EVERYDAY with PRACTICAL ELECTRONICS

FEBRUARY 1994

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.95

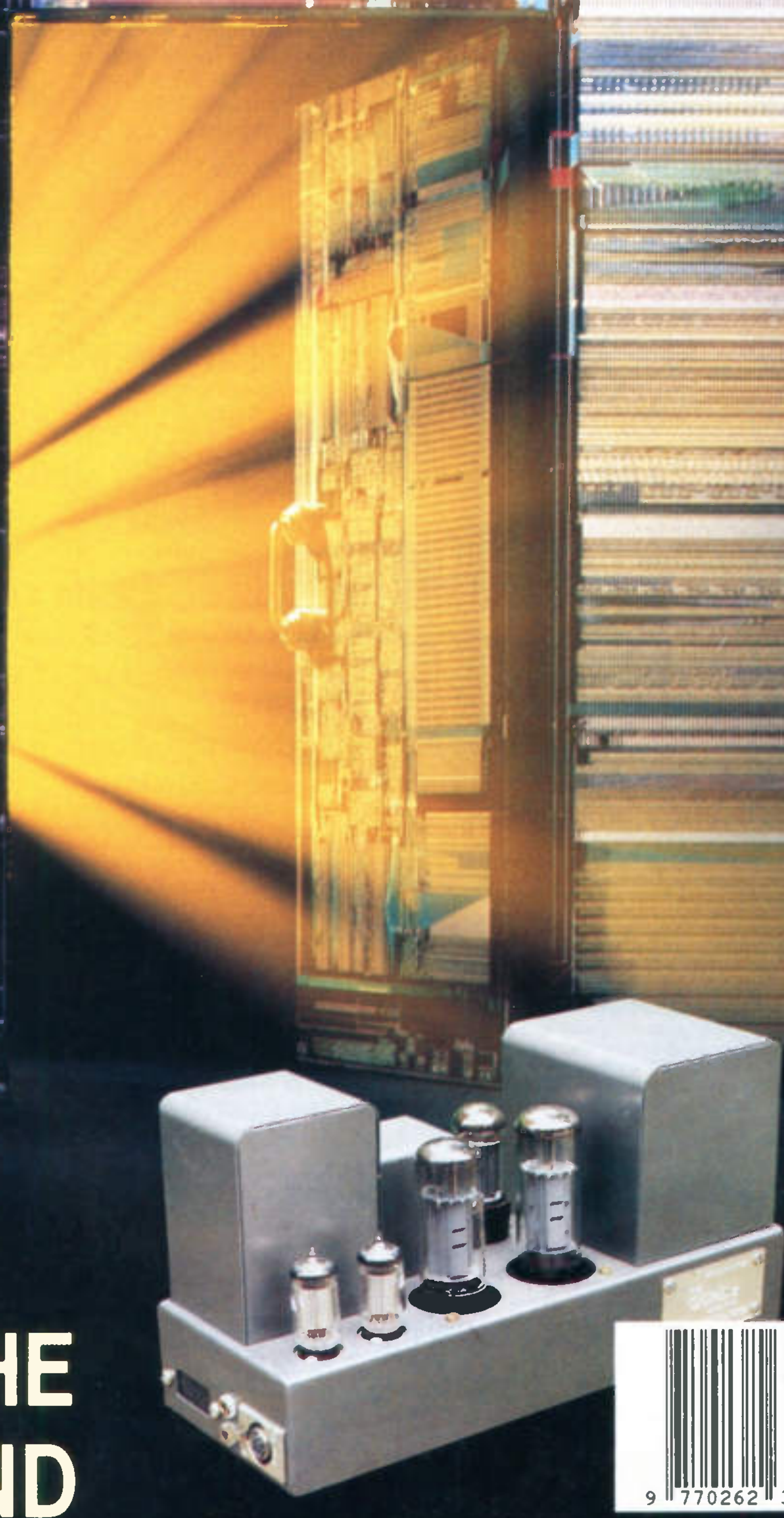
INTRODUCTION TO MICROCONTROLLERS – TIMEOUT

WHISTLE CONTROLLED LIGHT SWITCH

BALANCED MIC PRE-AMPLIFIER

FREE INSIDE!

GREENWELD CATALOGUE SUPPLEMENT



REVIVING THE VALVE SOUND

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

AMSTRAD DMP4000 Entire printer assemblies including printhead, platen, cables, stepper motors etc. Everything bar the electronics and case. Good stripper!! Clearance price just £5 REF: MAG5 or 2 for £8 REF: MAG8

VIEWDATA SYSTEMS Brandnew units made by TANDATA complete with 1200/75 built in modem, Infra red remote controlled keyboard, BT approved, Prestel compatible, Centronics printer port, RGB colour and composite output (works with any TV) complete with power supply and fully cased. Price is just £20 REF: MAG20 Also some customer returned units available at £10 each REF: MAG10

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INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects.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 suitable 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 operation. £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

PHILIPS LASER 2MW helium neon tube. Brand new full spec £40 REF: MAG40. Mains power supply kit £20 REF: MAG20P2. Fully built and tested unit £75 REF: MAG 75.

SPEAKER WIRE Brown two core, 100 foot hank £2 REF: MAG2P1

LED PACK of 100 standard red 5mm leds £5 REF: MAG5P4

JUG KETTLE ELEMENTS good general purpose heating element (about 2kw) ideal for allsorts of heating projects etc. 2 for £3 REF: MAG3

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF: MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

OZONE FRIENDLY LATEX 250ml bottle of liquid rubber, sets in 2 hours. Ideal for mounting PCB's, fixing wires etc £2 each REF: MAG2P2

***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. Transmits to any FM radio. 9v battery req'd. £5 REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit, as supplied to detective agencies etc. 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 we have generally have the locks missing and sometimes broken hinges. However they can be adapted for their original pupose 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 and 1 P channel, £3 a pair REF: MAG3P2

VELCRO 1 metre length of each side 20mm wide (quick way of fixing for temporary jobs etc) £2 REF: MAG2P3

MAGNETIC AGITATORS Cosisting of a cased mains motor with lead. The motor has two magnets fixed to a rotor that spin round inside. There are also 2 plastic covered magnets supplied. Made for remotely stirring liquids! you may have a use? £3 each REF: MAG3P3 2 for £5 REF: MAG5P6

TOP QUALITY SPEAKERS Made for Hi Fi televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality general purpose speaker. £2 each REF: MAG2P4 or 4 for £6 REF: MAG6P2

TWEETERS 2" diameter good quality tweeter 140R (would be good 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 modification 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

XT KEYBOARDS Mixed types, some returns, some good, some foreign etc but all good for spares! Price is £2 each REF: MAG2P6 or 4 for £6 REF: MAG6P4

PC CASES Again mixed types so you take a chance next one off the pile £12 REF: MAG12 or two identical ones for £20 REF: MAG20P4 component pack bargain 1,000 resistors +1,000 capacitors (all same value) £2.50 a pack. REF: MAG2P7

1994 CATALOGUE OUT SOON

BULL'S BULLETIN BOARD

MASSIVE

WAREHOUSE CLEARANCE

FANTASTIC £20.00 REDUCTION

REFURBISHED PC BASE UNITS COMPLETE WITH KEYBOARD

FROM ONLY **£29.00**

AMSTRAD 1512 BASE UNITS

GUARANTEED

PERFECT WORKING ORDER.

A LOW COST INTRODUCTION TO THE HOME COMPUTER MARKET.

AMSTRAD 1512SD

1512 BASE UNIT, 5.25" FLOPPY DRIVE AND KEYBOARD. ALL YOU NEED IS A MONITOR AND POWER SUPPLY. WAS £49.00

NOW ONLY **£29.00**

REF: MAG29

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**

REF: MAG39

SOLAR POWER PANELS

3FT X 1FT 10WATT GLASS 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

ALSO 1FT X 1FT GLASS SOLAR PANELS 12v 200mA ONLY £15.00. REF: MAG15P3

FREE SOFTWARE!

Brand new, UNUSED top quality *Famous brand* licensed software discs. Available in 5.25" DSDD or 5.25" HD only. You buy the disk and it comes with free BRAND NEW UNUSED SOFTWARE. We are actually selling you the floppy disc for your own "MEGA CHEAP" storage facilities, if you happen to get software that you want/need/like as well........ you get a "MEGA BARGAIN" to!

DSDD	PKT10 £2.99 REF: MAG3P7	PKT100 £16.00 REF: MAG16
HD	PKT10 £3.99 REF: MAG4P3	PKT100 £26.00 REF: MAG26P1

LARGER QANTITY PRICES AVAILABLE ON APPLICATION

££££££££WE BUY SURPLUS STOCK££££££££

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

COMING SOON

1994 CATALOGUE.

PLEASE SEND 42P, 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

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT

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

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY

TELEPHONE ORDERS WELCOME

TEL: 0273 203500

FAX: 0273 323077

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 16P These are ex Virgin Atlantic. You can have 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: MAG3P5 or 20 for £8 REF: MAG8P4

FIBRE OPTIC CABLE Made for Hewlett Packard so pretty good stuff! you can have any length you want (min5m) first 5m £7 REF: MAG7 thereafter £1 a metre (ie 20 m is £22). REF: MAG1 Max length 250m.

SNOOPERS EAR? Originall 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.

FOREIGN DOS 3.3-German, French, italian etc £2 a pack with manual. 5.25" only. REF: MAG2P9

MONO VGA MONITOR Made by Amstrad, refurbished £49 REF: MAG49

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

JUST A SMALL SELCTION of what we have- to see more get our 1994 catalogue (42p stamp) or call in Mon-Sat 9-5.30

HAND HELD TONE DIALLERS Ideal for the control of the Response 200 and 400 machines. £5 REF: MAG5P9

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 Customer returns but ok for spares etc £12 REF: MAG12P2 Tested and working units are £69.00 REF: MAG69

COMMODORE 64 TAPE DRIVES Customer returns at £4 REF: MAG4P9 Fully tested and working units are £12 REF: MAG12P5

COMPUTER TERMINALS complete with screen, keyboard and RS232 input/output. Ex equipment. Price is £27 REF: MAG27

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

SURFACE MOUNT STRIPPER Originally made as some form of high frequency amplifier (main chip is a TSA5511T 1.3GHz synthasiser) but good stripper value, an excellent way to play with surface mount components £1.00 REF: MAG1P1.

MICROWAVE TIMER Electronic timer with relay output suitable to make enlarger timer etc £4 REF: MAG4P4

PLUG 420? showing your age? pack of 10 with leads for £2 REF: MAG2P11

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. Comes with electronics but no information. £15 REF: MAG15P4

SUPER SIZE HEATSINK Superb quality aluminium heatsink. 365 x 183 x 61mm, 15 fins enamble high heat dissipation. No holes! £9.99 REF: MAG10P1P

REMOTE CONTROL PCB These are receiver boards for garage door opening systems. You may have another use? £4 ea REF: MAG4P5

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.

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 30KeV 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

EVERYDAY WITH PRACTICAL ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY

VOL. 23 No. 2 FEBRUARY 1994

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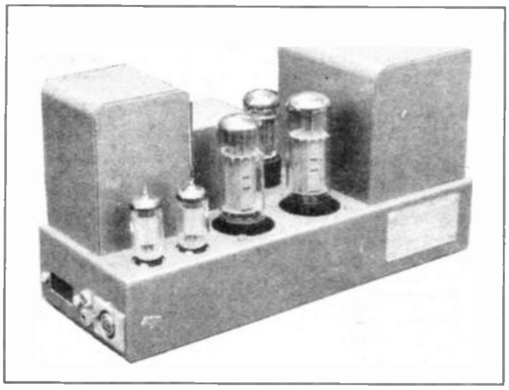
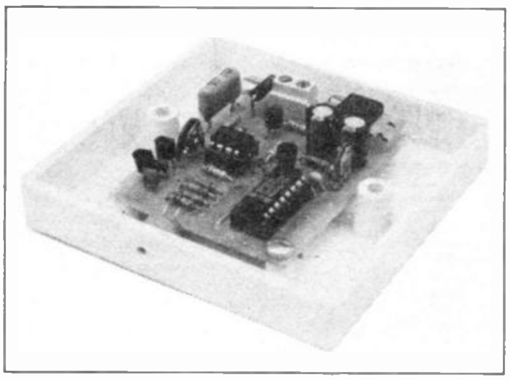
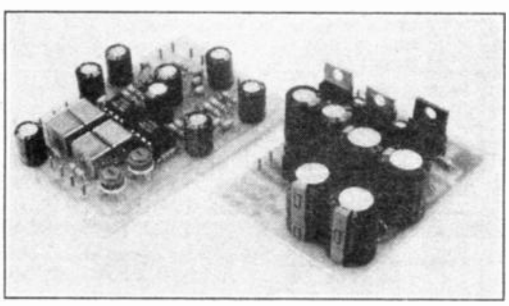
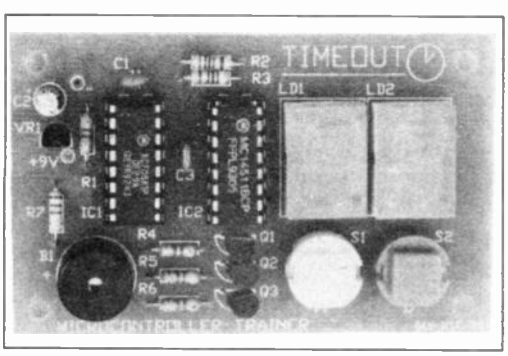
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Our March '94 issue will be published on Friday, 4 February 1994. See page 91 for details.

Projects

WHISTLE CONTROLLED LIGHT-SWITCH by Bart Trepak 104
Replaces a standard light switch to provide touch or whistle control

REVIVING THE VALVE SOUND by Jake Rothman 112
Complete technical details, including circuits, to rebuild the Quad II valve power amplifier

INTRODUCTION TO MICROCONTROLLERS – TIMEOUT by Peter Crowcroft 128
A simple countdown timer that will get you involved with microcontrollers

BATTERY TO MAINS INVERTER AND UNINTERRUPTABLE POWER SUPPLY – 3 by Mark Daniels 134
The U.P.S. charger and control section of the unit.

MULTI-PURPOSE AUDIO SYSTEM – 5 by Max Horsey 156
Balanced microphone preamplifier and power supply

Series

CIRCUIT SURGERY by Alan Winstanley 120
Your problems solved, circuit ideas, hints and tips

INTERFACE by Robert Penfold 144
The page for computer enthusiasts

CALCULATION CORNER – 2 by Steve Knight 146
Removing the fear from circuit design calculations

SAFETY FIRST – 3 by T. R. de Vaux Balbirnie 150
Electrical safety in the home and caravan

TECHNIQUES – ACTUALLY DOING IT by Robert Penfold 164
Cutting large holes in panels

AMATEUR RADIO by Tony Smith G4FAI 172
All the news and views from the world of amateur radio

Features

EDITORIAL 103

INNOVATIONS 108
Everyday news from the world of electronics

NEW TECHNOLOGY UPDATE by Ian Poole 110
Developments in superconductors

EUROPEAN INTERNATIONAL AUDIO & VIDEO FAIR by Barry Fox 122
New developments and products from last years show

FOX REPORT by Barry Fox 132
The BBCs 3D transmission experiments

ELECTRONIC PRINCIPLES 133
A new software service for those studying electronics

SHOPTALK with David Barrington 143
Component buying for EPE projects

HOME BASE by Terry Pinnell 154
Jottings of an electronics hobbyist

ELECTRONICS VIDEOS 166
Our range of educational videos to complement your studies

DIRECT BOOK SERVICE 167
A wide range of technical books available by mail order

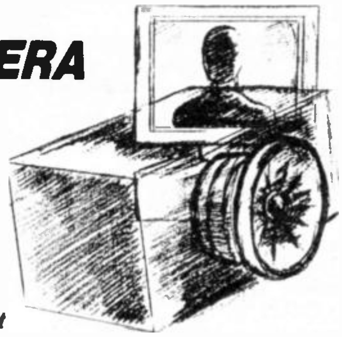
PRINTED CIRCUIT BOARD SERVICE 170
PCBs for EPE projects – some at half price!

ADVERTISER'S INDEX 176

FREE GREENWELD CATALOGUE SUPPLEMENT between pages 132 and 133

Readers Service • Editorial and Advertisement Departments 103

CCD TV CAMERA



Give an eye to your computer or neighbourhood watch with this money-saving monitor.

This monochrome closed-circuit television camera was originally designed as a low cost unit for inputting live visual images into a PC-compatible computer for graphical and general amusement purposes. However, following a spate of crimes in the author's locality, its potential as a security camera was recognised and the circuit was expanded to also allow live and recorded image interfacing with a cheap monochrome TV receiver.

The cost of the author's camera was kept low by using a lens from an old 35mm camera, and by the use of an image sensor inexpensively purchased as a slightly sub-standard manufacturing test sample.

In this constructional article, the camera circuitry and its TV receiver interface are described. A follow-up article will describe the PC-compatible computer interface, the 'Frame Grab', which allows live images from the TV camera to be output to the computer, where it can be displayed, modified, coloured, stored on disc, printed to paper, or output back to the TV screen via the camera unit. Programming examples will be included.

The camera can be used on its own without a computer, and the Frame Grab can be used without the camera for other data gathering purposes.

FREE WALL CHART

Both our March and April issues will carry free wall charts covering just about every formulae you could possibly want for general electronics work. Next month's chart gives formulae for D.C. Electricity i.e. everything from Ohms Law to T and π sections. It also covers the colour code and provides a capacitance conversion chart.

AUDIO/RF MONITOR

This project started life when the author wanted to monitor the i.f. output from a TV tuner with which he was starting to experiment. A quick lash-up with a detector diode and a rather elderly amplifier was only partially successful, due among other things to mains hum. A small self-contained battery operated amplifier, specifically designed to operate with a matching r.f. detector probe was therefore designed and built. It seemed sensible at the same time to make the amplifier so that it was suitable for monitoring audio signals directly, over a wide range of amplitudes. The resulting instrument is described next month.

SMART KEY IMMOBILISER

In the UK approximately 25 cars are stolen every fifteen minutes. Living in an inner city area, you have a 1 in 10 chance of having your car stolen. Auto crime accounts for nearly 30 per cent of all nationwide crime.

With statistics like this, it makes sense to install some sort of car alarm/immobiliser.

The design described next month, is a coded "Smart Key" immobiliser, which features anti-scan circuitry, fuel pump cut-off, ignition cut-off and a facility which prevents hot wiring.

The design is suitable for cars, boats, lorries or vans, the only amendment required being a suitable voltage relay – i.e. 24V for lorries.

EVERYDAY WITH PRACTICAL ELECTRONICS

MARCH '94 ISSUE ON SALE FRIDAY, FEBRUARY 4th 1994

MAILTECH

ELECTRONIC COMPONENTS

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

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

All sizes are in millimetres

CRYSTAL OSCILLATORS

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

MICRO SWITCH roller arm operation spdt 40p each

MINIATURE TOGGLE SWITCHES

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

MINIATURE PUSH TO MAKE SWITCH 50p each

DIL RELAYS 5 volt dp/changeover 60p 10 for £5.00

12 volt dp/changeover 80p 10 for £6.00

RELAY 10 amp contacts sp/changeover 12 volt coil £1.20 each

CAR HORN RELAY in metal can with fixing lug, s/pole on 10 amp contacts £1.00 each 6 for £5.00

20 AMP RELAY dp on 12 volt coil £1.50 each 4 for £5.00

REED RELAY 12 volt 50p each 10 for £4.00

240 VOLT AC RELAY. 3-pole c/o 10 amp contacts £1.50 each 4 for £5.00

'D' CONNECTORS

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

SEMICONDUCTORS – TRANSISTORS – ICS – DIODES – REGULATORS – ETC

VOLTAGE REGULATORS

1 amp 7805/7812/7815 all 33p each. 7905/7912/7915 all 39p each

2 amp 78505/785212 54p each

100mA 78L05/78412/78L15 all 26p each. 79L05/79L12/79L15 all 29p each

Adjustable LM317T 47p each. LM723 29p each, L200 £1.28 each

Transistors TIP2955 70p each, TIP 3055 70p each

2N3053 29p each, 2N3055 70p each, 2N4403 28p each, 2N3819 40p each

MICRO IC'S –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

SPECIAL OFFER PROJECT BOX
In white high impact ABS
50 x 70 x 25mm
60p each 10 for £5.00

OPTO DEVICES – LEDS – ETC

5mm rnd red/yellow/green/amber	10p each 12 for £1.00 any mix
5mm rnd high brightness red/green	20p each 6 for £1.00 any mix
5mm rnd flashing	red 60p each, yellow/green 70p each
5mm rnd bi-colour	35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green	30p each, 4 for £1
LED mounted in a black bezel red only	25p each, 5 for £1.00
PLASTIC BEZEL for 5mm rnd leds	10 for 40p
High brightness bi-colour l.e.d., rectangular, red/green, two leads	40p each

TEMPERATURE PROBE

High quality probe made for the medical profession. Consists of a resistive sensor mounted in a plastic covered probe with a 1 meter curled lead. Temp. range −40 to 150°C. Resistance at: 150°C 188.3 ohms; −40°C 336.5 kohm; 25°C 10.0 kohm ± 70 ohms. The original price of these probes was over £24.00. Full data supplied. **OUR PRICE £3.76**

RESET TIMER PCB

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

UNIVERSAL BELL TIMER

10 or 20 minute bell cut off +ve or −ve trigger' timed relay contacts. £4.96

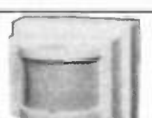
ALARM CONTROL UNIT

Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.

Facilities: – Normally closed loop for pir sensors, door/window contacts etc. Normally open loop for pressure mats. 24-hour loop for personal attack button Visual indication that the system is operational. Automatic entry/exit delay. Automatic system reset. Alarm output cmos logic level.

SIREN
12 volt dc for external use 115db £8.95

PRICE COMPLETE WITH FULL INSTRUCTIONS £8.95



SUB-MINIATURE PASSIVE INFRA-RED SENSOR ONLY £7.95
Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.

EX INSTALLATION SENSORS tested working.

Type 1. Measures 180 x 112 x 70mm with walk test led, relay output and tamper protection. 12 volt dc supply required £8.50 each

Type 2. As above but a smaller unit 123 x 62 x 50mm £11.75 each

Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. £15.70 each

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

DOOR/WINDOW CONTACTS
Surface or flush mounting, white £1.10 each

JUNCTION BOX
white 6 way 60p

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

ALARM CONTROL PANEL ST3000

'Wire free alarm control panel, detectors communicate with the panel by means of radio transmitters'. Speech synthesis for programming and general operating guidance'. Built in user programmable telephone dialler'. Up to 32 transmitters can be be used'. Programmable exit/entry and bell timers'. Programmable user codes.' Full installation data supplied, the only thing that has to be handwired is the output to the siren/bell unit (not supplied)'. These control panels cost over £300.00. Yours for only £59.95.

Suitable **PASSIVE INFRA SENSOR/TX £25.85**

Battery operated, available in 8m range, 10m range or 25m range.

