for the optional PC-compatible Interface board described next month.

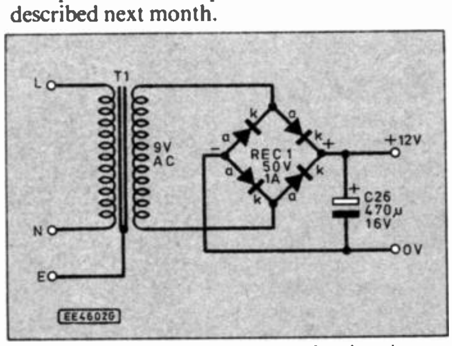


Fig. 5. Mains power supply circuit.

ASSEMBLY

The printed circuit board (p.c.b.) topside component layouts and full size copper foil master patterns for the Preamp, Filter and Pump Controller are shown in Fig. 6. These boards ae available from the *EPE PCB Service*, code 889 (Preamp), 890 (Pump Con.) and 891 (Filter).

The boards have been designed for compactness and for stacked mounting inside the boxes where required. Components may be assembled in any order you find most convenient.

The on-board links can be made using resistor off-cut wires. It is recommended that terminal pins are used for all interwiring points, except for the mains power points 28 to 35 for which a screw-terminal block TB1 is used.

Next Month: Final wiring and a PC-Compatible Interface.

CHARGED UP

KEN LEE

Don't get overcharged when you need to replace the clock back up battery in your computer.

I AM not an avid computer user so during the summer months when I prefer the great outdoors the monster only gets switched on when it is absolutely necessary. On the occasion when this did happen recently I saw that the time was way out, more than usual that is, as this computer has always run slow since it was new, the time always appears on boot up as I have added this instruction to the prompt line.

I set this time right and thought I had better check the date and to my horror this was weeks out, this could only mean one thing, the internal battery was running out of energy. After the short session I switched off and removed the mighty cover and with my trusty digital voltmeter checked the battery voltage. It was 3·64V, about half of what it should be. The next day with £5 in my pocket, I cycled the four miles into town to the local computer shop to purchase a new battery.

SERIOUS BUSINESS

"We have the very thing you want" said the shop keeper, "And what is more it is your lucky day, we have just reduced the price from £32 to £23, plus VAT of course". I felt sick and weak at the knees at the same time, because being out of work for a couple of years, £27.03 is a lot of money for a six volt battery, and raises the serious question can I afford to go on running a computer.

"That's ludicrous" I said, "Think yourself lucky you do not require a battery for a Cannon printer, that's £59 plus VAT", he said pointing to what looked like a black plastic drain pipe hanging in a plastic bag on the wall. Funny I thought, I don't remember seeing that in the test reports. On my way home I thought the affordable way out was to replace the "High Energy Lithium Battery" as it was called with standard alkaline cells.

The next day I cycled back into town and purchased a battery holder for four AA cells for 69 pence and four AA cells for £1.99, making a total of £2.68, saving £24.35!

CELL TALK

Let me put reader's minds at rest before they reach for their pens by looking at the lithium cell. This cell has two points in its favour, they are: (a) The power/size/weight ratio, which is fine for wrist watches but there is enough space inside my box for a dozen D cells, (b) six to 10 year shelf life because of their low internal leakage, which is fine for manufacturers and shop keepers as they should turn over their stock in six years even in a recession! Do not confuse shelf life with battery life in use. The big disadvantage is cost, which some manufactures have enhanced with their "specials" making it even more costly.

Now lets look at useable battery life, cell manufacturers call this Voltage Capacity and it is measured in milliamp hours, so if a battery is quoted as 1000mAH and your apparatus draws 1mA then it will run for 1000 hours continuously on average. Remember batteries are a chemical device and as such each cell will vary.

If we now look at the manufacturers' published data for C cells we find the following:

CELL TYPE	VC mAH
Alkaline	*5,000*
NiCad	*2,000*
Lithium	*1,000*

It can now be seen that as far as usable battery life is concerned, lithium is at the bottom so why fit lithium in the first place? Unless you have got a space/weight/size problem there is no need at all.

REPLACEMENT

The original battery supplied was a white plastic box that measured 60 × 40 × 20mm, a black and red twisted pair of wires and a 4-way p.c.b. socket. I decided to open it up and see just what I would have got for my £27.03. Inside there were two AA size lithium batteries and a 47kΩ resistor in series with the positive lead, which I did not expect. The resistor is a safety component which restrict's the discharge rate if a short circuit develops, due to the small current taken by the computer, the computer does not notice it.

It took very little time to solder the original lead and resistor to the new battery box and install it, replace cover, run set up and I was computing again at a price I could afford.

BENEFITS

It is possible to buy computer type lithium batteries by mail order which only cost around £12 but this is still more than four times my total cost. Also check that the battery in your computer is not fitted with an internal anticharge diode, to prevent the supply trying to charge the battery when the computer is on and the battery voltage is low. If it is fit a similar diode in the supply lead to your battery – a 1N4148 will unfortunately add another 5p or so to the total price!

Battery replacement next time will be easy, AA alkaline cells are sold in lots of places, even on weekends, no special journey to the specialist shop. They will probably not last any longer, even though they have a greater capacity, as the internal leakage of alkaline is slightly greater than lithium.

You may ask why do computer manufacturers not fit alkaline in the first place? I cannot answer that, but what I do know is that if your profit or mark up is 33 per cent then on £3 you make a £1, on £33 you make £11 and it all adds to the great high priest mystique of computing which the computing industry loves to cultivate. Or could it be the VAT man looking for a bigger return? *(Our rather old Apricot computers used for our Subscription Service are fitted with PP3s in the keyboards – nice and cheap and easy! – Ed.).* □

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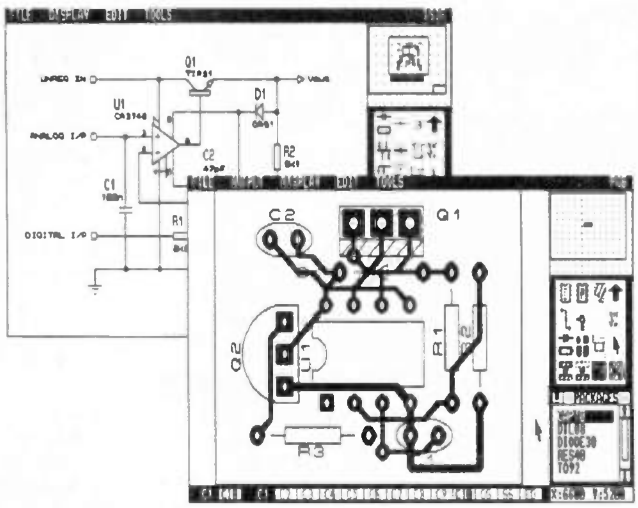

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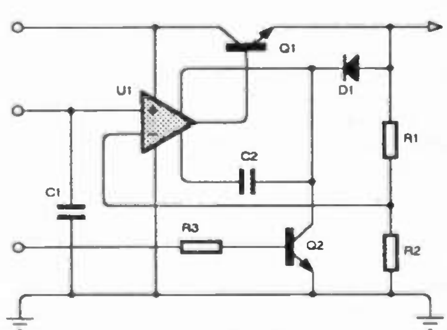

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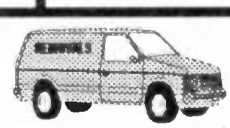

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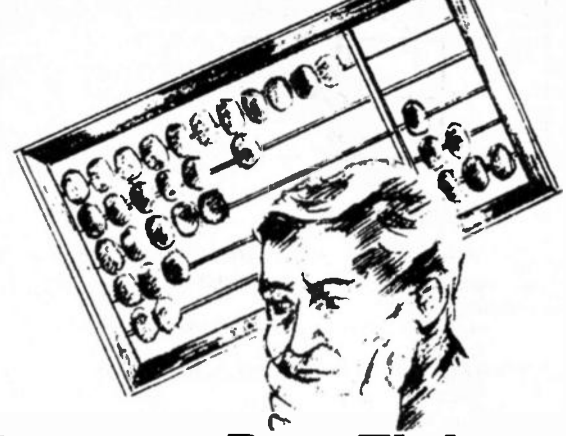

Kirchhoff's Laws

STEVE KNIGHT

Part Eight

This series is designed to help you make your way, at your own pace, through the often imagined fears of mathematics, as this is applied to electronic and electrical engineering matters.

For many of you, the mention of Kirchhoff's laws may arouse some foreboding, but as we will discover these laws are simply generalisations of the ideas developed from the previous parts of this series which greatly assist in the calculation of currents in circuit networks which are rather more complicated than those we have encountered so far.

Kirchhoff's laws are essentially an extension of Ohm's law, which by this stage you should have mastered reasonably well and, as you will see, require only the mathematical ability to solve simple simultaneous equations. Here are the two laws.

THE CURRENT LAW

The current law tells us that at any junction (or node) of conductors in a network, the sum of the currents flowing towards the junction is equal to the sum of the currents flowing away from it.

From the junction shown in Fig. 8.1 we see that three currents, a, b and c are entering and two currents, d and e, are leaving. Then, because there can be no accumulation of charge at any junction, we can write

$$a+b+c=d+e$$

or $$a+b+c-d-e=0$$

This last expression is known as the *algebraic sum* of the currents since account is taken of the signs given to the currents – those entering are taken to be positive and those leaving as negative. So what Kirchhoff's current law is really telling us is that the algebraic sum of the currents meeting at a junction is always zero.

THE VOLTAGE LAW

The voltage law tells us that in any closed loop (or **mesh**) of a network, the algebraic sum of the IR voltage drops around the loop is equal to the algebraic sum of the e.m.f.s acting in the loop.

Interpreting this law is not so grim as it sounds to the newcomer. Look at Fig. 8.2; there is a single source of e.m.f. here, the battery, and the conventional direction in which this e.m.f. is acting is shown by the arrow drawn alongside. There are also three p.d.s or voltage drops present in the circuit, these being the three voltages developed by the passage of current I through resistors R_1, R_2 and R_3, that is IR_1, IR_2 and IR_3 respectively.

Then Kirchhoff simply tells us (going clockwise around the loop) that

$$IR_1+IR_2+IR_3=E$$

or $$IR_1+IR_2+IR_3-E=0$$

The application of Kirchhoff's law is best illustrated by worked example and this we will now do, adding the necessary precautions as we proceed.

WORKED EXAMPLES

1. Use Kirchhoff's current law to find the currents x, y and z, and their directions, in the network branches of Fig. 8.3a.

We have been given three current values and their directions and we have to find the other three. First of all, mark the junction points A, B and C as in Fig. 8.3b. Then starting at junction A we see that a current of 8A is *entering* the junction and that a current of 3A is *leaving* the junction. Hence their difference of 5A must be *leaving* the junction at A and going towards C; hence x = 5A.

Now going to junction C, two currents, x and y are *entering* and 7A is *leaving*; but x = 5A, hence y must be 2A flowing from B towards C.

To complete the story, junction B has 3A *entering* from A and y = 2A *leaving* towards C. Current z must therefore have a value of 1A *leaving* the network from B. Fig 8.3b is now completed.

It is always useful as a working check to ensure that the total current entering the network (8A here at junction A) is equal to the *total* current leaving the network, (1 + 7) = 8A at points B and C.

Notice, incidentally, that the triangle of conductors ABC, forms a loop or mesh which is what we look for when applying Kirchhoff's voltage law.

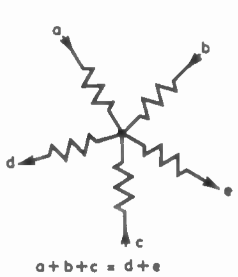

Fig. 8.1. Illustrating Kirchhoff's current law.

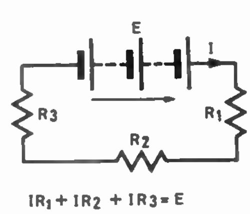

Fig. 8.2. Illustrating Kirchhoff's voltage law.

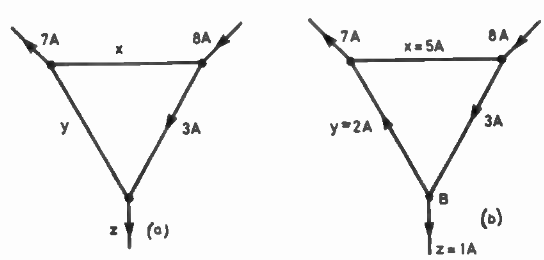

Fig. 8.3. An exercise in the use of the current law.

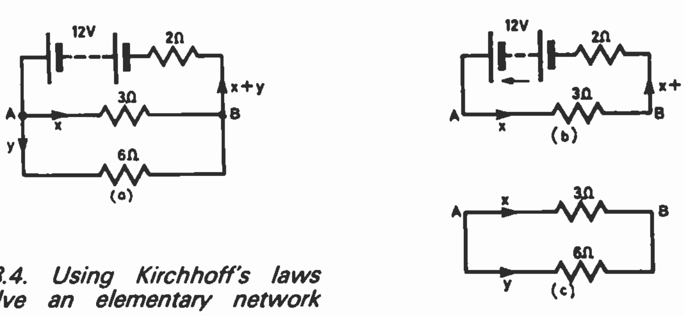

Fig. 8.4. Using Kirchhoff's laws to solve an elementary network problem.

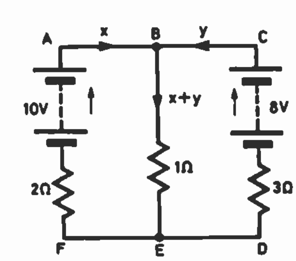

Fig. 8.5. A more difficult network to solve.

2. In Fig. 8.4a find the currents in each branch of the circuit using Kirchhoff's laws.

Now this is a very simple circuit which could be quickly solved by the elementary Ohm's law procedures covered in earlier parts of this series. However, we are here illustrating the application of Kirchhoff; we therefore label up the junction points as A and B in Fig 8.4a and then assign currents (using the current law) to the various branches.

So, for junction A, we let the current flowing in the 3Ω branch be x amperes and the current flowing in the 6Ω branch be y amperes. Then, by Kirchhoff's first law, the current flowing in the battery branch will be $(x+y)$ amperes.

We now have the *three* parallel branches labelled for the currents, but only *two* unknown currents are involved. It is always an advantage to keep the number of unknown currents to a minimum by combination as we have done here, as this reduces the number of final equations which have to be solved.

We now apply the voltage law. There are three possible loops available in this circuit: the upper loop, the lower loop and the "outside" loop. We have to use as many different loops as there are unknown currents, hence two loops must be selected for our purpose. *The solution is totally unaffected by whichever loops we choose.*

Using the upper loop first, then, we derive an equation in the manner shown in Fig. 8.4b, equating the voltage drops to the e.m.f. (if any) in the loop. Going anticlockwise we get

$$3x+2(x+y)=12$$

or $$5x+2y=12\text{........(i)}$$

This gives us one equation relating currents x and y; we need another to solve for both x and y

Using the lower loop this time, as shown in Fig. 8.4c, we start at A and go clockwise, noting that when we do this, the current y in the 6Ω branch is acting in *opposition* to our chosen direction and must therefore be given a negative sign. We then get an equation for the loop

$$3x-6y=0\text{......(ii)}$$

there being no source of e.m.f. within this loop.

Using these two equations, we can find the two unknown currents:

$$5x+2y=12\text{.....(i)}$$

$$3x-6y=0\text{......(ii)}$$

Multiplying (i) by 3 to equalize the y terms

$$15x+6y=36$$

$$3x-6y=0$$

and *adding* these, we have

$$18x=36 \text{ or } x=2 \textbf{ amperes}$$

Substituting this value back into either of the first equations we find

$$y=1 \textbf{ ampere}$$

Summarizing: current in the 3Ω branch $=x=$ **2A**
current in the 6Ω branch $=y=$ **1A**
current in the 2Ω branch $=x+y=$ **3A**

PRECAUTIONS

When applying Kirchhoff's law, the following precautions must be carefully observed at all times: when applying the current law, the choice of current direction is purely arbitrary; if you have chosen the "wrong" direction for your arrowheads, the answer to the current value will turn out to be negative. This simply indicates that the current actually flows in a direction *opposite to your choice;* the actual value obtained is correct.

When applying the voltage law around a loop, whenever your choice of direction round the loop takes you in opposition *either* to a current direction in a resistor path or against the direction of action of an e.m.f. you *must* assign a negative sign to that voltage drop or e.m.f.

The next worked example will illustrate these points. Follow each step carefully and, with a bit of practice, you should be able to apply Kirchhoff's laws with confidence.

3. In the circuit network of Fig. 8.5, find the currents flowing in each branch.

Here we have a more complicated circuit that is not so easily solved using only an Ohm's law approach.

First of all we mark in the directions in which the battery e.m.f.s are acting by arrows drawn alongside; we then use capital letters to mark out the various loops into which the network can be divided. Having done this as the figure shows (and try always to copy this approach), we apply the current law.

We *suppose* that current x flows from point A, current y to flow from point C, and the sum of these, $(x+y)$ to flow along the centre branch from point B. Remember; these allocated directions are arbitrary; do *not* try to work out from an inspection of the circuit which way the currents might *actually* flow, just keep in mind that Kirchhoff's current law *must* be obeyed at any junction. This is of absolute importance.

Now we have two unknown currents to find so we need two independent equations. We get these from any two of the three possible loops available in the circuit.

In loop ABEF the 10V e.m.f. is acting in a clockwise direction, so equating the sum of the IR products to this gives us

$$1(x+y)+2x=10$$

or, collecting up: $3x+y=10$.....(i)

In loop BEDC the 8V e.m.f. is acting in an anticlockwise direction, so going round the loop in this direction gives us

$$1(x+y)+3y=8$$

or, collecting up: $x+4y=8$......(ii)

This gives us the two independent equations we need to find currents x and y, and then, of course, the third current $(x+y)$. Multiplying equation (ii) by 3 and subtracting equation (i) gives us $11y=14$ so that

$$y=\frac{14}{11} \text{ or } \textbf{1·28 amperes}$$

Substituting this value back into equation (ii) gives us

$$x+4\left[\frac{14}{11}\right]=8$$

from which we find $x=\frac{32}{11}$ or **2·91 amperes**

The current in the centre branch $=(x+y)=$ **4·19 amperes.**

As all these results have a positive sign, our choice of current directions was correct.

We could of course have used the outer loop ACDF for one of our equations; check for yourself that the equation for this outer loop will be $2x-3y=2$ and that this, used with either of the other loop equations, still provides us with the same solutions.

6. Suppose, as an experimenter, you want to supply a current of 1A to a 2Ω load resistor. You have a potentiometer of total track resistance 16Ω and a heavy duty d.c. supply of 12V.

You accordingly hook up the circuit of Fig. 8.6a so that you can adjust the sliding contact of the potentiometer to provide the 1A

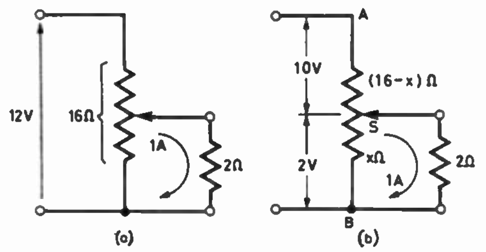

Fig. 8.6. A problem with the adjustment of a potentiometer to provide a given output.

current in the 2Ω load. Unhappily, you have no ammeter to hand to measure this current; whereabouts along the track would you set the slider so that you could feel certain that your required condition was satisfied? (Take it that the scale of the potentiometer is marked off in 1Ω steps).

Well, here's another nice mess we've got ourselves into, as Mr Hardy might say. Let us draw a circuit diagram of the situation, and this has been done in Fig. 8.6b.

A current of 1A will be flowing through the 2Ω load resistor, so the voltage drop across this resistor will be 2V. This voltage must also be present across the points SB of the potentiometer, hence the voltage across AS must be $(12-2) = 10V$.

If now we call the lower portion of the potentiometer $x\Omega$, the upper portion must be $(16-x)\Omega$. All this information has been marked in on Fig. 8.6b. We now need to find the value of x so that we can determine the position of the sliding contact along the potentiometer track.

Kirchhoff's current law will come to our assistance. Applying the law to point S, then:

Current entering the junction = current flowing in AS

$$= \frac{10}{16-x}\text{A}$$

Current leaving the junction = current in SB + current in the load

$$= \frac{2}{x} + 1 = \frac{2+x}{x}\text{A}$$

These currents must be equal and so we have

$$\frac{10}{16-x} = \frac{2+x}{x}$$

Cross multiplying $10x = (16-x)(2+x)$

or $10x = 32 + 14x - x^2$

Rearranging the terms we get a quadratic

$$x^2 - 4x - 32 = 0$$

which factorizes into $(x-8)(x+4) = 0$

Hence $x = 8\Omega$ or -4Ω. We can ignore the negative result here, consequently the sliding contact must be set **half-way** along the track.

This example is a good illustration of how the output of a potentiometer is *not* proportional to the position of the slider when the load resistance is small in relation to the total track resistance. Here, setting the slider to the mid-way position on the track does not give us half the input voltage, but something considerably less i.e. the 2V that we actually desired. You will find a reference to this effect on your first wallchart (given free with the March '94 issue).

Throughout this month's work I have emphasised the necessity to draw a carefully labelled diagram for each problem. In many examinations, problems are presented in word form, no diagram being given. So it is vital, if you are entering for any examinations (and if you are not as well!) be able correctly to interpret the wording into a neat diagram.

It is difficult to put over the applications of Kirchhoff's laws in a short article such as this, but I hope it contains enough information to enable any of you who have never tackled the laws before to get a working insight into them, and for those who have already met them, to consolidate and possibly clarify what you already know.

Now attempt the following self-assessment problems.

1. Two currents, x and y, in a certain network, lead to the following equations when Kirchhoff is applied. Find x and y.

$$2x + y = 2{\cdot}5$$
$$x + 2y = 3{\cdot}5$$

2. In the circuit of Fig. 8.7 find the currents in each branch and the current supplied by the battery. What is the p.d. between the points A and B? (Use Kirchhoff).

3. Find the current in each of the resistors shown in Fig. 8.8.

4. Find the current in the 2Ω resistor for the circuit of Fig. 8.9. What current does the 8V battery supply?

5. When resistance R in the circuit of Fig. 8.10 equals 8Ω, the ammeter reads 0.8A. What will it read when R = 2Ω? (Hint: find the ammeter resistance first).

6. Find the currents in each of the branches of the circuit of Fig. 8.5 if the 8V battery is reversed in polarity.

Last month's answers

1. (a) 4dB, (b) 10·8dB, (c) 20db, (d) 27·8dB. **2.** −23·5dB. **3.** (a) 100W, (b) 1mV. **4.** 8·16dB. **5.** 0·2V, 9·54dB. **6.** 26dB, 104dB. **7.** Approx 50Hz to 10kHz. **8.** True.

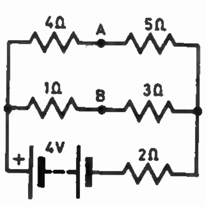

Fig. 8.7. Circuit for Problem 2.

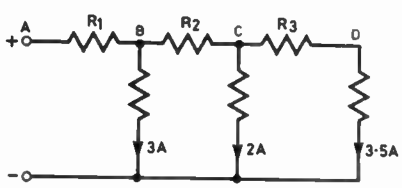

Fig. 8.8. Circuit for Problem 3.

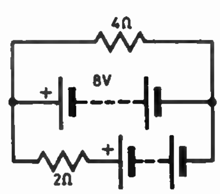

Fig. 8.9. Circuit for Problem 4.

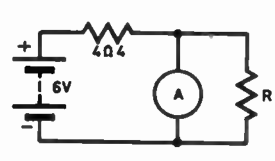

Fig. 8.10. Circuit for Problem 5.

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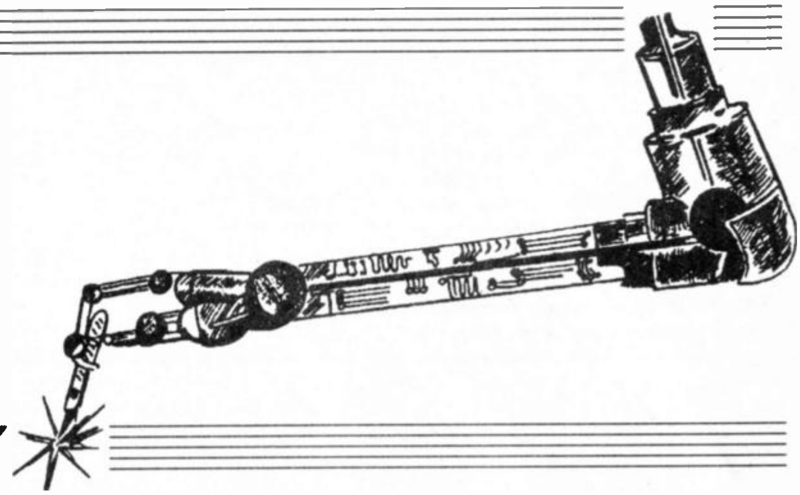


ALAN WINSTANLEY

Our monthly round-up of constructors' questions and suggestions this month includes a small selection of readers' own circuit ideas, also more information on capacitor identification and a battery back-up for boat owners.