UNIVERSAL TX

For connection of normally open or closed contacts e.g. door/window switches, pressure mats etc. £17.63

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BO28 **12 x 2N3904** Transistor
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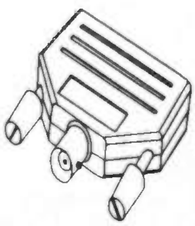

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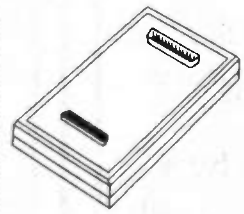
ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
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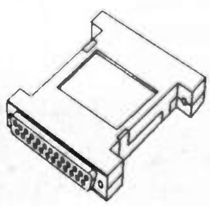
ADC-11



- 15K samples per second
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- Digital output
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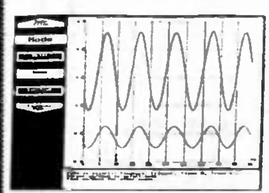
- Parallel port connection
- Includes both PicoScope and PicoLog software

11 Channel 10 bit ADC £75

PicoScope



Scope, voltmeter, spectrum analyser

'Virtual instrument' software package for the ADC-10, ADC-11 and ADC-12.

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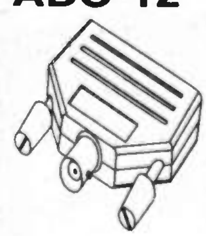
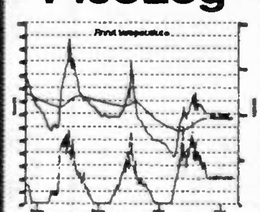
ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

Single Channel 12 bit ADC £85

PicoLog



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Picolog is also available for the ADC-10: call for details.

Typical application	ADC-10	ADC-11	ADC-12	ADC-16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●		●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Chromatography				●
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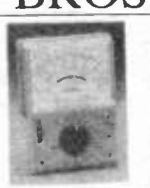

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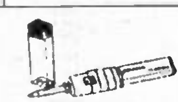

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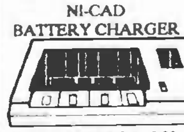

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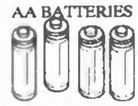

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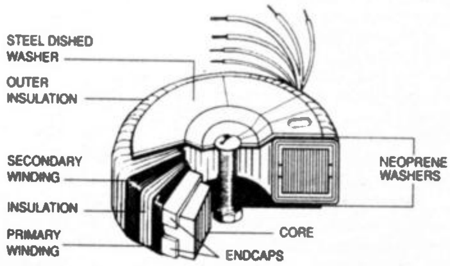

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£10.68	03011	9+9	0.83
	03012	12+12	0.63
	03013	15+15	0.50
	03014	18+18	0.42
	03015	22+22	0.34
	03016	25+25	0.30
	03017	30+30	0.25
30VA	13010	6+6	2.50
£12.21	13011	9+9	1.66
	13012	12+12	1.25
	13013	15+15	1.00
	13014	18+18	0.83
	13015	22+22	0.68
	13016	25+25	0.60
	13017	30+30	0.50
50VA	23010	6+6	4.16
£13.84	23011	9+9	2.77
	23012	12+12	2.08
	23013	15+15	1.66
	23014	18+18	1.38
	23015	22+22	1.13
	23016	25+25	1.00
	23017	30+30	0.83
	23028	110	0.45
	23029	220	0.22
	23030	240	0.20
80VA	33010	6+6	6.66
£15.43	33011	9+9	4.44
	33012	12+12	3.33
	33013	15+15	2.66
	33014	18+18	2.22
	33015	22+22	1.81
	33016	25+25	1.60
	33017	30+30	1.33
	33028	110	0.72
	33029	220	0.36
	33030	240	0.33
120VA	43010	6+6	10.00
£16.45	43011	9+9	6.66
	43012	12+12	5.00
	43013	15+15	4.00
	43014	18+18	3.33
	43015	22+22	2.72
	43016	25+25	2.40
	43017	30+30	2.00
	43018	35+35	1.71
	43027	20+20	3.00
	43028	110	1.09
	43029	220	0.54
	43030	240	0.50
160VA	53011	9+9	8.89
£19.21	53012	12+12	6.66
	53013	15+15	5.33
	53014	18+18	4.44
	53015	22+22	3.63
	53016	25+25	3.20
	53017	30+30	2.66
	53018	35+35	2.28
	53026	40+40	2.00
	53028	110	1.45
	53029	220	0.72
	53030	240	0.66

TYPE	SERIES NO.	SEC VOLTS	RMS CURRENT
225VA	63012	12+12	9.38
£21.04	63013	15+15	7.50
	63014	18+18	6.25
	63015	22+22	5.11
	63016	25+25	4.50
	63017	30+30	3.75
	63018	35+35	3.21
	63026	40+40	2.81
	63025	45+45	2.50
	63033	50+50	2.25
	63028	110	2.04
	63029	220	1.02
	63030	240	0.93
300VA	73013	15+15	10.00
£22.94	73014	18+18	8.33
	73015	22+22	6.82
	73016	25+25	6.00
	73017	30+30	5.00
	73018	35+35	4.28
	73026	40+40	3.75
	73025	45+45	3.33
	73033	50+50	3.00
	73028	110	2.72
	73029	220	1.36
	73030	240	1.25
500VA	83016	25+25	10.00
£29.57	83017	30+30	8.33
	83018	35+35	7.14
	83026	40+40	6.25
	83025	45+45	5.55
	83033	50+50	5.00
	83042	55+55	4.54
	83028	110	4.54
	83029	220	2.27
	83030	240	2.08
625VA	93017	30+30	10.41
£32.64	93018	35+35	8.92
	93026	40+40	7.81
	93025	45+45	6.94
	93033	50+50	6.25
	93042	55+55	5.68
	93028	110	5.68
	93029	220	2.84
	93030	240	2.60

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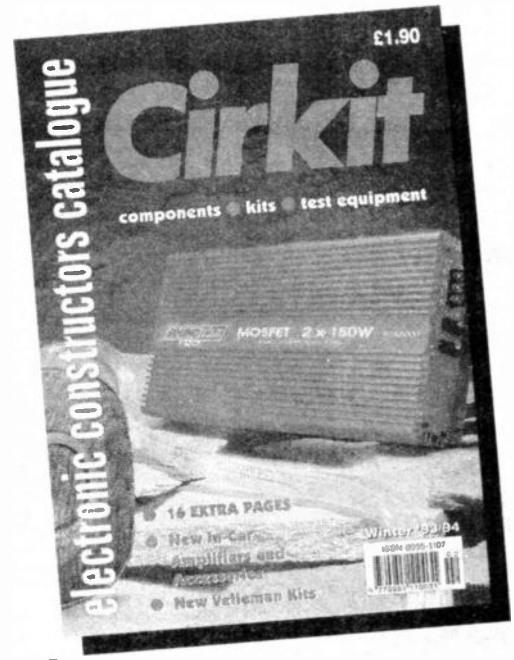

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PRICE £39.95

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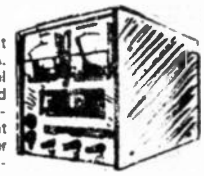

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KIT 814..........................£21.44

12V EPROM ERASER
A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

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Our own widely acclaimed design. This sensitive Pulse Induction metal detector picks up coins and rings etc up to 20cm deep. Negligible 'ground effect' means that the detector can even be used with the head immersed in sea water. Easy to use, circuit requires only a minimum of setting up as a Quartz crystal provides all of the critical timing. Kit includes search-head, handle, case, PCB and all components.

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A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

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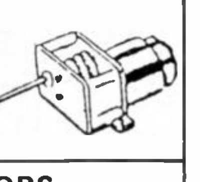

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EVERYDAY WITH PRACTICAL ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY

VOL. 23 No. 2 FEBRUARY '94

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EVERYDAY with PRACTICAL ELECTRONICS EDITORIAL,
6 CHURCH STREET, WIMBORNE,
DORSET BH21 1JH
Phone: Wimborne (0202) 881749
Fax: (0202) 841692. DX: Wimborne 45314.
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50's TECHNOLOGY

The valve sound seems to be a major topic again, with valve amplifiers and kits available and much commotion in the hi-fi press. There have also been some published designs, most of which show little change from the original designs of the 50's and 60's. A cottage industry has grown up around refurbishment of certain amplifiers and small fortunes are being asked for some refurbished products.

To give you an insight into this fascinating area of activity Jake Rothman has produced a full article showing how to rebuild one of the best amplifiers of its time, the *Quad II*. The article gives all the neessary technical details and should allow almost anyone to recreate the type of amplifier that is presently changing hands for several hundred pounds.

Jake is also working on a new valve amplifier design for us, one that will employ some of the knowledge gained over the last 30 years, rather than just a rehash of an original. If this area of audio interests you then watch this space!

90's TECHNOLOGY

At the other end of the technology scale we also present a project using a Motorola K series microcontroller. The application of *Timeout* is simple but we hope that the project will help readers to get involved with modern microcontroller i.c.s.

Once again this fast developing area of electronics is fascinating. It could of course eventually lead to the demise of many hobbyist projects. Perhaps the time will come when one simple universal microcontroller board can be used for virtually any application, then we might be reduced to publishing programming hints and tips. However that day is not yet here and once again we offer you a diverse range of projects. Hopefully something to interest everyone.

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self addressed envelope and international reply coupons.** Due to the high cost **we cannot reply to overseas readers queries by Fax.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

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

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TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

WHISTLE CONTROLLED LIGHT SWITCH

BART TREPAK

A compact unit that can replace a standard light switch to provide control by whistling. It also includes a touch switch.

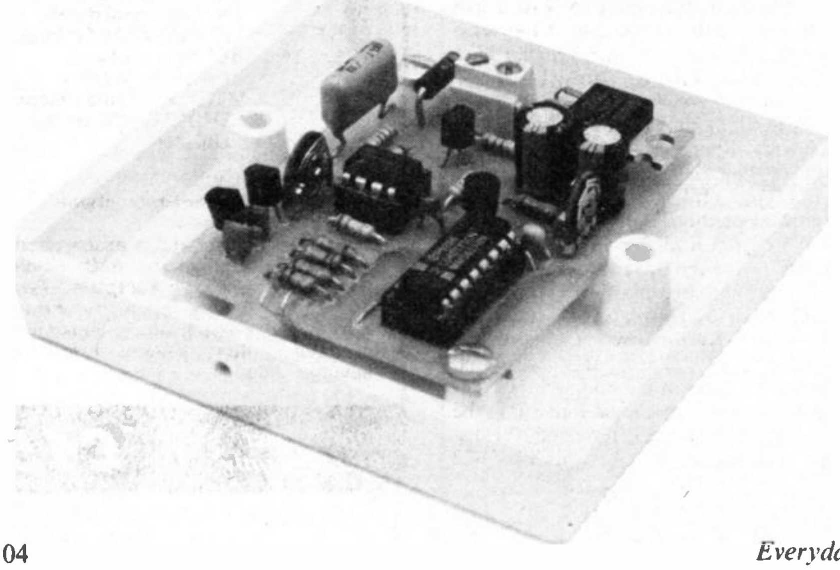
REMOTE control of various appliances has enjoyed a great deal of popularity in the past few years, especially as the cost of adding such a facility to a product has decreased with the falling cost of integrated circuits. This can be seen in the proliferation of gadgets to be seen around your armchair for controlling the television, video, hi-fi and, if you are a keen electronics enthusiast, the curtains, the heating and any other gadgets which you can think of.

While these perform admirably they all suffer from the same weakness; namely they all need a transmitter. Not only does one need two or three different transmitters to control the various appliances (although nowadays it is possible to purchase one programmable transmitter to replace all the others) but by *Murphy's Law* the transmitter you need to change channels to see your favourite TV programme is out of reach on the coffee table at the far end of the room. Since you have to get up to get it anyway and the TV is nearer, you may as well not have a remote control handset and perform the task manually.

SPEAKING OUT

The TV is perhaps not a good example of where a remote control is of paramount importance as "getting up" may be the only exercise many viewers get in an evening! The lightswitch on the other hand would perhaps be more useful as one often enters a room (such as a kitchen for example) carrying the shopping or a tray which makes it difficult to reach the switch to turn the lights on. In this case unfortunately, it would be no easier to operate your remote control handset even if this were to hand.

But do we need all these handsets? Well if we intend to use some form of remote control link we have to have some way of producing the necessary signal and if more than one appliance or function is to be controlled, we need to be able to generate a corresponding number of different signals. So if we want to do away with all these transmitters, the only approach is to use a form of link which uses signals that we can generate without the need for additional gadgets.



The answer is, in fact, the most natural of all remote control links – the human voice. It has an almost unlimited number of possible channels and would, in fact be the ultimate remote control. *"TV on, Channel two, Hi fi off, Lights Dim"* is the stuff science fiction is made of.

The problem in the real world is of course, noise immunity not to mention simply decoding the sounds. While you are saying "TV on" someone might be calling from the kitchen. "Do you want a cup of tea?" drowning out your command.

Even decoding the sounds is not enough, as the receiver would also have to "understand" what was being said. You might be explaining to a friend that "We often have the *TV on* and the *lights dim*" to find that the system switches on the TV and dims the lights! Worse still, (or perhaps better still) you may be watching *Neighbours* and a character in the programme says in the dialogue "switch that TV off, I want–..." and the TV goes off!

Voice recognition systems do exist but are based on microcomputers which apart from being relatively expensive and too complex to fit into a standard lightswitch box at present, also require the user to speak clearly into a microphone which is conveniently placed close to his lips. This would probably be more inconvenient than the handset we are trying to replace!

BLOWING THE WHISTLE

Fortunately, there is another way and one for which a special integrated circuit is available. The only problem (there has to be one) is that the user needs to be able to whistle, but even this problem has been solved by including a touch control although, in this case of course, the user will have to forgo the "remote control" feature. The moral is that if you want to communicate you have to learn the language!

The whistle switch circuit described here is based on an i.c. of the type used in keyfinders except that instead of the circuit responding with a tune, this chip has an output transistor which switches on or off. It has been found to have quite a good noise immunity and works even when the TV is on.

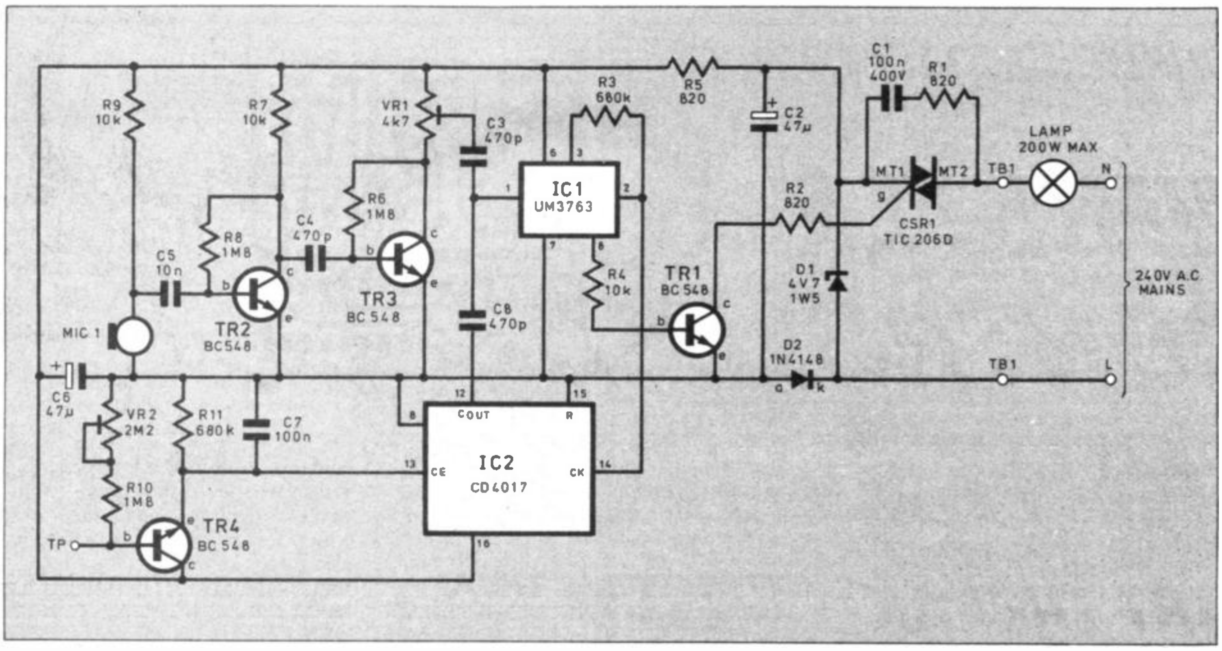


Fig. 1. Complete circuit of the Whistle Controlled Light Switch.

The only time it seemed to switch the lights on other than to a whistle was when our small son screamed (he seemed to have just the right pitch). It was then, of course, a simple matter to whistle and switch the lights off again.

Apart from its convenience (you could now switch on the lights *before* you entered a room) and providing a talking point amongst your friends, this device also has its serious uses. The advantages of such a light switch for the old or disabled person or in situations such as kitchens or workshops where the hands are otherwise occupied are obvious. It also means that the lightswitch need no longer be sited by the door which can save a lot of work chasing out walls if additional lights are to be provided in a room. All this and you don't even need a transmitter!

CIRCUIT DESCRIPTION

The complete circuit diagram for the Whistle Controlled Light Switch is shown in Fig. 1. As shown, the device is a two wire circuit which derives its power through the load and can therefore be fitted in place of a conventional light switch without altering any of the house wiring.

This is a big plus over many designs for the home constructor, which usually require the provision of a Neutral (N) wire which is of course not normally available at the switch box. The live and load connections are shown as for a conventional switch but in practice which of the two terminals on the switch is connected to live is not important except in the case of the touch control circuit, IC2. If the touch control feature is not required, IC2 and its associated components may be left out and the circuit connected either way around.

The sound (whistle) is picked up by an electret microphone MIC1 and fed to a two stage amplifier based on transistors TR2 and TR3 with the preset VR1 acting as a sensitivity control. At a pinch, a single stage amplifier could have been used as IC1 contains a further amplifying stage but on the basis that it is better to have too much gain and then reduce it, than not enough in the first place it was decided to use two transistors – and hang the expense!

Apart from the amplifier, IC1 also contains an oscillator running at a frequency determined by resistor R3. With the value shown, this is about 18kHz and in operation the internal logic switches the output on and off each time an input signal of between one-tenth and one-fifteenth of the clock frequency (i.e. 1·2kHz and 1·8kHz) is received over a period of 256 clock cycles. This gives the circuit a fair margin of noise immunity without requiring a whistle of exactly the correct frequency to operate the unit.

The output transistor TR1 is used to trigger the triac CSR1 and switch the lights directly, and since d.c. or continuous triggering is employed, the triac conducts continuously and no radio frequency interference is generated thus eliminating bulky chokes and suppressor capacitors.

TOUCH CONTROL

The touch control circuit consists of transistor TR4, decade counter IC2 and associated components. This i.c. simply divides the clock signal by ten and feeds it to the input of the whistle switch IC1 which causes it to switch the lights on and off each time it receives 256 cycles. Normally this circuit is inhibited because the CE input (pin 13) is held low by resistor R11.

Although the i.c.s operate from a voltage of about 4 volts due to the action of the Zener diode D1, the whole circuit is at some 240V a.c. with respect to N or Earth since N and Earth are roughly at the same potential. This means that when the base (b) of transistor TR4 is "earthed" via the small capacitor consisting of your hand, the plastic front plate and the metal foil "touch" plate behind it, its emitter (e) is still at 240V a.c. This has the same effect as far as TR4 is concerned as if the emitter was earthed and a 240V a.c. signal was injected into the base via a small capacitor. (Note the metal "touch" plate is inside a fully enclosed plastic switch blanking panel, thus safely isolating the user).

Transistor TR4 thus switches on during the positive half cycles of this a.c. signal and charges capacitor C7 taking the CE input (pin 13) of IC2 to a logic 1 enabling the circuit. When the hand is removed, C7 discharges via resistor R11 and disables IC2 again.

D.C. SUPPLY

The problem of obtaining a d.c. power supply for the circuit is solved in an unusual way because being a two wire circuit, there would normally be no voltage across the switch when the light was on. In this case the load current is made to flow through the Zener diode D1 (as well as the triac CSR1) and the resulting a.c.

COMPONENTS

Resistors

R1, R2, R5	820 (3 off)
R3, R11	680k (2 off)
R4, R7, R9	10k (3 off)
R6, R8, R10	1M8 (3 off)
All 0·6W 5% carbon film	

See SHOP TALK Page

Potentiometers

VR1	4k7 enclosed carbon preset, vertical
VR2	2M2 enclosed carbon preset, vertical

Capacitors

C1	100n polyester, 400V
C2, C6	47µ radial elect. 16V
C3, C4, C8	470p ceramic
C5	10n ceramic
C7	100n poly. layer

Semiconductors

D1	4·7V 1·5W Zener diode
D2	1N4148 signal diode
CSR1	TIC206D 400V 4A triac
TR1 to TR4	BC548 *npn* silicon transistor (4 off)
IC1	UM3763 whistle switch
IC2	CD4017 CMOS decade counter

Miscellaneous

MIC1	Electret microphone insert

Printed circuit board available from *EPE PCB Service*, code 860; single switchbox blanking frontplate (see Shop Talk); 2-way, p.c.b. mounting, mains screw terminal block; aluminium foil, about 4cm square; insulating sleeving; solder.

Approx cost guidance only **£15**

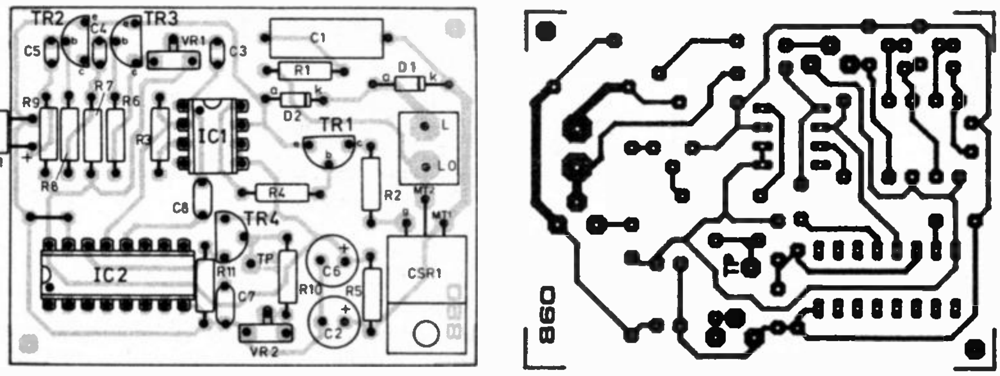


Fig. 2. P.C.B. master and component layout for the Whistle Controlled Light Switch.

voltage across this component is rectified by diode D2 and smoothed by capacitor C2. When the triac is off, a smaller current is provided by the "lossless dropper" capacitor C1 with resistor R1 limiting discharge current of C1 which could damage the triac when it is switched on.

Another way of obtaining a d.c. supply would be to delay the triggering of the triac slightly at the beginning of each half cycle and rectify the resultant voltage across the triac but this method would generate radio frequency interference (r.f.i.) which would require further components to suppress. The advantage of this circuit is that there is no delay in switching the triac and so no r.f.i. is generated.

On the down side however, the maximum load current is limited by the maximum dissipation in diode D1. During the negative half cycle this amounts to the load current times the forward voltage drop in D1 (about 0·6V), while in the positive half cycle it is the load current times the Zener voltage.

For a 1·7W 4·3V Zener the maximum load current will be about 600mA which represents a load of approximately 150W which should be sufficient for most applications. If a higher load is to be switched, a 5W Zener can be fitted, giving a maximum load current of 2A which is equivalent to 500W.

CONSTRUCTION

This unit carries mains voltages and it should NOT be constructed by anyone without some experience of building mains powered projects. Any reader who is not certain of being able to build it safely is strongly advised to seek professional advice and help.

Bearing in mind that the unit is at mains potential, and to ensure safety, the use of the ready made printed circuit board (p.c.b.) is recommended. This board is available from the *EPE PCB Service*, code 860. The p.c.b. topside component layout and full size underside copper foil master pattern is shown in Fig. 2.

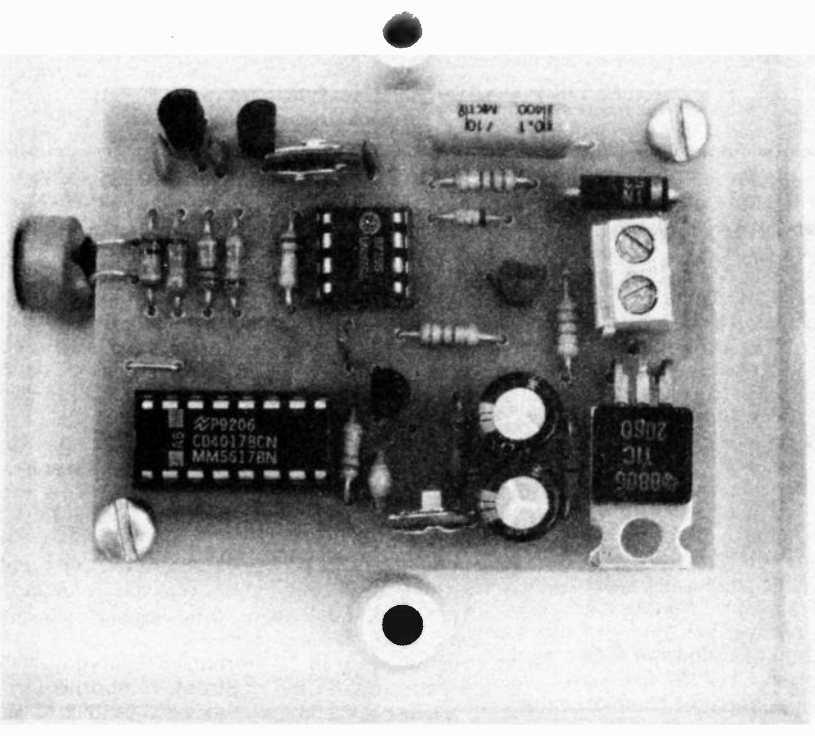
The circuit is best constructed on a printed circuit board as there is not much space available in the wall box and the high mains voltages that exist in some parts of the circuit could cause problems if tracks are inadvertantly connected. If the board layout shown is used these problems should not arise.

Start construction by inserting and soldering low profile components such as resistors and diodes first, paying particular attention to component orientation where this is important (i.e. with diodes, electrolytic capacitors etc). Make sure also that components are pushed down onto the board and not left standing on long leads which could touch adjacent components or even the wall box with potentially disastrous consequences.

The triac CSR1 is mounted flat on the board as shown in Fig. 3. Note that the heatsink tab is *internally* connected to the centre lead of the device and should therefore *NOT* be allowed to touch any other component on the board. The i.c.s should be mounted in sockets and normal precautions observed as these are both static sensitive devices.

The electret microphone is mounted "off the board" on short pieces of stiff wire, such as discarded component leads, so that it will be near the 2mm to 3mm dia. hole in the side of the plastic front plate which will need to be drilled in the appropriate place. Note the polarity of this component: the negative lead, which is the pad connected to the microphone body, should go to the hole nearest the transistors on the p.c.b. If it is not obvious which pad this is, a multimeter set to the ohms range may be used.

Make sure that the body of the microphone insert will not touch the metal wall box when the unit is mounted by insulating it with a piece of insulating tape or heatshrink sleeving. When construction is complete, check your work carefully as unlike many battery powered projects, **mistakes can result in the destruction of the whole p.c.b.**



TOUCH PAD

The next step is to solder a short piece of stiff wire (again a discarded component lead will do) to the base of transistor TR4 (the pad marked "TP") on the copper side of the p.c.b. This will form the connection to the touch plate by simply touching the metal foil. A piece of aluminium foil about 4cm square should now be stuck to the *inside* of the plastic front plate between the mounting holes.

Clean off an area of the foil around the place where the wire from the p.c.b. will touch it with a piece of fine abrasive paper or wire wool and mount the p.c.b. onto the rear of the plastic front-panel plate using two self-tapping screws as shown in Fig. 4. It is **strongly recommended that you use the front plate specified and not a standard type available from electrical suppliers** as these are not as deep and can result in components touching the earthed metal box when the unit is mounted in the wall.

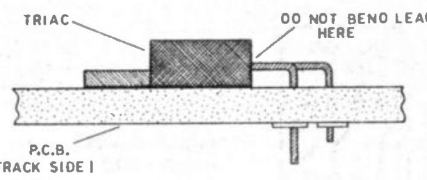
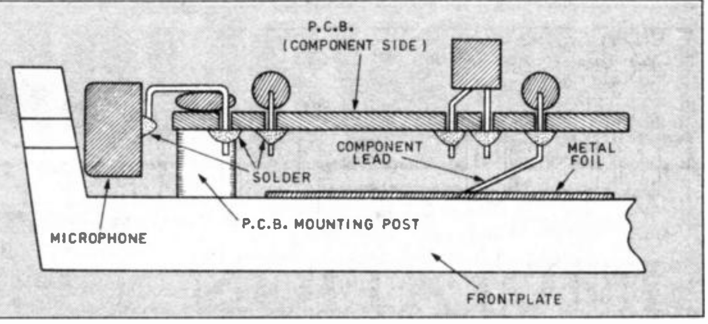


Fig. 3. Mounting CSR1 on the p.c.b.

Fig. 4 (right). Touch plate connection inside the plastic mounting plate.



TESTING

Mains voltages are present on the p.c.b. and the finished unit should be carefully checked *before* wiring it in. Also, if possible, do not attempt to test the unit without first mounting the p.c.b. in a temporary fully enclosed plastic box, with holes drilled for leads and access to the preset controls.

Remember that the circuit operates at mains voltage and *must not* be connected to Earth. SWITCH THE MAINS OFF before fitting or making any alterations to the circuit and use an insulated screwdriver when adjusting the presets. Failure to observe these precautions could at best result in you having to purchase a new set of components and a circuit board, and at worst never purchasing anything again!

Connect the mains with the live as shown and a 60W to 100W lamp to the terminal block on the unit (see Fig. 5). If you get the polarity of the mains wrong it will not damage the unit but you will find that the touch circuit will not operate.

Turn the "wipers" of the presets VR1 and VR2 fully anticlockwise and switch on. A short whistle should turn the lamp on. Initially try whistling at various frequencies to ascertain the correct pitch required. Preset VR1 may now be adjusted until the required sensitivity is obtained.

To set preset VR2 (which controls the touchplate sensitivity), touch the centre of the plastic faceplate and turn VR2 clockwise until the light turns on. If you keep you hand on the switch, the light will switch on and off continuously. If you find that the light does not come on, switch off and check that the wire is touching the aluminium under the p.c.b. and that the polarity of the mains is correct.

If all is well, the unit may be mounted in the wall box replacing the existing light switch ***(remembering to switch off the mains supply first)***, although the presets VR1 and VR2 may require re-adjustment to suit the new location. When you remove the existing lightswitch, make sure that the you know which wire is Live (usually the red one). This can be checked by testing with a neon mains tester screwdriver and it will be the wire which lights the neon. if you are unsure, connect the unit one way and if the touch circuit does not work simply reverse the connections.

The maximum load for the circuit should *NOT EXCEED* 150W as mentioned above. Higher powers up to a maximum of 500W could be handled by fitting a more powerful Zener diode and a suitable heatsink to the triac although it may then be difficult to fit the unit in a wall box, let alone remove the heat from such a confined space effectively so a figure of 300W would be more reasonable, which should be sufficient for most applications.

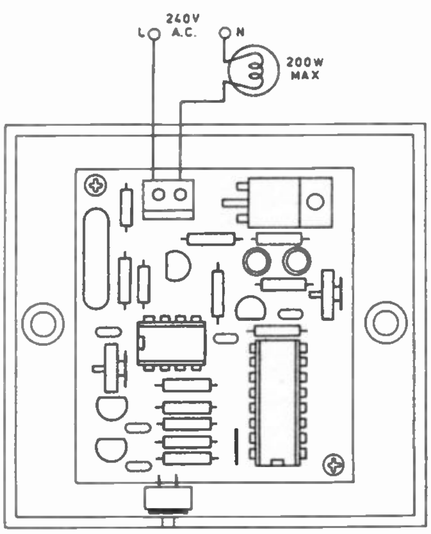


Fig. 5. Wiring to the mains supply and the load.

WHISTLING IN THE DARK

Although the circuit was designed primarily for ordinary tungsten lamps it is also suitable for switching fluorescent lights or other loads such as transformers provided, of course, that the maximum load is not exceeded. There is also no minimum load requirement to enable the triac to latch as in the on state the triac is continuously triggered. It should however be remembered that the unit will pass about 10mA in the off state due to the current flowing in capacitor C1 so that very low power loads such as neon lamps or mains relays many not switch off unless a power resistor is connected across the load.

Since the frequency to which the unit will respond is determined solely by resistor R3, it should be possible to control a few lights or appliances independently by selecting different value resistors for R3, although this has not been tried. As each resistor will enable the unit to respond to a range of frequencies, this will limit the number of such units (depending on the frequency range of your whistle and how good an ear you have) to perhaps three of four if there is to be no overlap in the frequencies.

In any event, you will now have the luxury of being able to command your lights, stereo or whatever to switch on or off without first looking for your remote handset but remember not to go around your house whistling absent mindedly! □

Innovations

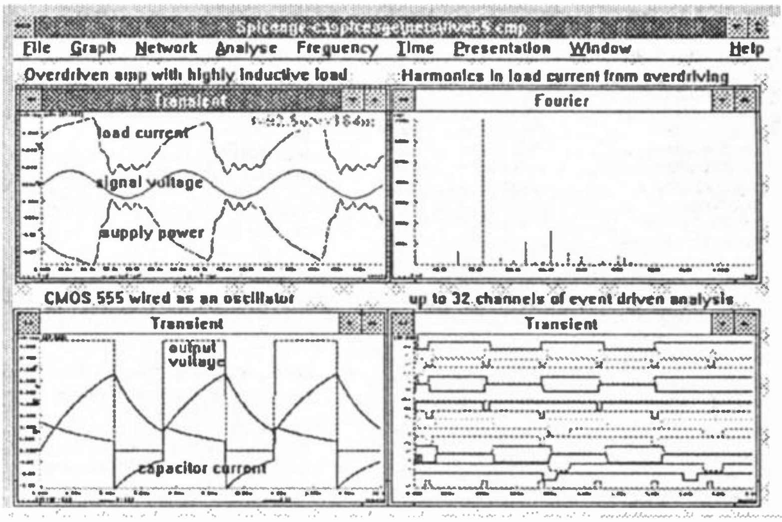
A roundup of the latest Everyday News from the world of electronics

FASTER SIMULATION

Version three of SpiceAge for Windows is now available from Those Engineers Ltd. The new verson of this well known circuit simulation package gives an order of magnitude of speed rise over SpiceAge 2.

To support this, a new 32-channel logic analyser display is available, more digital models are provided and input signal bus structures are supported. The Zetex SPICE library of analogue semiconductor models is shipped with V3 and the analogue side is further expanded by a brand new op.amp model especially developed to exploit the linear extrapolation pragmas provided in SpiceAge's polynomal functions. Not only is this topology more accurate than many SPICE models but is faster to analyse.

Level 3 (professional base level) costs £395. Extra levels available at £150 each. It is published and supported by Those Engineers, specialists in circuit simulation software since 1982. Contact; Those Engineers Ltd, Dept EPE, 31 Birkbeck Road, London NW7 4BP. Tel. 081 906 0155, Fax. 081 906 0969.



4 Band Radio

If you are still looking for something to spend your Christmas money on then a neat new radio from Roberts Radio might be of interest. The R309 compact radio packs in a wide range of features for just £17.99.

The set is attractive, with a digital clock/alarm display and is finished in matt charcoal. For the shortwave enthusiast, the R309 is the first model in the range to incorporate SW alongside FM, MW and LW. It also has a preset facility for 20 stations – five for each band.

For over 60 years, Roberts has been *the* name for stylish classic radios. Now its expanding range of modern lifestyle and world radios are rapidly gaining recognition.

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RESIDENTAL COURSE IN BIO-ELECTROMAGNETICS

Are powerlines safe, or do they cause cancer? Could exposure to those non-ionising fields lie behind unexplained disorders like ME, cot death, MS, and other newly-identified illnesses? Could electromagnetic fields and radiation impair mental and sexual performance? Might there be long term genetic effects? Could my computer screen be causing unexplained miscarriage or RSI? Or could the application of specific electromagnetic fields even heal people?

These are only some of the vital questions arising from mankind's new use of electrical energy in this century. The public wants answers, but few UK scientists have any real expertise in this multi-disciplinary scientific field. Government agencies and other vested interests at last appear to admit the possible risks but give few guidelines concerning the hazards, and carry out even less research.

These residential courses offer a general introduction to bio-electromagnetics, embracing the principles, practice, historical overview, and the most up-to-date scientific literature from molecular biochemistry to epidemiology. No formal qualification in any particular scientific discipline is necessary. Practical hands-on experience of measuring electric and magnetic fields in the domestic or work environment at power etc frequencies will be provided.

For further information contact Coghill Research Laboratories (Medcross Ltd), Dept EPE, Ker Menez, Lower Race, Pontypool, Gwent NP4 5UF. Tel/Fax: 0495 763389.

Novel Dual Audio Op.Amp

New from Analog Devices, the SSM-2135 is a dual-channel op.amp with a unique set of performance specifications for +5V single-supply audio applications, including ultra-low noise and distortion, wide voltage output swing, and high current output. Computer and ditigal audio systems will particularly benefit from the SSM-2135's ability to drive headphone loads (approximately 24Ω) directly with ultra-low distortion and without the addition of higher voltage and/or negative supplies.

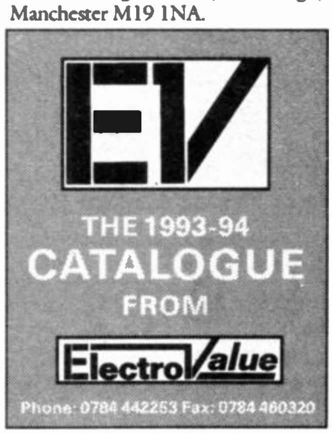
Analog Devices Ltd, Dept EPE, Station Ave, Walton-on-Thames, Surrey KT12 1PF.

BEST YET CATALOGUE

The press release that came in with Electrovalue's new catalogue reads: "This is beyond question, the best yet that Electrovalue have produced since they began business in 1965 supplying to the consumer market by mail order and to the trade, industry and educational bodies. Amongst well known quality product names, that of SIEMENS features prominently in this 140 page A4 catalogue."

Electrovalue are one of those companies that have quietly and efficiently supplied hobbyists, education and industry with components for nearly 30 years. Their product range includes a wide selection of pot cores, many of which are not readily available to hobbyists from any other source. They also supply a number of capacitors which are also difficult to find elsewhere, these include high voltage electrolytic types. Electrovalue have a nominal UK prepaid postage charge of only £1+VAT.

Electrovalue Ltd mail order dept, is at Dept EPE, Unit 3, Central Trading Estate, Staines TW18 4UX. Tel: 0784 442253, Fax: 0784 460320. The catalogue costs £1.50 inclusive. They also have shops at 28 St Judes Rd, Englefield Green, Egham, Surrey TW20 0WB and at 680 Burnage Lane, Burnage, Manchester M19 1NA.



New Technology Update

Ian Poole investigates the latest research developments in super-conductive materials.

SUPER-CONDUCTORS were once just a laboratory curiosity. Now they are beginning to be used, and they are just starting to repay some of the enormous amount of money invested into their development.

They offer the promise of tremendous performance in many areas. However in view of the very low temperatures needed, their acceptance has been quite slow. The results of many years of work are beginning to pay dividends as they are nearing a state where they can be used in many more applications.

What are They?

It is found that very few substances become super-conducting when they are cooled below a certain temperature. This temperature, called the transition point varies from one substance to another. The main problem with super-conductors at the moment is that most of the ones which have been discovered require *very* low temperatures – often only a few degrees above absolute zero.

Super-conductivity seems to defy the laws of nature because it allows electricity to flow without any resistance. It puzzled researchers for some time. However, a theory developed in the late 1950s has been generally accepted.

In a normal conductor the vibrations of the atoms causes the free electrons carrying the current to be impeded. They can only travel a short distance before they "collide" with an atom. This takes energy which has to be supplied by the external source, and it means that power is dissipated in the conductor. In theory at absolute zero when there is no energy in the lattice all the vibrations should stop and the material should become a super-conductor.

To explain how a super-conductor works above absolute zero another theory is required. A theory was put forward stating that instead of impeding the flow of electrons the crystal lattice behaves in a different way. It allows the electrons to pair with one another and then it does not impede their flow. In this way the current can flow without any resistance.

How they were Discovered

Super-conductivity was first noticed back in 1911. It was discovered that below 4°K (i.e. −269°C) mercury lost all its resistance. Since then many other metals and alloys have been shown to exhibit the same effect.

The main problem has always been the very low temperatures required. In fact until recently the highest recorded temperature for a metal or alloy was 23°K (−250°C).

For the effect to be put to any practical use it needed to be able to operate above the temperature of liquid nitrogen 77°K (−196°C). The situation remained static for a number of years. Then in the 1980s reports appeared showing that some specialised ceramic materials became super-conducting at higher temperatures.

Initially the temperatures were not much higher than those of the metal alloys. However soon after a ceramic was discovered which remained super-conducting up to a temperature of 120°K (−153°C).

New Discoveries

The main problem with the ceramics has been that they are very brittle and can break when they are flexed. As many applications for super-conductors are in electrical machines, any movement of the conductor can cause major problems, limiting the number of applications.

Now another group of super-conductors has come to light. At first sight they appear to be just as unlikely to be super-conductors as ceramics. These new materials are all organic. However in view of the number of organic compounds which can be made the possibilities for a whole new family of super-conductors are very exciting.

The first steps for these new compounds were made when it was discovered that a number of organic compounds could be made which actually conducted electricity. Once this was done people wondered if these compounds could be made to superconduct. This was soon proved to be so, but the transition temperature for the first organic super-conductor was less than one degree Kelvin.

Since then many other organic super-conductors have been discovered. In fact the rate at which these new compounds are being discovered is quite staggering and it gives great promise for the future.

Temperature is still a problem as the highest transition temperature yet discovered is 33°K. In view of the number of organic compounds it seems highly likely that transition temperatures will rise quite considerably before too long.

Super-conducting I.C.s

Whilst the obvious uses for super-conductors are in power transmission and high power electrical machinery, they are also investigated with a view to being used in integrated circuits. Their use would bring two advantages. The first is speed. The second is that the super-conductors would dissipate no power.

Power dissipation is one of the main problems for i.c. designers today. The problem of removing heat from the chip and preventing it from overheating is one of the main factors limiting the size of individual chips. If this could be overcome by the use of super-conductors then i.c. technology would take a large step forward.

A number of companies are investigating technologies which could make super-conducting i.c.s a reality. Recently a breakthrough was reported which appears to be a major step forwards.

The super-conductors which are being used for this type of application are the ceramic oxides. One of the major problems has been in processing them so that they can be deposited onto the substrate and withstand the temperatures and any further processing.

One method previously used to overcome the problem was to adopt a two stage process. The first deposited the basic material. A second process was then needed to convert the basic material into a super-conductor.

Now a single stage process has been adopted. The particular material chosen is one of the thalium family of ceramics and it is ideal because its transition temperature is as high as 125°K (−148°C).

However, at the temperatures of around 800°C required for manufacture the material decomposes and the thalium evaporates. To overcome this a new deposition process has been used. This requires a temperature of just over 500°C. Thus reducing some of the problems associated with manufacture.

Commercial Viability

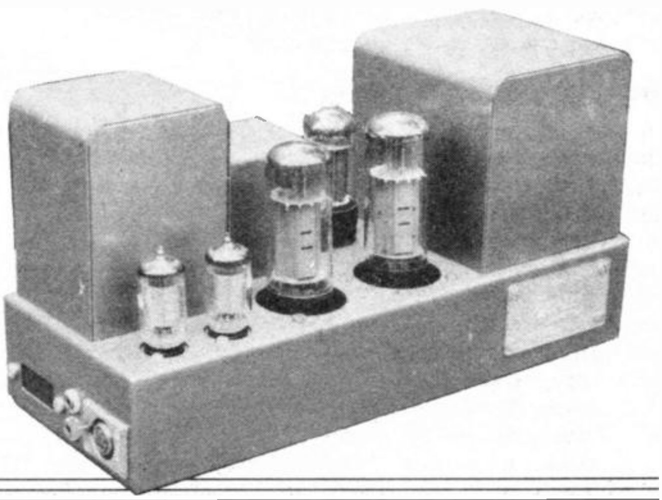
A number of companies are actually using these high temperature super-conductors in their electronic circuitry. Obviously one of the main problems to overcome is that of the basic super-conductor material itself.

Whilst large amounts of development effort has been expended in this area, this is not the whole picture. Highly specialised refrigerators are needed to maintain the very low temperatures needed. Now solid state refrigerators can be used that occupy a fraction of the space and require considerably less power than the older units.

This development on its own now means that super-conducting electronic circuits are a viable solution in some applications. For example they are now being used in some microwave applications where the non-existent resistance of the circuit enables filters with extremely sharp responses and low losses be made.

These and many more applications are beginning to become viable. No doubt as more research is performed into these strange and interesting materials their operating temperatures will rise. This will bring them into very widespread use.

REVIVING THE VALVE SOUND



JAKE ROTHMAN

With a whiff of nostalgia and cooking valves, Jake rebuilds a pair of Quad II power-amps.

MADE FAMOUS by the Acoustical Mfg. Co. of Huntingdon Quad II valve power-amplifiers have had a loyal following for many years. They represent that 1950s British technology typified by English Electric Locomotives and the Vulcan bomber.

The design was engineering led, the looks being determined by function, rather than by some pink bow-tied market-led designer. Most of this technology is easy to rehabilitate because of its simplicity, ruggedness and bolted-together construction.

With the current valve revival, it is worth rebuilding old Quads to enjoy their inherent beauty and sound quality, as well as for profit – as some hi-fi companies are now doing. There have been some articles about Quads in the hi-fi press but these did not deal much with the electronic side. The aim here is to give the missing technical data.

ONLY THE BEST

Many Quads have survived, and they appear to be the most common old valve amps around. The best sources for second-hand Quads are *Loot* and car-boot sales in affluent (pre-recession!) areas. Market prices for a pair of unrebuilt, but operational Quads start at around £150. Fully renovated they can fetch £350. Non-functioning chassis can be obtained for around £45.