Marine Battery Back-up

We covered the topic of power back-up systems in some depth in earlier *Circuit Surgery* articles, illustrating various ways of using custom-made chips such as the MAX 8211 and the 7673. A boat-owner himself, ***Mr. G.M.C. Taylor*** from Worcestershire asks a question relating to one of these specialised integrated circuits.

My requirement is to provide a back-up for the Decca and GPS navigators which require 10V to 15V d.c. at about one amp. At present they are operated from the 12V services battery with manual change-over to the starting battery, but I'd prefer a system of automatic changeover to a "dedicated" Ni-Cad battery.

Mr. Taylor pointed the way in his letter by referring to the 7673 device (see *Circuit Surgery*, April 1994). This 8-pin d.i.l. device monitors two power supply input voltages (V_{pri} and V_{sec}) and automatically switches its output pin (V_o) to the highest supply, behaving as a super-fast (50µS) break-before-make change-over switch. It will cope with up to 15V d.c. supplies (18V absolute maximum) and will drive loads in the low tens of milliamps directly. It's possible to make the secondary battery a rechargeable nickel-cadmium (Ni-Cad) and have this constantly trickle-charging, as shown in April's issue. By adding a pair of external *pnp* pass transistors, the chip can be made to drive higher loads.

A suggested circuit for a battery back-up system is shown in Fig. 1. This circuit is intended as a starting point for readers to experiment with "in the field". As always, any readers' feedback or experiences are welcome. R1 and D1 provide a trickle charge current for the back-up battery. Without a doubt, it is worth shopping on the surplus market for a source of cheap Ni-Cads. Eight cells are required in series to obtain a 10V d.c. back up (the minimum level specified), and buy the largest capacity cells you can afford. They **must not be paralleled** in an attempt to increase capacity.

Resistor R1 is selected for a trickle current of say C/10 to C/50, where C is the total battery capacity in Ampere-Hours. If the primary supply is a nominal 12V, assume a voltage drop of 2V across the resistor and calculate the trickle current flowing through it. For example, a series connection of eight 2AH cells would provide 10V which assuming a trickle of C/50 suggests a series resistor of 50 ohms (2V/40mA).

The two transistors could be Darlington types such as the BDX34B, rated at a very conservative 10A with an hFE of 750. They shouldn't need a heatsink. Once again, I emphasise that this is a *suggested circuit only* but it is very simple and will hopefully operate a complex load without any problems.

Capacitor Markings

In May's *Circuit Surgery* we looked at capacitor nomenclature and the unusual markings which appear on some types of capacitor. ***Mr. W. Carter*** of Holmfirth, Yorkshire followed up on that "unidentifiable capacitor" shown in May's issue (Fig. 1d). He advises that it's actually a 300pF ±5% 100V working voltage type – so I was wrong on that one! Mr. Carter also kindly sent me an example of a 5·6pF ceramic "NP0" type. I am especially indebted to ***Mr. B.J. Taylor*** of Rickmansworth who supplied exhaustive data on these capacitor types and fully identified that cap. Mr. Taylor says:

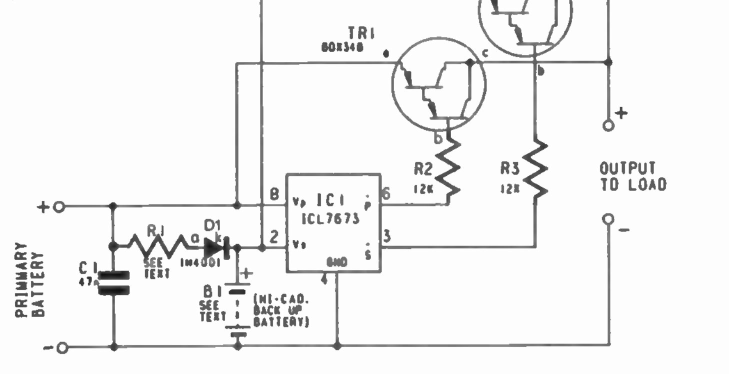
Regarding Mr. Key's mysterious capacitor, I would expect this to be a 300pF ±5%, 100V maximum working voltage, with a negative temperature co-efficient of minus 750 parts per million per degree Celsius, which is what "N750" indicates. At one time it was jolly useful to specify a capacitor's tempco. to cancel out tuning drift in home-made FM tuners without AFC circuits – these tended to drift when the cabinet became warm! Sometimes a coloured band on the body of a ceramic is used to indicate the temperature co-efficient as follows:

Black	*NP0 (i.e. zero tempco.)*		
Brown	*N030*		
Red	*N080*	Blue	N470
Orange	*N150*	Violet	N750
Yellow	*N220*	Grey	P030
Green	*N330*	White	P100

The figures equate to p.p.m. per degree Celsius and "N" represents a negative and "P" a positive co-efficient. Note the "NP0" mark which equates to a zero temperature co-efficient.

Apart from the NP0 group, there are other variants, too – such as the X7R and Z5U classes which trade off stability against the size of the capacitor body, and although these aren't often listed in a retailer's catalogues, the right type is important if you're involved with miniature surface-mount boards where you

Fig. 1. Marine Battery Back-up circuit.



might be forced to compromise between temperature stability and physical size.

Spoilt for choice

It can be quite a job to decide what sort of capacitor to pick for a particular application, but unless you have a particularly demanding requirement, generally the choice boils down to a small number of varieties which are readily available from all the usual sources. Capacitors are classified by their *dielectric material*, i.e. the material which is used to separate and insulate the two capacitor plates. Different dielectrics give rise to particular characteristics which can affect the performance of the circuit. ***Mr. Kenneth Yeo*** of Glasgow asked for help in this respect:

I started my practical interest in electronics by buying some mixed capacitor packs, but even with the help of catalogues, I find the various types confusing with respect to their specific applications. Could you help me to sort them out?

Table 1 below summarises the readily available types we see so often in our projects.

Table 1. Capacitor Selector.

Dielectric Material	Typical Range	Typical Tolerance	Leakage	Typical Applications
Ceramic	1pF - 0.47µF	-20% to +80%	Average	RF, decoupling
Electrolytic	100nF - 470,000µF (!)	-20% to +50% or worse	Very poor	PSU smoothing, decoupling, timers.
Polycarbonate	100pF - 10nF	10%	Good	High stability decoupling, filters and timers.
Polyester	1nF - 1µF	5 to 20%	Good	General purpose
Polypropylene	100pF - 47nF	1 to 20%	Very good	High stability, high voltage, filters, tuned circuits etc.
Polystyrene	10pF - 33nF	1 to 5%	Excellent	Low loss, high stability, filters, tuned circuits.
Silver Mica	3.3pF - 4.7nF	1% typical	Very good	High stability, RF, filters.
Tantalum Bead	100nF - 100µF	±20%	Poor	Timers, PSU decoupling. Compact.

You will find that an EPE project designer will specify any critical factors concerning any particular capacitors, in the constructional article itself. Also, we always include any extra buying information in our monthly *Shop Talk* column. This will indicate any part numbers, sources and other essential data where any unusual components may be called for. You should check the Components List closely in addition, just to be certain.

Ahoy Landlubbers!

Some interesting correspondence ensued following my simple Bilge Pump Controller project (June issue). ***Mr. David Dewey*** of Bovingdon, Herts, had a similar sort of problem with a "water still" pump controller some year ago. He suggests:

My solution used a pressure switch from an old washing machine. These are used to control the water fill level and are available from junk yards. I used an upturned funnel connected by a length of rubber tube to the pressure switch. As the water level gradually rises, the air in the funnel is compressed into the level switch, until the switch turns off the still – or it could operate a bilge pump directly. The solution was so simple that I recommend it to anyone wishing to control virtually any liquid.

A brilliant example of lateral thinking, if I may say so! ***Mr. R. Chatfield*** of Reading went further, suggesting a variety of home-spun improvisations which incorporated a cistern ball-cock and float, a brake light switch, alternatively a mercury switch or a car petrol tank float sender unit would have sufficed. Mr. Chatfield suggested that my controller was "needlessly expensive and unnecessarily complex" and also indicated that something like a washing machine level switch was adequate for the job.

Well, Mr. Chatfield, our original enquiry did ask for an electronic solution and no matter how elaborate or complex the original circuit may seem, the design is in electronics terms an extremely simple one. The LM1830N integrated circuit performs a complex function very easily and neatly, and solves many potential troublesome problems at a stroke.

There are often other ways in which constructors can improvise – an essential quality of hobbyists – but an electronic module such as my own Bilge Pump Controller provides a completely reliable, maintenance-free solution with no moving parts (except for a relay). You can also readily tweak the circuit to make it perform exactly as you require – it's the way to go!

Meanwhile, reader ***Alwyn Beck*** over in Rochdale is using the Bilge Pump Controller to help pump drinking water! Well not quite – like many modern caravans, his tourer has a fully submerged 12V electric pump for hot and cold water which can be damaged if the water tank has emptied. The water's necessary to circulate through and cool the pump – so Mr. Beck has used the controller circuit to disconnect the supply before the water level had dropped too far. As an extra refinement, the relay's changeover contacts are used to sound an alarm buzzer: it warns that the 12V supply must be switched off and the tank refilled.

"Illegal" logic

My item on logic bistables (*Circuit Surgery*, May issue) prompted an interesting query from ***Andrew Judge*** of Tadworth, Surrey.

I found your article very clear but have one query – what does it mean when you say that "pressing both switches produces a 'forbidden or indeterminate state'? If both switches are pressed, pins 1 and 5 are grounded (LOW logic). Assume pin 2 is high, pin 3 output will be a logic HIGH, so would output pin 6. Is this only "forbidden" in the sense that it may not be a change from a previous state?

The reason for the "illegality", Andrew, is that in the context of bistables, it is technically impossible to have both outputs at the same logic levels – they must always be mutual opposites.

You're right to point out that this particular circuit, which is constructed from logic gates, will still hang together and the truth tables of the individual gates themselves will still be obeyed if both switches are closed. However, bistables have two outputs, actually designated Q and $\overline{Q}$. Being *complementary* or the opposite of each other, it's impossible for both outputs to have the same level and the logic laws of a bistable to be obeyed. Hence, pressing both switches will produce an "illegal" state in the general context of a logic bistable circuit.

And finally

A small number of readers' ideas are shown below this month. These may help or stimulate thinking but have not been proven by ourselves. Last month we invited your opinions about re-introducing the *Practical Electronics "Ingenuity Unlimited"* feature. Please tell us what you think. We will pay between £10 to £50 for your electronic circuit designs, which must be the readers' own work and not have been published elsewhere. If there is sufficient interest we will be glad to re-instate this popular feature. We look forward to hearing your views.

Readers' Bright Ideas

This month we reproduce a small number of readers' hints and tips. These have not been proven by ourselves but they may stimulate further thought.

Regulator Protection

A dual ±15V power supply is shown in Fig. 2. By adding two rectifiers across each regulator as indicated, extra protection is afforded to them which might save the cost in due course of replacement capacitors or regulators. D1 and D2 protect the i.c.s from C3 and C4 discharge. This is also useful with bench power supplies to avoid the possibility of any capacitors in the load circuit trying to discharge backwards into the regulators when the main power is switched off, when the i.c.s would possibly become reverse biased.

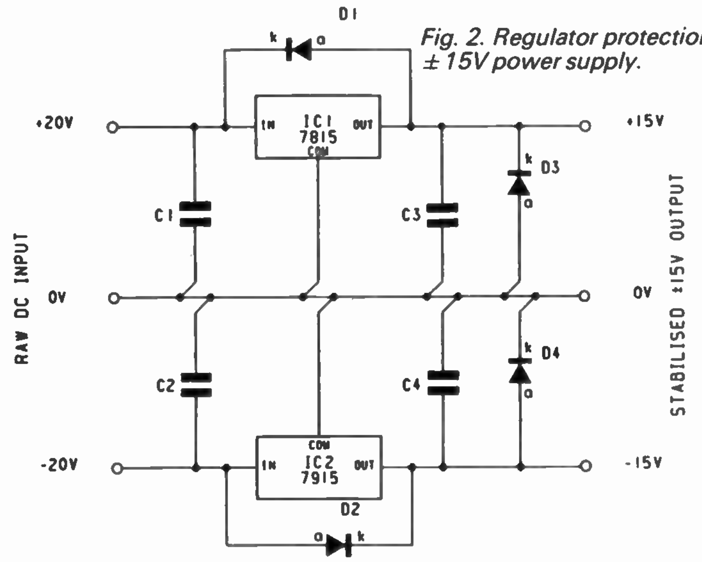


Fig. 2. Regulator protection diodes for ± 15V power supply.

I found that sometimes, the regulators don't "start up" properly, for example the + 15V rail may measure correctly but the negative rail is only − 1V or so. On one occasion a full + 28V appeared on the positive rail and − 2V on the negative rail! The cause might be partly due to unequal current demand on the two rails at switch-on. The two diodes D3 and D4 seemed to cure this, and are well worth the extra 10p. or so. ***Barry Taylor****, Rickmansworth, Herts.*

Car Battery Monitor

A "cheap and cheerful" voltmeter which measures the condition of a 12V car battery, is shown in Fig. 3. A 2V f.s.d. voltmeter monitors the potential between points "A" and "B", starting at zero with a 12V battery, and rising to 2V at 14V d.c., thus the 2V meter scale expands the region of 12V to 14V battery voltage and gives a direct indication of the car battery's condition.

The Zener diodes D1 and D4 form a bridge network. At 12V supply, point "A" is 6·2V and "B" is 6·4V. At 14V input, "B" becomes 8·4V instead, the meter displays roughly 2V. The 2V7 Zener (D2) protects the meter against over-voltage whilst D3 protects against reverse voltages, which will occur below 12V d.c. input. The circuit could be used for boat or caravan batteries too. ***J.P. Brady****, Calstock, Cornwall.*

4017 limit resistors; Polaroid batteries

When using a CMOS 4017 Decade Counter to drive a series of light-emitting diodes, only one series resistor is needed for all ten l.e.d. s because only one output is active at any time, see Fig. 4a. This does not apply to certain circuits such as traffic light sequencers or circuits with "delay off" capacitors for each l.e.d.

A source of "free" power can be derived from the Polaroid Image System film pack which contains a battery, this has some power remaining even when the films have been used, refer to the illustration in Fig. 4b. The battery can be used with a 270 ohm series resistor for testing l.e.d.s and also can be used to power other projects.

The spring metal contacts were cut off the Polaroid pressure device of the film pack and screwed to an insulating base, the battery itself can then be slid under the springs to make electrical contact with the battery terminals. A "flat" battery in shape only! ***R.L.A. Latham****, Weeping Cross, Stafford.*

Circuit Surgery tries to help readers and students who may have encountered problems in electronics. If you have any suggestions for topics to include in this column, or ideas for potential projects – or advice which you think might benefit others – then write to me: Alan Winstanley at *Circuit Surgery*, 6 Church Street, Wimborne, Dorset, BH21 1JH. Please note, I cannot advise on the repair of commercial equipment and whilst I cannot guarantee an individual reply, we do read every letter. Your views count, so write in. See you next month!

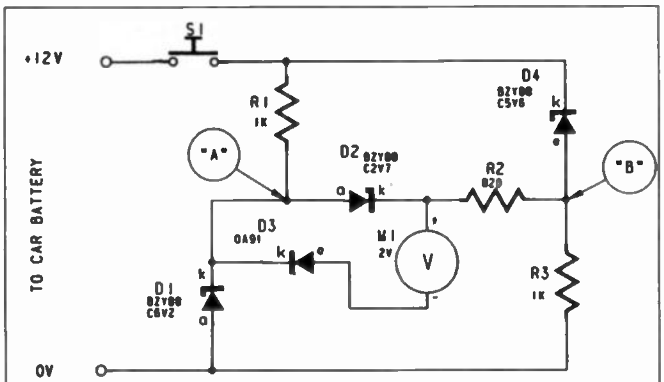


Fig. 3. Car battery monitor circuit.

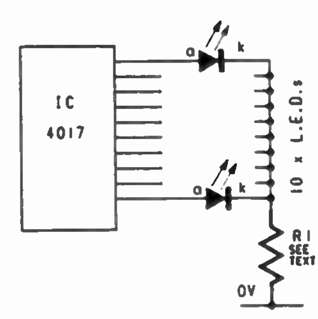


Fig. 4a. Single limiting resistor for 4017.

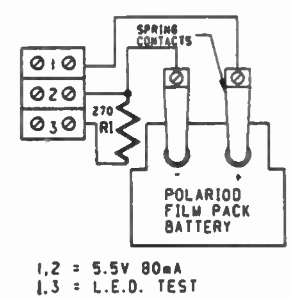
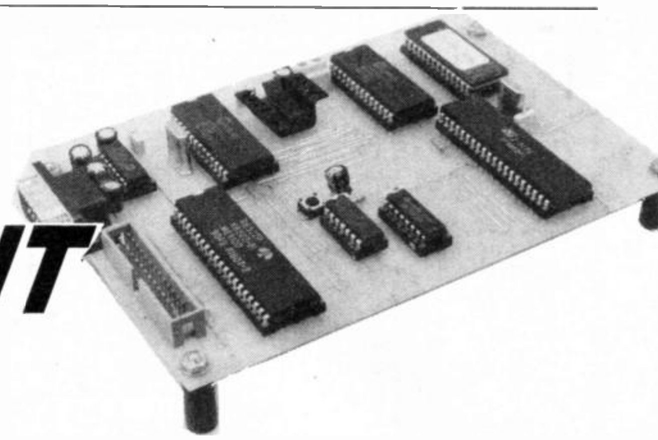


Fig. 4b. Using a Polaroid battery.

Constructional Project

6802 DEVELOPMENT BOARD



RICHARD STONE

A microprocessor development system that employs "Public Domain" and "Shareware" software to provide an inexpensive but practical and versatile unit.

THIS article describes the design and construction of a small microprocessor development board based around the Motorola 6802 eight-bit microprocessor. The article came about as it was perceived that there were a large number of electronics enthusiasts who would like to be able to develop applications using microprocessors who were unable to due to the comparatively high cost of "professional" microprocessor development tools.

This high cost generally precludes the use of such tools to commercial concerns. However, suitable software exists as Public Domain Shareware for the IBM PC and compatibles and the required hardware is fairly simple and hence relatively cheap as well. The development system that is described here is illustrated in Fig. 1, this also shows typical costs of this system compared to a professional system.

SYSTEM FEATURES

The 6802 Development Board has the following hardware and software features:

(1) 6802 microprocessor running at 4MHz.
(2) 6522 Versatile Interface Adaptor (VIA) featuring 20 I/O (input/output) lines and two 16-bit interval timers.
(3) 6551 Asynchronous Interface Adaptor (ACIA) to provide serial communications with the host computer via an RS 232 compatible serial link.
(4) 8K bytes of system ROM containing a monitor program.
(5) 8K bytes of system RAM to contain user program.
(6) The monitor program provides the following functions:

- Inspect/change user memory
- Inspect microprocessor registers
- Download user program from host PC
- Execute user program
- Set/Clear breakpoint in user program

A block diagram of the development board hardware is shown in Fig. 2.

6802 MICROPROCESSOR

The Motorola 6802 is an 8-bit microprocessor which is software compatible with the earlier 6800 microprocessor. It does however feature some enhancements on the hardware side, namely on chip clock generation circuitry and 128 bytes of on chip RAM. These enhancements generally serve to reduce the chip count compared to a 6800 based system which is one of the reasons why the 6802 was chosen.

Although the 6802 is now considered rather "long in the tooth", being first introduced in the late 1970's, it has several features that make it particularly suitable for beginners to learn about microprocessor hardware and software. These include an easy to understand interface to peripheral chips and memory and a simple and flexible machine language. However, readers should note that the 6802 has sufficient processing power to undertake quite complex tasks and is certainly not obsolete.

Any microprocessor of whatever complexity can be described in terms of a hardware timing diagram and a software programmers model. The timing diagram (in conjunction with the data sheet) enables the hardware designer to interface the necessary memory and peripherals in order to realise a working system. The software programmers model is essentially a symbolic representation of the internal microprocessor registers which the programmer must manipulate (using the microprocessor machine language) in order to perform the given task.

The hardware timing diagram for the 6802 microprocessor is shown in Fig. 3 and Fig. 4 is the software programmers model.

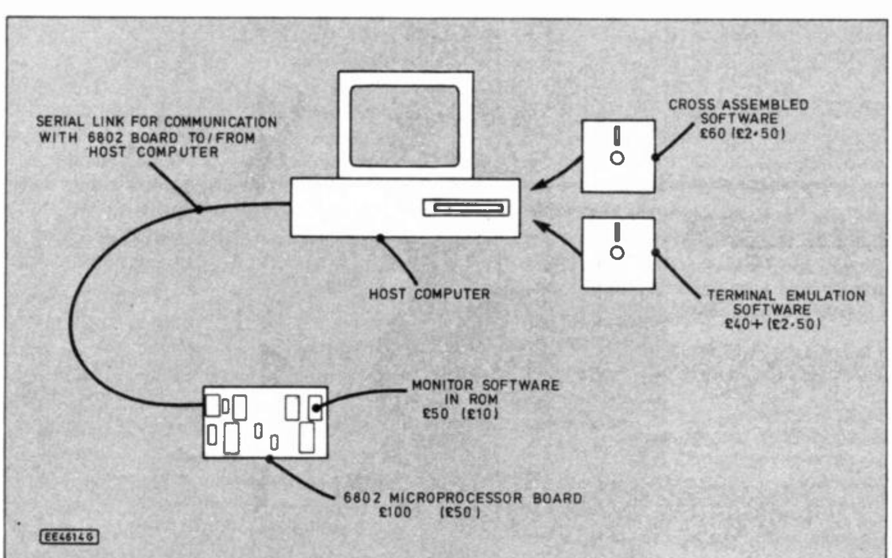


Fig. 1. Comparison of the 6802 Development Board with a professional system.

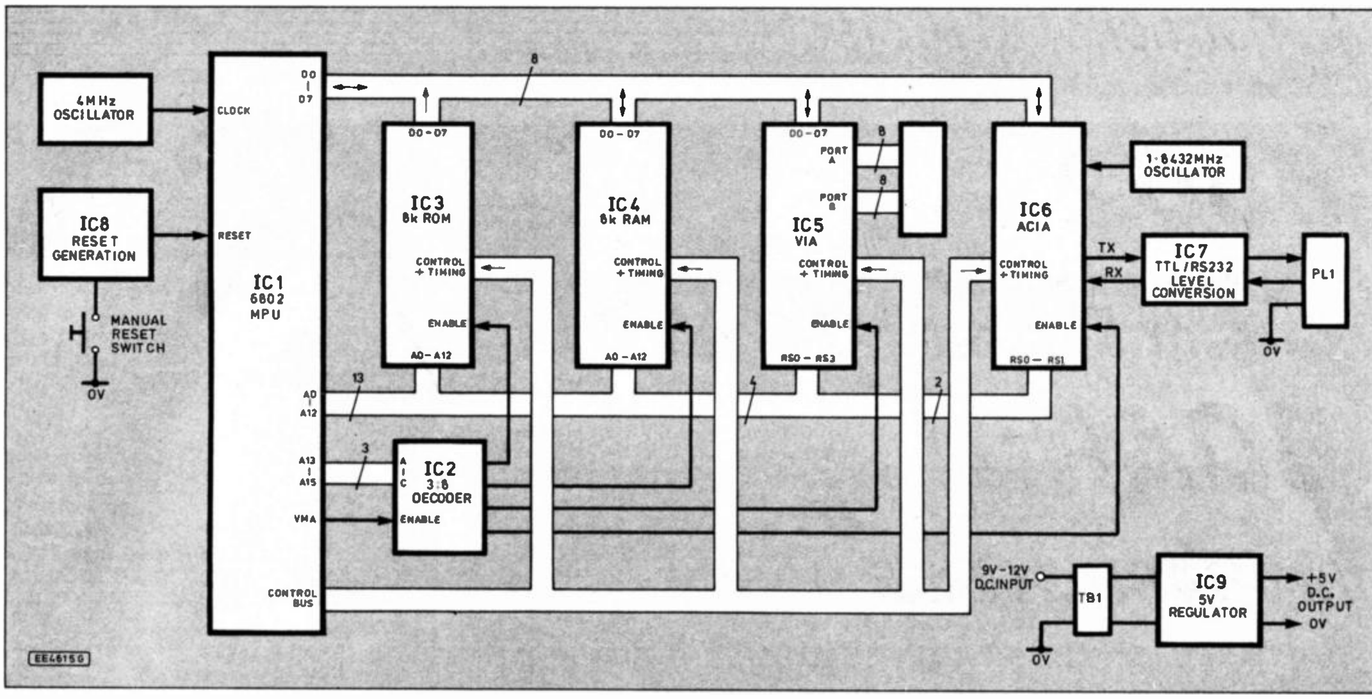


Fig. 2. Block diagram of the 6802 Development Board hardware.

These two diagrams will be referred to in more detail later.

6802 HARDWARE

The hardware design for the 6802 Development system is fairly simple as is most microprocessor based design at this level. The main point of note is that the peripheral chips used in this design (6522 and 6551) were originally intended for use with the Rockwell 6502 series of microprocessors.

This is not a problem as the 6502 and 6802 are termed "bus compatible" which means that the hardware timing diagrams are virtually identical. To have used the Motorola 6800 family peripheral chips would have quite significantly increased the chip count of the design with little or no extra benefit.

The complete circuit diagram for the 6802 Microprocessor Development Board is shown in Fig. 5 and should be referred to whilst reading the following paragraphs.

Address Decoding

The 6802 (IC1) has a 16-bit address bus which means that it can uniquely address any one of 2^{16} (65536 or 64K) byte wide memory locations. However, most memory chips and all peripheral devices intended for use with 8-bit microprocessors have considerably less addressable locations than this and hence it is necessary to divide (or decode) the 64K addressing range of the 6802 into smaller more convenient segments.

This is a very common problem in microprocessor systems design and specific chips are available to perform this task in both the TTL and CMOS logic families. The chip used in this design is a 74LS138 3-line to 8-line decoder (IC2).

The 74LS138 decodes the binary code present at the inputs (A, B and C) and drives one of the outputs ($\overline{Y0}$ to $\overline{Y7}$) logic low, with the non decoded outputs remaining logic high (providing the chip is correctly enabled at the time). In this implementation the select inputs (A, B and C) of IC2 are connected to address lines A13 to A15 of IC1 (pins 23, 24, 25) respectively. This effectively decodes the 64K addressing range of the 6802 into eight 8K segments.

The outputs ($\overline{Y0}$ to $\overline{Y7}$) of IC2 pins 13, 12, 10 and 7 are used to enable or "select" the appropriate memory or peripheral chip when the microprocessor outputs the appropriate address on the address bus. This can be illustrated by means of a "memory map" for the system which is shown in Fig. 6. This shows that the 27C64 EPROM (IC3) occupies the address range E000 to FFFF (hex) and is enabled by the $\overline{Y7}$ output (pin 7) of IC2.

The 6264 RAM (IC4) occupies the address range A000 to BFFF (hex) and is enabled by the $\overline{Y5}$ output (pin 10) of IC2. In a similar fashion the 6522 and 6551 peripheral chips (IC5 and IC6) occupy the address ranges 6000 to 7FFF (hex) and 4000 to 5FFF (hex) and are enabled by the

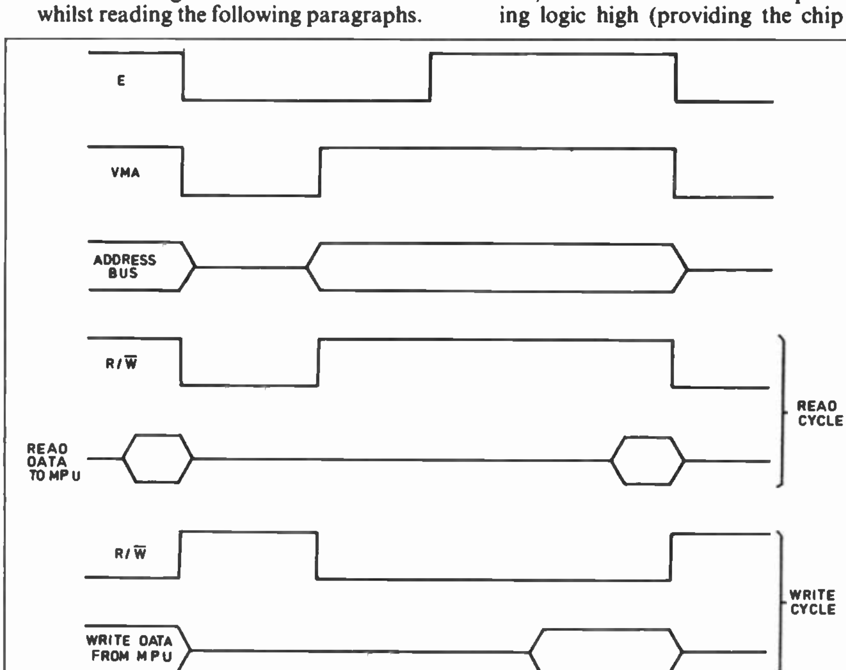


Fig. 3. The hardware timing diagram.

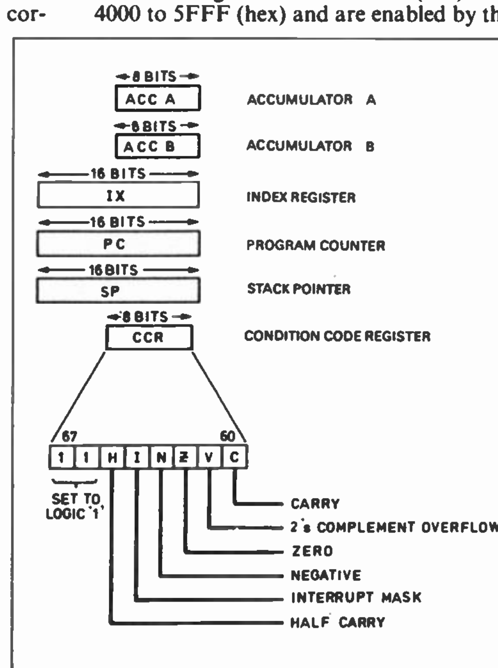


Fig. 4. Software programmers model.

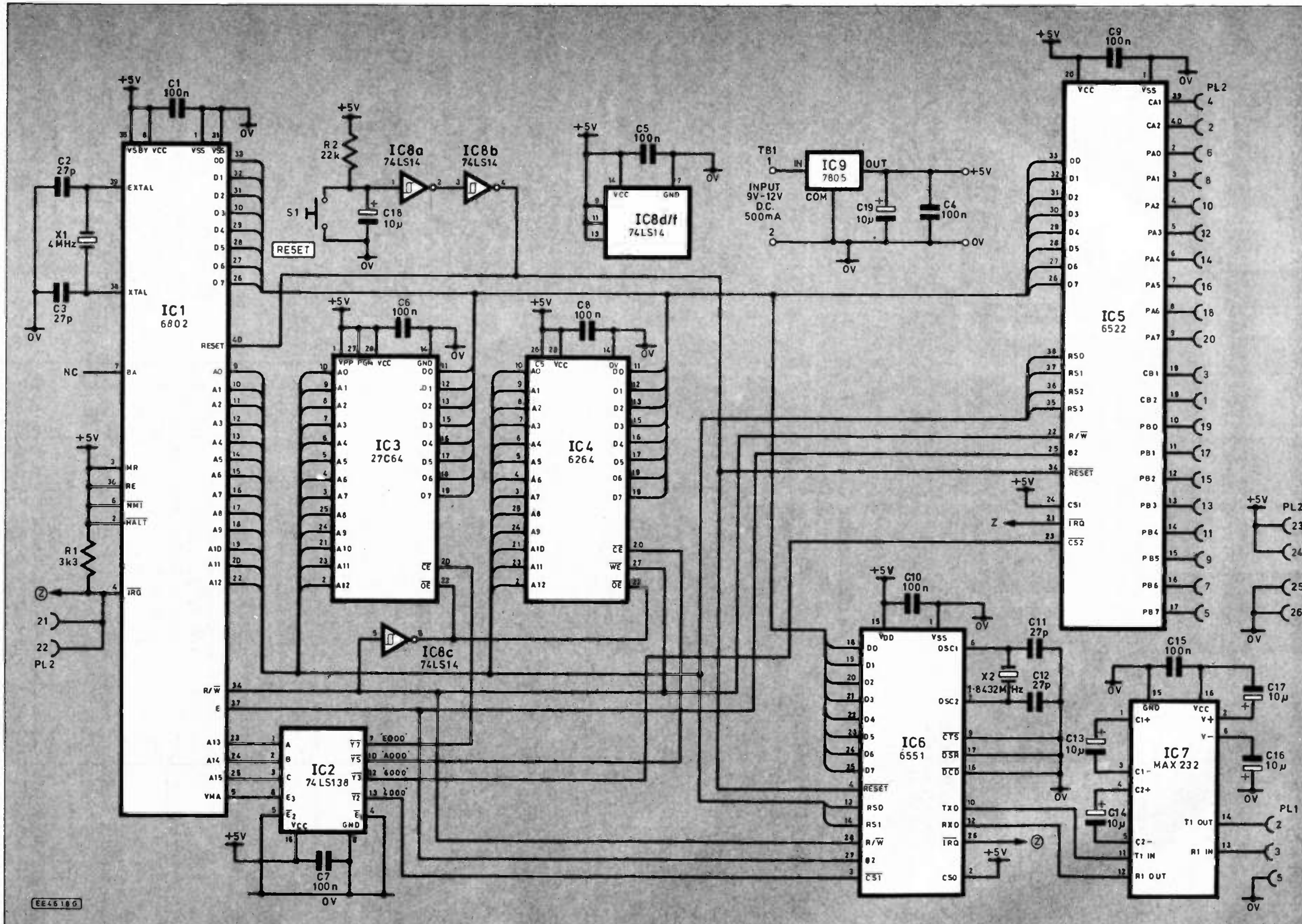


Fig. 5. Complete circuit diagram of the 6802 Development Board.

$\overline{Y3}$ (pin 12) and $\overline{Y2}$ (pin 13) outputs of IC2 respectively.

The 74LS138 IC2 has three enable ($\overline{E1}$, $\overline{E2}$ and $\overline{E3}$) inputs which must all be correctly asserted otherwise all the outputs ($\overline{Y0}$ to $\overline{Y7}$) remain at a logic high level regardless of the input state. Two of these inputs are active low ($\overline{E1}$ and $\overline{E2}$) and these are permanently asserted by connecting them to 0V.

The third input (E3) of IC2 is active high and this is connected to the VMA (Valid Memory Address) output of the 6802. As the name suggests this signal is only active (logic high) when the 6802 (IC1) outputs an address during a memory read or write cycle.

This can be seen by referring to the hardware timing diagram Fig. 3. By enabling the 74LS138 (IC2) in this way it ensures that there is no possibility of memory being corrupted by being enabled if spurious signals appear on the address bus at any time.

Memory Interface

The 6802 Development Board features two memory chips, both of 8K capacity. These are a 27C64 EPROM (IC3), which contains the monitor software, and a 6264 RAM (IC4) which is used to store data used by the monitor software and also to store user generated programs whilst they are being debugged. These two chips interface to the 6802 microprocessor in a very similar fashion; only the differences between the two chips will be highlighted.

Each chip has thirteen address lines (A0 to A12), which correspond to 2^{13} (8192) memory locations within each chip. These address inputs are connected directly to the appropriate address outputs of the 6802 (IC1). Each chip also has an 8-bit data bus (D0 to D7) which again are connected directly to the appropriate pins of the 6802.

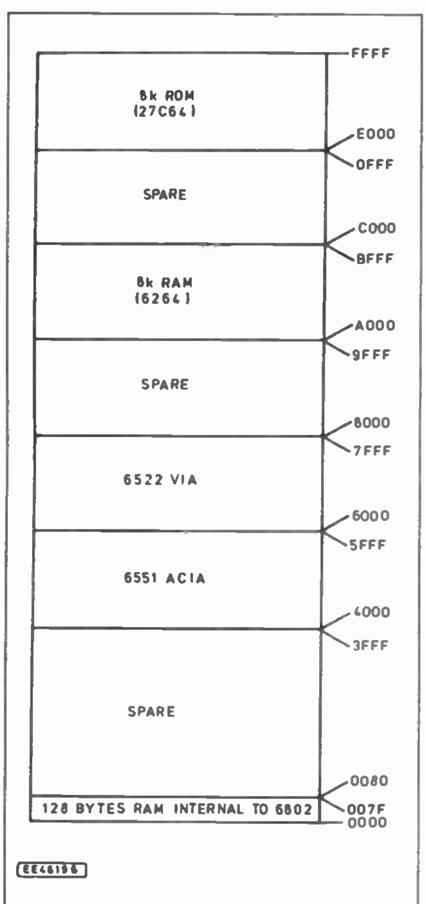


Fig. 6. System memory map.

The 6264 RAM IC4 has two chip enable inputs ($\overline{CE}$ and CS) while the 27C64 EPROM IC3 has a single $\overline{CE}$ input. The CS input of IC4 is permanently asserted by connecting it to the +5V line so that both IC3 and IC4 chips are enabled by the single $\overline{CE}$ input. These inputs are connected to the appropriate outputs of the address decoder (IC2) as explained earlier.

If IC1 needs to read data from either IC3 or IC4 then the R/$\overline{W}$ output is logic "high" during the memory access cycle (see Fig. 3). Both memory chips will only output data onto the data bus (D0 to D7) when their $\overline{OE}$ inputs are at a logic "low" level and the respective chip enable inputs are asserted.

Consequently, the R/$\overline{W}$ output of IC1 is inverted by a section of a 74LS14 Hex inverter IC8 before being connected to the $\overline{OE}$ input of IC3 and IC4. The 6264 RAM IC4 also has a write enable ($\overline{WE}$) input which is used when IC1 needs to write data to the device.

In this case the R/$\overline{W}$ output of IC1 is logic low during the memory access cycle. As the $\overline{WE}$ input of IC4 (pin 27) is an active low input, R/$\overline{W}$ is connected directly to it. The 27C64 EPROM IC3 has two other inputs, V_{pp} and $\overline{PGM}$, which are used during programming of the chip and need to be connected to +5V for normal operation.

Versatile Interface Adaptor

The 6522 Versatile Interface Adaptor IC5 (VIA) is a very powerful and flexible device which provides all of the system I/O (input/output) necessary in a simple system like this one. The data sheet for this chip alone runs to nearly twenty pages so it is only possible to summarise the features of the chip within this article.

The 6522 VIA communicates with the "outside" world via two 8-bit bi-directional ports. Each one of these sixteen lines can be individually programmed as either an input or an output. The 6522 also contains two 16-bit interval timers which can be used for generating pulse waveforms or counting externally applied pulses.

In addition to this it contains a serial-to-parallel/parallel-to-serial shift register and has the capability to generate an external interrupt signal if certain internal conditions are satisfied. The 6522 modes of operation are programmed by means of sixteen internal registers which appear to the 6802 (IC1) as normal RAM.

Interfacing the 6522 (IC5) to the 6802 (IC1) is extremely simple for the reasons mentioned earlier. The signals D0 to D7, R/$\overline{W}$, $\overline{IRQ}$ and $\overline{RESET}$ from IC5 connect directly to the appropriate pins of IC1. The 6522 signals register select inputs (RS0 to RS3) of IC5 are, as the name implies, used to address internal registers within the 6522 and hence these are connected to the A0 to A3 outputs of IC1. The $\phi 2$ input is used for synchronisation between the 6802 and the 6522 and is connected to the E output of the 6802. The $\phi 2$ nomenclature (which represents "phase 2") is a legacy from the days of the 6800 and 6502 microprocessors which used two phase clock circuits. The E output of the 6802 (IC1) is generated internally but carries the same timing information as the 6800/6502 $\phi 2$ signal.

COMPONENTS

Resistors

R1 3k3
R2 22k
0·6W 1% carbon film

See SHOP TALK Page

Capacitors

C1, C4 to C10, C15 — 100n ceramic (9 off)
C2, C3, C11, C12 — 27p ceramic (4 off)
C13, C14, C16 to C19 — 10µ radial elect. 50V (6 off)

Integrated Circuits

IC1 — 6802 microprocessor
IC2 — 74LS138 3-line to 8-line decoder
IC3 — 27C64 ready-programmed EPROM (see *Shop Talk* page)
IC4 — 6264 RAM
IC5 — 6522 VIA (versatile interface adaptor)
IC6 — 6551 ACIA (asynchronous communications interface adaptor)
IC7 — MAX232 RS232 transceiver
IC8 — 74LS14 Hex Schmitt inverter
IC9 — 7805 +5V 1A voltage regulator

Miscellaneous

X1 — 4MHz crystal (can HC-49/U)
X2 — 1·8432MHz crystal (can HC-49/U)
TB1 — 2-way p.c.b. mounting terminal block (5mm)
PL1/SK1 — 9-way right-angled D-plug, with straight pin socket
PL2/SK2 — 26-way IDC non-latching header plug, with straight pin socket
S1 — Miniature p.c.b. mounting push-switch

Printed circuit board available from *EPE PCB Service*, code 894; clip-on TO220 heatsink; insulated 15mm p.c.b. spacers (4 off); single-core link wire; multistrand connecting wire; solder etc.

Software

Text Editor, 6802 Cross Assembler and Terminal Emulation programs – see *Shop Talk* page.

Approx cost guidance only **£65**

The 6522 (IC5) has two chip enable inputs, CS1 (pin 24) and $\overline{CS2}$ (pin 23) for address decoding purposes. CS1 is permanently asserted by connecting to +5V line and $\overline{CS2}$ is connected to the relevant ($\overline{Y3}$) output of IC2, the 74LS138 3-line to 8-line decoder i.c discussed above.

Asynchronous Communications Interface Adaptor

The 6551 Asynchronous Communications Interface Adaptor, or ACIA for short, is used in the Development System to communicate with the host computer by means of a serial link. The 6551 (IC6) accepts data from IC1 in an 8-bit parallel format and converts this to a serial format. It then transmits this serialised data to the host computer serial port. Conversely, serialised data received by IC6 from the host computer is converted to a parallel format which can be read by IC1 via the data bus.

One of the advantages of using the 6551 ACIA (compared to the 6800 family 6850 ACIA) is that it incorporates on-chip baud rate generation circuitry which only requires the addition of a 1·8432MHz crystal X2 and a couple of capacitors (C11, C12) if the CMOS version of the 6551 is used. The 6850 would require additional circuitry to perform the baud rate generation function.

The 6551 IC6 interfaces to the 6802 IC1 in exactly the same way as described above for the 6522 IC5. IC6 has two chip enable inputs, CS0 pin 2 and $\overline{CS1}$ pin 3 for address decoding purposes. CS0 is permanently asserted by connecting pin 2 to +5V line and $\overline{CS1}$ is connected to the relevant output ($\overline{Y2}$) of IC2.

Serialised data is transmitted by IC6 via the TXD output (pin 10) and serial data is input to the RXD (pin 12). There are also three inputs, $\overline{CTS}$, $\overline{DSR}$ and $\overline{DCD}$, which are for use when IC6 is used to control a Modem. In this application they are required to be connected to the 0V line.

RS-232 Level Conversion Circuitry

The serial data output from the TXD (pin 10) of IC6 is at TTL voltage levels and it requires serial data input to RXD also to be at TTL voltage levels. However, the host computer requires that serial data transmission and reception is at bipolar RS232 voltage levels. Hence there is a requirement for interface circuitry between the 6551 IC6 and the host computer to perform the necessary voltage level conversion.

This is a common problem for the microprocessor systems designer and consequently several semiconductor manufacturers have come up with chips to solve this problem. One of the most popular solutions is the Maxim MAX232 RS232 transceiver chip (IC7).

This chip will both generate the necessary RS232 voltage levels for transmission and convert received RS232 format data to TTL levels whilst only requiring a single +5V supply. It generates the +10V and −10V voltages by means of internal "charge pump" circuitry which only requires the addition of four external capacitors to function. Some RS232 interface chips from other manufacturers require external dual supplies which would be a nuisance on a system that otherwise operates on a single +5V supply.

Power Supply

The 6802 Development Board requires the addition of a smoothed external 9V to 12V d.c. supply capable of supplying 500mA. The simplest way to supply this is to use one of the "plug top" transformer type power supplies. This is regulated down to the +5V required by the integrated circuits by means of a 7805 three terminal voltage regulator (IC9).

The +5V output from the voltage regulator IC9 is smoothed and ripple reduced by means of capacitors C19 and C4 connected in parallel across the output. All other chips used on the board are "decoupled" by means of individual 100nF capacitors (C1, C5 to C10, C15) mounted physically near the i.c.s and connected across the supplies.

Microprocessor Support Circuitry

In order to ensure that the 6802 IC1 functions correctly on power-up it is necessary to provide a logic low level pulse at the 6802 RESET input (pin 40) which remains low for a certain amount of time after the supply voltage has reached the correct level.

The simplest way to obtain this delayed pulse is to use an *RC* delay. This is implemented by resistor R2 and capacitor C18.

At power-up the slow rising edge at the output of this *RC* combination is "squared up" by inverter IC8a and then further inverted by IC8b. The output of IC8b provides the RESET pulse for the system. It should be noted that the peripheral chips (IC5 and IC6) are also required to be reset at power-up so the RESET pulse is fed to these as well.

The 6802 microprocessor IC1 requires a clock of some form to be present in order to operate. The 6802 has its own internal clock generation circuitry and only requires the addition of a crystal X1 and a couple of capacitors C2, C3. This feature also helps to reduce the amount of external circuitry necessary in order to design a 6802 based system compared to a 6800 based system.

The external clock frequency (4MHz in this case) is divided by four internally to give an E output clock frequency of 1MHz. 4MHz is the highest frequency that a standard 6802 should be clocked at though the 68A02 and 68B02 versions have maximum clock frequencies of 6MHz and 8MHz respectively.

The 6802 IC1 has several inputs MR, RE, $\overline{NMI}$, $\overline{HALT}$, and V_{sby} which are not required in a simple system so these are connected or tied to +5V. IC1 also has an interrupt request input ($\overline{IRQ}$) which when at a logic low level can be used to interrupt an executing program.

This input, pin 4, is "pulled up" to +5V by resistor R1 and hence several interrupting sources can be connected to it, providing their interrupt output is of the "open drain" or "open collector" type. The 6522 IC5 and 6551 IC6 interrupt outputs are both of the "open drain" type and hence are connected directly to IC1 $\overline{IRQ}$ input pin 4.

It should be noted that when multiple interrupt sources are connected to the $\overline{IRQ}$ input in this way, the 6802 has no inherent way of knowing which source caused the $\overline{IRQ}$ input to go low and the programmer has to use a software technique known as "polling" in order to determine this.

SOFTWARE MONITOR

One of the major problems of producing software for a microprocessor based design is that of "debugging" successive versions of the program until a version that functions correctly is obtained. It is an accepted fact amongst programmers that only the simplest and most trivial programs have any chance of working correctly first time.

Due to the inherent nature of microprocessors it is very difficult to find out why a program is not working correctly as the most important clues are hidden away in the internal registers of the chip. The cheapest way to develop software for a microprocessor is termed "burn and crash".

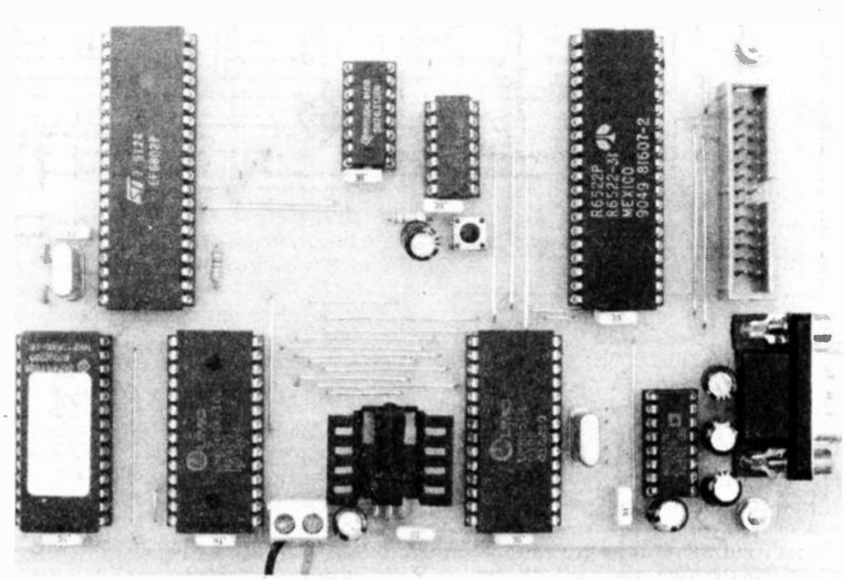
This involves burning an EPROM with the program and then trying it on the target system. The programmer must then try and infer from the external results why the program is not functioning correctly. Needless to say this is a very time consuming process although the author has developed programs successfully using only this technique.

Developing software with the aid of a monitor program is a huge improvement on the "burn and crash" technique. A typical monitor program,running in ROM on the target system, will allow the program to be downloaded into the target system RAM from the host computer via a serial link. The program in RAM can then be tested, modified and retested under control of the ROM based monitor program.

The monitor program for the 6802 Development System is designed to interact with the user via a terminal. This will require the running of a "terminal emulation" program on the host computer if a dedicated terminal is not available.