Production of the Quad II ran from 1953 to 1970 and many thousands were made. It was replaced by the transistorised 303, introduced in 1968. A single Quad II was not cheap; being 21 Guineas in the early 1960s, which would be around £200 today (£400 for a stereo pair). Along with Leaks and Radfords, the Quad IIs were among the best available at the time. The specification of the Quad II is shown in Table 1.

It is interesting to compare Table 1 specification with modern amplifiers, and the only thing that's much worse, is the power output, which will only satisfy those who listen at low volumes. The sensitivity is half that of most power-amplifiers today, unfortunately preventing it being driven directly by most CD players.

The distortion characteristics are very well specified, taking into account the subjective characteristics of the different harmonics. At low levels, the distortion is better than many modern amplifiers, because it operates in Class-A, and therefore has no crossover distortion. Loudspeaker damping is quite low, which may result in boomy bass with some reflex loudspeakers, but with some overdamped closed-box designs, it may give the impression of extra bass.

THE QUAD SYSTEM

Quad II Power Amplifiers were originally designed to be used in conjunction with a Quad Pre-Amplifier, or Control Unit as they were then known. The power-amplifier was designed to be hidden in the depths of a wooden radiogram cabinet and the mains was supplied to it from the pre-amplifier, which had the power switch mounted on the volume control. High tension (HT) and low tension (LT) filament supplies were then sent to the pre-amp from the power-amp.

All of this, including the audio, was conveyed in thick multi-core screened cables terminated in Painton Multicon six-pin plugs. These connectors are usually found to be totally oxidised and are now unobtainable. For reference the pin-out of the original connector is shown in Fig. 1.

RESTORATION WORK

Most of the restoration work entails adapting the power-amps so that they can be used on their own, employing standard connectors, without having to use the pre-amp. Most people prefer to use the Quad IIs without the Quad pre-amps, such as the Stereo 22 and the Mono II, because their sound quality is below that offered by modern pre-amplifiers.

The Quad 22 control unit also has a lot of redundant features, such as complex scratch filtering, mono source switching and multiple record EQ standards.

Table 1: Quad II Specification

Power Output:	15W r.m.s. from 20Hz to 20kHz
Frequency Response:	20Hz to 20kHz ±0·2dB
Distortion:	Total third harmonic and higher order: <0·1% at 700Hz. Higher order alone: <0·03% at 700Hz. Valve mismatching up to 25% not to cause total distortion to exceed 0·18%. Total distortion at 50Hz not to exceed 0·25%.
Sensitivity:	1·4V r.m.s. (+6dBu) for 15W r.m.s. output.
Signal-to-Noise/Hum Ratio:	80dB.
Output Impedance Matching:	Output transformer secondaries in series, 15Ω. Effective output impedance 1·5Ω, giving a damping factor of 10. In parallel, 8Ω.
Power consumption:	90W.

CIRCUIT DESCRIPTION

The basic circuit topology is standard for the time, consisting of a two-valve phase-splitter (which provides anti-phase drive signals) a.c. coupled to a push-pull beam-tetrode output stage. A small amount of overall negative feedback is used to reduce distortion, flatten the frequency response and lower the output impedance.

The full circuit diagram for the Quad II Power Amplifier, with the first stage consisting of a common-cathode voltage-amplifier built around an EF86 pentode valve, is shown in Fig. 2. The input impedance is set by resistor R1 which holds V1 grid at ground potential. This gives an input impedance of 1·5M with 10pF capacitance.

Resistor R5 is the anode load for V1 and this is used to develop an inverted amplified output voltage to drive output valve V3 and the second driver valve V2. The signal to V2 is attenuated by resistors R7 and R8 and this, in conjunction with negative feedback, results in an overall stage gain of unity. Only inversion of the signal is required to drive the second output valve V4, since the necessary voltage amplification has been provided by valve V1.

The screen grid of the EF86 (pin 1) is held at 110V by resistor R2 in the case of V1 and R3 in the case of V2. Capacitor C1 is strapped across the screen grids on both valves, decoupling any signal voltage that may be present. Normally this capacitor would go to ground, but in this case, it is employed to provide the same function for the second driver valve V2. Since the signal voltages involved are anti-phase, they cancel out, saving one capacitor and simplifying the wiring.

Cathode bias for V1 and V2 (pin 3) is provided by the voltage drop across resistors R4 and R10. Part of the amplifiers output is applied across R10, developing the negative feedback voltage in correct proportion in conjunction with R11. Some of the negative feedback (NFB) is also applied to the grid (pin 9) of V2 via R8, which also helps define the gain of V2 at unity. This negative feedback compensates for any change in the valves gain and ensures that reasonable symmetry is obtained.

This form of phase splitter, sometimes called a "floating paraphase", is not the best, because it can go out of balance. However, to change it to something better, such as a triode split-load phase-inverter followed by separate triode drivers, as pioneered by the Williamson amplifier; would involve a lot of extra work for little improvement.

OUTPUT STAGE

The output stage is almost a standard push-pull, apart from one unique feature, there is local negative feedback from the output transformer to the cathodes of the output valves, accomplished by a special winding. Biasing for the output valves is derived from a shared cathode resistor (R12) dropping 25V. This holds the control grids of the output valves at −25V with respect to their cathodes. This resistor is bypassed by an electrolytic capacitor C5, to maximise stage gain.

These two components are often totally destroyed when valve failure (with inter-electrode shorts) occurs. Resistor R12 is rated at 3W in the original design, but its actual dissipation is often above this.

The renowned KT66 beam-tetrode valves were originally used for the output stage. These valves were specially developed by the the Marconi Osram Valve Co. (a subsidiary of the General Electric Co. Ltd.) for low-distortion audio amplifiers. The valve is now very rare and hence fairly expensive to replace, but an alternative is available – see later.

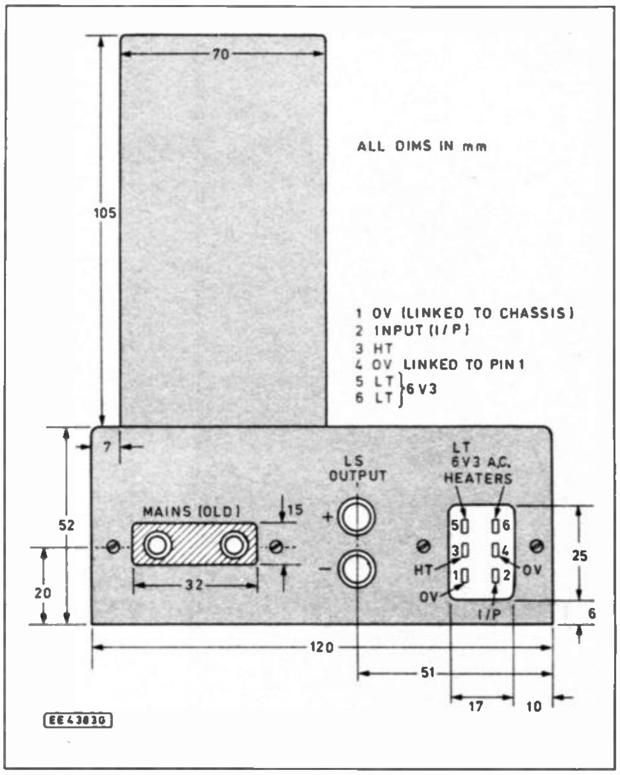


Fig. 1. Pinout details for the original six-pin Quad II connector.

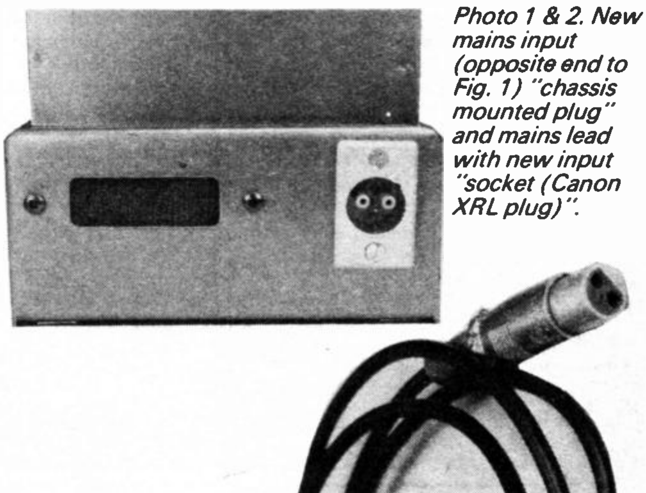


Photo 1 & 2. New mains input (opposite end to Fig. 1) "chassis mounted plug" and mains lead with new input "socket (Canon XRL plug)".

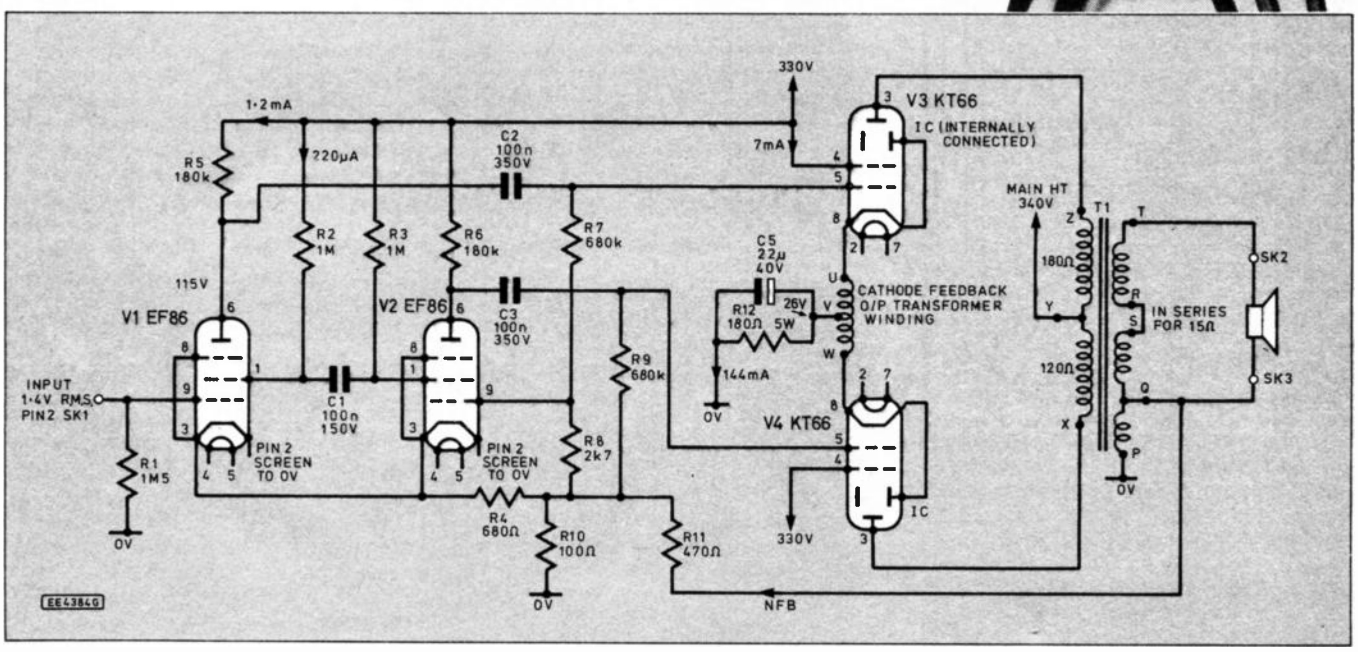


Fig. 2. Complete circuit diagram for the Quad II Power Amplifier. (Courtesty Quad.)

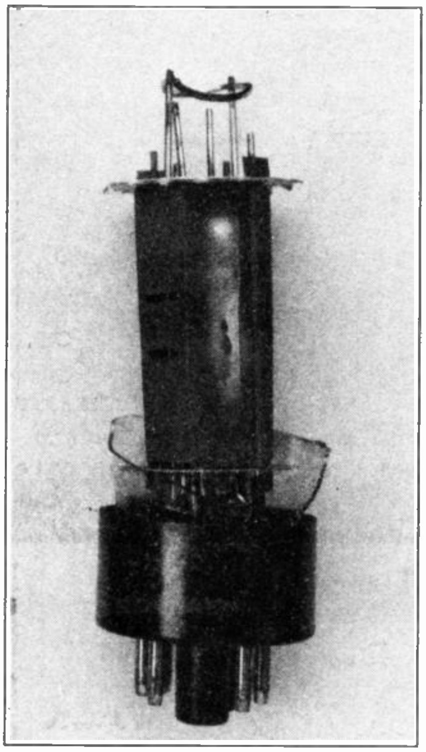


Photo 3. "Spotted" anode on an EL34 valve, a result of excessive dissipation.

Drive to the output valves is via coupling capacitors C2 and C3 which block the 115V present on the phase-splitter valve anodes. For this reason, they must have very high leakage-resistance, or the output valves may become biased fully-on, resulting in the anodes becoming red-hot.

It is worth replacing the original paper capacitors with decent polycarbonate or polypropylene types of at least 400V rating. Photo 3. illustrates the consequences of allowing a valve to overheat, the anode melts!

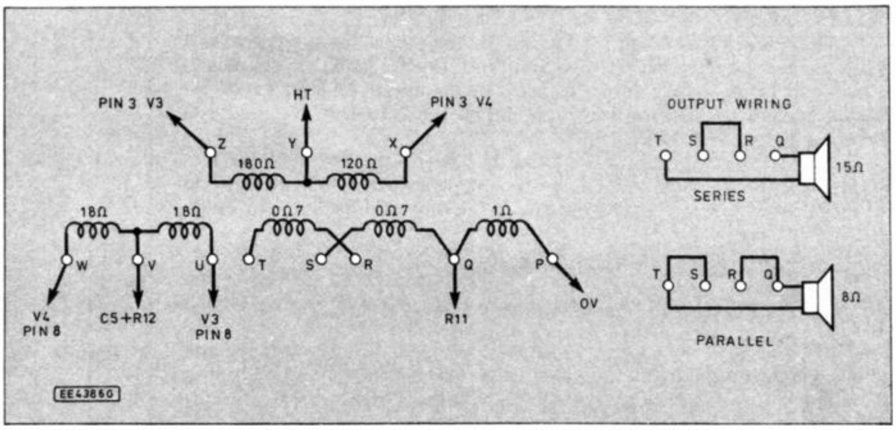


Fig. 4. Output transformer pinout details and typical d.c. resistances of the windings. Bottom view of output transformer. Check also for interwiring shorts, especially between Y *and* P.

OUTPUT TRANSFORMER

The layout of the inductive components and valves on top of the chassis is shown in Fig. 3. The output transformer T1 is the key to the design and if this component is damaged it may not be worth overhauling the amplifier. Quad still supply output transformers on the basis that when a sufficient number of orders have built up, they will get a batch made. The trade price is in the region of £70 + VAT. This high price is because the primary and secondary windings are specially split into sections and interleaved with each other to minimise capacitance. This also makes rewinding virtually impossible, so it is essential to ascertain that the output transformer is okay before buying a Quad II. To assist with this, Fig. 4 shows the pinout and d.c. resistances of the transformer to allow checking with a pocket DMM (Digital Multimeter).

Some Quad IIs were designed to drive 100V line systems, such as some BBC monitor loudspeakers that contained integral transformers. These amplifiers have a high impedance output windings (43 ohm d.c. resistance) which means they are useless for hi-fi puposes. These units can be identified by the presence of a black flying lead from the output transformer. This is the other end of the feedback winding, which in the normal transformer, is connected internally to Q terminal of the speaker winding.

For most modern four ohm to eight ohm loudspeakers the secondaries are best wired in parallel, for higher impedance 10 ohm to 20 ohm speakers, such as the LS3/5A, series connection is better.

DISSASEMBLY AND REBUILDING

For a full-scale rebuilding (usually only necessary where the unit is suffering from crumbling insulation in the wiring loom) the unit is stripped down to its bare chassis as shown in Photo 4 and Photo 5. The

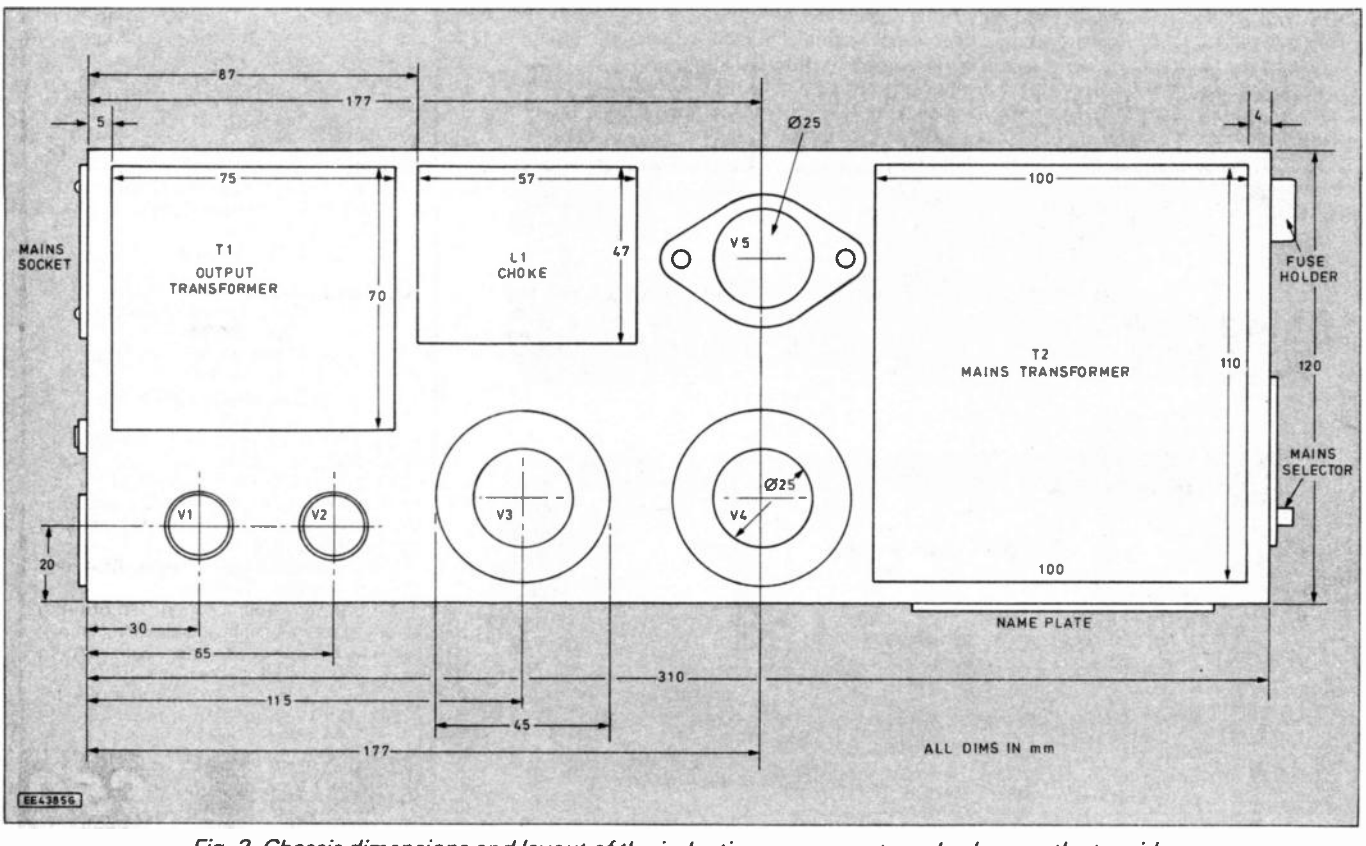


Fig. 3. Chassis dimensions and layout of the inductive components and valves on the topside.

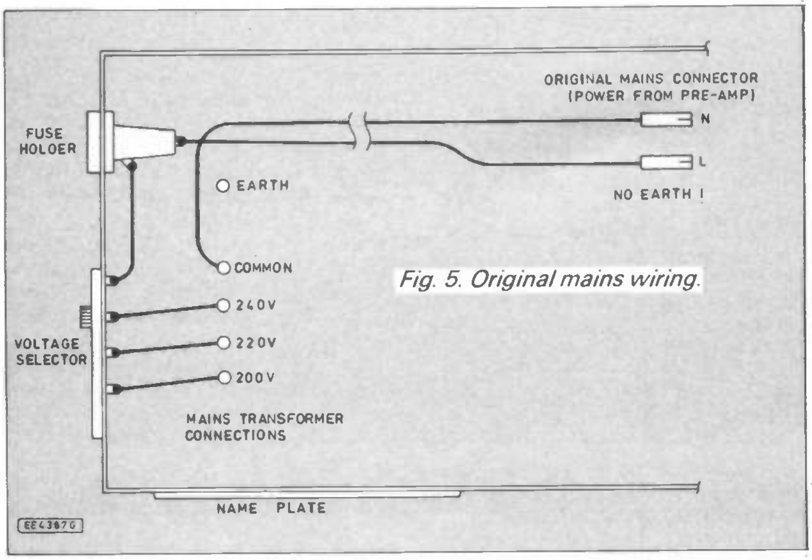


Fig. 5. Original mains wiring.

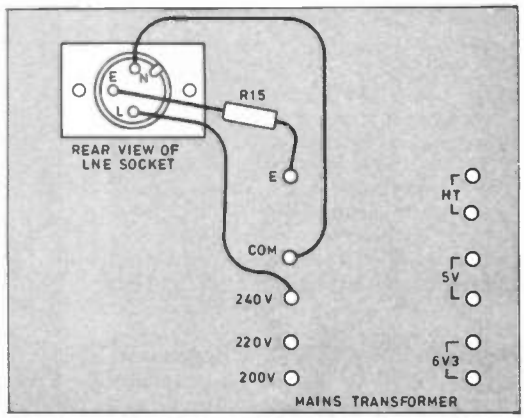


Fig. 6. New mains wiring to the Cannon connector.

most effective way to remove the baked-on grime of 30 years is to use tissue paper and a nylon pan-scourer (for the difficult bits) with plenty of isopropyl alcohol. A re-spray is quite difficult because the unusual gun metal colour cannot be obtained in most car shops. A good rub with T-Cut worked wonders on the original paint.

All the inductive components are held on with 4BA bolts, as is the output valve assembly. A small tag board is used to hold the driver valves and most of the small passive components – see Photo 5 and Photo 7. This can be removed by undoing the 6BA nuts near the B9A valveholders on top of the chassis.

Take care when removing the name plate screws (which also hold the smoothing capacitor) since the gold paint may have stuck to the metal and may flake off. Unfortunately, Quad no longer have any spare name plates in stock.

(Photographs by David Tarlo.)

MAINS WIRING

When installing the new mains connector, it is a good idea to put it close to the mains transformer. In the original design this was at the opposite end of the chassis, as shown in Fig. 5.

A Cannon mains XLR connector (a professional broadcast standard) will fit in the fuseholder hole, with only a little reaming. This is illustrated in Photo 1. Photo. 2 shows the mains plug.

Some readers may prefer to use an IEC or Euro socket, possibly with integral filter. The mains fuse, being 2A, can go in the mains plug. The voltage selector can also be removed, since all areas of the UK are now 240V, although some readers in Europe may need to use the 220V tapping.