The monitor program provides the following functions:-

- Inspect/change user memory **(M)**
- Inspect microprocessor registers **(R)**
- Download user program from host PC **(L)**
- Execute user program **(J)**
- Set breakpoint in user program **(+)**
- Clear breakpoint in user program **(−)**



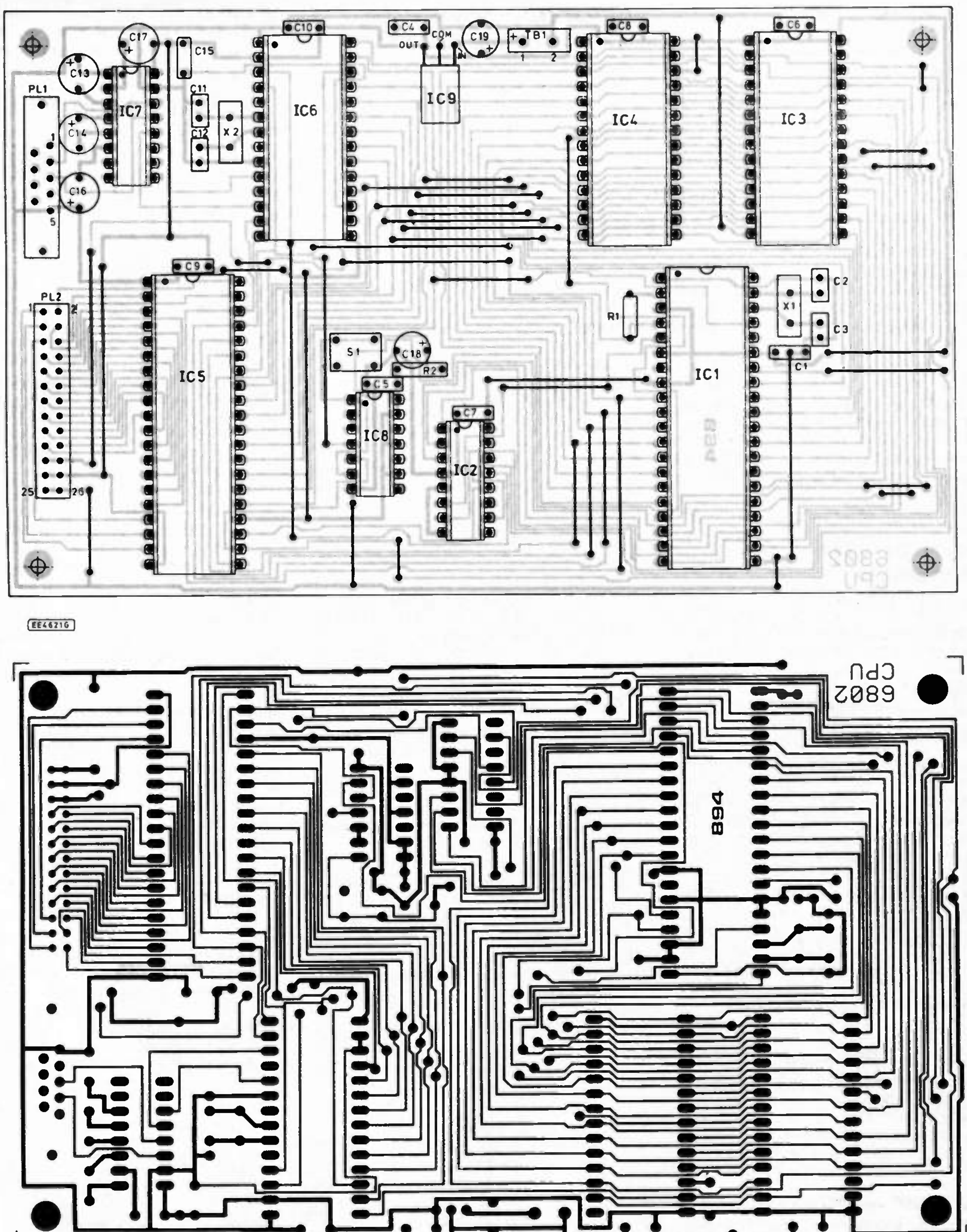


Fig. 7. P.C.B. layout and wiring for the 6802 Development Board. Note that a small clip-on heatsink is required for the regulator IC9, as can be seen in the photograph.

Each function is invoked by typing a single character on the terminal as shown above. Depending on the particular action required supplementary input may also need to be input.

When the monitor is ready to accept a new command, the ">" prompt will be displayed on the terminal. Each monitor command will now be explained in greater detail in the following text.

Inspect/Change User Memory

To invoke Inspect/Change User Memory command: **'M'** must be typed at the terminal followed by the four-digit hexadecimal address of the location to be examined. The monitor will respond by printing the address followed by the memory contents.

The user can then view the contents of the next memory location by typing any character other than 'carriage return', 'space', '.', 'B' or 'N'. Typing any of these characters will cause the following alternative actions to occur:

'B' will cause the preceding memory address and contents to be displayed.

'N' will allow the user to enter a new four-digit hexadecimal address and the

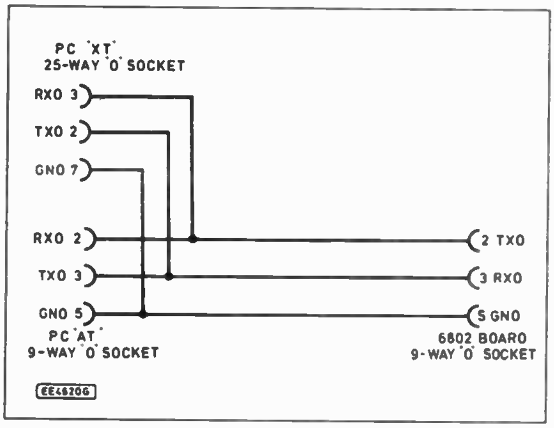


Fig. 8. Wiring diagram for the serial connector cable.

monitor will display the contents of this address.

'.' will display the memory data in the form of one machine code instruction per line.

'space' followed by two hexadecimal characters of data will attempt to replace the current data of the address by the new data. If the monitor is unable to store this data correctly (e.g. if the address is that of ROM or faulty memory) then a **'?'** will be displayed followed by the data actually read at that address location.

'carriage return' will cause the Inspect/change memory function to be terminated and the '>' to be displayed.

Inspect Microprocessor Registers

To invoke the Inspect Microprocessor Registers command: **'R'** must be typed at the terminal. This will result in the 6802 registers (see Fig. 4.) being displayed on the terminal in the following order:-

Condition code register
Accumulator B
Accumulator A
Index register X
Program counter
Stack pointer

It should be noted that this command will only display valid register contents if invoked immediately after an interrupt has occured.

Download user program from host computer

To invoke this command: **'L'** must be typed at the terminal. The monitor will then expect a file to be transmitted to it from the host computer.

The file will be read by the monitor program and stored in the 6802 Development system RAM. The file must be in the form of Motorola S1-S9 records which is the default format produced by most assemblers for Motorola 8-bit microprocessors.

The monitor program continually checks the received file for transmission errors and will flag these at the terminal after the file transmission has ended. This will ensure that the user does not attempt to execute an incorrectly loaded program.

Execute User Program

To invoke this command: **'J'** must be typed at the terminal. This should be followed by a four-digit hexadecimal address which would normally be the start address of the user program.

The monitor will then "jump" to this address and begin execution of the user program.

Set breakpoint in user program

To invoke this command: '+' must be typed at the terminal. This should be followed by a four-digit hexadecimal number which should be the instruction address where the user wishes to halt execution of the user program. The monitor will replace the byte stored at this address by the 'SWI' (software interrupt) op-code.

When the user program reaches this point a software interrupt will be executed. The monitor program handles this by displaying the microprocessor registers on the terminal, in the same format as for the **'R'** command, before awaiting further input.

It should be noted that if a 'SWI' instruction is encountered in the user program without a breakpoint being active then a user supplied interrupt service routine will be executed instead.

Clear breakpoint in user program

To invoke this command: **'-'** must be typed at the terminal. The effect of this command is to clear a previously set breakpoint. The 'SWI' op-code is replaced by the original contents of the memory location.

CONSTRUCTION

The 6802 Microprocessor Development Board is intended to be used as the basis for investigation and experimentation and consequently is not enclosed in a case. As mentioned earlier a "plug top" transformer – better known as a 3-pin Mains Adaptor – is the only external component required.

All other components are mounted on a single printed circuit board (p.c.b.) which is supported on four plastic "stand-offs". External d.c. power is applied to the board via a 2-way terminal block.

All of the components for the 6802 Development board are mounted on a single-sided p.c.b. of standard single Eurocard size, 160mm x 100mm. This board is available from the *EPE PCB Service*, code 894.

The printed circuit board topside component layout and full size copper foil master pattern is shown in Fig. 7. Assembly of the components onto the p.c.b. is relatively straight forward but it is recommended that the following sequence is adhered to :

Before beginning assembly, the p.c.b. should be inspected to ensure that all holes are drilled and clear and no tracks are "shorted" together. If these prove to be all correct then the next stage is to begin mounting the p.c.b. with the components.

The initial task is to fit all the wire links using tinned copper wire of an appropriate gauge (e.g. 22 s.w.g.). There are a total of 40 of these so care should be taken not to omit any. Some of the wire links are close to each other so it is important to ensure that none of these links are shorting to adjacent links.

The resistors, R1 and R2, can be fitted next followed by the i.c. sockets, if these are to be used. Although the use of i.c. sockets is not strictly essential, it is strongly recommended that they are used. The sockets will be marked in some way to indicate orientation and this should be checked against the p.c.b. component layout.

The capacitors (C1 to C18) and the crystals (XT1 and XT2) can be fitted next. Capacitors C13, C14, C16, C17, and C18 are polarised types and care should be taken that these are orientated correctly. Also, note that capacitor C1 actually straddles the end of one of the wire links.

Extra attention needs to be taken to ensure that no inadvertent short circuits occur. It should be noted that capacitors C11 and C12 are only required if a CMOS version of the 6551 (IC6) is used.

The Reset switch (S1) and the three connectors should be fitted next. The pins of S1 may need a little bending in order to fit correctly into the p.c.b.

It is also important that the 26-way IDC header is fitted with pin one positioned towards the middle of the p.c.b. edge. Care should be taken when mounting the 9-way D-plug to ensure that the sprung retaining clips locate correctly within the p.c.b.

The final component to be fitted is the 7805 voltage regulator (IC9). This component dissipates a certain amount of heat and is therefore fitted with a clip-on heatsink. This should be fitted and then the leads of IC9 should be gently bent to a right angle to the component body. IC9 can now be soldered in place.

It may be necessary to gently bend the regulator/heatsink combination backwards in order to avoid it fouling nearby components or to avoid the heatsink touching the regulator leads.The orientation of this component is important and Fig. 7. should be referred to if there is any doubt.

As the voltage regulator and heatsink combination stands proud of the rest of the p.c.b. it is important that no stress is imparted to this component during handling of the p.c.b. or fracture of the component leads is likely to result. The final operation in the construction is to fit the four stand-offs to the corners of the p.c.b.

TESTING

The first test of the assembled p.c.b. should be a visual one, to check for any soldering defects and the correct orientation of the polarised components. If this is satisfactory then an external voltage (7·5V to 9V d.c.) should be applied to the terminal block TB1, taking the utmost care to ensure correct polarity.

Check that +5V d.c. (± 5%) is present at all the relevant points on the p.c.b. If this voltage is only present at certain points then the p.c.b. should be checked using a continuity checker for dry joints or track breaks. If the measured voltage is outside the stipulated range, the fault is almost certainly with the voltage regulator IC9.

Once the power supply has been verified then the integrated circuits can be inserted into their appropriate sockets. This should be done with *power off* and care should be taken to ensure that the chips are both orientated correctly and mate correctly with their respective sockets.

At this stage the 6802 Development Board can be powered up and connected to the host computer. The wiring diagram for the serial cable is given in Fig. 8. The actual connector required at the computer end will depend on the host computer used.

The serial cable should be connected between the host computer and the 6802 Development Board and then the host computer should be switched on and the "Terminal Emulation" program run. The important parameters for the "Terminal Emulation" program are:

- Transmit and receive baud rates set to 1200.
- 8 data bits, 1 stop bit, no parity.
- Local echo at host computer.

The 6802 Development Board should then be powered up. If the system is functioning correctly then the '>' prompt should be displayed on the host computer screen.

If this is not the case then power should be removed *immediately* from the Development Board while further investigations are carried out.

The first check that should be made, and also the easiest, is that the "Terminal Emulation" program is configured correctly as described above. The documentation supplied with this program should be studied if there is any doubt. It is probably worthwhile to check the integrity of the serial cable wiring using a continuity checker or similar.

Once satisfied that the above aspects are OK then the system can then be tried again using the procedure described above. If the system still fails to work then it is likely that the fault lies with the 6802 Development Board itself.

Microprocessor based systems are difficult to test without specialised equipment and it should be noted that unless incorrect operation is due to faulty soldering or some other easily remedied problem, then replacement of integrated circuits or other components may be necessary. In the author's experience, *it is extremely unlikely that integrated circuits, which have been handled correctly, are faulty from new*.

They are, however, very likely to be damaged by incorrect handling, insertion or faulty external circuitry. Therefore the importance of performing all the preliminary checks to the assembled board before power is applied cannot be overstressed.

USING THE 6802 SYSTEM

The software run by the host computer to support the 6802 Development Board comprises three distinct programs:-

- Text Editor Program.
- 6802 Cross Assembler Program.
- Terminal Emulation Program.

These programs are a mixture of "Public Domain" and "Shareware" programs. **It is the responsibility of the user that any conditions of use imposed by the original authors of these programs are adhered to.**

All of the programs contain sufficient documentation for the user to be able to operate them. However, a couple of tips are included here which may help the user avoid some common pitfalls:

- Ensure that the source code file produced using the Text Editor Program is saved as an ASCII file (if this is not obligatory) and with the correct file extension required by the Cross Assembler Program.
- The Monitor Program uses the RAM from A000 to A200 (Hex) so this area should be avoided by user programs.
- Ensure that the Terminal Emulation Program is configured correctly for the 6802 Development Board each time it is run by saving the settings as "defaults".
- Ensure that all files reside in the correct directories for them to be found by the program requiring them.

Obviously it is beyond the scope of this article to fully describe 6802 assembly language programming but a suitable textbook is:

Using Microprocessors and Microcomputers: The Motorola Family. (2nd Edition 1988). Authors: Greenfield and Wray. Publisher: Simon and Schuster.

This book describes the basic theory behind microprocessors, before going on to describe the hardware and software aspects of the 6800/6802 in greater detail. It contains several useful examples of assembly language programming. □

Footnote:

1. The software monitor for this project was based on one originally written by Dr. Alan Clements of the University of Teeside. The author would like to extend his appreciation to Dr. Clements for his permission to use his original monitor design.

INTERFACE

Robert Penfold

IN THE world of computing there are various developments which are perpetually just around the proverbial corner. I think that it is fair to say that speech recognition systems have fallen into this category. Speech recognition systems have actually been in existence for many years, and I described a simple system for the BBC computers in an article in the April 1987 issue of *Everyday Electronics*.

Despite tremendous advances in computer hardware, plus a few significant developments on the software front, we have only just arrived at a PC that can genuinely take dictation. There is now one IBM system that can take dictation once the user has read a fairly long text to it to "teach" it his or her pronunciation etc.

There are also lower cost systems that can recognise a limited vocabulary of learned words, and these are designed to be used as a means of controlling programs. For example, if you were using a drawing program you could call up the circle drawing command simply by saying the word "circle". I believe that some of the Apple Macintosh computers are supplied as standard with a speech recognition system of this type.

Possibly the new generation of RISC chip computers will be the basis for low cost systems that can turn any plain speech into 99.9 percent accurate text files – or maybe this will still be something that awaits the next generation of computers!

DIY Speech Recognition

Although it is difficult to produce a speech recognition system that works to a worthwhile degree, it is not impossible to produce a do-it-yourself system. You have to settle for a fairly small vocabulary, and the finished system is likely to be of limited practical value due to problems in integrating it into applications programs. It is an interesting field for experimentation though, and it does not require any particularly expensive hardware.

The success of speech recognition systems (or lack of it) is to a large extent dependent on the efficiency of the software. It is a line of research which should therefore appeal to the software enthusiast who would like to tackle something that is both challenging and a little different. Some basic speech recognition software will be provided, but there is plenty of scope for users to refine it, or to try out there own ideas.

The obvious approach to speech recognition is to first digitise the audio input signal. This operates in the manner shown in Fig.1, where the signal voltage is sampled at regular intervals, and the series of voltage readings obtained is stored in memory. These voltage readings provide the computer with an accurate mathematical representation of the speech waveform, and a pattern recognition routine should be able to match the waveform to the appropriate word.

Problems

In practice there are a few problems with this approach. In order to obtain an accurate mathematical representation of the input waveform the signal must be sampled at a fairly high rate. In our example of Fig.1 the sample rate is barely high enough, and on the higher frequency parts of the waveform the sampled voltages provide only a rather rough model of the waveform.

In order to obtain reasonable results the sample frequency must be at least double the maximum input frequency, and should ideally be three or more times the maximum input frequency. Speech contains a wide range of frequencies, but frequencies above about 3kHz are not essential to intelligible speech. The minimum acceptable sample frequency is therefore about 6kHz.

Words vary in duration from about 0.5 to two seconds, which represents between about 3k and 12k of data per word. Modern computers have plenty of memory, so there is no difficulty in storing a number of digitised words for comparison purposes. The problem with a straightforward digitising system is a lack of speed. Large amounts of data require large amounts of processing, which can easily render the system too slow to be of any practical value.

Also, the more detailed the digital representation of the word, the harder it is to produce an effective pattern matching system. It is easy to end up with a system that "can't see the wood for the trees". Bear in mind that the same word never sounds the same twice, even if spoken by the same person. If a speech recognition system is made too pernickety, it will hardly ever produce an accurate enough match. Rather than producing a high degree of reliability, the system will fail to recognise more than the occasional word.

A system that keeps things as simple as possible has definite advantages. Digitising each word into (say) 100 bytes makes it much easier to identify each word, and greatly speeds things up. The drawback of simplifying the system is that it reduces its ability to distinguish between two similar words.

A simplified speech recognition system is therefore only able to support a limited vocabulary, but in most cases this is all that is needed. Also, it is necessary to avoid using "key" words that have very similar sounds, but in practice there should be no problem in doing this.

Shaping Up

One way of simplifying the numerical representation of each word is to digitise the envelope shape. Fig. 2 helps to explain the way in which this process works. First input waveform (a) is half-wave rectified to produce waveform (b). This signal is then smoothed to produce the envelope waveform of (c).

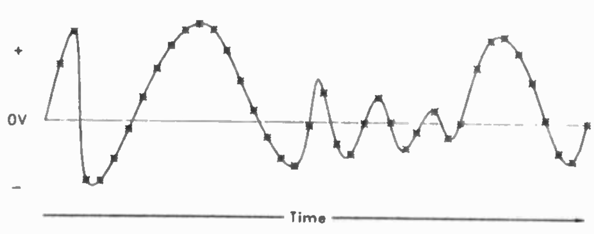
The envelope waveform follows the changes in the average amplitude of the input signal. It varies at a much slower rate than the input signal, and a low sampling rate will provide an accurate numerical representation of the envelope shape. In fact a sampling rate as low as about 25Hz seems to be satisfactory. This enables words to be digitised into about 25 bytes of data.

Unfortunately, in practice this method simplifies things too far. A lot of words which sound quite different have very similar envelope shapes. The basic envelope sampling method will work, but only if the system is limited to very few words which have significantly different envelope shapes. In "real world" applications this is likely to be too limiting for such a system to be of any practical value.

Much improved results can be obtained using a system of the type outlined in the block diagram of Fig. 3. This probably represents the most simple system that will be of any real use.

The signal from the microphone is at a very low level, so it is amplified by a high gain preamplifier in order to produce a more

Fig. 1. Digitising gives an accurate numerical representation of the input waveform, but produces large amounts of data.



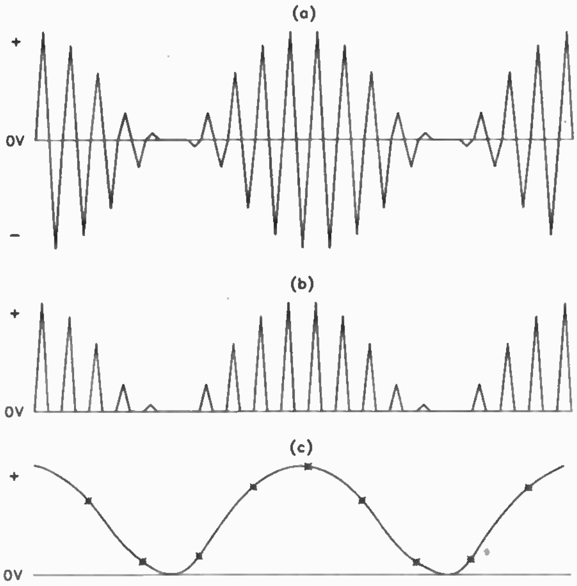


Fig. 2. (left) Input signal (a) is half-wave rectified (b) and smoothed to produce the waveform of (c). This is then digitised using a low sample rate.

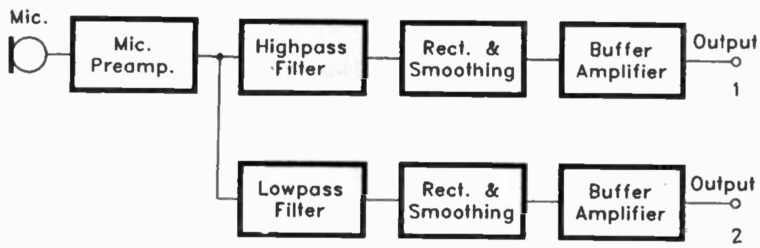


Fig. 3. Block diagram for a minimal speech recognition system.

usable signal level. The output from the preamplifier is split two ways. One signal path is through a highpass filter, a rectifier and smoothing circuit, and then to one output via a buffer amplifier. This produces an envelope waveform that can be digitised by the computer, but it is the envelope of the high frequency part of the input signal.

The other signal path is through a lowpass filter, a rectifier and smoothing circuit, and then to a separate output via a buffer stage. This again produces an envelope waveform, but this time it is the envelope of the input signal's low frequency content.

Advantages

This splitting of the high and low frequencies increases the amount of data per sampled word, but it still only uses about 50 bytes per word. Although there may seem to be little advantage in this separate sampling of the high and low frequency bands, it enables the unit to differentiate between different types of sound that have similar overall envelope shapes.

For example, "shhhh" and "arrrr" sounds might have very similar overall envelope shapes. However, their frequency content is very different. There is a strong high frequency content in a "shhhh" sound, but only weak signals at low and middle frequencies. Conversely, an "arrrr" sound has a strong low frequency content, but only relatively weak components at high and middle frequencies.

When processed by this system the two sounds will therefore produce very different pairs of envelope shapes. A "shhhh" sound will produce a strong signal from output 1, but only a weak signal from output 2. An "arrrr" sound will produce a strong signal from output 2, but only a relatively weak signal at output 1. This makes it easy for the pattern recognition system to differentiate between most words that have similar overall envelope shapes, but which sound quite different.

This method is not perfect, and it is still possible for two words to sound different, but produce similar output signals from a voice recognition system of this type. In practice the system will only have to handle a few words, and you would be unlucky to choose two words that proved to be indistinguishable. However, if necessary the system can be refined somewhat, with the signal being split into several bands.

The system for the BBC micro that I mentioned previously operated on the basis of a four way split, with approximate centre frequencies of 300Hz, 600Hz, 1.2kHz, and 2.4kHz. This system was usually capable of distinguishing between similar sounding words, but with any simple speech recognition system it is probably best to avoid using very similar words. The less similar the words you use, the more reliable the system will be, especially when your diction is something less than perfect.

A drawback of having two or more outputs is that the computer needs to have more than one analogue input port. As the sampling rate can be as low as 25Hz, a single port plus some electronic switching should be an adequate solution. Even with four outputs, sampling them all via a single analogue input only represents a total sampling rate of 100Hz. Many analogue ports can sample at rates over a thousand times faster than this.

One Voice

Anyone who uses a speech recognition system needs to be aware of a potential flaw. Virtually all practical systems operate on the basis of the user "teaching" the system various "key" words than must be recognised. In most cases each word is spoken into the system several times, and the software works out a sort of average response from the all the samples.