The chassis is effectively Earthed by the metal body of the mains connector. The signal earth (pin E on the mains transformer) is connected to the mains earth via a one kilohm 5W wirewound "ground lift" resistor (R15) to prevent "earth loops". The new mains input wiring is illustrated in Fig. 6.

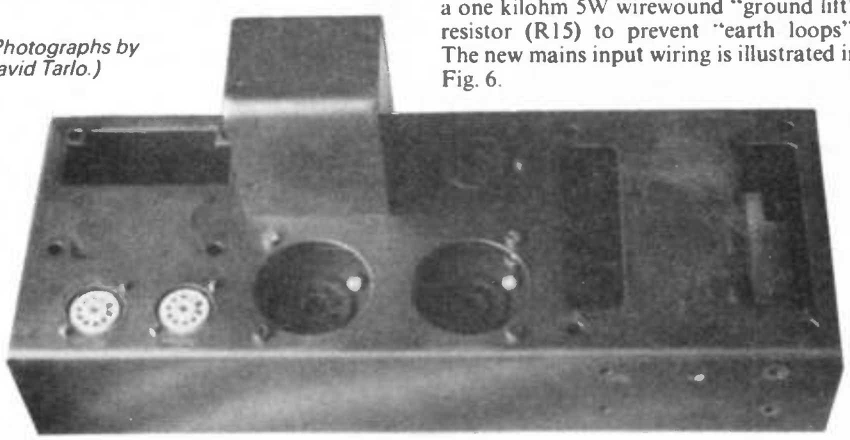


Photo. 4. Topside view of the stripped-down metal chassis.

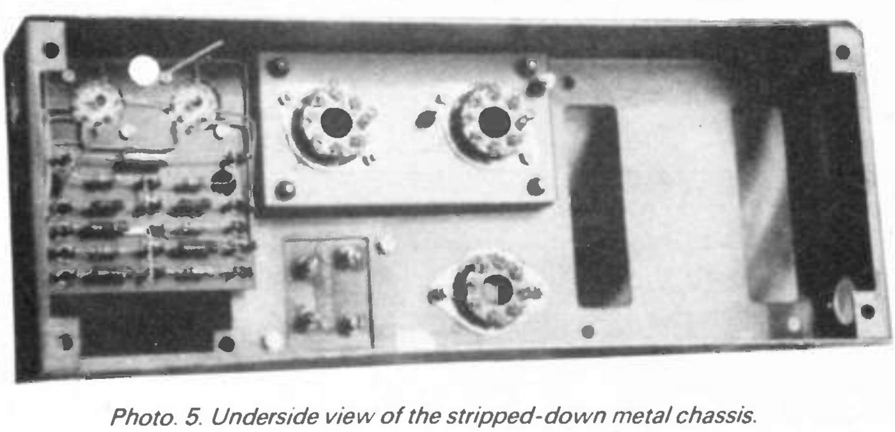


Photo. 5. Underside view of the stripped-down metal chassis.

COMPONENTS

Resistors

R1	1M5
R2, R3	1M (2 off)
R4	680
R5, R6	180k (2 off)
R7, R9	680k (2 off)
R8	2k7
R10	100
R11	470
R12	180 5W 5% wirewound (e.g. HSA05 metal-clad)
R13*, R14*	1k 1W metal-film (e.g. Vishay FP1.) (2 off)
R15	1k 5W 10% wirewound

See SHOP TALK Page

*Not needed for KT66 valves.
All resistors 0·5W 5, 2 or 1% metal-film eg. Vishay TR5 or RS except where stated.

Capacitors

C1	100n 150V axial plastic-film e.g. RS Stk. No. 113 049
C2, C3	100n 400V axial plastic-film (2 off) e.g. RS Stk. No.113 156
C4	15µ to 47µ >385V can electrolytic e.g. Philips 059 58479
C5	22µ to 100µ 40V axial electrolytic e.g. Philips 123 17479
C6	47µ to 220µ >385V can electrolytic e.g. Philips 059 58101

Valves

V1, V2	EF86 pentode (2 off)
V3, V4	EL34 beam tetrode (2 off) – see text
V5	GZ34 rectifier

Miscellaneous

T1	Output transformer Quad No. 1003A
T2	Mains transformer Quad No.1001
L1	Smoothing choke Quad No. 1002

Connectors: Mains XLR chassis plug AXR-LNE-32; Mains XLR free socket AXR-LNE-11; 5-pin female XLR chassis socket AXR-5-31; 5-pin male cable XLR plug AXR-5-31; pair of banana sockets for speaker connectors.

Valve sockets: pair chassis B9A unskirted; pair chassis octal.

Mounting clips, to suit smoothing capacitors pair; silicone sleeving (1mm); 22 s.w.g. tinned copper wire; lacing cord; 0·5in. 4BA cheese head bolts, (12 off); M3 12mm countersunk bolts for XLRs (4 off); solid-core wire.

Approx cost guidance only **£50** *excluding transformers*

POWER SUPPLY

The power supply is a typical 1950s design, using a pi-network inductor-capacitor filter and full-wave valve rectifier as illustrated in Fig.7. It is a good idea to retain the valve rectifier because it applies the HT gradually to the circuit as it warms up; reducing stresses to the capacitors and providing maximum valve life (because valves do not like HT applied before the cathodes have warmed up). If solid-state rectifiers were to be employed it would be *essential* to provide a standby (HT) switch or slow turn-on circuit.

To prevent buzz caused by charging currents, the wiring layout of the power supply is important and the connections should be "starred" (commoned) to the smoothing capacitors as shown in Fig. 8a. The old square smoothing capacitor is often dried-up and it can be replaced by modern types. It was found that two of the original holes could be used to mount a pair of circular capacitor clips (as recommended in the parts list) with only the necessity to drill one extra hole under the name plate.

Valve rectifiers have a maximum load capacitance they can tolerate, which is in the order of 47µF for a GZ34. This means that capacitor C6 should not be increased beyond this value. Capacitor C4 however, is after the choke, which limits the current surges, so this can be increased up to around 220µF if desired, to get lower hum. The original rectifier valves used were the GZ32 and 5V4G. These can now be replaced by the higher current and cheaper GZ34.

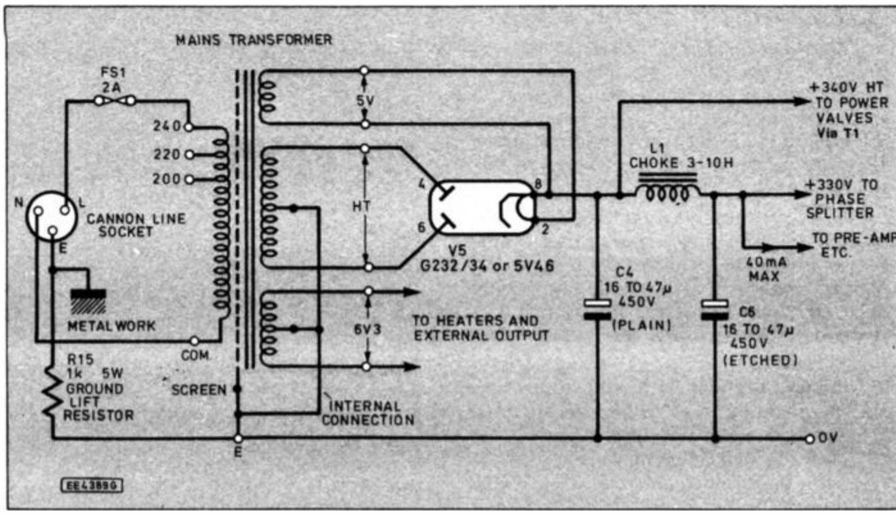


Fig. 7. Circuit diagram for the valve Power Supply. Note that the "ground-lift" resistor R15 is a 5W wirewound *type.*

TAG BOARD

For those wishing to undertake the least arduous and cheapest bit of renovation, the place to start is the tag board, which is located under the driver valves. After 30 years most high-value carbon composition resistors have a tendency to drift up. Quad designed for a long life by using 1W resistors where "half-watters" would have been adequate, but it is still worthwhile replacing these with modern metal film types, which would be better than the originals.

There is no need to go to ridiculous lengths like using precision Holco resistors, ordinary 1% 0·5W types will be fine. Note that these should be the industrial half-watt rated types which are at least 10mm x 3·2mm. The Maplin 0·6W metal films have the commercial rating, their industrial rating is only 0·25W, and their small size of 6·5mm x 2·5mm makes them too delicate for valve tag-strip work.

A drawing of the tag board is shown in Fig. 9 and a completely rebuilt tag board is shown in Photo. 6. When replacing the components, it is best to cut them off first and remove the wires one at a time, to minimise stress on the tags (the components can be replaced, but if a tag falls off it is much more difficult!) For those wishing to undertake a full rebuild of the tag board, the additional wiring is also shown.

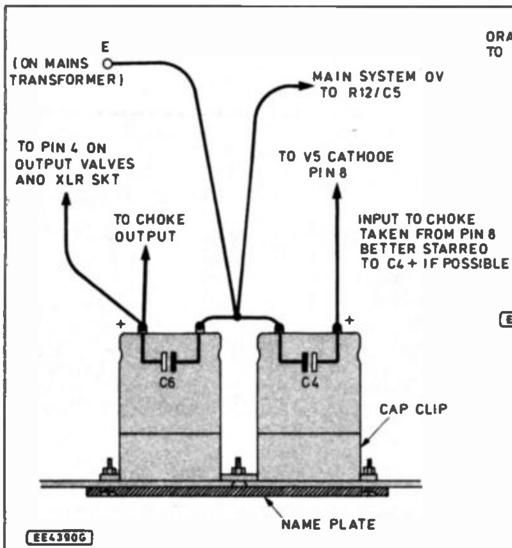


Fig. 8a. Wiring to the smoothing capacitors.

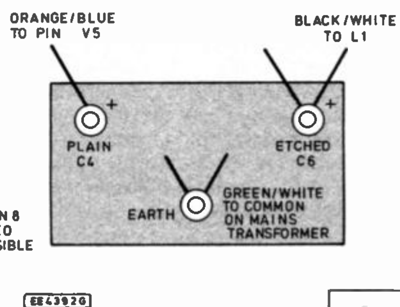


Fig. 8c (above). Old smoothing capacitor connections.

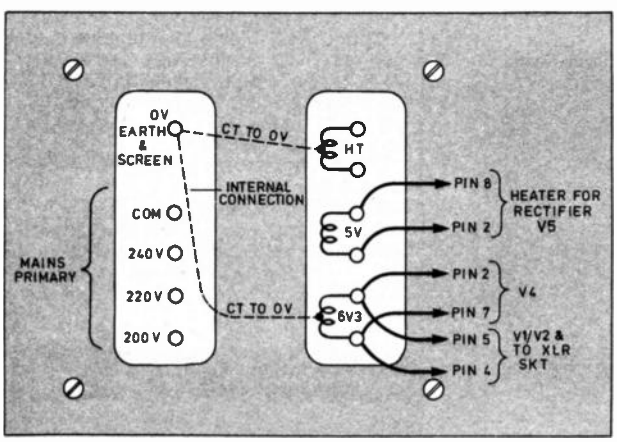
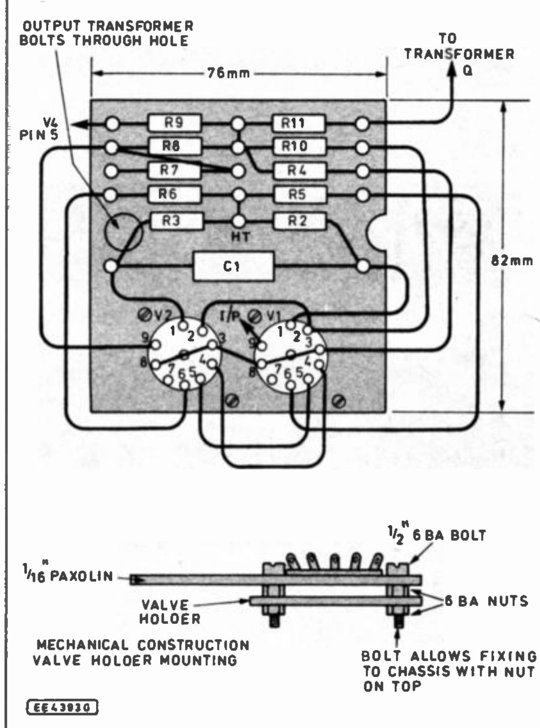


Fig. 8b (left). Mains transformer pinout details.

Fig. 9 (below). Tag board component layout, wiring and valve base mounting details.



OUTPUT VALVES

The original KT66 valves are now very expensive because of their scarcity. These can be replaced by EL34s with the benefit of a slight increase in output power. Since EL34s are made by many manufacturers, they are much cheaper and more readily available.

However, a modification has to be made, since the KT66s have their beam-forming plates internally connected to the cathode. This is not the case with the "replacement" valve and pin 1 must be linked to pin 8 (cathode). The wiring of the output valves in shown in Fig. 10.

Another worthwhile modification with EL34s, is to place 1k 1W (R13,R14) resistors in series with the screen grids. This modification reduces damage due to valve failure, aids stability and reduces the dissipation at the screen grid, giving longer life.

Quad IIs are relatively insensitive to valve mis-matching and tolerances because they were well designed, so there is no need to go to the expense of buying matched valves. Cheap East European ones do the job well and last about 80 per cent as long as the most expensive types. Buying specially selected "hi-fi buff" valves provides little sonic improvement, so do not be persuaded into paying more than about £15 for a pair of output valves.

Some people have old EL37s and these can be used with slightly higher distortion. Also 807s can be used if the pin-out is checked. The American 6L6s will work if R12 is increased to 270Ω, but will give 25% less output. Overall, EL34s are the best choice when cost is taken into account.

BIASING

Resistor R12 sets the standing current through the output stage at around 65mA for each valve. The voltage across R12 is around 25V, so this means that the dissipation is around 3·2W.

In most old Quads this resistor is worn-out from thermal cycling, so to improve reliability it was replaced with a metal-clad type bolted to the side of the chassis. R12 is bypassed with an electrolytic capacitor C5. I used a Philips solid-aluminium type which can't dry-out.

Two tags are provided on the base of the choke to support these biasing components, they have no internal connection to the choke itself. The wiring is shown in Fig.11. R12 can be replaced by a metal-clad type if desired.

The output stage circuit diagram using EL34s is shown in Fig. 12. An alternative biasing arrangement is also shown, where each valve has an individual cathode resistor. This is useful to allow tweaking in cases of severe valve mis-matching.

LOOM

The original wiring layout was retained because it gave excellent hum levels, so there was no point in changing it much,

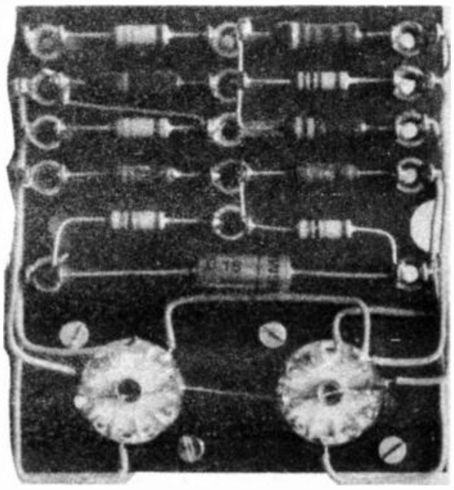


Photo. 6. Rebuilt tag board ready for installation into the chassis.

apart from the changes required for the minor modifications. If the loom needs to be remade, it is best to use (0·7mm²) solid-core wire for rigidity. Remember, the heaters are ***high-current*** (around 3·5A) and only 6·3V, so use reasonably thick wire (> 1mm²) for these to reduce voltage drops. Fig. 13 shows the details of the wiring loom.

A completely rebuilt Quad with a new wiring loom is shown in Photo. 7. To prevent confusion, use sensible colour codes for the wiring, such as red for HT

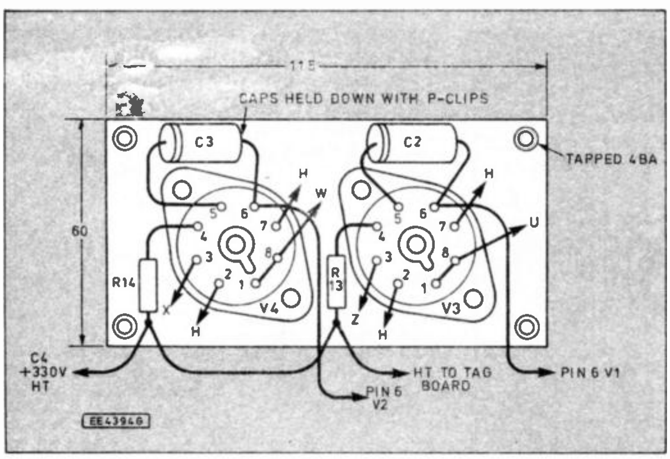


Fig. 10. Wiring to the new EL34 valve bases. The capacitors C2 and C3 should be held in place by P-clips.

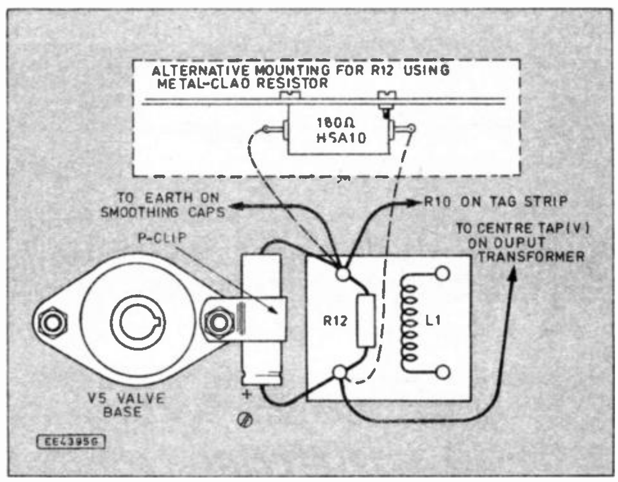


Fig. 11. Biasing components wiring. Resistor R12 can be, replaced with a metal-clad type (shown dotted) if desired.

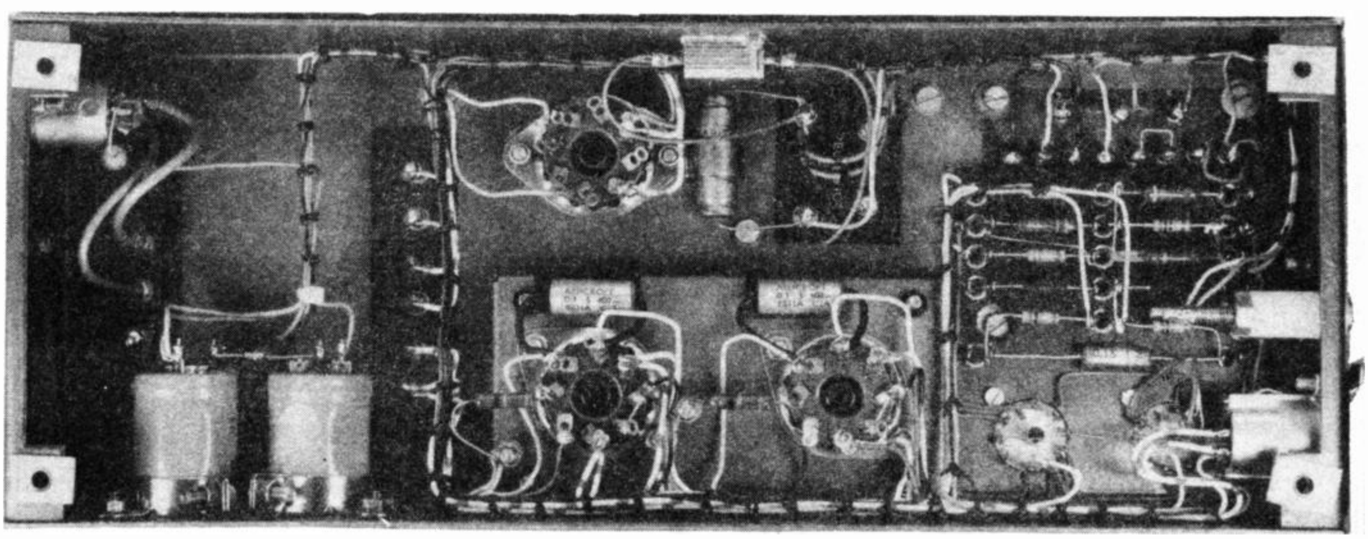


Photo. 7. Underside view of a completely rebuilt Quad showing new wiring loom, tag board and metal-clad resistor.

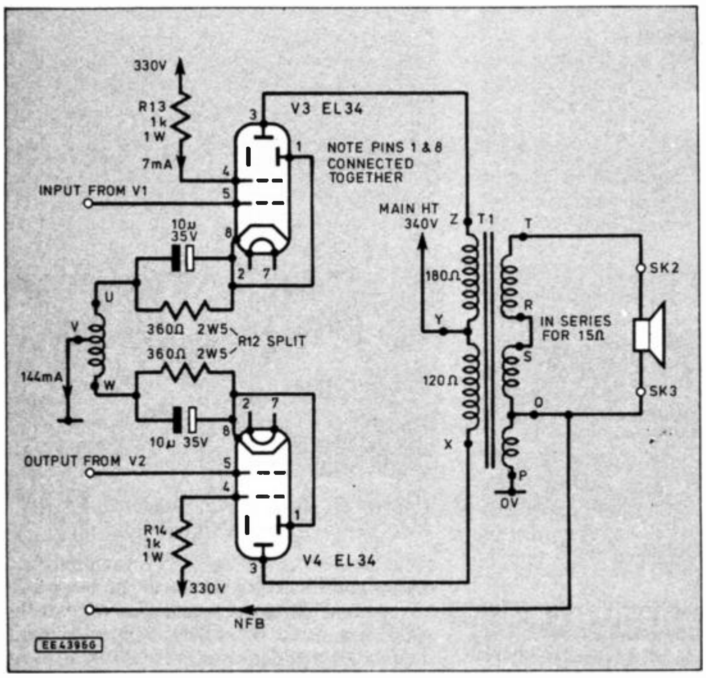


Fig. 12. Output circuit diagram using pair of EL34 valves.

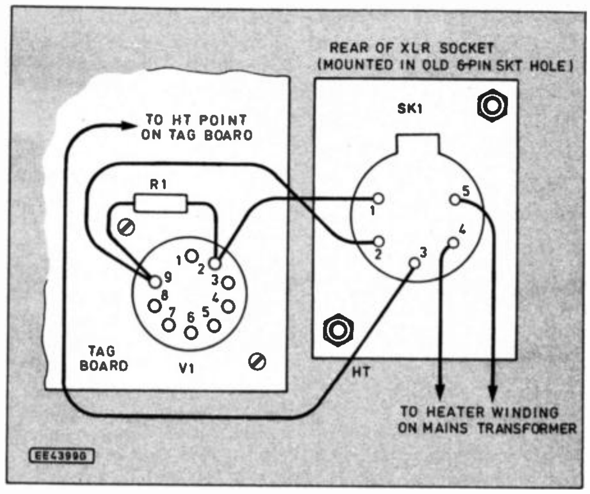


Fig. 15. Wiring to the new 5-pin "female" XLR socket.

and green or black for Earth. Putting a small loop of wire at each tag prevents strain and allows the connection to be remade if necessary. For the finishing touch, lace up the loom with nylon cord. The basic technique of lacing is illustrated in Fig. 14. and can be summed up as *"twice round, loop through, then pull"*.

INPUT SOCKET

A five-pin female XLR socket is used to replace the original six-pin connector, since it is an audio standard and very reliable. This socket carries the HT and LT as well as input and earth to enable a Quad 22 control unit or other valve ancillaries to be used. Fig. 15 shows the wiring associated with the socket, which is mounted in the same hole originally occupied by the six-pin socket.

The old mains socket hole is blanked off as shown in Photo 8. Fig. 16 shows the pin-out of the XLR.

PHONO ADAPTOR

Most hi-fi equipment uses the dreaded phono plug, so to provide a degree of compatibility with other equipment, it is worthwhile making a five-pin XLR to phono adaptor as shown in Photo 9. This is constructed by inserting a phono in-line socket into the rubber cable strain-relief bush. In this case only pins 1 and 2 are connected.

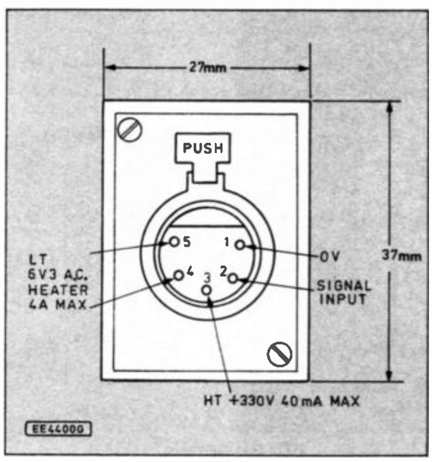


Fig. 16. Pinout details for the XLR socket.

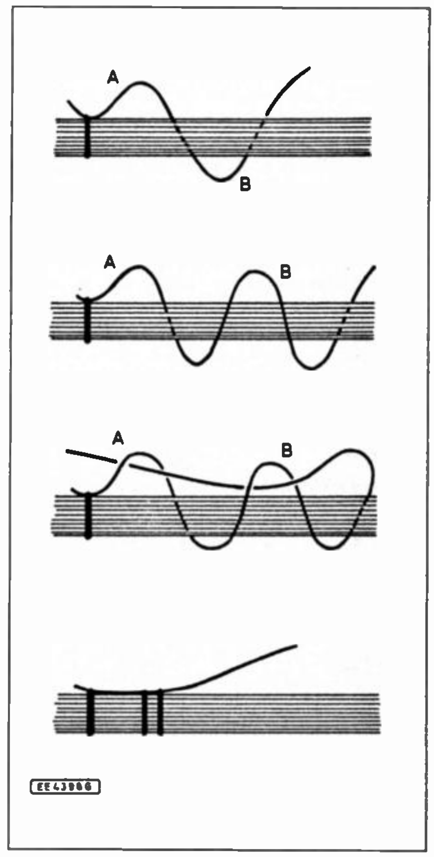


Fig. 14. Basic technique for lacing up the wiring loom.

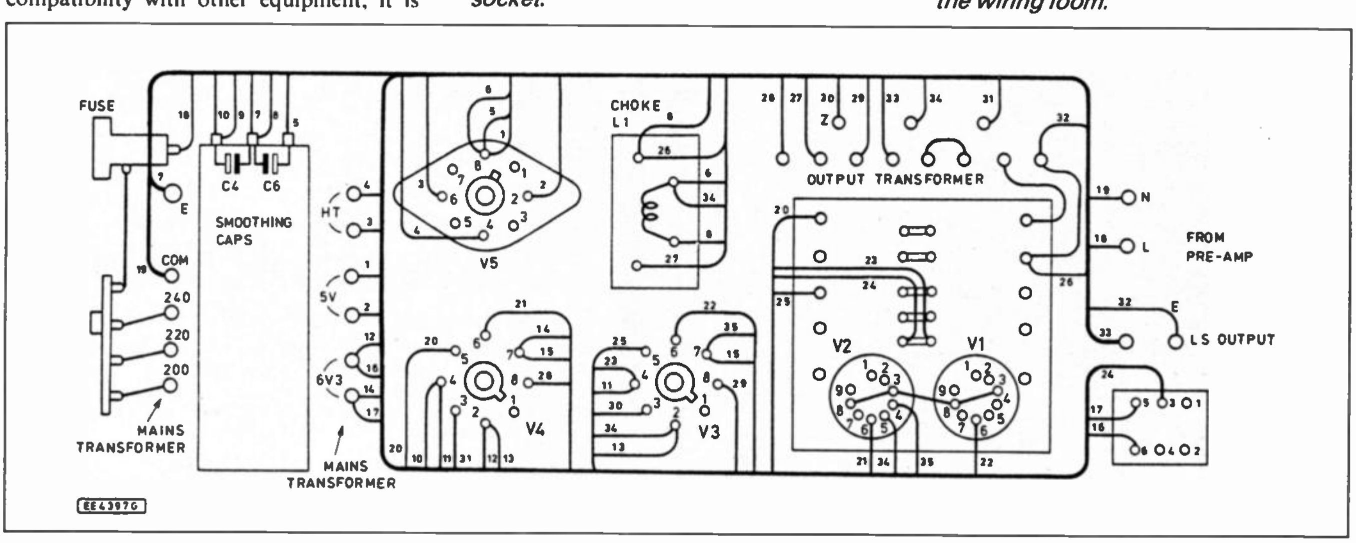


Fig. 13. Original wiring loom for the Quad power amplifier. If a new loom is made up use multi-coloured wires wherever possible, see Fig. 6 for new mains input wiring.

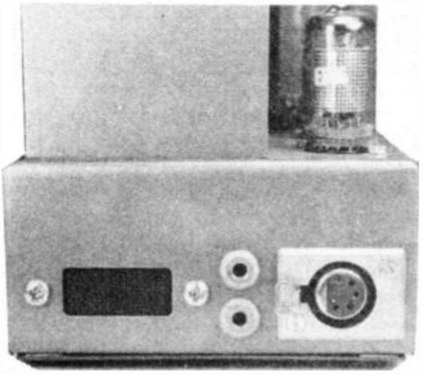
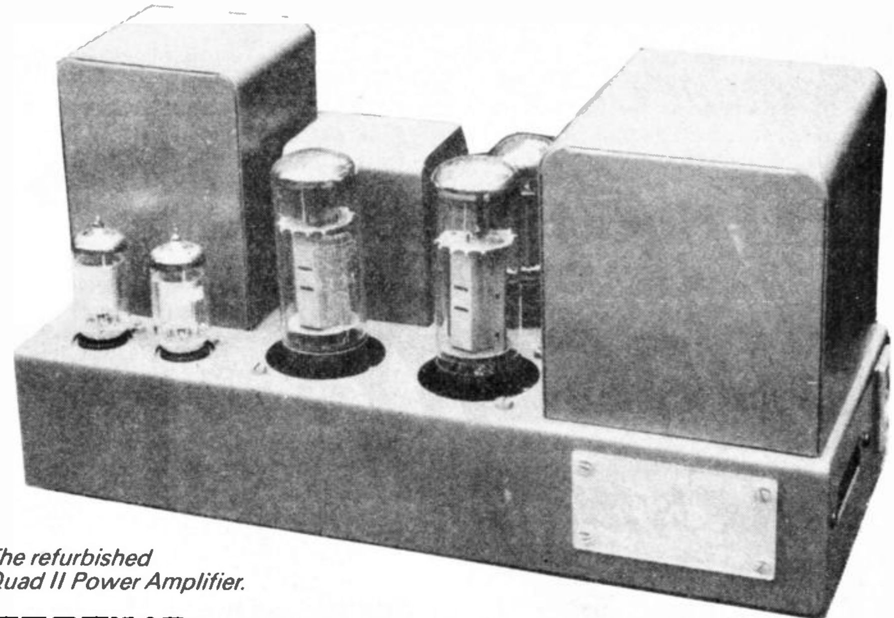


Photo. 8. Blanking of the old mains input socket cutout.



The refurbished Quad II Power Amplifier.

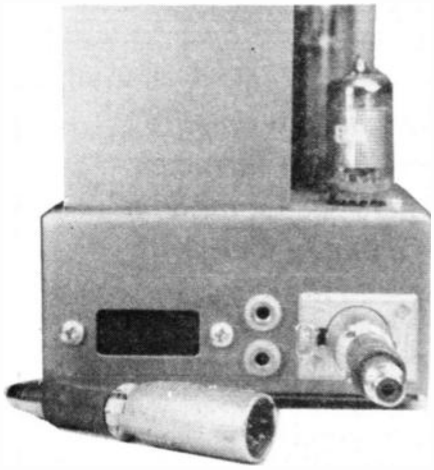


Photo. 9. Adding a 5-pin XLR to phono socket. Only pins 1 and 2 are connected.

TESTING

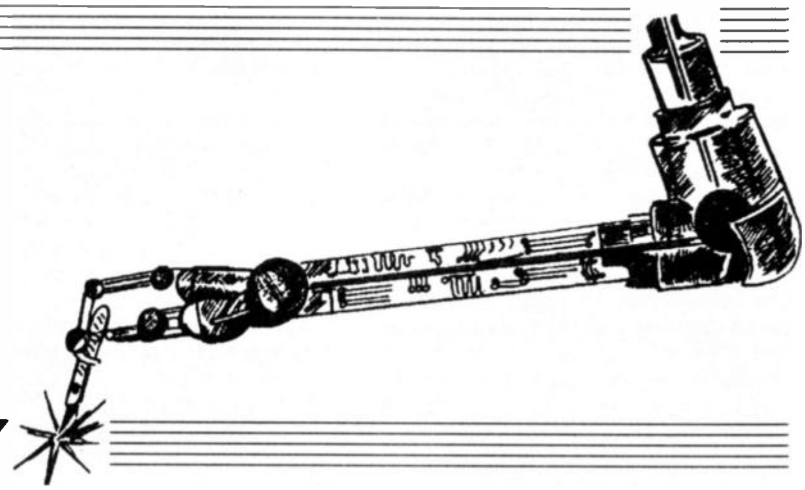
First of all, the obligatory warning – *THE HT VOLTAGE CAN KILL, it is worse than mains because it is d.c., which can cause the victim to become locked solid, unable to let go.* The old valve adage of keeping the other hand in the pocket while testing is sensible, because it will prevent voltages being developed across the chest (cue Casualty theme tune and de-fib' trolley!).

A Quad in good fettle should give around 55V peak-to-peak into a 15 ohm load resistor before clipping (using EL34s) when fed with a 1kHz sine wave. This corresponds to about 25W r.m.s. At lower frequencies, such as 20Hz, the power output is less, due to the finite primary inductance of the output transformer. About 5·75V peak-to-peak is needed at the input to get the output to clip, giving an overall voltage gain of 10. All these measurements were taken using the output secondaries in series.

Slight ringing is evident on 10kHz squarewaves, although this is typical of most valve amplifiers, because of the transformer electrical resonances. A Zobel network can be wired across the output to damp this out, but no sonic differences could be heard. Suitable values were 470nF in series with 22 ohm. In fact, the Quad II was optimised to drive the Quad Electrostatic loudspeaker which has a capacitative impedance characteristic. □

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

Circuit Surgery *is the monthly column which tries to help readers to simplify those suspect circuits and pass on handy hints and tips. If you have a particular problem in the field of hobby electronics then let* Circuit Surgery *shed some light! Or if you think you have a useful piece of advice which you'd like to share with your fellow constructors, then write in and I'll try to spread the word.*

THIS is **your** column but as regular readers know, space is often limited – so although I try to reply personally, please accept that I can't answer everyone individually. *Circuit Surgery* tries to appeal to readers of all abilities and relies on **your** queries which I will try to include on these pages where possible. Having munched my ration of mince pies, it's down to business!

Reed On

Firstly, thanks to ***Gavin Poulton*** of Fulwood, near Preston who put me in a jolly mood with this letter:

In last November's issue, Circuit Surgery *described a simple room alarm designed by Mike Tooley, using an l.d.r. (light dependent resistor) as a sensor. I reckoned the l.d.r. might be tricky to set up and disguise, so a better alternative might be to use a reed switch which can be hidden under the carpet by the door. A small bar magnet can be "blu-tacked" to the bottom of the door. I really bemused my brother this way!*

Sounds like you've got your security problems licked, Gavin – thanks for writing in! The reed switch would also solve the problem of reduced sensitivity during daylight hours, which Mike cured by adding a second compensating photoconductive cell (LDR). Reed switches themselves are readily available for use in burglar alarm systems, and it's interesting to see how they work. Fig. 1 shows a typical reed contact switch, of the sort which is encapsulated in a glass envelope.

They contain a set of springy metal contacts which generally are normally *apart*. A magnetic field is then created around the switch using, say, a bar magnet or a coil. This causes the contacts to become in effect, two adjacent bar magnets separated by the contact gap. The "poles" of the magnet adopt opposite magnetic polarities and become mutually attracted. Thus the contacts are magnetised together to make a circuit. Removing the external magnetic force permits the contacts to spring apart, breaking the circuit.

Low Power

Reed switches are only really suitable for low power circuitry – certainly not for mains voltages. Since the glass envelopes are a little delicate, it's possible to buy specially encapsulated reed contacts which are designed for rugged use – such as in burglar alarm systems. These can be sunk into door jambs where they become tamperproof. A *Hall Effect switch* is a solid-state, magnetically sensitive device which could be used as a proximity sensor, instead (see *Interface* last month. Ed.).

I have also used reed switches as a form of "invisible" keypad on security projects. They can be glued behind the surface of a plastic control panel so that nothing is visible from the outside – the panel can be suitably embellished with rub-down lettering.

To activate the project, touch the relevant part of the panel with a small magnet, such as a small horseshoe type available from d.i.y. stores. This fools any opportunists who hopefully would not come equipped to de-activate the alarm! You could perhaps adapt the principle to switch outdoor projects on or off, when you would avoid problems caused by exposing switches to weather. *The Waterproof Delay Switch* published last month worked in this way.

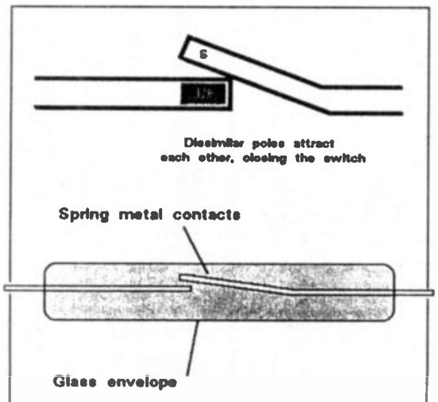


Fig. 1. A glass encapsulated reed switch.

Dinosaur Roar

An interesting letter came from ***Mr. H.S. Lenton*** of Oldbury, West Midlands, who asked for a dinosaur roar sound effects unit to entertain his young family. Drastic Park strikes again! Unfortunately it isn't that easy to create complex sounds using simple discrete circuitry. In the past I've dealt with chip manufacturers in Taiwan and Hong Kong who specialise in integrated circuits which can generate a variety of sound effects, mainly for novelty use.

Many of these devices are based on a standard i.c. chip which is customised during manufacture by using a process called "masking". Thus a basic chip is programmed or masked to produce a certain sound, which could be a digitised version of a real event – an animal noise, for instance. The customer (that's me) can pay several hundred U.S. dollars for a masking charge to have his own required effect etched onto a standard chip.

Alternatively, many standard sounds are available off the shelf. Otherwise the i.c. chip is specially fabricated onto a tiny p.c.b., protected by a blob of resin. All that's then needed is a piezo sounder and a watch battery (plus an order for half a million units), and you're away!

It's much easier to reproduce a sound this way by copying the real thing, rather than starting from scratch trying to emulate a complex noise. Video games often contain sampled effects and speech (and images, for that matter, such as the characters in the *Mortal Kombat* game – or "Mortal Wombat" according to my computer's Spellcheck!) because it is relatively easy to capture a sound or music track and then transfer this in digital form into the game cartridge chip. Sampled sounds and images are now finding their way onto games stored on compact disc, too.

Indeed our advanced *Teach-In Micro Lab* microprocessor trainer contains a sound sampling and playback facility as part of its demonstration routine, which will digitise and store an audio signal. All of which begs the question, what does a real dinosaur roar sound like? How do you know?

Battery Back Up

Mr. Andrew Judge of Tadworth, Surrey contacted us following on with a topic which was dealt with in *Circuit Surgery* quite a few issues ago – that of "low battery" warning devices:

I need a circuit that automatically switches from a first battery to a second back-up battery when the first falls below a certain (variable?) threshold. Ideally it should be possible to change the first without interrupting the supply and to know which supply is actually in use. Can you help?

Mr. Judge explained that his own attempts had drawn a blank, mainly because of the lack of a clean change-over, and also the back-up battery sometimes ran down before the first! *Power supply monitoring* seems to be an area of i.c. technology which is growing, because there's an increasing demand for these "supervisory" circuits. Often they are used in portable laptop computers, mobile phones, test equipment – even rechargeable razors!

Certain families of logic run at 3V d.c. – when it's vital that close attention is paid to the battery or power supply condition to prevent a mal-operation, and also the power supply may need to generate a "clean" reset signal for starting the logic properly in the first place.

I reckoned though that Mr. Judge's suggestion would be an ideal application for the 8211 Programmable Voltage Detector which we investigated in depth last month. Fig. 2 shows how an 8211 can be used to monitor the supply voltage *elsewhere* in a circuit. The load and the supply voltages weren't specified, but this circuit could easily be adapted to suit individual needs. B1 is the "main" battery – let's assume it's a 9V battery pack. R1 and VR1 monitor the potential of B1 and so a voltage appears at the threshold pin of IC1 (pin 3).

This threshold voltage falls as the battery starts to age. Remember that the i.c. has an internal 1·15V reference, and when the voltage at pin 3 falls *below* 1·15V (8211 only – the 8212 works in reverse), the output pin 4 goes low and sinks current.

All Change

When B1 is in a healthy state, it drives the load directly through D1. When the voltage of B1 falls to a point determined by VR1, then IC1 conducts which switches TR1 on. This *pnp* transistor saturates, connecting the higher voltage of the back-up battery B2 to the load. The rectifier D1 is then reverse biased and ceases conduction, so B1 is effectively disconnected. At this point the l.e.d. D2 illuminates (the current-limited sink of pin 3 is only a few milliamps) to warn that the back-up battery is now operating. The l.e.d. could be a high-intensity type for a much brighter display.

Hopefully it should then be safe enough to replace B1 without interrupting the drive to the load. I placed a large capacitor C1 across the load which helps to smooth the transition, though it will draw a minor leakage current from either battery. Note that both batteries must be commoned to 0V as shown. The operation of the circuit will also be defeated if you allow B2 to fall below the minimum voltage required across B1. Possibly add another 8211 with an l.e.d. to monitor B2!

There is room for experimentation and you can select the components TR1 and R3 to suit your own application. TR1 should be a *pnp* Darlington transistor. For example, a TIP125 is a 5A type in a TO-220 package – or you could try a BDX34B (10 Amps). If you are involved with low power projects then a modest type like a ZTX712 (500mA) might suffice. The rectifiers should be chosen for their forward current rating. An 1N4001 is good for up to 1A of course, an 1N5401 could handle 3 amps average.

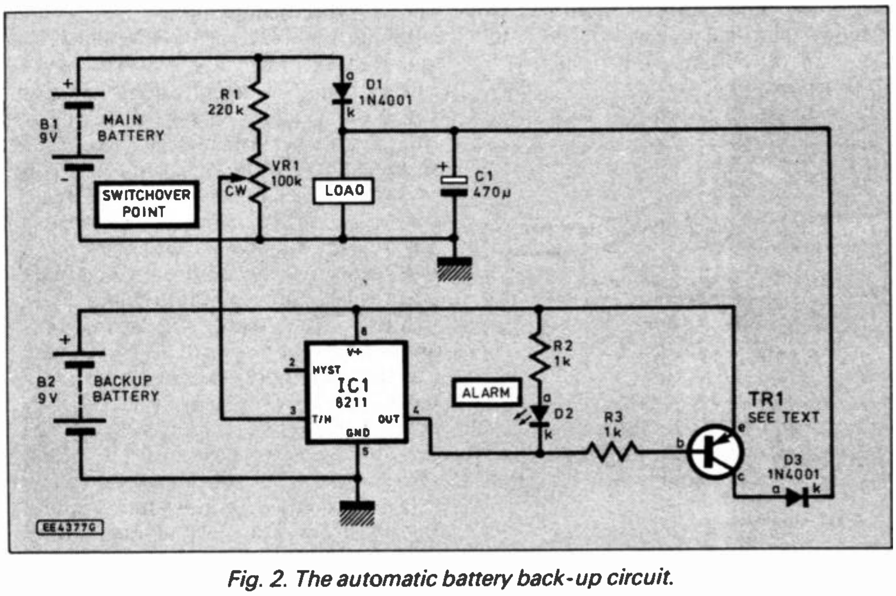


Fig. 2. The automatic battery back-up circuit.

Hysteresis

You could add some hysteresis by including a 1M resistor between pins 2 and 3. This will produce a difference in the switching levels should your circuitry be particularly sensitive to supply rail "jitters". Don't forget to adjust VR1 to give just over 1·15V at the required battery threshold voltage.

Fortunately the circuit does not add any appreciable load to the batteries, especially the all-important back-up B2. The bipolar ICL8211 has a low quiescent current and the potential divider would consume well under 50μA depending on the battery voltage. The CMOS MAX8211 version is even better in this respect, of course. Sources for these parts were given last month.

Incidentally, I prototyped and built this circuit on my own *Teach-In Mini Lab* which is equipped with both a fixed 12V and variable 1·25-18V d.c. supply. The 12V rail represented the back-up battery whilst the variable supply was deemed the main battery, slowly running down. It seemed to work perfectly!

(I recently learned that some 800 *Mini Labs* are now in use amongst readers – see the Magenta Electronics advertisement in this issue for details of the *Mini Lab* and *Micro Lab* kits.)

Electronics Club

My very first *Circuit Surgery* resulted in a letter from ***Mr. H.F. Howard,*** Chairman of the British Amateur Electronics Club, who says that the subject of fuse ratings and testing them has been a lively topic in the *BAEC Newsletter*, which is published quarterly and circulated amongst its members. Incidentally one idea I had regarding the simple fuse tester circuit was to use two adjacent metal "touch pads" (supplied by Maplin, Part. No. HY01B) on the front of the plastic box. Simply bridge the pads with the suspect fuse. I used this idea in my *Continuity Tester* design (*Everyday Electronics* July 1985 for loyal readers!).

If you would like further information about the BAEC, please refer to their advertisement in the "Classified" section at the end of this issue. If there are any other active Electronics Groups out there, especially in schools, *Circuit Surgery* will be delighted to hear from you.

If you have any topical queries or comments, hints or tips, why not drop me a line and I will try to feature it in this column. Regrettably I can't guarantee to reply individually (but I'll try) though I read every letter. Please write to me c/o *Circuit Surgery*, 6 Church Street, Wimborne, Dorset, BH21 1JH.

Happy New Year!