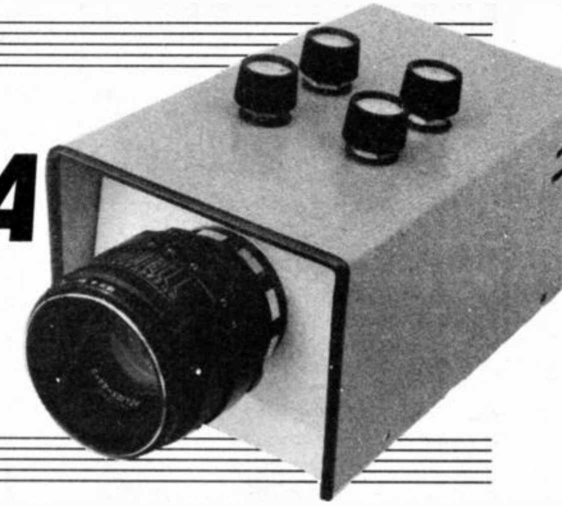
This method usually provides quite good reliability, but only when used by the person who "taught" the system the "key" words. This is sometimes put forward as an advantage, and I suppose that in some circumstances it could be. It would presumably prevent unauthorised use of the system.

On the other hand it can also be a disadvantage. If two or three people are to use the system, they will each need their own version of the control program, set up with their versions of the "key" words. This is not necessarily a major problem, but it is not very convenient either. There would seem to be no easy way around this problem, and it is something that users of simple speech recognition systems simply have to accept.

Next Month: Some practical circuits for speech recognition systems will be provided.

Constructional Project

CCD TV CAMERA UPDATE



JOHN BECKER

Viewing moons, stars and other matters.

SINCE the *CCD TV Camera* was published in the March and April 1994 issues of *EPE*, a number of questions have been raised by readers, particularly regarding the camera's use in astronomy. This article answers some of the queries.

First, I must comment that although I take an interest in the sky at night, I am not an astronomer and do not have a telescope. Consequently, I cannot answer the astronomical questions in detail. However, I have run a variety of tests and produced some very interesting results which seem to confirm the TV camera's potential usefulness for astronomical viewing.

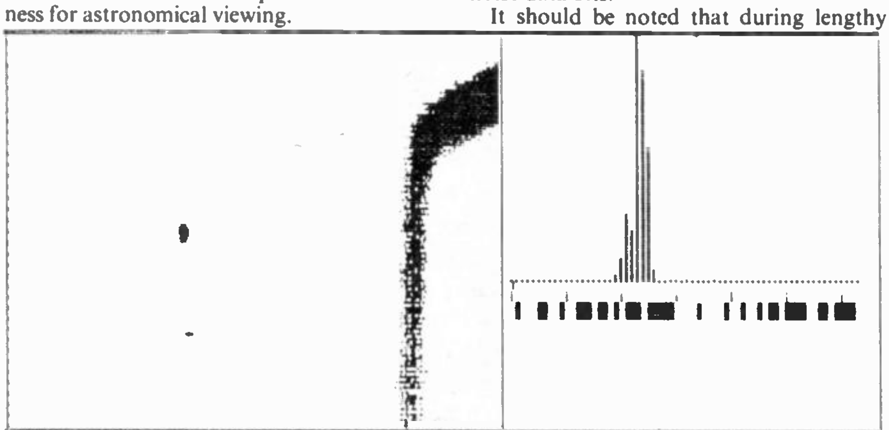


Fig. 1. Neptune and Spica (left) with the window frame centre. Data reference graph is on the right. Exposure time 20 secs, f2, 50mm lens.

STARGAZING

Using a 50mm focal length lens from a 35mm film camera, set at aperture *f16*, and without any circuit modification, I have used the TV camera to view the Moon, in daylight and at night, on a TV receiver and on a computer screen. With the same lens and with the addition of a simple sample-rate reducing (delay) circuit, I have also viewed, via the computer only, the planet Neptune and a bright star visually near to it, believed to be Spica (as deduced from one of Patrick Moore's books). For the latter view, the exposure time was best at about 20 seconds with an aperture of *f2*. Interestingly, I could still discern Neptune on the computer screen with an exposure time of only 0·2 seconds.

Looking at other regions of the sky, from the rather limited view through my workroom window, faint images of some other less bright stars have been just discernable. However, when increasing the exposure time beyond about 80 seconds, the inherent thermal noise from the sensor circuit, operating in an ambient room temperature of about 20°C, just began to result in the introduction of low level random noise data barely distinguishable from the tiny stellar images. I am sure, though, that readers who have telescopes, or camera lenses having focal lengths much greater than 50mm, will be able to obtain better images than my lens has allowed.

Theoretically, it is possible to use a Peltier-effect device to cool the sensor and reduce its noise-generation levels. It is also possible, of course, to write the software so that images are built up on the computer screen over several sample periods, using an averaging routine to suppress random noise data bits.

It should be noted that during lengthy exposures the Earth's rotation will cause images to shift across the screen unless the camera and telescope are attached to a synchronous tracking mount.

A monochrome computer-printout of one of my views of Neptune and Spica can be seen in Fig. 1. Part of the window frame dominates the centre, on the right is a data value graph and colour reference bar.

The screen image was more dramatic in colour and ideally it should have been photographed in colour for a permanent record of the viewing. I wonder if colour printers are useful for computer processed stellar images?

SAMPLE RATE REDUCER

To suit normal TV receivers, in the published circuit the TV camera's frame-sampling rate is fixed at 50Hz, resulting in an equivalent image exposure time of one-fiftieth of a second. As implied above, star light is too feeble to be adequately registered by the image sensor at such a short exposure, even when using a wide aperture lens.

Fortunately, though, the exposure time can be increased easily by the insertion of a Simple Delay timer into the camera control circuit. The Delay circuit is shown in Fig. 2. It is inserted between IC10a and IC18 of the *TV Camera* (see Fig. 5 on page 211 of *EPE* March 1994).

The circuit consists of 12-stage binary divider IC31, and switch S2 which selects the required binary output. Switch position 1 selects the normal 50Hz rate, then each subsequent switch position succes-

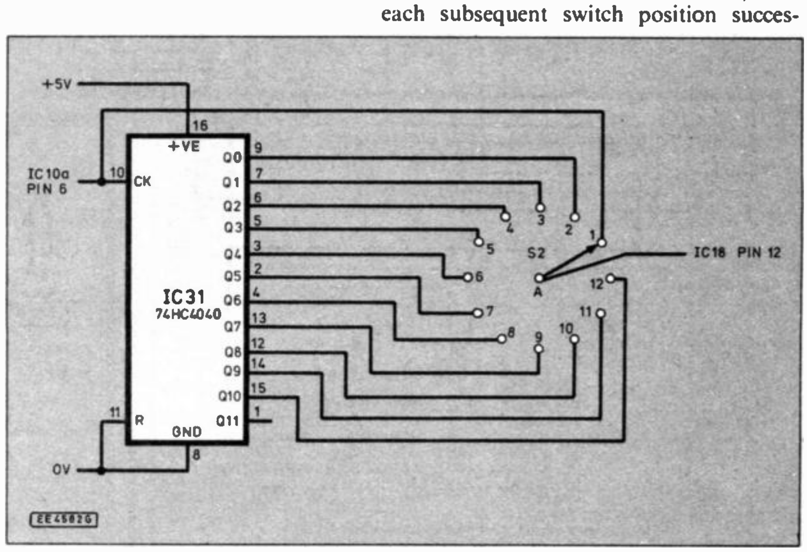


Fig. 2. TV Camera sample rate reducer.

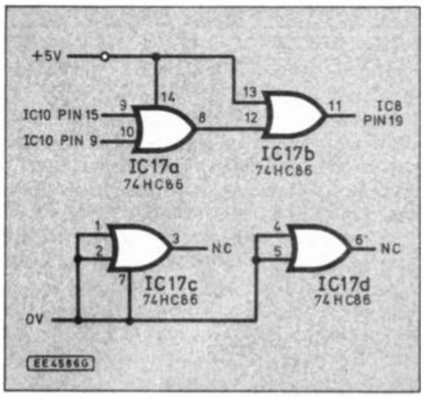


Fig. 3. Modification for Frame Grab use with sample rate reducer.

sively divides the rate by two, so progressively doubling the exposure times.

With position 12 selected, an exposure time of 40 seconds is obtainable. Longer exposure times can be produced by feeding the pole of switch S2 into a second identical circuit.

It is not possible to display the extended-exposure image directly on the TV receiver as the latter requires the fixed 50Hz rate for correct frame synchronisation. The modified image has to be input via the *Frame Grab Interface* to the computer, where it can be displayed or output back to the TV receiver as a processed image. The *Frame Grab* needs a simple modification to its circuit for use with the Delay circuit.

FRAME GRAB MODIFICATION

In the *Frame Grab* circuit, when reading the contents of memory chip IC7 (Fig. 19 page 305 *EPE* April 1994), the memory address counters IC4 and IC5 are stepped on by one place each time the computer makes a Read call to interface bus address decimal 768 (&H300). When the TV Camera's sampling rate is reduced below 50Hz, the Read calls made to this address while the computer is waiting for sync data line D7 to go high, can cause the total count on IC4 and IC5 to prematurely switch the circuit into Record mode before the correct synchronisation signal from the TV Camera is received. Consequently, I have had to change the address via which the computer looks for its sync data.

In the revised addressing, software calls to address 768 still step on the IC4 and IC5 counters as before, but examination of the status of line D7 is now made via Read calls to address 774 (&H306). The logical circuit implementation of this change requires that octal bus buffer IC8 must be enabled by either of the Read calls.

This is achieved by the addition of the circuit in Fig. 3, which consists of the two interconnected Exclusive-OR gates IC17a and IC17b. Read calls to addresses 768 or 774 respectively take low either pin 15 or pin 9 of IC10 in the original Fig. 19. In either instance, the output of IC17b in Fig. 3 is caused to go low, thus enabling IC8 and allowing its data output lines to be read.

To match this circuit change, Test Program Listing 1 on page 310 must be amended as follows:

```
360 F=INP(774) AND 128:IF F>0 THEN 360
370 F=INP(774) AND 128:IF F=0 THEN 370
```

CONSTRUCTION

The circuit additions for the *TV Camera* and *Frame Grab* can be mounted on two small pieces of stripboard, constructional details for which are shown in Fig. 4 and Fig. 5. Also shown in these figures are the amendments to the respective original printed circuit boards (p.c.b.s).

As shown in Fig. 4, the track on the component side of the TV Camera's main Control p.c.b. connecting from IC10a pin 6 to IC18 pin 12 is cut near to the latter pin. Connecting wires to the new sub-circuit are

COMPONENTS

FOR MODIFICATIONS

Semiconductors

IC17	74HC86 quad exclusive-OR gate
IC31	74HC4040 12-stage binary counter

Miscellaneous

C28	100n polyester capacitor
S2	1-pole 12-way rotary switch
S3	min s.p.d.t. toggle switch

14-pin d.i.l. socket; 16-pin d.i.l. socket; knob for switch S2; self-adhesive p.c.b. supports (2 off); two small pieces of stripboard to suit; connecting wire; solder etc.

Approx cost guidance only **£4**

soldered directly to the respective sections of the cut p.c.b. track. The power lines for the sub-circuit are soldered on the normal trackside to the same p.c.b. pads to which resistor R15 and capacitor C10 are also soldered.

With my camera, the sub-assembly board and the new switch were mounted on the lid of the camera's box, on the side nearest to the modified part of the main p.c.b. A hole should be drilled for the switch, and two self-adhesive p.c.b. supports used to fix the sub-assembly board.

In Fig. 5, the track on the component side of the *Frame Grab* p.c.b. connecting between IC10 pin 15 and IC8 pin 19 is cut at the most convenient point near to the latter pin. Connecting wires to the sub-circuit are soldered directly to the respective sides of the cut track.

Power lines for the sub-circuit are soldered on the component side of the p.c.b. to the nearest two conveniently placed

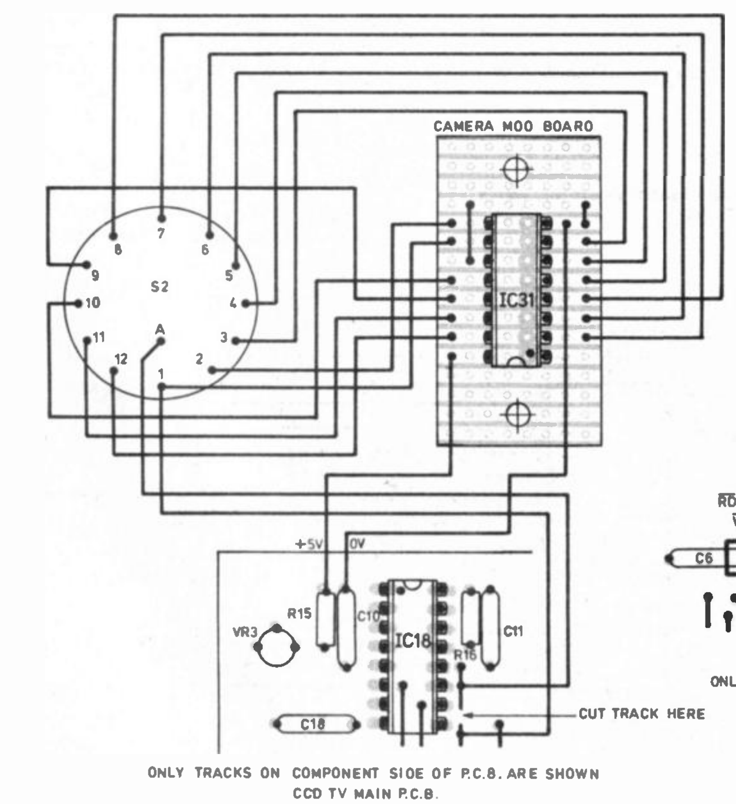
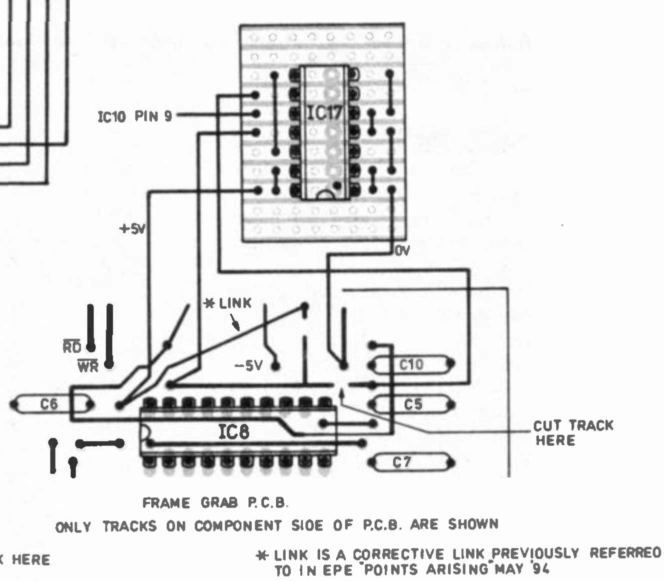


Fig. 4 (left). TV Camera modification board assembly and connection details.

Fig. 5. Frame Grab modification board assembly and connection details.



solder pads as shown. I used about 25mm of 18s.w.g. tinned annealed copper wire for each of the power lines, so rigidly attaching the sub-assembly to the main board.

PELTIER-EFFECT DEVICES

I have had no experience of using Peltier-effect devices (heat-pumps), and as I shall not be putting my TV Camera to serious astronomical use I do not feel justified in buying one for examination. However, I know that when supplied with an electric current, these devices can either be heated or cooled, depending on the direction of the current.

They can be attached to other electronic components in order to similarly change their temperature. In the cooling mode, the use of the devices helps to minimise the generation of unrequired thermal-electric noise.

Three sources of Peltier-effect devices are RS Components, Electromail and Farnell. Several Peltier-effect devices are stocked by these companies at prices ranging between about £12 and £100. Data sheets giving theoretical and practical use details are available from them.

The first two companies are part of the Electrocomponents Group and have identical catalogue numbers for components. Electromail and Farnell are the companies to which non-trade readers are referred, telephone 0536 204555 and 0532 636311, respectively.

You may be interested to know that the magazine *Astronomy Now* has recently been running a series of articles on CCD cameras as used in astronomy, written by Maurice Gavin. Further information can be obtained from the editor of *Astronomy Now*, Steven Young, 081-743 8888.

OTHER QUERIES

In Fig. 2 on page 210 of EPE March 1994, the image section of the FT800P sensor is shown as having 580 lines, yet the storage section has only 301 lines. What happens to the remaining lines?

The pixels in the sensor's image section are arranged as two interleaved blocks each consisting of 290 lines. Selection of which 290-line block is transferred into the storage section is determined by the phase relationship of the four waveforms of the AX clock signals. The additional 11 lines of the block transfer do not contain pixel data, but only blank data bits.

In a broadcast-quality camera, the control circuit would be designed to alternate the required AX clock phases to swap between the two blocks and build up the normal interleaved frame-pair image on the TV screen. The timing circuit would also effectively add additional blank lines so that the total number would match that required by the relevant broadcast standard. In Britain, that total would normally be 625 lines.

As stated in the opening paragraph on page 210 of *EPE* March 1994, the camera was originally designed for use with a PC-compatible computer. Since the standard EGA screen of a PC-compatible computer can only display a maximum of 350 lines in Screen Mode 9, the TV Camera and Frame Grab circuits were designed to process data from only one of the interleaved frame-pair blocks. Data from the second block is ignored.

The Frame Grab samples horizontal data at half the rate at which it is output to the TV receiver. All 131072 bytes of memory chip IC7 are filled during the image transfer/recording process, though some of these bytes contain synchronisation data, plus some irrelevant data beyond the end of the 290th line.

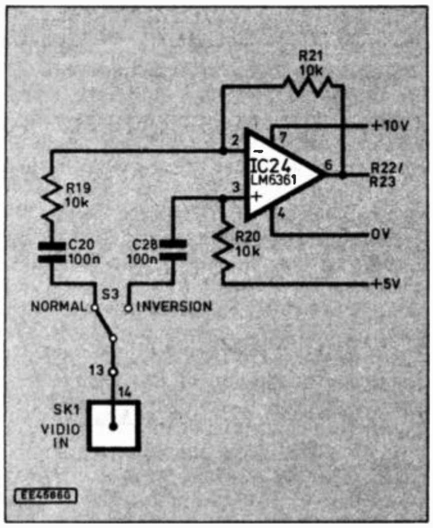


Fig. 6. Modification for image polarity inversion.

Software can input fewer than the maximum number of lines if preferred, to suit the screen mode selected. With my own software, in Screen Mode 9, I input and display all 290 lines but limit their length to 360 pixels, making a total display count of 104400 pixels. The remainder of the screen area is used for menu prompts, graph displays and so forth.

My camera produces a good image on the TV screen but this is marred by vertical interference bars and no amount of screening seems to help. How can I cure the problem?

Only one reader has asked this question and until then I was not aware of the condition. Now looking for the condition, on a cheap monochrome TV receiver (with which the camera is intended to be used) I can just make out tightly packed vertical grey bars of differing densities when the camera looks at a blank sheet of white paper. They are more apparent at higher amplifier gains as set by the control pots. They are likely to be more noticeable if the image is displayed on a colour TV receiver.

Tests show that the bars appear to be generated within the Image Sensor and are not caused by the amplifier circuit picking up stray digital signals. The bars appear to be an inherent result of the sensor's sampling and transfer clocking procedures, consequently, screening of interconnecting leads and of the amplifier has no effect on them. Nor does increasing the values of the electrolytic capacitors of the sensor circuit.

I have examined various simple ways of filtering out the bars but find that these techniques also reduce the sharpness of the normal image. Although more sophisticated filtering techniques are possible, their complexity and need for precision inductors and other components make their use unrealistic in this comparatively simple camera. The bars can be made less apparent by reducing the bias voltage set by VR1 of the image sensor circuit (Fig.4 page 211 March 1994), and by keeping low the gain settings of the amplifiers IC25 and IC26, as controlled by pots VR4 and VR5 (Fig.9, page 214 March 1994).

Normally, the bars are not evident when the image is displayed on a computer screen. Although I can program the software to make them visible, I can also similarly cause them to be suppressed.

INVERTED IMAGE

Is it possible to invert the video so that photographic negatives can be scanned and displayed as positives on the TV screen?

One way in which this can be done simply is shown in Fig. 6. The diagram shows the first stage of the TV camera's amplifier circuit as originally detailed in Fig. 9 page 214 of *EPE* March 1994.

By using S3 to switch the signal via the new capacitor C28, instead of via C20, the TV receiver and the computer will be fed with an inverted (negative-reversal, not upside-down!) image. One end of C28 should be soldered directly to the junction of R20 and IC24 pin 3.

Is the FT800P image sensor responsive to infra-red radiation?

The answer is both yes and no. In tests, I have produced very good images of a hot soldering iron in a blacked-out room, but I have not been able to similarly detect a cup of hot coffee.

It appears that the sensor will not respond to infrared of the wavelengths associated purely with heat radiation, such as that registered by the movement detectors of security systems, in the 10nm to 20nm (nanometre) ranges for example. The sensor does respond, though, to the wavelengths generated by infrared diodes, typically 800nm to 1000nm. It is assumed, therefore, that the soldering iron radiates in this longer wavelength range.

What defects are there likely to be in the sub-spec versions of the FT800P sensor?

A better term for me to have used instead of *sub-spec* would have been *test sample grade*. The sensor manufacturer advises that no major defects exist in this grade of sensor, although it is possible that occasionally adjacent pixels might be connected, or that a pixel or two might be inoperative.

I use two sensors of test sample grade, one in the main body of the TV camera, the other mounted on a quarter-plate camera as a roving extension having a wide angle lens; I cannot see any difference between them. It is believed that the vertical bars referred to above are not a defect found only in the test sample grade sensors.

Can the TV camera control circuit be used with other types of sensor instead of the FT800P?

No, it cannot without major redesign work since the FT800P has unique pinning and control requirements.

I cannot find a supplier for the 74AC164 chip, who supplied yours?

Farnell Electronic Components Ltd, telephone 0532 636311. They stock a wide range of the 74AC chips.

FINALLY

Since publication, I have considerably rewritten and extended my lengthy software program referred to in *EPE* April 1994. The entire program, including all machine-code routines, can now be run from QuickBasic as well as from GW-Basic. New routines allow images to be more versatily recorded onto disk and re-input for further processing, including easier data-byte modification and colour allocation, plus a new zoom facility.

Readers who have bought my original program can have a FREE copy of the new one if they send me a blank formatted 5.25 inch SSDD disk plus four 25p stamps to cover incidental postage costs. Other readers can purchase the program on disk for £15 inclusive of post etc. Write to: John Becker, 8 Finucane Drive, Orpington, Kent BR5 4ED. □

Special Series

THE BEST OF BRITISH

TERRY de VAUX-BALBIRNIE

Where is Britain's place in the world scene?

Last month was the "final" article in a "four-part" short series about the British electronics industry. However, since the time of writing some further information has come to light – so this one becomes the fifth!

IT IS obviously not possible to cover all areas and types of company in the electronics field in this series and no attempt has been made to do this. However it is felt that the extra information contained in this part warrants a place in *The Best of British*.

Power to the People

Quickroute, the p.c.b. and schematic design package from ***POWERware***, was reviewed in Robert Penfold's *Interface* (EPE December 1993). It is mentioned here because this product, in its various forms, has been completely revised and given many new features. In fact, by the time this article appears in print, the first three versions – *Quickroute 3.0 Designer, Quickroute 3.0 Designer+* and Quickroute Pro – will be on general release. All are designed to run on the IBM PC and compatibles under Windows 3.1 and using a mouse.

In the latest versions, the user interface has been completely re-designed to make it more user-friendly. New editing features are called "EASY-EDIT" – these include "auto alignment", powerful "pick-up-and-place" and a group capability. This latter point means that groups of objects spread around the design area (not simply in blocks which is the usual case) can be edited in the familiar ways – moved, copied, multi-copied, deleted, etc.

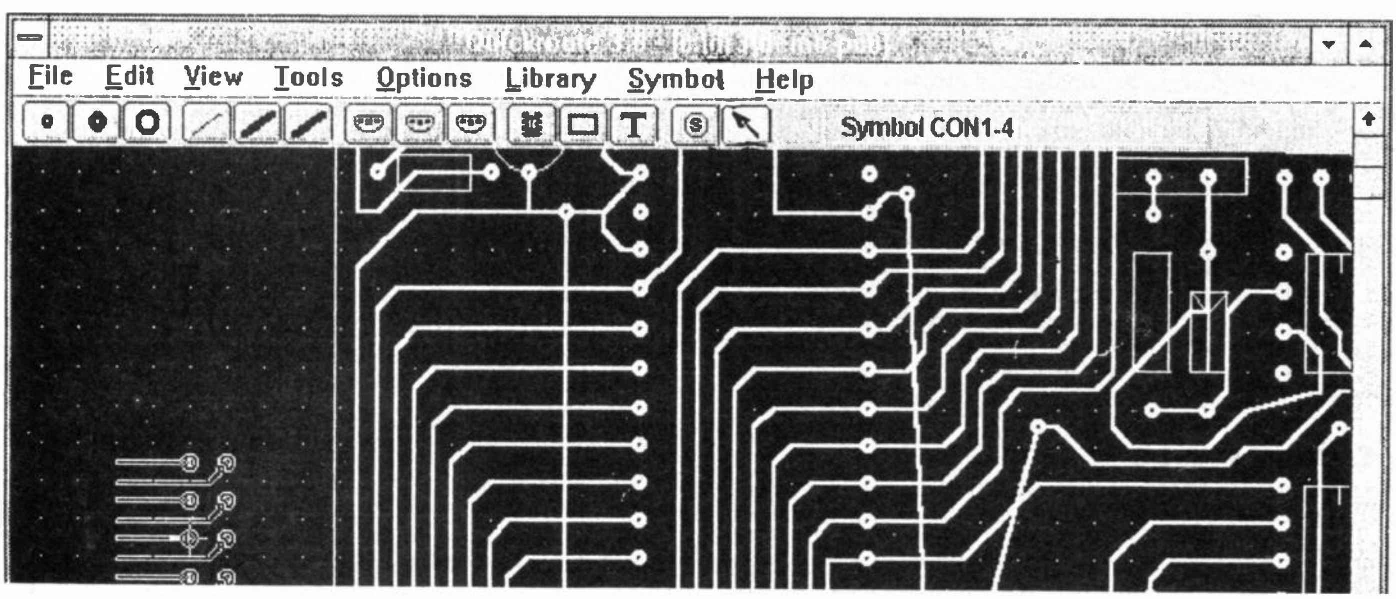
Groups can be copied on to the clipboard and the contents rotated, reflected and otherwise manipulated. This group facility sets *Quickroute* apart by its ability to handle objects which are not adjacent to one another on the screen.