EUROPEAN INTERNATIONAL AUDIO and VIDEO FAIR

BARRY FOX

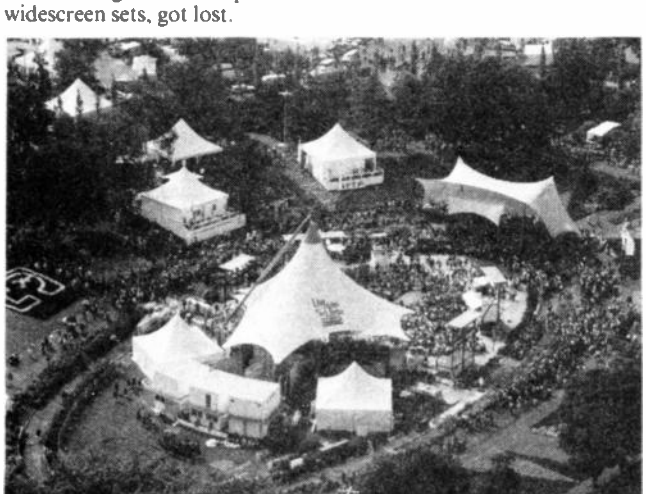
There has been a public Radio Show or Funkausstellung in Berlin since 1924. In 1970 the biennial show was renamed the International Audio and Video Fair and has become the European showcase for new electronics. Last year there were 740 exhibitors from 33 countries spread through some 30 large halls and pavilions.

ARE you going to write your usual piece about the Berlin *Funkausstellung* calling itself an "international" show, but still not living up to the name, someone asked me. I hope not, but I expect so, was all I could say.

And yes. Some things never change. Although the Berlin Radio Show changed its name to the International Audio and Video Fair in 1970, the event still remains a resolutely German show. Grundig, for instance, held a large press conference to tell Europe how the company is "going on the offensive with new products and a new organisation", but talked about its plans only in German.

At least Grundig had some English language literature which is more than can be said of many others. Sharp and Swiss company Swatch, for instance, held press conferences in German only, with only German literature, despite Swatch's plans to launch its wristwatch pager in the UK next year.

The PALplus group provided no translation either, leaving those in the audience who rely on English (Brits, French, Spanish, Italian, Scandinavian etc) wondering what the German speakers were talking about, and leaving some of the German press struggling to understand the points being made by the UK broadcasters. Joked Richard Ellis, of Granada TV, "It falls on me to add the international flavour to this meeting", So much of the good news message, that PALplus transmissions could stimulate sales of widescreen sets, got lost.



The tented "village" at the Berlin Audio and Video Fair.

New TV Systems

IFA 1993 was the first Berlin Show for more than ten years at which high definition television (HDTV) was not being launched. There was virtually no mention of MAC anywhere, and the demonstration of HD-MAC was buried at the end of a small hall devoted to technical specialities.

A sign proclaimed, "Post Olympic Improvements", including improved compatibility between HD-MAC transmission and D2-MAC reception, with "reduction of motion judder etc."

HD-MAC was sold on the promise of compatibility with D2-MAC. It is thus quaintly ironical that only now, after MAC and HD-MAC are dead, the developers admit that they needed to improve on the core issue of compatibility.

Digital TV

The demise of MAC and HD-MAC has left the way clear for digital TV and HDTV. The HD-Divine consortium of Scandinavian broadcasters and electronics companies has now signed a deal with Nokia of Finland. The HD-Divine group has developed a digital HDTV system which will work over terrestrial, satellite or cable networks. Nokia will make the receivers.

The target is to have demonstration receivers available for the 1994 Winter Olympics in Lillehammer, Norway. Even before that,

Inside one of the many exhibition halls.

terrestrial transmissions will be demonstrated at the International Broadcasting Convention to be held in Amsterdam in September 1994.

PALplus

How does this affect the chances of PALplus, people asked? It doesn't, because digital transmissions can only be seen by people who invest in new receivers or decoders. PALpus is compatible with existing PAL receivers; it gives letterbox pictures on existing 4:3 PAL sets and higher quality widescreen pictures on 16:9 sets.

Despite the language barrier created by failure of the PALplus group to provide translation, two messages came clearly across. One is that German broadcasters ARD (public) and ZDF (commercial) are now prepared to start PALplus broadcasting, provided that they can win the subsidy money recently promised by the European Commission. So are satellite broadcasters Pro 7 and Premiere.

In the UK the BBC has no official plans, but Channel 4 has already broadcast programmes in PALplus without telling anyone, to see if there were any objections from viewers. So far there have been none, because no-one has noticed any difference. The picture looks just like a conventional letter-box movie. The analogue helper signal, buried in the top and bottom bars to help future widescreen sets display a clear picture, is – as it should be – invisible on existing 4:3 sets unless the picture brightness is turned up to absurd levels.

The main sticking point now is on how the EC interprets its funding promise. Those who claim a share of the EC subsidy money must match it ECU for ECU, with their own money. Dr. Albert Ziemer, Chairman of the PALplus steering committee believes that the broadcasters may seek money from industry, namely the TV set manufacturers. But the TV set manufacturers must invest money in producing PALplus sets so will not want to give money to the broadcasters as well.

It will cost the broadcaster just 370,000 DM (£150,000) to buy a PALplus encoder. There is then nothing more to pay for using it to transmit widescreen films. By buying decoders now, the broadcasters get half their money back from the EC. This is why ZDF undertook PAlplus "field trials" in November, and Pro 7 at around the same time.

Philips has invested in the development of a PALplus chip set which will be ready in 1995. Nokia will use the Philips chip set, but is building a prototype receiver which relies on microcomputer software processing to emulate the functions which the chips will perform when ready. So far there are only two prototype PALplus receivers, one from Nokia and one from Grundig, both using large cabinets of outboard electronics.

The big news of the PALplus briefing was that the all-European committee has now welcomed Sony on board. Until now the PALplus committee has jealously guarded its secrets, and made them available for European companies only. But Sony is developing its own PALplus chip set and although there is clearly dissension inside the European committee, it has accepted that the only way to get PALplus moving is to throw the technology open to Japanese manufacturers as well as European companies.

Although this will get PALplus moving, it also creates the risk that what began as an all-European initiative will end up as another example of Europe developing the technology, and Far Eastern manufacturers reaping the rewards.

Political highspot of the press conference was the protestation, by Ron Sommer, President and CEO of Sony in Europe, that Sony is a European company. Yes it employs Europeans, but where do the profits go? As with all Japanese ventures in Europe, back to Tokyo.

DCC

There is a growing feeling in the trade that the only thing that will pull Digital Compact Cassette (DCC) through to success is a radical re-think on price. Says Henk Bodt, Head of Philips Consumer Electronics Division: "DCC will always be more expensive. It needs more silicon and more complicated heads. When will the price differential between analogue and digital recorders give people sufficiently good reason to buy digital? We still think this is two years away. In the long run a price differential of between $75 and $100 is achievable."

The DCC partners fear a price pull in 1995 will be too late. By then DCC will have missed the boat. Philips will very soon offer part-exchange on old cassette decks. But this will not please dealers who will have to take back the old gear.

Thomson (French owner of Ferguson) is supposedly a supporter of DCC, but is now rumoured to be backing Mini Disc. Thomson held a press briefing with top man Alain Prestat but the invitation list was carefully tailored to protect him from awkward questions, like "why is Thomson not giving Philips the support it needs" and "why did Thomson buy Ferguson if all it wanted to do was shut Ferguson's factories"?

JVC is hedging bets, and will start manufacturing its own record/playback Mini Disc portable this year and its own DCC deck next year. JVC already presses Mini Discs, at its CD pressing plant in Japan. Hiroki Shimizu, General Manager of JVC's audio division admits "Sales in Japan are still very small".

Says Shimizu "Mini Disc could be very good for dictation recording or conference recording where you want fast access. It could also be good as a ROM carrier for games, where you do not need the full data capacity of a 5in. CD-ROM".

BASF, is hedging bets too. The German company has invested heavily in the production of DCC tape, and is now getting very worried about slow sales of DCC hardware, and correspondingly small demand for tape. Significantly BASF took a bow at Sony's MD press conference, as a new supplier of MD blanks.

At Panasonic's press conference, the company reaffirmed commitment to DCC, but then cleared the room of journalists, and sent the remainder to sleep, by launching into an extraordinarily boring description of the "virtual battery operation" of Technics amplifiers. DCC seemed very low on Panasonic's priority list.

Philips will not give numbers for DCC sales until after a year of sales. "Until then they do not mean anything", says Henk Bodt.

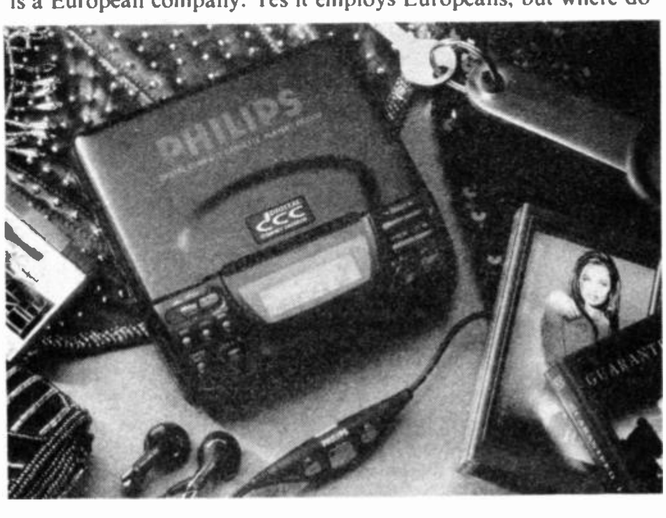
Mini Disc

"Mini Disc is well on the way to becoming a world standard", said a panel of top brass including Norio Ohga, Sony's President, Michael Schulhof, Head of Sony Music, Ron Sommer, head of Sony's operation in Europe plus Toshikazu Mitsuda, Executive Director of Sharp.

"In 1993 worldwide shipments of Mini Disc hardware have been 300,000 units, with 100,000 into Europe" they said. "Sony has produced 3 million discs, a million of them going to Europe....hardware sales will reach 10 million by the end of 1995". But Ohga ducked the question of how many of the players "shipped" have actually been sold for cash to customers.

"The real future of tape is definitely a disc" said Sommer.

Michael Schulhof then screened a lengthy selection of video music clips. The projected pictures were predictably poor, and the over-loud sound was riddled with distortion.



Philips DCC130 Digital Compact Cassette personal stereo.

The Sharp MD-D10 Mini Disc player.

Exclaimed Schulhof "You have just witnessed an amazing example of the power of technology ... digital quality sound ... the optical disc experience".

In fact, as Sony then had to admit, what Schulhof thought was "digital quality sound" and "the optical disc experience", was in fact the analogue sound you get from the Betacam SP video tape.

CDI/Video CD

Sega and Nintendo dominate the games market. The more advanced multimedia market is now shaking down to a straight fight between CD-I, developed by Philips and supposedly backed by Panasonic, and 3DO, developed in California and most definitely backed by Panasonic. CD-I is already on sale and 3DO is promised for sale this winter.

The two systems are wholly incompatible, although both players will play CD audio discs, CD+G discs that have simple graphics buried in the audio sub-codes, and Photo CDs.

There is now a digital video compression standard, MPEG-1, for putting 74 minutes of Full Motion Video on a CD. Philips will start selling a plug-in MPEG adaptor which lets a CD-I player play CD-I/FMV discs. 3DO promises a similar adaptor, for 3DO/FMV discs.

Philips, Panasonic, Sony and JVC recently agreed a new "White Book" standard for Video CD, or Digital Video CD. This is a CD with MPEG FMV, but without the control codes which a CD-I player uses to provide full interactivity. Video CD is "linear" format, like a video tape. You play it and watch it from start to finish.

Video CD follows the CD-ROM XA "Bridge" standard, like a Photo CD. This lets it play on a Personal Computer with CD-ROM drive and FMV decoder, a CD-I player with FMV decoder, or a new generation of Video CD player which is broadly similar to an audio CD player but has a built-in FMV decoder.

Because the Video CD is a ROM XA disc, it has a Yellow Book data flag in the bit stream. This flag will (or should) mute all the outputs of a CD audio player, to prevent speaker damage. This kills the idea of making Video CDs play on a conventional audio CD player, of the type which has a digital output, connected to an add-on decoder.

Nimbus has suggested that the problem can be solved, very simply, by making the Video CD follow the Red Book i.e. not have a data flag. But this would stop the Video CD playing on a CD-I player, or ROM drive, because both these are designed to treat any Red Book disc as a music disc. They will try and decode the FMV data as audio, and fail.

Also the White Book now specifies control codes for VCR functions, like fast search and freeze frame. So the decoder must feed control signals back to the player drive. There is no input for these control signals on any existing CD audio player.

Confusion

Even before Berlin there was massive confusion over this scenario. And it all stems from the clumsy wording of a joint statement put out in late June by Philips, JVC, Sony and Matsushita (parent of Panasonic). This statement on the White Book promised playback of Video CDs on "modified CD players (with a digital data output) with an add-on Video-CD box".

What they meant to say was that there will be a future generation of CD audio players, built slightly differently to play either Red Book audio CDs or Yellow Book Video CDs, when connected by digital output to a Video decoder. But what people undestood them to say was that Video CDs will play on existing Red Book audio CD players which already have a digital audio output, connected to an external video decoder.

Just as we thought everything would be clarified by statements at the giant Berlin *International Audio and Video Fair*, the same four companies put out another statement which made things even worse by repeating the error, this time without even the qualifying word "modified".

"Video CD discs can be played on ... CD players (with a digital data output) with an add-on Video CD adaptor".

Press briefings held in Berlin both by Panasonic and Philips merely compounded the confusion.

After puffing 3DO with video clips of promised software, a panel of top brass chaired by Panasonic's Managing Director in Europe, Yoshihide Tsujimoto answered questions. "Yes" they said "you can use CD-I discs on a 3DO player". "Yes" they said again when asked to confirm that all four Panasonic executives really did think a CD-I disc would play on a 3DO player.

It won't, of course, unless 3DO takes a CD-I licence, which would create a new format, 3D-I, and that seems pretty unlikely.

All four Panasonic executives then collapsed into a heap of confusion when asked to explain how a CD audio player could play a Video CD with muting data flag. No-one present had any technical understanding of the issues involved. Two days later I got an answer from an engineer. "We were talking about future players, that are modifed".

By then Philips had held its own press conference, like Panasonic with no-one on hand to answer technical questions. John Hawkins failed to volunteer the promised clarification. He answered questions with the clear confirmation that the FMV movie discs due this winter from Philips (with Paramount titles) will be on CD-I format discs, not linear Video CDs. But then he got into a muddle over questions about Video CDs playing on audio players.

All it needed, both at the Panasonic and Philips conferences, was one engineer on hand to answer technical questions. Both companies employ engineers who could have done the job. But the executives thought they could manage without them. They couldn't.

The facts of the matter, which the four largest electronics companies in the world seem incapable of drawing, is this:

There will be at least two types of FMV CD. One will be a CD-I/FMV disc which plays back on CD-I players, when equipped with an FMV decoder. These discs will not play on another player.

The other version will be a White Book linear Digital Video CD. This will play on CD-I players with FMV adaptors, on personal computers with CD-ROM drives and FMV adaptors, and on a new generation of Linear Video CD player which are designed to work either with Red Book audio CDs or White Book Video CDs. These discs may play on a 3DO player, but no-one will know until 3DO delivers a player with FMV label.

Flat screen TV

While most Japanese elctronics companies pin their faith for future flat screen TVs on liquid crystal technology, Matsushita has been developing a flat version of the traditional cathode ray tube, called Beam Matrix.

Matsushita first showed a prototype BM screen at the *Tsukuba Expo* in Japan in 1985, and at Berlin showed a new TV set with 36cm BM screen, just 10cm thick. This Flat Vision set will go on sale in Japan next month under the Panasonic brand.

In a conventional cathode ray tube, an electron gun produces an electron beam which is scanned across the screen surface by magnetic coils. A BM tube is a sandwich of plates. A rear plate

The Virtual Vision "Sport glasses" are claimed to allow the wearer to view their favourite TV programme while carrying out other work.

carries strip cathodes which produce electrons. A perforated control plate is electrostatically charged to focus these electrons into pencil beams. The beams then pass first through a modulating plate, which varies their strength, and then through horizontal and vertical deflection electrodes, which move the beams sideways and up and down.

At the front of the sandwich there is a phosphor-coated screen plate, which is divided into 10,000 small rectangular sections. Each section is scanned by its own beam, so each section thus forms a small part of the picture. The trick is to get all the small parts of the picture to combine, and provide a full TV picture, without any seams or joins showing.

Although Matushita has made BM technology work, people who want flat TV sets will have to pay for the priviledge. Flat Vision sets will cost 288,000 yen (nearly £1500). Matsushita is only making a thousand a month.

Voice Control

With so much confusion over technical issues it was entirely predictable that the popular press would latched onto Philips' new easy-to-understand infra red remote control for TV sets and VCRs. It looks like a conventional unit but incorporates a micrphone and speech recognition circuitry. On purchase the owner switches to learning mode and speaks words into the microphone which correspond to a list of basic commands, like "On", "Off","BBC-1", "ITV", "Play" and "Record". The words can be different from the commands, and in any language, for instance "Wake up" for "On" or "Shut up" for "Off".

The remote control has four memories, for four voices, so each member of a family can use the same control, but only one can talk to it at a time. Although mainly a gimmick, the remote could be very useful to people who are physically handicapped, for instance with arthritis.

The Philips voice recognition remote control will accept up to four voices.

Goggle Box

US company Virtual Vision of Redmond, Washington says it will start selling its "Sport" TV spectacles in Europe by the end of this year, for around £750. The aim is to let someone watch TV while doing something else.

The viewer wears a pair of dark spectacles, like large sunglasses, which connect to a battery-powered belt pack. The pack feeds a video signal, from a TV tuner, VCR or camcorder, to a small colour l.c.d. screen which is mounted inside the top of the spectacles frame. A prism and lens reflects the image from the l.c.d. and superimposes it on the wearer's natural field of vision. So the wearer sees a TV picture apparently hanging in space. Although the picture is clear, and its position can be adjusted, the effect is likely to be fatiguing.

Shocker

An innocent-looking little gadget, tucked away in a corner of the exhibition hall, could prove very dangerous in the wrong hands.

The Z-Force Power Elektro Shocker looks like a battery-powered shaver, but with two metal prongs on the front. These connect with circuitry inside which steps up the low voltage delivered by 9V radio batteries, to 80,000, 120,000 or 175,000 volts. Squeezing a trigger delivers the high voltage through the electrodes in pulses lasting between 0·25 to 5 seconds, which the German exhibitor assured will "go through clothing, even leather".

Although the current flow is small, the shock effect of such high voltages is debilitating, much worse than grasping the leads which run from a car ingition coil to the sparking plugs. These usually carry only 25,000 volts but inflict a very unpleasant shock.

Ostensibly intended for self-defence, the Elektro Shocker could equally well be used for offence. Dealers can buy them for a trade price of between 80 and 100 DM (under £40).

The Home Office says the device would be classed as a "probibited weapon" under the Firearms Acts, and that anyone trying to import them would risk prosecution.

Power Saver

Perhaps the most important innovation at the Berlin IFA show was also the simplest, and most widely overlooked.

All modern TV sets now have a remote control. The set sits, on average, twenty hours a day, waiting for an infra-red pulse to bring it to life. While on standby the set consumes up to 10 watts of mains power, which it wastes as heat.

The power is wasted in the primary coil of the mains transformer which powers all the circuitry in the TV. Although this transformer is only delivering a small amount of power to the infra-red sensor when the set is in standby mode, all transformers are inefficient and waste power when connected to the mains.

Power is also wasted in the set's de-gaussing coil. This is only occasionally used to remove residual magnetism from metalwork of the set, which would distort the electron beam in the picture tube and sour the picture colours. But the coil is powered even in standby.

Nokia of Finland has thought laterally and redesigned the infra-red sensor. A simple circuit, ahead of the transformer and degaussing coil, has only one function. It senses any incoming infrared pulse and switches a semiconductor to allow power through to the mains coils. This sensor draws only 0·1W from the mains. So power waste in standby mode is reduced by a factor of a hundred.

Says Dr Helmut Stein, Vice-President in charge of Research and Development at Nokia. "Multiply 10 watts by the number of TV sets in a country and you realise how much energy is being wasted as heat".

In the UK there are around 20 million homes with at least one TV set, which equates to a standby power drain of 200 megawatts, 20 hours a day. With Nokia's design this could be reduced to two megawatts.

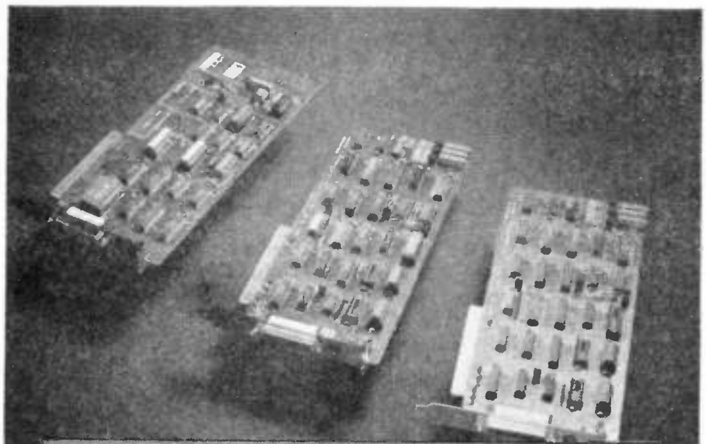
Power Loser

Swiss company Swatch plans to launch is Beepup wristwatch pager in the UK, this year. Swatch is already selling Beepup in Los Angeles, Dallas and Atlanta, and in Switzerland, Italy and Germany. The company needs to strike a deal with an existing paging service, is talking with British Telecom, Mercury and Hutchison, but currently favours Hutchison.

Beepup looks like a rather large wristwatch and costs around £100 (plus the similar cost per year of subscribing to a paging service). It beeps when receiving a message, and displays up to 15 digits on a small display, signifying a telephone number to be called. Swatch says people can use it to stay in touch at all times, whatever they are doing, even surfing.

Beepup runs on expendible lithium button cells. When the pager is left switched on, waiting for a signal, the battery goes flat within 18 days. Acknowledging the need to have a spare battery always available, Swatch makes room for one in the wristwatch strap. But the battery is secured in the waterproof shell by a plate and four very tiny screws. These can only be removed with a matching, precision screwdriver, for which there is no mount in the strap. So the user must remember always to carry a matching screwdriver, and hope not to lose or damage the tiny screws when removing them every 18 days.