All objects in the design have editable attributes – double click on any to change its size, width, etc. Note also that any Windows 3.1 text font may be used to produce professional-looking artwork. A set of symbol libraries for both schematics (circuit diagrams) and p.c.b. layouts are included in the package.

One very useful feature is that buttons on a button bar can be customised by the user and may be used to call up much-used pads, tracks, symbols, etc. according to his or her preferences. This can save a lot of time.

Designer is the entry-level package and it comes with all the features mentioned above. There is also an auto-router capable of routing two-layer boards – this is a limited version of the full auto-router available on the more advanced packages. Designer+ includes the *full* auto-router and the ability to export GERBER and NC-DRILL files (important for the professional user). It can also handle more complex designs.

In addition to all this the professional package, *Quickroute 3.0 Pro*, has a powerful schematic capture facility. Thus, once the circuit diagram has been drawn, symbols and the wiring made between them are "captured" and converted into an equivalent set of p.c.b. symbols and "rats



nest" interconnections. This may be subsequently auto-routed or manually-routed as required.

All versions come with a comprehensive manual. Designer is priced at £99, Designer+ £149 and Pro, £199. Prices are based on the single-user rate and exclude VAT and carriage. Information and costs of site licences are available from the company.

Ease of use has been "built-in" by using a logical and consistent approach to design. In terms of the facilities offered, Quickroute represents very good value and readers contemplating using this type of software should certainly look at it. Anyone making a serious enquiry can obtain a free demonstration disc with limited facilities. This will give them a feel for the product before making a commitment to buy. The address of POWERware is given at the end of this article.

A lifeline

Amplicon Lifeline is an entirely British organisation based in Brighton. They began business as the distribution company Amplicon 21 years ago but soon began manufacturing digital panel meters and computer instrumentation products.

As Amplicon Lifeline, the company in its present form began about six years ago. The product range now includes data acquisition control boards and software for PC's, l.e.d. and l.c.d. panel instruments and displays. Also, communications boards printers and fibre optic links.

The company currently employs 40 people with all stages from design and development to actual manufacture taking place on site. Work is supported by a team of technical authors with access to full desk top publishing and typesetting facilities.

The company's export policy involves the development and expansion of overseas distributors combined with extensive international advertising. Distributors now exist throughout Europe and in such diverse places as Egypt, New Zealand, Pakistan, Singapore, South Africa and the U.S.A. Their aggressive philosophy is paying off with a doubling of export sales in only two years.

Purchasing is usually made via the local distributor but may be made direct if one does not exist. Write to the company for the address of the local distributor – details are given at the end.

Green discs

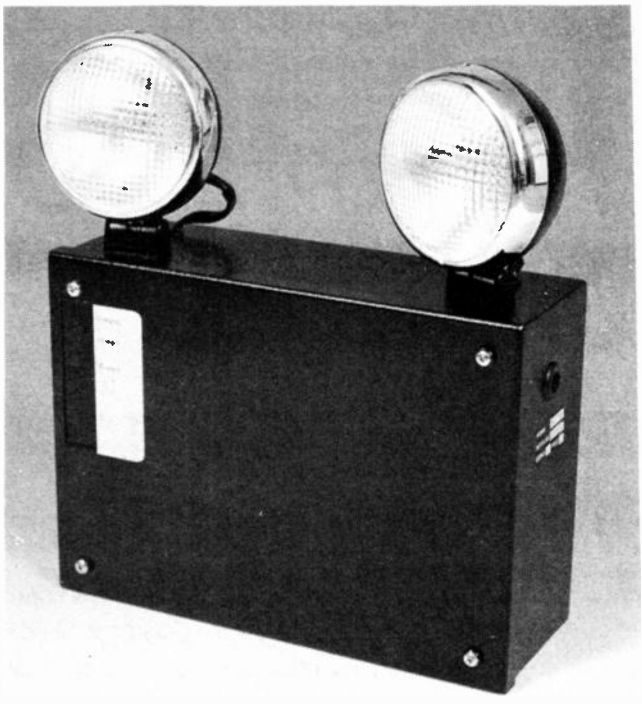
Greenweld Electronics Ltd have recently ventured into budget CD's and tapes and have made a free catalogue available listing hundreds of titles which should appeal to just about every taste (the titles were also listed in their Summer Sale Catalogue given away with last months *EPE*). When various arguments about the price of CDs are raging Greenweld have put out around 700 titles for just £2.99 each. They are all "pressed" by Tring International PLC, thus ensuring good quality.

Greenweld have been supplying hobbyists with a wide range of components for the past twenty years and have specialised in surplus items. Peter Green, who started the company by selling surplus bits to collegues when he worked for BT, tells us they now have a turnover of nearly £1 million with 35,000 listed customers who are mailed several times a year. They issue a major catalogue every year and subscribers receive a monthly newsletter plus their latest list of bargains for an annual subscription of £6.

Most orders are turned around the same day and, with an average of around 2,000 orders a week (including shop sales), the staff are kept fairly busy. They operate from 12,000 sq. ft. premises near the docks in Southampton.

Crafty lot

The ***Lab-Craft*** brand name will be familiar to readers who use 12V lighting, low-voltage power supplies, battery charging equipment, shaver inverters, control panels, etc. in boats and caravans. Lab-Craft is a small British manufacturing company founded in 1956 and still owned by the original three families. The factory is based in Harold Wood, near Havering, Essex, with warehouse sales offices in Chelmsford not far away. The company employs a workforce of approximately 120.



The Lab-Craft twinspot emergency lighting system.

In the early days, the sales line was electronic instrumentation products. However, Lab-Craft soon found a niche market using their pioneering work on transistorised fluorescent lighting in 1961. It is still for this type of equipment that Lab-Craft is often remembered. However, for commercial rather than leisure purposes, the company supplies low-voltage lighting to various vehicle manufacturers such as Ford, Vauxhall, Renault and Volvo.

Less well known, but highly successful is the company's design, manufacture and marketing of emergency equipment. This includes a range of lighting, sounders, alarm panels, smoke detectors and heat detectors (for use in smoky environments where a smoke detector would give false alarms). Lab-Craft products are found in such diverse places as the British Museum, Guys Hospital, the Royal Naval Dockyards – even in motorway tunnels in Bahrain!

Keeping up with demand and staying one step ahead of the opposition is the philosophy boasted by this company. An example is the development of lighting powered by batteries and charged by solar panels. Of new leisure products, the *Tri-Lite* is a low-voltage fluorescent light with the option of operating one, two or three 8W tubes to enable the user to match the lighting to the need.

At the commercial end, the *Twinspot* emergency lighting system may be seen in factories and supermarkets all over the country. This is a maintenance-free system based on twin halogen spotlights powered by lead-acid batteries. Recently, lighting has been developed for use in the harsh environment of refrigerated vehicles which, traditionally, suffer from a poor level of illumination. □

ADDRESSES

POWERware, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD. Tel: 061 449 7101.

Amplicon Lifeline Ltd., Centenary Industrial Estate, Hollingsdean Road, Brighton, East Sussex, BN2 4AW.

Lab-Craft Ltd., Bilton Road, Waterhouse Lane, Chelmsford, Essex, CM1 2UP. Tel: 0245 359888.

Greenweld Electronics Ltd., 27 Park Road, Southampton SO15 3UQ. Tel: 0703 236363.

Techniques

ACTUALLY DOING IT!

by Robert Penfold

WHAT is the difference between a rectifier and a diode? This is one of those perennial questions which I seem to have been answering for more years than I care to remember. I suppose that there is actually very little difference between the two.

A diode allows a current to flow in one direction but blocks a current flow in the opposite direction, and so does a rectifier. I think that the diode name actually goes back to the valve era, when a diode was a valve that had two electrodes, and a triode was a valve with three electrodes.

JUST PLAIN DIODES

These days the word diode is generally used to describe a semiconductor diode that can only handle low currents. These are sometimes referred to as "small signal" diodes, but are more commonly known as just plain diodes. A rectifier is generally taken to be something that can handle higher currents, and is primarily intended for use in power supply circuits.

The 1N4148 is an example of a diode. This has a respectable reverse voltage rating of 50 volts, but it can only handle forward currents of up to 75 milliamps. The popular 1N4002 rectifier can withstand reverse voltages of up to 100 volts, and it can handle forward currents of up to 1 amp (1000 milliamps). This is quite modest by rectifier standards, and reverse voltage ratings of 1000 volts or more and current ratings of several amps are quite common.

Physically, diodes and the smaller rectifiers are very similar. Surprisingly perhaps, they are not necessarily much different in size either. The most obvious differences are that the bodies of diodes have rounded ends, whereas rectifiers are flat-ended. Also, the leadout wires of rectifiers are normally much thicker than those of diodes, resistors, etc. This is partially due to the fact that the leadout wires of rectifiers have to handle relatively high currents, but it is mainly to aid the removal of heat from a rectifier. In effect, the leadout wires act as small heatsinks.

POLARITY

It is essential to fit diodes and rectifiers with the correct polarity. Even in low power circuits, connecting a diode round the wrong way can result in a large current flowing through the diode, plus (possibly) a driver transistor or other component in the circuit. Getting the polarity of rectifiers wrong tends to produce an output of the wrong polarity from the power supply circuit, which in turn tends to produce exploding electrolytic capacitors and integrated circuits! Always double-check that diodes and rectifiers are connected properly before trying out a newly constructed project.

The polarity of most diodes and small rectifiers is indicated by a band marked around the cathode ("k" or "+") end of the body. With some diodes this band completely covers one end of the component, but either way there should be no difficulty in identifying the cathode lead.

In most cases you will probably be following printed circuit or stripboard overlays which clearly show the band, and it is then just a matter of making sure that your circuit board matches up with the component layout diagram. The only likely exception is where a diode is mounted vertically. On the diagram one lead of the diode should then be marked with a "+" or "k". You simply have to remember that this lead is the one which is designated by the band.

SYMBOL

A little more care is needed if you are working from a circuit diagram. At one time a few diodes were marked with little diode circuit symbols, which made life much easier for beginners. Unfortunately, this seems to have totally gone out of fashion, and is something you are unlikely to see on anything other than a few high current rectifiers. It is still quite easy to get the polarity right, since the cathode end of the diode symbol, like the real thing, has a bar across.

Incidentally, the arrow part of the symbol indicates the direction in which the diode will pass a current (i.e. from anode to cathode). We are dealing with conventional current flow here (from positive to negative), not electron flow. To a current flowing in the opposite direction the diode acts as a barrier, which is represented by the bar part of the symbol.

Some diodes are marked with a number of coloured bands around their bodies, rather like resistors. Apparently this is a form of colour coding, and 1N4148 diodes sometimes have the "4148" part of the type number marked in the same manner that is used for the first two digits of a resistor colour code. The bands would therefore be yellow, brown, yellow, and grey. These multiple bands obviously make it slightly more difficult to work out which way round the diode should be connected. If you look carefully at a diode of this type you should find that one band is much thicker than the others. This band is at the cathode end of the component.

In practice the thicker band is often not that much thicker than the others, but you should be able to sort things out if you look closely enough. The broad band is the first one in the colour code (the first yellow band for a 1N4148). This method of marking seems to be falling from favour, which is perhaps not surprising.

Rectifiers which can handle currents of up to a few amps often lack the band which designates the cathode lead. These larger rectifiers usually have a sort of bullet shaped casing, with the cathode lead coming from the "pointed" end of the case. Fig. 1 explains the methods of polarity marking used for a variety of common rectifiers and diodes.

SMASHING TIME

Rectifiers normally have plastic encapsulations which make them physically very tough. Diodes mostly have glass encapsulations, and this makes them very vulnerable to physical damage. If you should accidentally tread on a diode, drop a pair of pliers on one which is on the workbench, or something similar, the diode will almost certainly be smashed.

Less obviously, bending a leadout wire close to the body of the component can result in the case cracking. This will often result in small pieces of the case actually breaking off. This does not necessarily result in the diode being damaged badly enough to prevent it from working properly, but this can happen, and at best the component will be seriously weakened.

It is not really a major problem with modern diodes such as the 1N4148, which are very small and relatively tough. It is the larger glass cased diodes such as the OA90, OA91, and many Zener types which seem to be the most vulnerable to this type of damage. If a component layout dictates that the

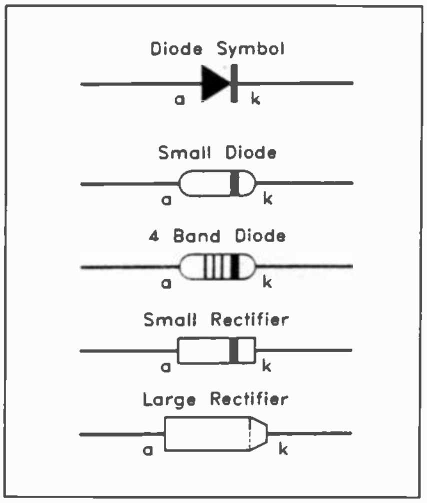


Fig. 1. Methods of polarity indication for most popular diodes and rectifiers.

leadout wires must be bent close to the body of the diode, proceed very carefully. Ideally each leadout wire should be gripped next to the body of the diode using tweezers or a small pair of long-nosed pliers, so that the lead can be bent without putting the glass encapsulation under stress.

Glass cased diodes are more easily damaged by excessive heat than most other semiconductors. Also, germanium based semiconductors are relatively easily damaged by heat. Although germanium transistors have been obsolete for many years, germanium diodes are still used a great deal. This is due to the lower voltage drops that germanium diodes provide, which makes them superior to silicon diodes in some applications.

In the past it was normal to use a heatshunt on each lead of a diode before soldering it in place. A heatshunt is a simple metal clip which is fitted on the leadout wire close to the body of the diode. Modern heatshunts are mostly in the form of tweezer-like implements which have jaws that lock together. The basic idea is that a lot of the heat flowing up the lead from the soldered joint is diverted into the heatshunt, and is kept away from body of the diode.

I have not found it necessary to use a heatshunt when fitting modern glass bodied diodes, even the germanium variety. Modern diodes seem to be that bit more hardy than those of 20 or so years ago. However, each soldered joint should be completed reasonably quickly. Also, once the first joint has been completed it is a good idea to let everything cool down a little before proceeding to the second joint.

ACID TEST

If the polarity marking of a diode is ambiguous, or the markings have simply rubbed off, a check with a multimeter will soon show which lead is the cathode. When using an analogue multimeter to test a diode, set it to a middle resistance range and connect it across the diode. If a low resistance reading is obtained, the diode's cathode lead is the one connected to the positive test lead. If a very high reading is obtained, the cathode is connected to the negative test lead.

The same basic procedure can be used with a digital multimeter, but the test works the other way round. If the resistance reading is high, it is the cathode that is connected to the positive test prod. If the reading is low it is the cathode lead that is connected to the negative test prod.

Most digital multimeters have a diode checking range, and when available this range should obviously be used. On the normal resistance ranges the test voltage might be too small to give a low forward resistance from a silicon diode or rectifier.

SEEING THE LIGHT

The diodes that give the most trouble are undoubtedly the light emitting variety. A l.e.d. is a true diode, and will only conduct (and light up) if it is connected the right way round. One reason for the difficulty in determining the polarity of l.e.d.s is that they are now supplied in a vast range of sizes, colours, and shapes. However, most l.e.d.s, including the more exotic varieties, have a cathode lead that is slightly shorter than the anode lead.

At one time ordinary (round) l.e.d.s also had cases which were flattened slightly next to the cathode lead. Most l.e.d.s still have the shorter cathode lead, but the "flat" is now often absent, or so slight as to be barely detectable.

Various instant methods of telling l.e.d. polarity have been put forward from time-to-time. Unfortunately, for every method that is suggested there seem to be a few l.e.d.s which disprove the rule. The only 100 per cent certain method is to actually try each l.e.d. in a test circuit. I always check every l.e.d. before connecting it into circuit, even if it does have all the usual polarity indicators.

The multimeter check described above will work with most meters, although a few might not provide a high enough test voltage. The simple test arrangement shown in Fig. 2 will work with any l.e.d. that produces visible light. There is no need for any soldering as it is quite easy to hold the l.e.d. and series resistor in place.

Never connect a l.e.d. directly across a battery or other power source. Without the series resistor a high current will flow, and the l.e.d. is likely to be almost instantly "zapped". Fortunately, connecting a l.e.d. the wrong way round will not result in it being damaged. Therefore, if you should get a l.e.d. connected with the wrong polarity, simply reversing the connections to it should cure the problem.

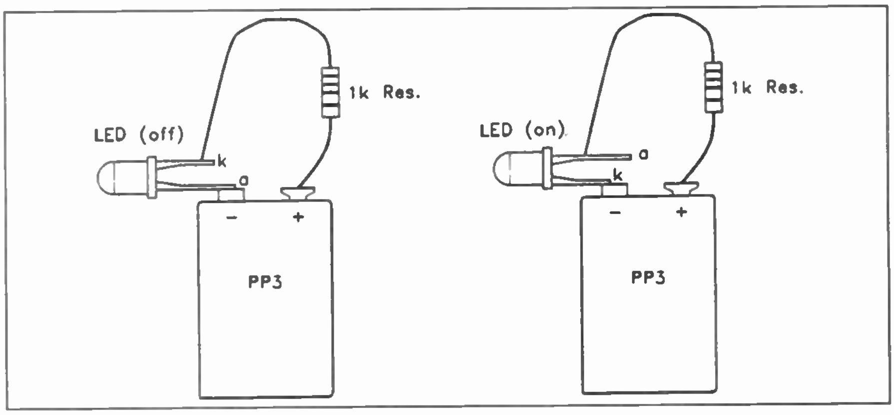


Fig. 2. Checking the polarity of an l.e.d.

Home Base

Jottings of an electronics hobbyist–Terry Pinnell

Poor ceiling

When a section of downstairs ceiling fell onto my carpet, it didn't take long to establish that faulty sealing around the bath upstairs was the cause. I was a bit ashamed not to have noticed the gradually increasing stain in the plaster, but in mitigation you just don't make a point of looking up there very often, do you?

It was a simple matter of water seeping through the sealing at the edge of the bath and into the plaster below. Repairs completed, my mind turned to future avoidance. Ideally I wanted a more helpful warning of trouble than the appearance of yet another ominous stain. Clearly a plausible excuse to design an electronic damp detector.

The first step was a bit of research. Browsing through countless old magazines and books, which I keep for just such an occasion, I found many circuits which might be relevant. These fell into two main categories, the most common being the rain or water alarm type, which typically detected water in large volumes. Applications included a bath reaching a certain level, an overflowing washing machine, a flooded bilge in a boat, and so on.

Putting a damper on it

But it was the second type of circuit that I was interested in, the moisture detectors. What was needed was to be alerted to insidious dampness, not an outright flood. However none of the examples I dug up seemed at first sight to do what I had in mind.

For a start it had to be battery operated – no question of using a mains supply in the bathroom. Secondly it had to have negligible quiescent current consumption, so that I could forget about changing the battery for a year or two. Thirdly, it should be possible to just leave it switched on, with no intervention. Obviously, when the

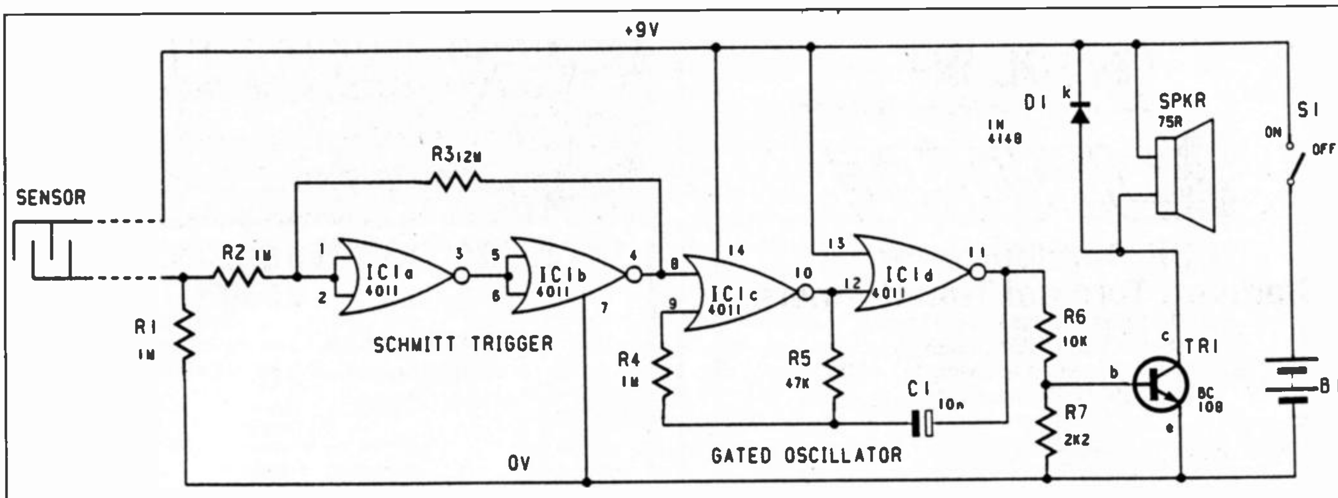


Fig. 1. The damp detector circuit.

alarm was triggered I would then want to be able to turn it off, so it did still need an on/off switch.

Despite being restricted to a battery, I decided that the alarm should also be loud enough to be heard downstairs in normal conditions. To cover the situation when I wouldn't have heard it, I did fleetingly consider the trouble of adding a visual indicator downstairs, but that was overkill. (Where to draw the line – a lamp in every room?) Anyway, I reckoned that the battery would cheerfully keep the alarm going at virtually full blast for several hours, so unless I was engrossed in a war epic on TV or something, I would undoubtedly hear it at some point in that period.

Positively alarming

A fifth objective was reliable and clean-cut switching. One characteristic of most of the circuits I looked at was their difficulty in dealing with the sort of "intermediate" state I anticipated, when the floor underneath the bath was neither flooded nor bone-dry.

Completing the sextet of requirements, I also wanted it to be simple and cheap. These tend to go hand in hand of course, but I've come across circuits which achieve their simplicity of construction by using complex, specialist i.c.s, which are often also pricey.

For those of you thinking of rigging up something similar, the circuit that evolved to meet these specifications is shown in Fig. 1. It is straightforward enough, with the resistance of the sensors forming the upper half of a voltage divider, which turns the resistance into a voltage. This is fed to IC1a and IC1b, which form the two gates of a Schmitt trigger to give it clean switching. The output from that stage then enables a conventional CMOS oscillator made from IC1c and IC1d. In turn, the oscillations from that are fed to the final stage, the speaker driver.

You could substitute whatever miniature speaker you had available, adding a protective series resistor if your transistor was low powered like the one I used. Of course, some of your battery power would then be going into warming that resistor rather than being turned into alarm sound.

The basic sensor is a piece of copper stripboard with adjacent tracks wired to two separate points. These therefore present a resistance which falls dramatically when there is moisture across any one or more of the gaps. I also used a sensor made out of blotting paper folded around lengths of stripped solid core wire. When it absorbs moisture, the resistance between the wires embedded inside it dropped from many megohms to perhaps a few hundred kilohms.

Another sensor was even more basic: just lengths of bare wire laid about a centimetre apart on top of the dusty plasterboard, kept flat by anything handy, like a few strips of wood or plastic. In all I used five sensors, of several types, placed strategically, such as along the wall where the previous trouble had arisen, below the taps, and close to the U-bend. All were wired in parallel, so that if the resistance across any of them dropped below a pre-set level, then the alarm would be triggered.

ESP

In addition to those five sensors under the bath I also fixed a pair of springy wires to the unit itself. Its case was made, appropriately enough, from a length of plastic, rectangular-section rain guttering, of the type I described in earlier ramblings. When fitted with the neat end-caps, this is raised a few millimetres from the surface, so the wires in the bottom could be arranged to slant down to make firm contact with the bathroom floor, where the unit was resting beside the bath. So that when I got too enthusiastic while having a shower and sprayed the floor, this would immediately alert me. This proved to be a useful afterthought, although it scared the wits out of me the first time it was activated a few weeks after installation, in those few seconds before I remembered what the heck it was.

Another reason for choosing that guttering for the case was that it was a perfect fit for the PP9 battery I chose. This gave a very long life; around four years for that first one I think.

The first time the alarm went off apart from that was a good six months later. After the boring bit of removing some ten screws from the panel on the side of the bath I was surprised to find nothing obviously wet. Although this was good news, it did highlight a shortcoming in the way I'd wired up the sensors, connecting all five together inaccessibly underneath the bath, with just two wires going out to the unit. Even those two were not accessible for easily measuring the resistance across them. I subsequently changed the wiring so that I could take a resistance reading not only across all six (including the in-built prongs) but also across the five inaccessible sensors.

In practice this proved worthwhile, because I never actually found one of the sensors sitting in a puddle – even my pathetic skill with a tube of that gooey bath sealant stuff was sufficient to keep most of the water inside the bath. No, in practice, I always wanted to find out just which sensor was responsible for the overall low resistance, so that I could isolate the cause of the trouble.

AC/DC?

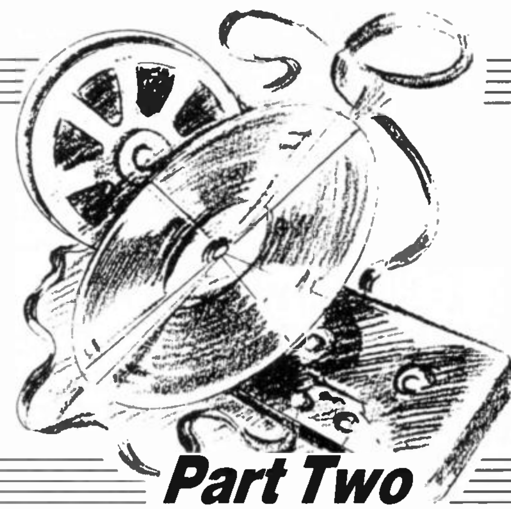
After a year or two I started to get false alarms, which turned out to be due to corrosion of the sensors rather than any significant leaks. No doubt there are materials which would operate properly forever, but copper strips and wire in particular do suffer from both tarnishing and corrosion.

Chemistry graduates please don't write in, but I presume the former is due to oxidation, and the latter to reaction with water and other trace elements. The result is to coat the copper with compounds of various kinds, which wreak havoc with the basic operating principle, because they cause a low resistance to be measured across the input of the detector, thus giving false alarms.

One of the circuits found during my earlier magazine-browsing proposed a novel approach to the corrosion problem. Its author claimed that a.c. current through the sensors would drastically minimise the effect, and his circuit therefore generated low-level a.c. with a CMOS oscillator, which was then fed to the sensor. If its resistance was low enough, the signal would be transmitted with sufficient strength to the next stage. This rectified the a.c. back into d.c. and then passed it to Schmitt trigger and alarm stages, as in my circuit. I understand this type of circuit is now available in a dedicated chip.

I wonder if this additional complexity is worth the effort? Meanwhile I'll continue with my simple version, changing the battery every Leap Year and giving the sensors their annual MOT. □

Constructional Project



STEREO HI-FI CONTROLLER

DAVID GEARY

Part Two

Provides a smooth professional "fade-in" to your chosen background music/speech once the CD, disc or tape etc. has finished playing.

LAST month we outlined the facilities of the Controller and described the System Power Supply. This month we conclude with Main board construction and add an optional Expansion/Display board.

CONSTRUCTION

Construction of the Main Control Board is also straightforward, follow the usual rules mentioned last month, and watch out for the links! The p.c.b. component layout and full size underside copper foil master is shown in Fig. 10. This board is also available from the *EPE PCB Service*, code 887.

Again, the specified p.c.b. connectors are well worthwhile. Note the mounting holes in the p.c.b. are just right for M3 bolts.

If you intend to use the Expansion Board, as no doubt most will, resistors R17 and R18 should be omitted and capacitors C7 and C8 replaced with wire links. If this is not done, these components combine with others on the Expansion p.c.b. to form a reasonably effective high pass filter to priority inputs!

TESTING AND SETTING UP

Having checked for solder bridges, etc, apply power to the Main Control board via connector PB5. Set preset VR1 to maximum resistance and VR4 to two-thirds maximum. Connect an oscilloscope, or failing that, an amplifier to PB10.

Apply a signal from a signal generator or music source (a robust one) to PB6. Allow ten seconds or so and the signal should fade up. Now move the signal input to PB9, and after four seconds or less it should fade up again. Gain should be adjustable using preset VR2 (Background) and VR3 (Priority).

If all does not seem well, check the outputs of IC5 at the links across the "ground" connection to IC6. Pin 2 of IC5 should be high with no signal at connection point PB9. Also check for approximately 1Hz at the long link from IC4 to IC6. With the signal connected to PB9, check there are pulses on the short link from IC4 to IC6 over the ground connection to IC5.

If the fault still does not come to light, recheck all component values, placements, etc.

If your board is not going to be used with the Expansion Module, you can set the gain controls VR2 and VR3 to give a gain of unity or any other gain up to about 2.5 that you require. Presets VR1 and VR4 can be adjusted to provide the necessary sensitivity for your application, but should not be set so the board is over-sensitive and triggers when the fridge compressor comes on! (I'm serious...).

COMPONENTS

Approx cost guidance only **£32**

MAIN BOARD

See SHOP TALK Page

Resistors

R4, R5, R7, R8, R25, R26	12k (6 off)
R6, R27, R43, R47, R48, R50	1k (6 off)
R9, R13, R21, R22, R28, R29, R34, R38, R42, R46, R49, R51, R55	10k (13 off)
R10, R11, R14, R15, R35, R36, R39, R40	470 (8 off)
R12, R16, R37, R41	39k (4 off)
R17, R18	180k (2 off)
R19, R20, R30, R31, R44, R45	4k7 (6 off)
R23, R24, R32, R33	5k6 (4 off)
R52, R53	1M (2 off)
R54, R56	100k (2 off)

All 0·6W 1% metal film

Potentiometers

VR1, VR4	100k enclosed horizontal carbon preset, lin.
VR2, VR3	22k enclosed horizontal carbon preset, lin.

Capacitors

C5 to C13, C18 to C20, C23, C25	150n metallised polyester film (14 off)
C14, C15	100µ radial elect. 16V or greater (2 off)
C16, C17	1µ radial elect. 16V or greater (2 off)
C21	4µ7 radial elect. 16V or greater
C22, C24	10µ radial elect. 16V or greater (2 off)

Semiconductors

D6	1N4148 signal diode
D7, D8	1N4001 1A 50V rect. diode (2 off)
TR3, TR4	BC109C *npn* silicon transistor (2 off)
IC1, IC2	LM13700 dual transconductance op.amp (2 off)
IC3	LF347N quad j-f.e.t. op.amp
IC4	4093BE quad 2-input NAND Schmitt trigger
IC5	4013BE dual D-type flip-flop
IC6	4017BE decade counter
IC7	TL082 dual bi-f.e.t. op.amp

Miscellaneous

Printed circuit board available from the *EPE PCB Service*, code 887 (Main); steel metal case, size 175mm x 155mm x 58mm; 8-pin d.i.l. socket; 14-pin d.i.l. socket (4 off); 16-pin d.i.l. socket (2 off); chassis mounting phono sockets, mounted on Paxolin panel; 3-way p.c.b. connector, with latch housing and terminals (5 off); 4-way p.c.b. connector, with latch housing and terminals; connecting wire; solder; M3 14mm threaded spacer (4 off); M3 nylon spacer (or 6BA drilled out) (4 off); M3 10mm bolt (4 off); M3 20mm bolt (4 off); M3 full nuts (12 off); nuts and bolts, required for front and back panels.

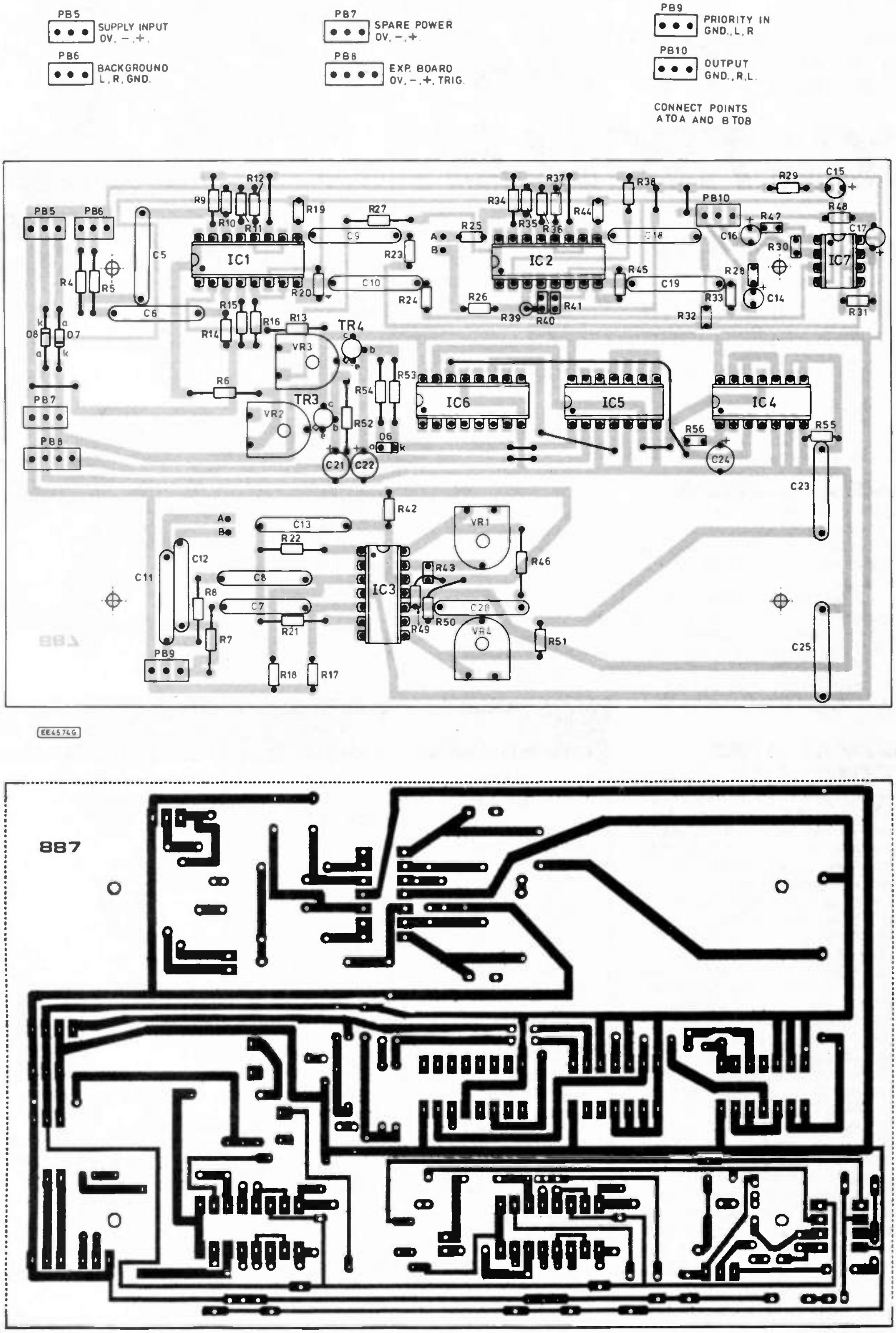


Fig. 10. Printed circuit board component layout and full size copper foil master pattern for the Main Control Board. The p.c.b. connector pin details are shown at the top.

EXPANSION AND DISPLAY BOARDS

The Expansion board increases the number of Priority Inputs to four. In addition, a Tape Output facility is provided and a dual seven-segment display to indicate status of main and tape outputs. The tape output is also provided with a fixed gain output amplifier with a gain of 1.47.

This board is fairly straightforward as can be seen from the block diagram Fig. 11. The only special connection to the Main board is the trigger signal, so the Expansion Module could be added later if desired, subject to the component changes mentioned earlier.

The Expansion/Display circuit diagram is shown in Fig. 12. It is almost as simple as the block diagram. Once again, a 4093 (IC8) provides the clock frequencies. Two counters are required, a 4520 dual counter (IC9) provides these efficiently. Note that as only the first two data lines are required (LSB, LSB + 1), either a BCD or Binary counter can be used. The data lines drive IC13 and IC14, 4511 7-segment decoders, and IC10, IC11, 4052 bilateral switches.

The available technical data for these "switches" (4052) suggest making pin 7 negative with respect to ground (pin 8) for the best a.c. performance. Having evaluated this mode of operation against making pins 7 and 8 the same potential, no noticeable degradation in performance was found to justify the extra complication (the rest of the CMOS would be running on a different ground potential). Although it would be possible to separate pins 7 and 8, no practical advantage was evident and I have therefore ignored this suggestion.

The required gain for the tape output is provided by the dual op.amp IC12. Capacitors C29 to C36 in conjunction with

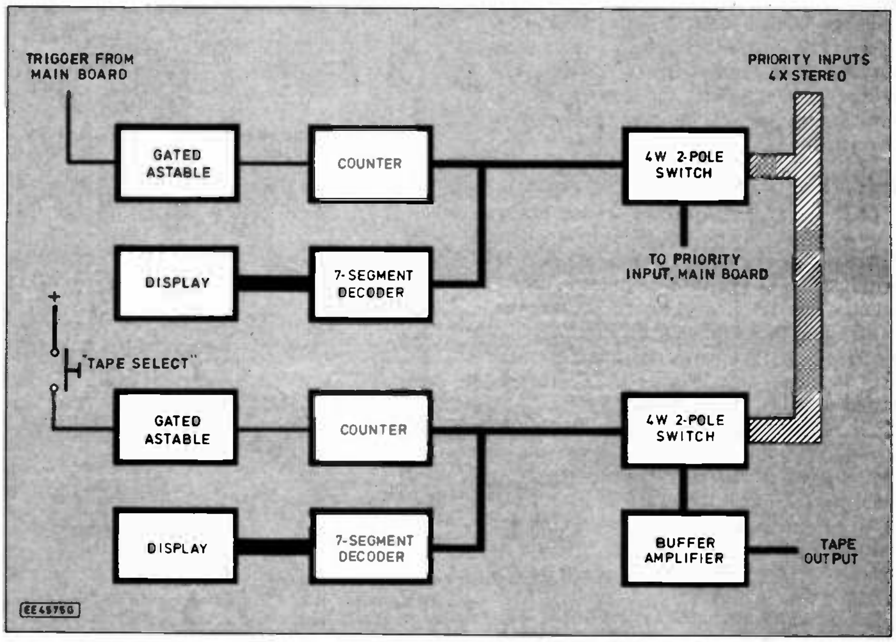


Fig. 11. Block diagram for the Expansion/Display boards.

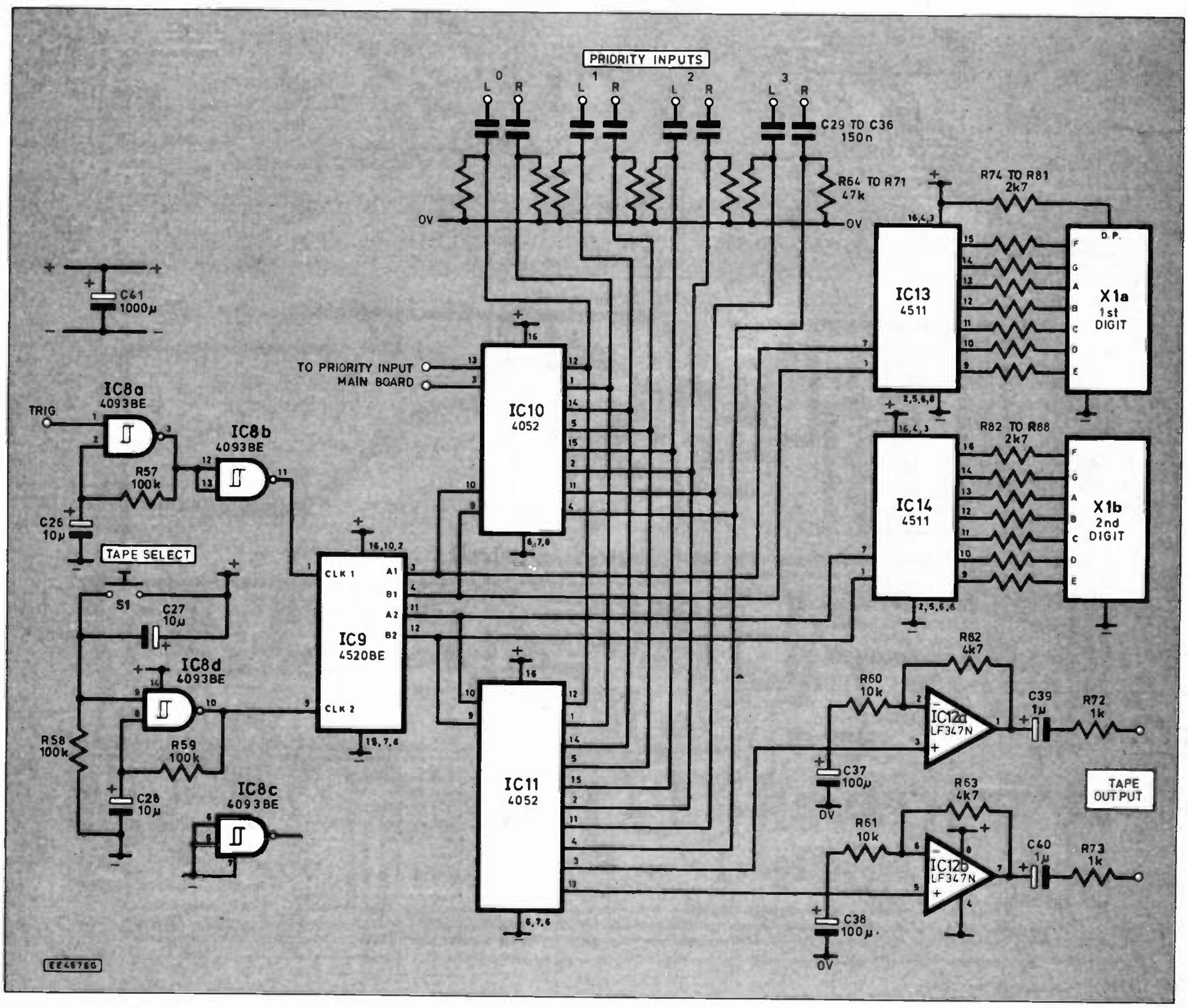


Fig. 12. Complete circuit diagram for the Expansion and Display boards for the Stereo Hi-Fi Controller.

resistors R64 to R71 decouple the inputs. (Hence C7/R17 and C8/R18 are not required). This configuration removes the danger that a slight d.c. offset at the input could prevent the system operating correctly.

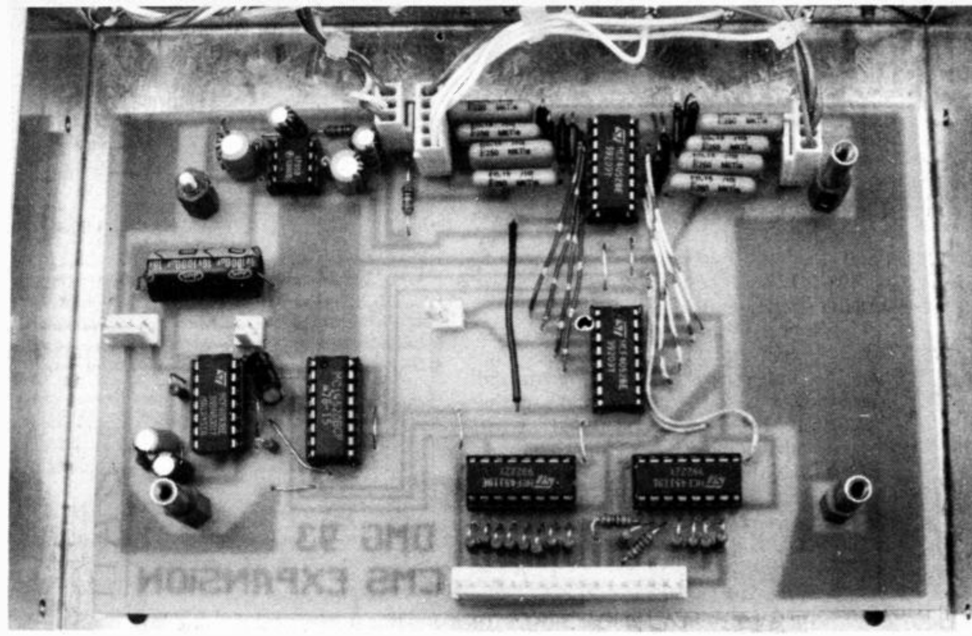
HOW IT WORKS

The trigger input from the Main board is high when the clock is required to stop, i.e. a signal has been found. This is used to stop IC8a from oscillating by gating off the Schmitt NAND gate. IC8b inverts the output from IC8a to prevent the counter triggering on the rising edge that could result, and therefore stopping at the count required + 1.

The same gated astable configuration is used on IC8d, but the inversion is not required as the pushbutton switch S1 will be released quickly when the correct count is reached. These clock pulses, when present, clock dual up-counter IC9. The LSB and LSB+1 outputs from each half of IC9 drive the seven-segment displays (X1, X2) via decoder/drivers (IC13, IC14), and 4-way double-pole bilateral switches (IC10, IC11).

The inputs of the bilateral switches IC10 and IC11 are paralleled so as to make the four inputs accessible for both tape and main outputs. The tape output selector IC11 is connected to a conventional negative feedback op.amp IC12 to provide a gain of 1.47 (an arbitrary figure) and buffering, so that any noise on this output cannot feed back to the rest of the circuit.

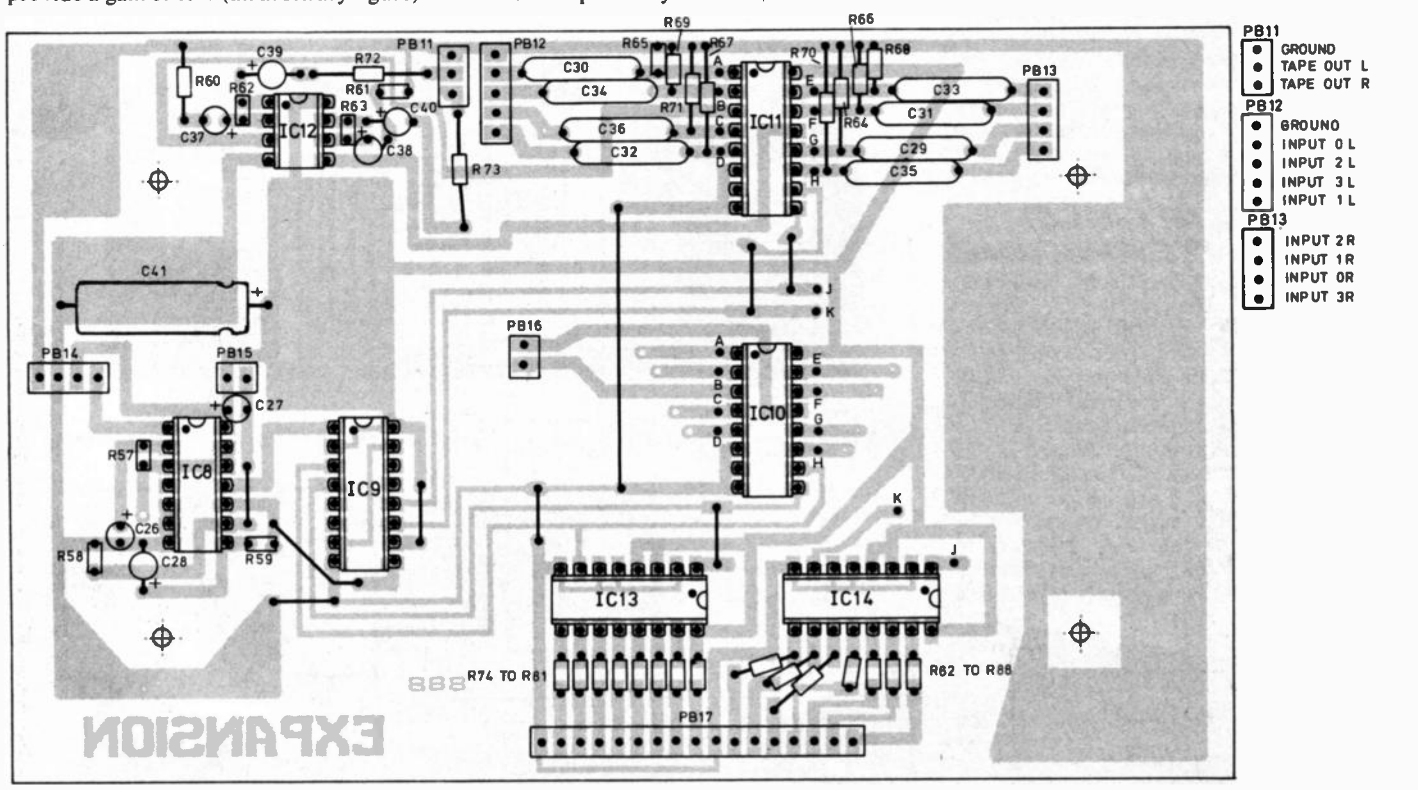
Unused inputs are tied to ground. Capacitor C41 blocks any supply-borne pulses causing spurious triggering on the main board.



CONSTRUCTION

Both the Expansion board and Display board are quite easy to build, but bear in mind there are a number of links to be made. In addition, there is the 17-way connector to the Display board, which can be a little tedious. However, a little care here will pay dividends in the shape of a project which should work first time.

The p.c.b. component layouts and full size underside copper track masters for the Expansion and Display boards are shown in Fig. 13 and Fig. 14. These boards are available from the *EPE PCB Service*, code



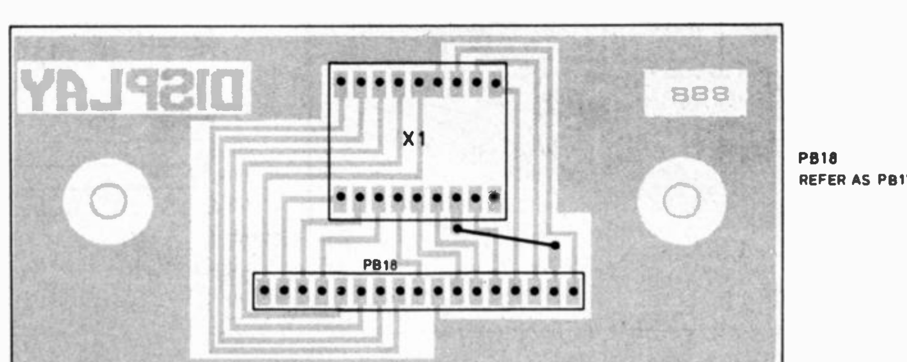


Fig. 13. Printed circuit board component layouts for the Expansion and Display p.c.b.s.

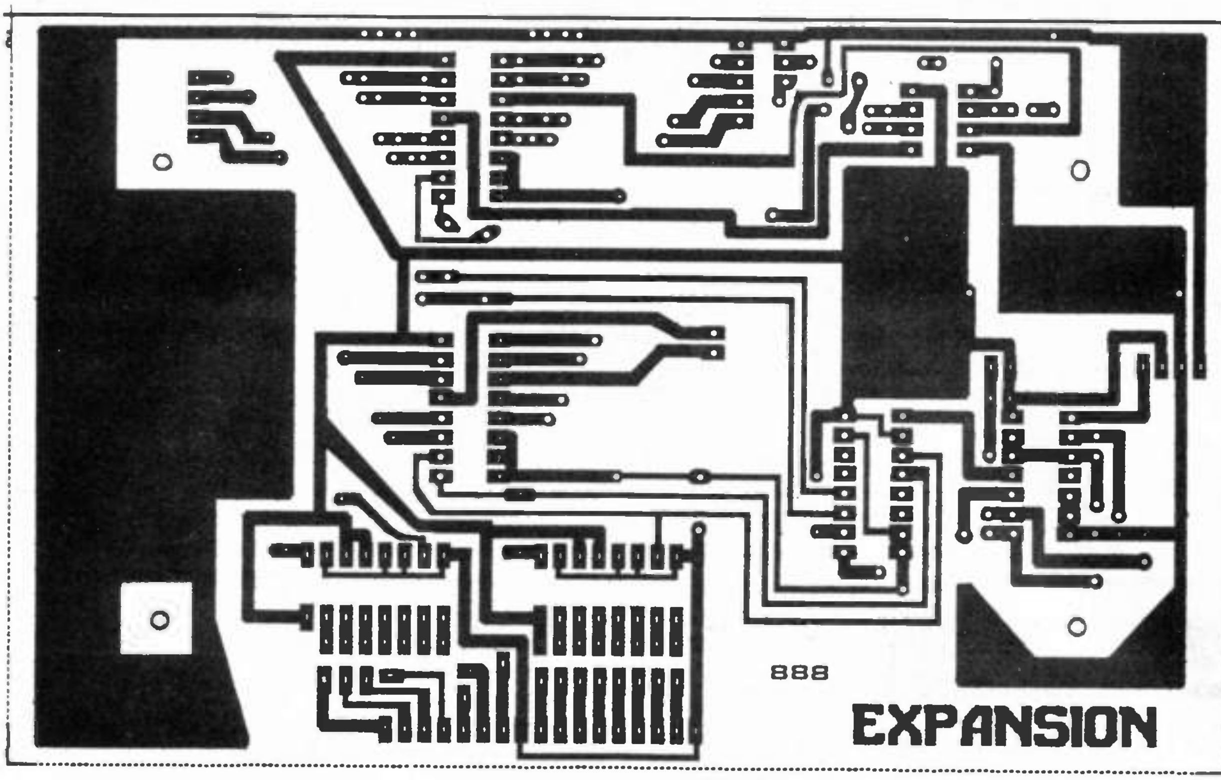
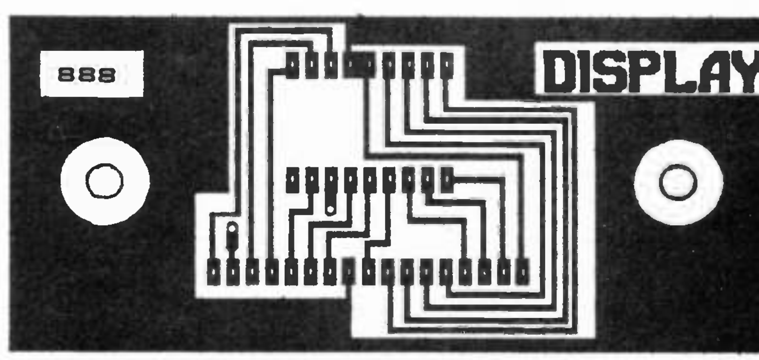


Fig. 14. Full size copper foil printed circuit board master patterns for the Expansion board and the Display board.



888 (Expan/Dis). Note that the pads on the Display board exactly match those on the Expansion board, both for spacing and order of connection.

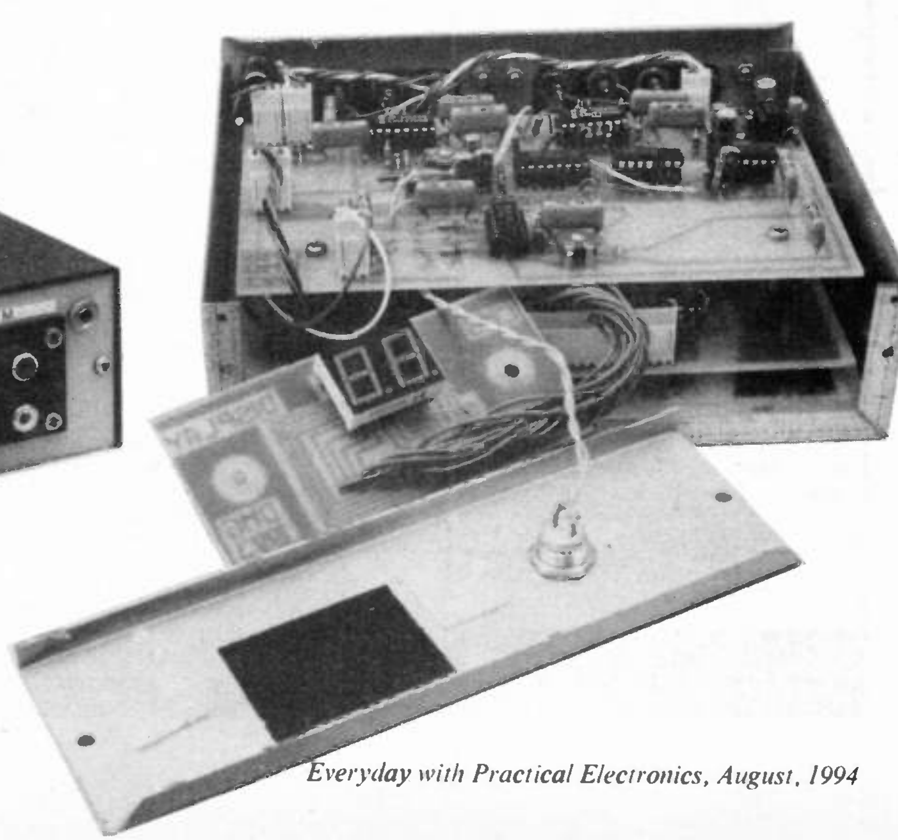
Be careful of componment orientation, bridged tracks, etc. None of the boards in this project are very difficult to complete given some attention.

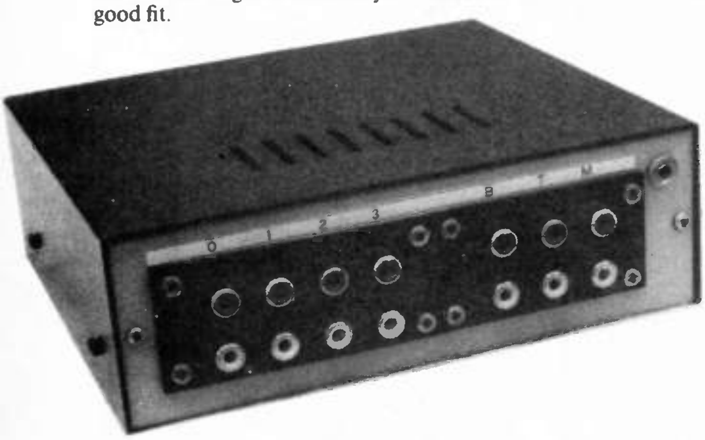
CASE DETAILS AND INTERWIRING

Once construction of the p.c.b.s is complete, you should have three boards to install in a box; Main Board, Expansion Board, Display Board. The specified metal case has removable front and rear panels. It suggested that the rear panel is made up first. It is a bit of a squeeze but it does fit!

You will need to cut away part of the "rebate" at the back of the case to allow for the power jack if you use the specified case. I used phono sockets on Paxolin for convenience (they are also very easy to solder neatly); and they can be trimmed around the edges if necessary to ensure a good fit.

The front panel removed from the unit showing the p.c.b. "stacking" arrangement.





Rear view of the Controller showing the Paxolin phono socket panel.

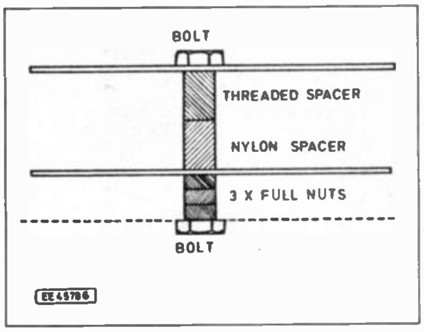


Fig. 15. Suggested method of mounting the two larger boards using spacers and nuts.

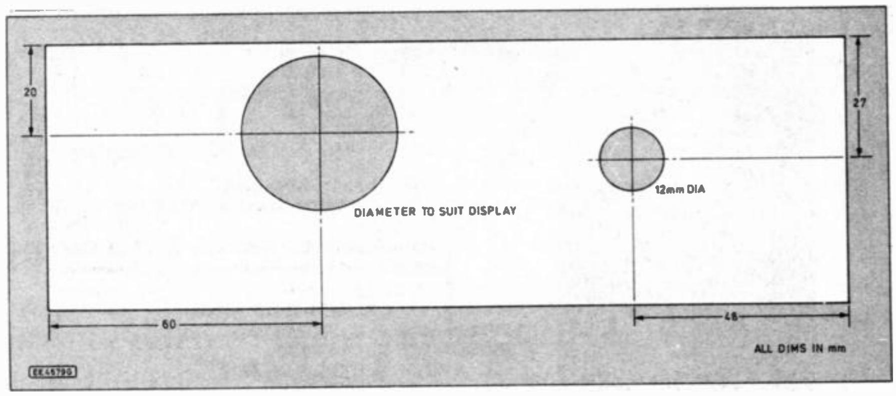


Fig. 16. Front panel drilling and cutting details.

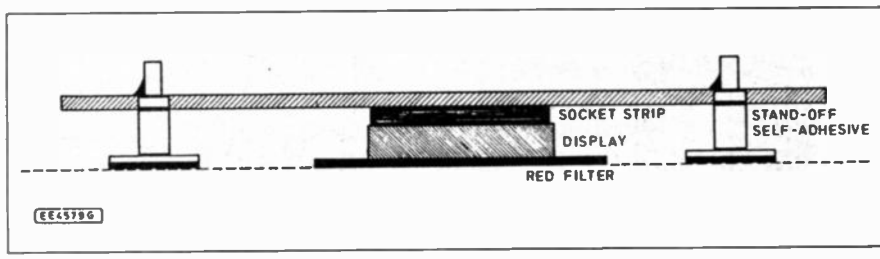


Fig. 17. Using self-adhesive p.c.b. stand-offs to mount and position the Display board behind the front panel.

The two larger p.c.b.'s are mounted inside the case using an unusual arrangement using threaded spacers. Having drilled four 3mm holes in the right places, pass an M3 bolt through each, and put three nuts on the inside. This will locknut the boards very securely and provide the right spacing.

Pass the Expansion Board over the bolts, followed by a nylon spacer and a threaded steel spacer. Then put the Main board on top to check it all fits. It should be possible to screw into the threaded spacers with short M3 bolts to secure the Main board – Fig. 15.

Do not tighten down the Main board yet. If using the specified p.c.b. connectors, make up jumper leads to run from PB8 (Main board) to PB14 (Expansion board), and from PB9 (Main board) to PB16 (Expansion board). Plug the Expansion board ends of the leads in position, leaving the Main board ends free for now.

Wire from the pair of Tape Output jacks to PB11 and plug in. Do the same for the left and right sets of inputs to PB12 and PB13 respectively.

Solder a pair of wires to the front panel pushbutton switch and put a two-way socket on the other end of the wires to suit PB15. The specified pushbutton and p.c.b. connector allows the connector to pass through the front panel cutout on final assembly and connect to PB15. Finally, connect seventeen leads to PB17, soldering them to the Display p.c.b.

Install the Main board. Connect the flying leads from the Expansion board to PB8 and PB9. Connect PB5 to the power jack, and PB6 and PB10 to the Background input and main output respectively. Connect PB17 to the Expansion board.

COMPONENTS

EXPANSION AND DISPLAY

See SHOP TALK Page

Resistors

R57 to R59	100k (3 off)
R60, R61	10k (2 off)
R62, R63	4k7 (2 off)
R64 to R71	47k (8 off)
R72, R73	1k (2 off)
R74 to R88	2k7 (15 off)

All 0·6W 1% metal film

Capacitors

C26 to C28	10µ radial elect. 16V or greater (3 off)
C29 to C36	150n metallised polyester film (8 off)
C37, C38	100µ radial elect. 16V or greater (2 off)
C39, C40	1µ radial elect. 16V or greater (2 off)
C41	1000µ axial elect. 16V or greater

Semiconductors

IC8	4093BE quad 2-input NAND Schmitt trigger
IC9	4520BE dual binary counter
IC10, IC11	4052BE 2-pole 4-way bi-directional analogue switch (2 off)
IC12	LF347N quad j-f.e.t. op.amp
IC13, IC14	4511BE BCD to 7-segment decoder driver (2 off)
X1	Double digit 0·56in. common cathode display

Miscellaneous

Printed circuit boards available from *EPE PCB Service* code 888 (Expan/Dis); pushbutton switch, push-to-make; 8-pin d.i.l. socket; 14-pin d.i.l. socket; 16-pin d.i.l. socket (5 off); 20-way socket strip; 2-way p.c.b. connector, with latch housing and terminals (2 off); 3-way p.c.b. connector, with latch housing and terminals; 4-way p.c.b. connector, with housing and terminals (2 off); 5-way p.c.b. connector, with housing and terminals; 17-way p.c.b. connector, with housing and terminals; connecting wire; solder.

Approx cost guidance only **£21**

TESTING

If the Main board worked correctly, then there is little to go wrong. The displays should never show a number other than 0,1,2 or 3. The middle decimal point should illuminate permanently.

If the left-hand digit is counting, the "background" input should pass through to the Main Output. Try each priority input in turn, left and right channels separately, checking that the count stops at the correct number. If not, check your wiring.

Using the Tape Select pushbutton S1, advance the tape selection counter (right digit). Try each priority input in turn, checking that the corresponding channel is passed to the Tape Output. If it doesn't, and the priority input worked OK, your links are incorrectly made on the Expansion board.

You may need to adjust presets VR1 and VR4 to get best results.

If all is well, switch off and make up the front panel as shown in Fig. 16, mounting the display board as indicated in Fig. 17. The display cutout diameter is 27mm.

You will need to remove the Main board in order to finally assemble the unit, because of the pushbutton connection to PB15. Once assembled for the last time, connect a signal generator to the Background Input and set the required gain on VR2. (This is why the Main board goes on top).

Disconnect the "sig-gen" and reconnect it to one of the Priority Inputs. Repeat adjustment, this time with preset VR3. A feature of this design is that you can set the background to be slightly quieter than the priority inputs if you wish, by reducing the gain of IC1 (turn VR3 anti-clockwise).

USING THE CONTROLLER

Interconnect the unit with your hi-fi system as shown in Fig. 1 (last month), with the top cover off. Try using different sources to ensure the unit triggers reliably. You may need to adjust preset VR1 and VR4 for best results. Once set, you can finally adjust VR2 and VR3 to set the gains required and refit the top cover.

An idea: Connect a stereo video. Set it on Camera input, so that unless a tape is playing, both video and audio outputs are nil. Start a commercial tape, watch the film/titles start, and the background source fade out in favour of stereo video. □

Acknowledgments/References

Op.Amp Circuits Manual, Ray Marston, Heinemann Newnes, ISBN 0-434-91207-7.

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.

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Mike Tooley BA (published by *Everyday Electronics*)
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SORRY SOLD OUT
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Full details … …G assessment, details of assessmen… …ents required and information on the c… …al are given.
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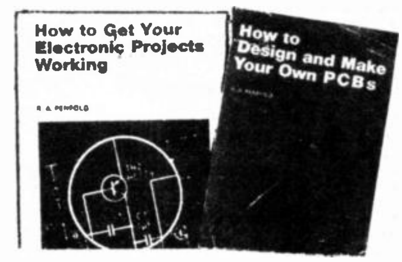

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Tony Smith G4FAI

IARU TO CONSIDER MORSE ISSUES

The president of the International Amateur Radio Union, Richard L. Baldwin, W1RU, recently announced his intention to appoint a special ad-hoc committee to examine the issues relating to the amateur Morse test and to propose the position the IARU should take on this controversial matter.

In a statement in the June issue of *Morsum Magnificat*, the Morse magazine, Mr Baldwin explains the reasons for this decision:

"In Article 32 of the Radio Regulations of the International Telecommunication Union appears Regulation 2735 which has a mandatory requirement for competency in Morse code operating to be shown before a radio amateur is permitted to operate on the HF bands – the 'DX' bands below 30MHz.

"There are some groups of radio amateurs who from time to time query the necessity for this mandatory Morse code requirement. On the other hand, many radio amateurs – indeed possibly complete societies and even whole regions – continue to support the continuance of this provision.

"As part of an on-going review of the Amateur Service, the Administrative Council of the International Amateur Radio Union (IARU AC) has established a 'CW Ad-Hoc Committee' to produce a report for consideration by the IARU AC at its meeting in Singapore in September 1994.

"The Committee comprises: Fred Johnson, ZL2AMJ, a Director of IARU Region 3 as Chairman; Dr John Allaway, G3FKM, Secretary IARU Region 1; and David Sumner, K1ZZ, from the IARU International Secretariat and the American Radio Relay League, as members. The Committee is thus drawn from the three IARU Regions.

"It is expected that after consideration by the IARU AC, the Report of the Committee may be made available to the IARU Regional organizations for further study and comment."

CALL BOOK ON DISK

Obtainable for many years only in printed form, the UK amateur radio callbook is now available on disk for use with IBM compatible computers. The first edition, published by G0LOV & G4LUE, covers all current UK calls issued up to 10th April 1994, namely G0UQZ (Class A), G7SGS (Class B), 2E0AHR (Novice A) and 2E1CUL (Novice B).

The basic data was purchased from the Radiocommunications Agency (RA) and supplied by Subscription Services Ltd (SSL) on their behalf. Other information was supplied by user groups and other sources "to the best of their knowledge."

Menu driven, the callbook comes on three 3.5 inch HD disks, requires DOS 3.1 or above and about 15Mb of hard disk. It is easy to install and provides some useful facilities not readily available from the printed version.

It covers individual UK call signs, repeaters, beacons, mailboxes and nodes. The name and address of a particular licensee can be found by simply typing in the callsign. Entries on either side of the selected call can be run on or back by using the F1 or F2 keys.

A search facility enables information to be obtained when only the address (town) or postcode is known. This lists all the amateurs in that town or postal district and each in turn can be individually displayed if required.

Some years ago, some amateurs I know ploughed through the whole call book to find the addresses of all those within reasonable distance who might be interested in joining a newly re-started local radio club. It must have taken days. With this new program, the job could have been done in minutes.

If you have only part of the call sign, e.g., G4F** or G4FA*, a wild card facility will display all calls in those series enabling the wanted one to be tracked down.

Information on repeaters, beacons, mailboxes and nodes can be called up by typing in the callsign or address (town) to obtain details of the type of station, its frequency, location, keeper, town and county. Lists of all stations can be displayed and the desired calls selected as required.

SMALL PROBLEMS

Inevitably, in a first edition, there are one or two small difficulties that need to be put right. I didn't find anything too dramatic myself but there were a couple of problems when searching by address (town name).

If a name is normally hyphenated, and it is used in the call book without the hyphens then two separate lists are thrown up by searches. For example, "Leigh-on-Sea" has eleven amateurs listed and "Leigh on Sea" (the same place) has 40 more listed.

Also, if the name of another town is part of an address, e.g., Glen Holt Park, Plymouth, then this address comes up when searching for amateurs in Holt, Norfolk. However, if you key in "Plymouth" Glen Holt Park comes up again, this time with all the other Plymouth callsigns.

The first problem is probably a result of inconsistent entries in the original data provided by SSL Ltd., on behalf of the RA. The second is clearly an error in the program. Both can easily be rectified for future editions and do not necessarily detract from the value of the callbook as currently offered, so long as users are aware of them.

If you want details of a particular call sign you can still get it fast – unless it is one of those listed as "Particulars Withheld"! For security reasons, I suspect there may be more of those in the future now that all the amateurs in a given area can be so easily identified.

It was inevitable that the call book should eventually be produced on disk, and it is surprising that no one seems to have thought of it before. The initial problems seem minimal. The publishers have asked for feedback on any difficulties encountered and they will probably have sorted them out long before this review appears in print.

The *G0LOV & G4LUE Spring 1994 UK Callbook on disk* is available from J. Bailey, 8 Hild Avenue, Cudworth, Barnsley, South Yorks S72 8RN, price £10.00 plus £1.50 post and packing. Overseas, £10.00 plus £5.00 post & packing, payable in sterling only. If you order a copy, please mention that you read about it in this column.

SUMMER BROADCAST GUIDE

Short wave listeners will welcome the publication of the International Short Wave League's *Guide to English Language Short Wave Broadcasts to Europe – Summer Schedules 1994*. This biannual guide provides an invaluable, and inexpensive, means of keeping up with schedule changes across the whole short wave spectrum.

Changes take place as a result of cutbacks by some stations and seasonal variations by all. Some of the data presented originates from direct monitoring by ISWL members and some from the published schedules of individual stations; and every possible care is taken to ensure that the information presented is accurate and current.

As usual, broadcasts are listed in time order round the clock (GMT/UTC), and include station names, country of origin, frequencies, and brief details of the type of programme to be heard. Also included are details of transmissions not beamed at, but receivable at an acceptable quality in Europe.

I have always found this publication to be extremely useful and never hesitate to recommend it, especially to those just taking up short wave listening. It has 33 A4 pages and costs just £1.30 or two IRCs (stamps to the value of £1.30 also acceptable).

It can be obtained from ISWL HQ, 10 Clyde Crescent, Wharton, Winsford, Cheshire, CW7 3LA, or from the ISWL stand at various amateur rallies during the coming season. If you do send off for it, be sure to mention that you read about the guide in EPE!

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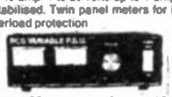

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