Anyone who has ever fiddled with precision screw fittings will know that this will be a vain hope. If any one thing in this world is certain, it is that small screws want nothing more from life than to leap off as soon as they are freed and get lost in a deep carpet, patch of grass or dirt, or nearest drain. □



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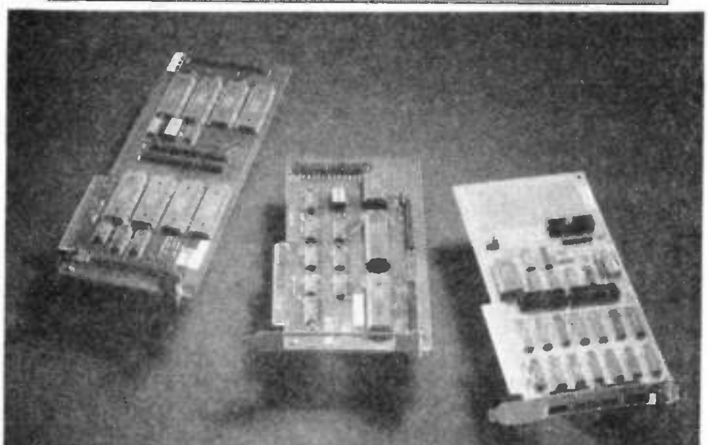

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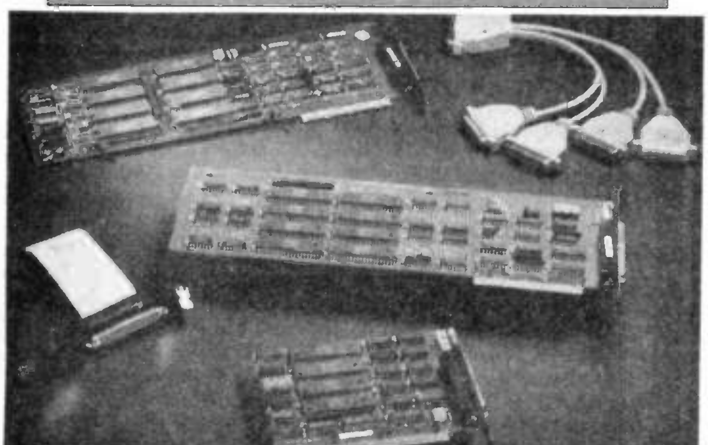

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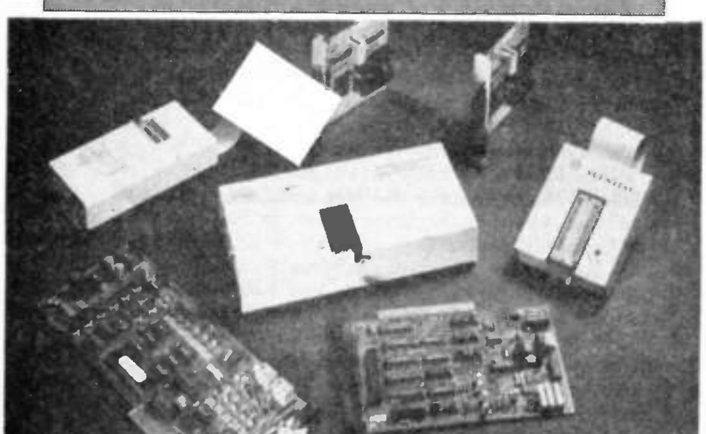

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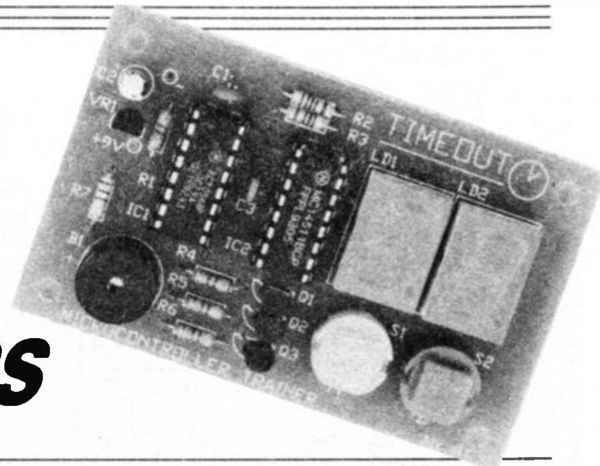
Constructional Project

TIMEOUT

INTRODUCTION TO MICROCONTROLLERS



PETER CROWCROFT

Timeout will count down from 60 seconds or 90 seconds, bleep every ten seconds and every second of the final ten seconds, but more importantly it will introduce you to the world of microcontrollers.

A QUIET revolution is taking place in electronics today. It is almost as important as the replacement of valves by transistors and i.c.s in the 60's and 70's. This is the rise of the microcontroller. Their increasing power and versatility at steadily decreasing prices is now such that many of the simplest logic i.c. circuits may now be better designed using them.

Microntrollers are a computer on a single chip – a central processing unit plus memory, clock, input/output plus some sort of peripheral device (for example, a timer, AD/DA, communication ports.) Nowadays these devices are to be found all around us. To name a few applications; washing machines, microwave ovens, mobile phones, bar code readers, printers, video casette players, photocopiers and, most importantly, motor cars – engine fuel management, braking systems, active suspension, multiplexed wiring, mirror and window movement.

In all cases the application program inside the microcontroller is not accessible to the hobbyist and therefore of little use. Even if it was the tools to develop programs for these devices are expensive – typically over £500. Also learning the programming language has not been easy.

It has generally been true that to learn to program a microntroller attendance at a technical college or some similar formal teaching institution has been required. To try to teach yourself the older devices such as the 8748 or 8051 family from a data book was not easy.

TIMES HAVE CHANGED

This situation has changed in the last year or two. Microcontrollers and the tools to develop them and program code for them have now reached a level the amateur can afford and understand. Two chips have led the way. They are the PIC series from Microchip and the K series chips from Motorola.

The PIC chips have been out longer but the development tools to use them are relatively expensive (though they are coming down in price) and the instruction set is a bit strange. We will not discuss them further here. (Small Controllers from other manufacturers also suffer from the problem of high cost of tools for code development and programming, even higher than the PIC series.)

The beauty of using the K1 Motorola range of microcontrollers is that the full range of development tools needed by the amateur to develop applications are readily available at low cost, say under £150. The programs (called assemblers) to develop code for the chips on a PC are freeware and are available from Motorola and its distributors. The hardware schematic for the programmer is published in the Motorola Data Book and the software to use the programmer is also freeware.

A low-cost in-circuit simulator, which also acts as as programmer, is also available with software and the chip comes in various packages including the EPROM version. A truly excellent manual *Understanding Small Microcontrollers* which introduces the K series of microcontrollers from basic principles is also available.

With this project we have tried to do two things:

Firstly, bring you face to face with a modern microcontroller, and show you that it is now possible for anyone to learn to program them.

Secondly, to demonstrate how a microcontroller can replace circuits built out of traditional logic i.c.s with simpler and far more versatile circuits.

We have attempted to make this article as easy as possible for beginners to understand. We gave first drafts of it to computer literate people who had no experience with microcontrollers and noted their questions and areas of difficulty. We have added increased explanation in those areas. It is intended that this be read together with the Technical Data manual for the K1 and the "Understanding" book.

The unit is constructed on a single-sided printed circuit board. Software was developed in part using a Motorola 68HC705K1 ICS (in-circuit simulator). There is no copyright what-so-ever on the Printed Circuit artwork, program code or documentation. We encourage you to copy, learn from and add to the annotated software code. The project is available in kit form but individual components including the programmed K1 and the p.c.b. are available separately.

TIMEOUT

Timeout is a down-counter. The circuit for it is shown in Fig. 1. It is preset to start from 60 or 90 seconds. Press any button to wake it up. There is no off/on switch. Press B to start the countdown; during count down pressing B will pause the count. Pressing it a second time will restart the count down. Pressing A will toggle the initial count setting between 60 and 90 seconds.

During the count down the buzzer will beep every 10 seconds. It will beep every second for the final 10 seconds and give a long beep when zero is reached. If another count down is not started within a minute the unit will power-down and turn off.

As described so far this counter could be constructed using logic i.c.s. The component count would be higher (especially all the current limiting resistors on the displays) and the area needed on a p.c.b. would be greater but it could be done. However, using the microcontroller opens up a versatility not possible with straight logic components.

Suppose you wanted a counter to start at 68 seconds, beep every 8 seconds then give a different beep for the last 4 seconds, then restart automatically to 68 seconds again. Try to do that using logic i.c.s! With Timeout it is a simple matter of minor changes to the software program.

This single example should be sufficient to demonstrate the enormous advantages that microcontrollers have to offer over straight logic.

CIRCUIT DESCRIPTION

The heart of the circuit is the K1 microcontroller and the software it contains (Fig. 1 IC1). The other components are the power supply, external passive components for the oscillator and I/O components to get information into and out of the microntroller. The K1 is a low-end version of the Motorola 68HC05 8-bit controller. Its 16-pin d.i.p. is the smallest pin package for any 8-bit

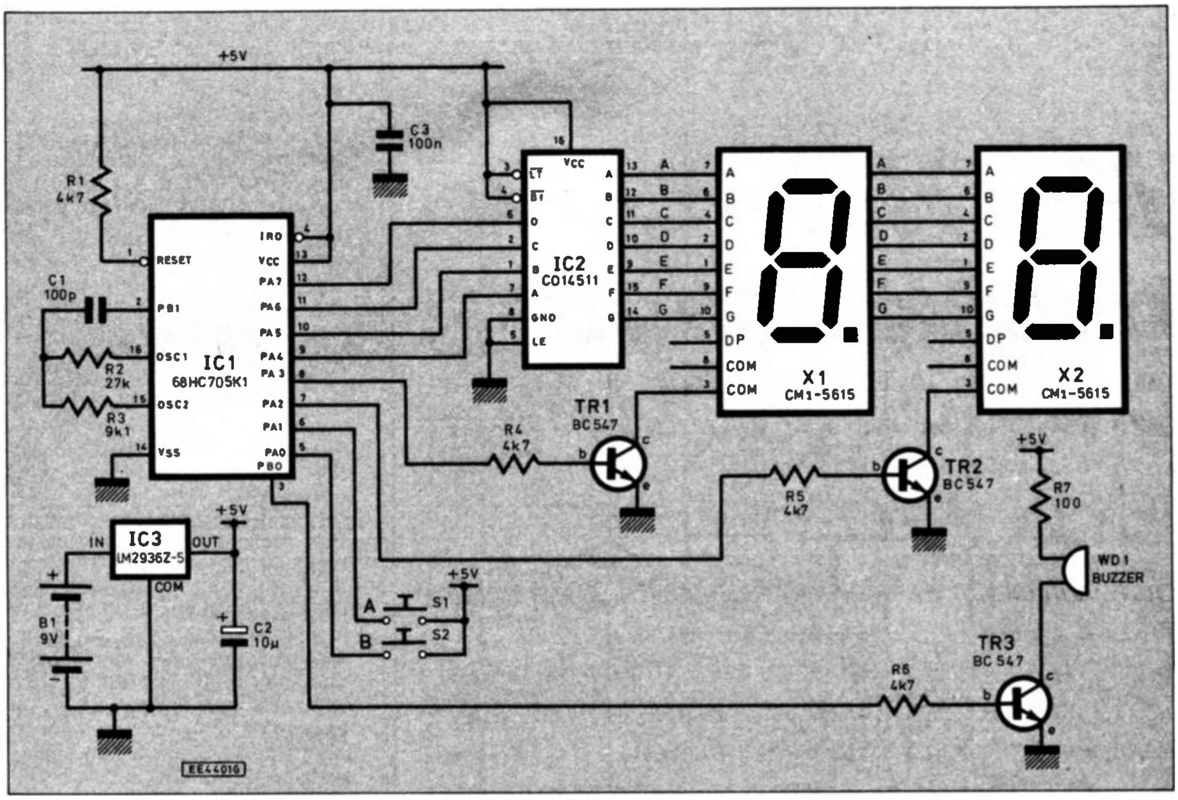


Fig. 1. Complete circuit diagram of Timeout. IC1 is the microcontroller.

microcontroller. We will not spend time describing it in depth here – please see the MC68HC705K1 Technical Data manual.

The LM2936 (IC3) from National Semiconductor is an ultra-low quiescent current 5V regulator which is used to provide power to the circuit. There is no hardware off/on switch as the current drain from the battery, both when it is operating and when it is in STOP mode, is so low – approximately 25 micro-amps when the K1 is in STOP mode and 19 milli-amps when it is running. The off/on switch is in software.

The 15 bit multi-function timer inside the microcontroller is used to do the one second counting. The frequency of operation is then 262.144Hz. The three pin oscillator using R2, R3 and C1 was chosen as the simplest option for the project. If more exact timing is required then a crystal oscillator can be used with appropriate software changes.

The K1 controls the display through port A. PA4 to PA7 present BCD code to IC2 which decodes it into seven segment representation. Pins PA3 and PA2 control TR1 and TR2 respectively which determine which display is turned on.

The two pushbutton switches, S1 and S2, are connected to PA0 and PA1. They use the programmable pulldown resistors built into the K1 to eliminate the need for external pulldown resistors on each switch. Also these pins will bring the K1 out of the low power STOP mode. This facility eliminates the need for an off/on switch.

SOFTWARE DESCRIPTION

Print out the *timeout.lst* program contained on the floppy disk supplied with the kit. This is a combined listing of the software code, mnemonics used to write the code, a line number for reference and, most important, a lot of comments to explain what is happening. Also print out *k1def.lst*.

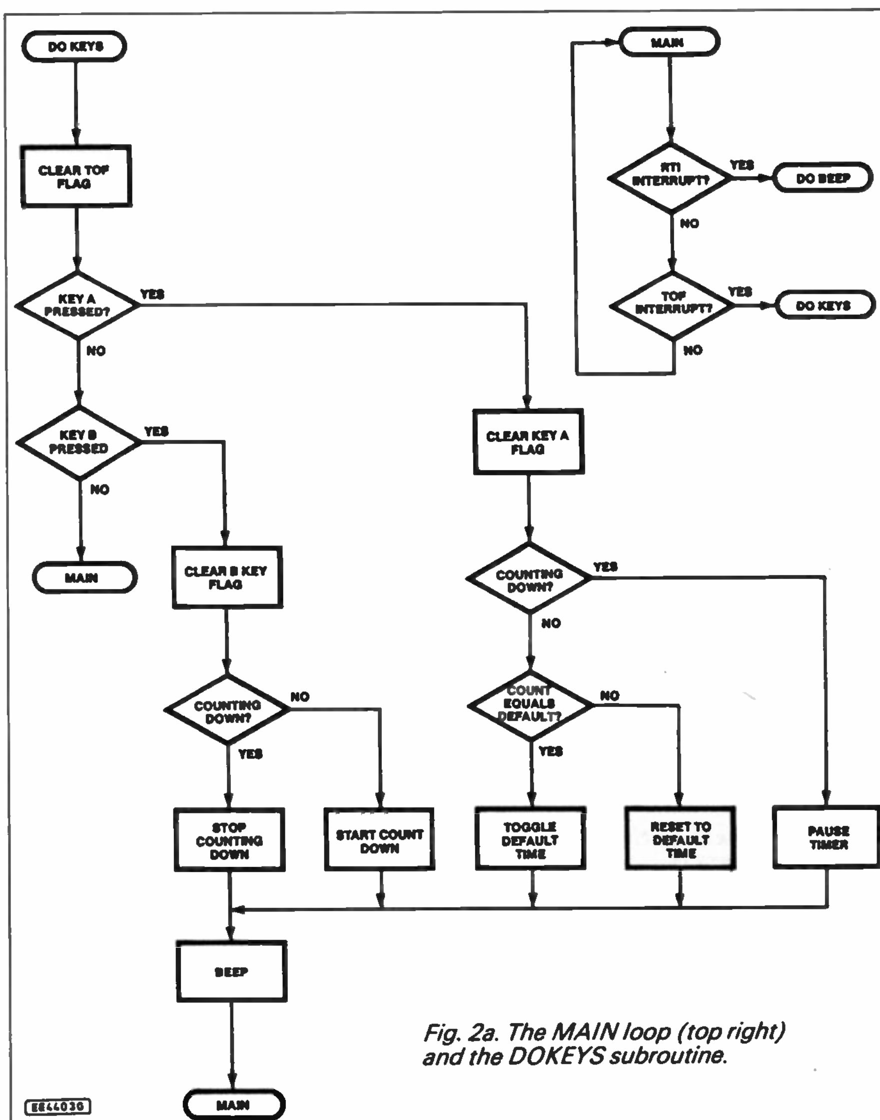
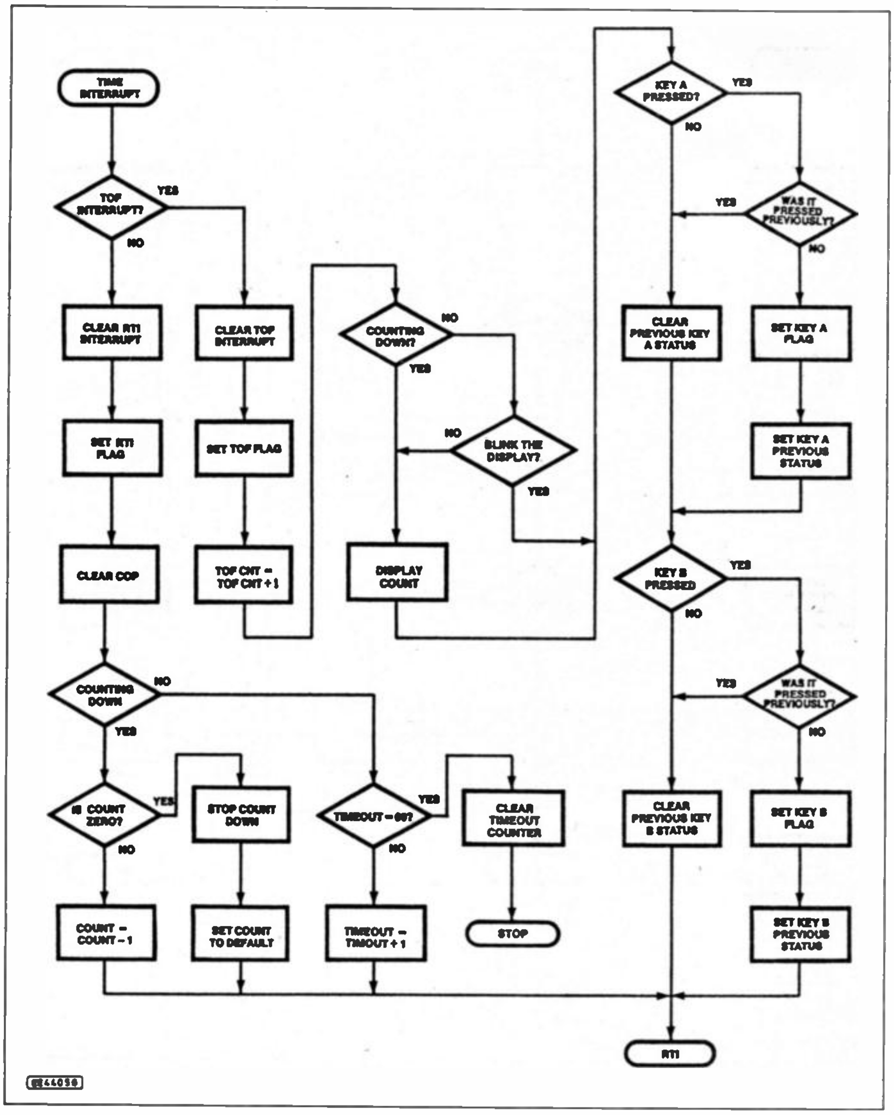


Fig. 2a. The MAIN loop (top right) and the DOKEYS subroutine.



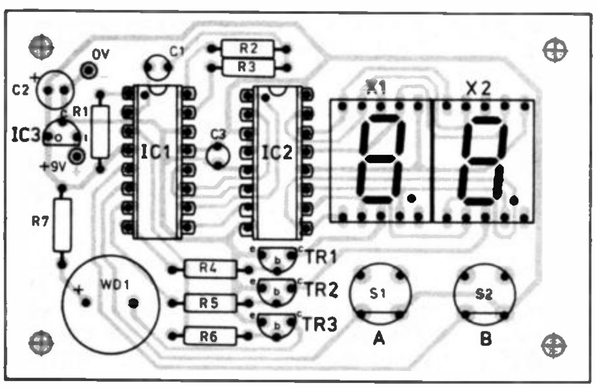
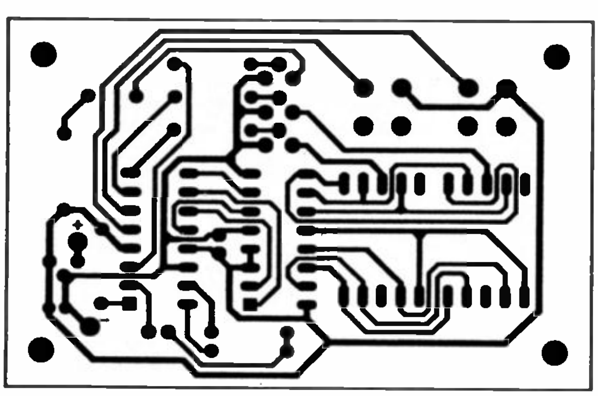
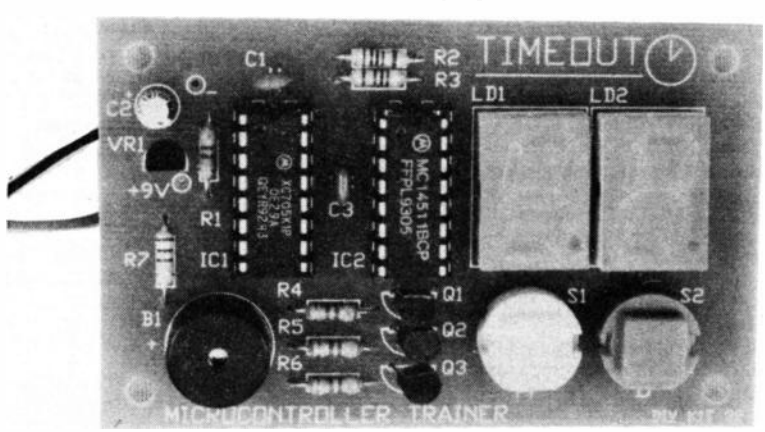


Fig. 2b (above). The TIMER interrupt subroutine.

Fig. 3. (left). Full size p.c.b. layout and master for Timeout.





This is the header file. Flowcharts to the code are shown in Fig. 2a, b and c.

See the Learning Code section on the next page if you have not studied any assembly language code before.

The software may be divided into six sections. These are summarized in the six flowcharts. They are:

What happens when the battery is first connected to the circuit.
What happens when a key is pressed and the unit is woken up.
The MAIN loop where the most of the time is spent when Timeout is working.
The DOBEEP subroutine.
The DOKEYS subroutine.
The TIMER interrupt routine.

The microcontroller sits in a powered down state drawing just a few micro-amps until either key is pressed. There is no off/on switch. The timer is based around the multi-function timer in the K1. The Real Time Interrupt (RTI) generates an interrupt every second. The Timer Overflow (TOF) interrupt generates an interrupt every 7.8 milliseconds.

RTI is used to decrement the count and stop the timer when zero is reached. It is also used to enter STOP mode when the counter has not been counting down for 60 seconds.

TOF is used to scan the displays and check the pushbuttons. The register TOFCNT counts the number of TOF interrupts. This register is equivalent to the most significant bits of the multifunction timer which are not accessible to the programmer except as sources of RTI interrupts. Bit 5 of this register is used to blink the display twice a second if the timer is not counting down. If the timer is counting down then the display is scanned every TOF interrupt.

The TOF interrupt checks the status of the keys by detecting a rising edge on PA0 and PA1. It compares the current status of the keys to what they were last time the TOF interrupt was serviced. If the status is the same then there has not been a keypress. However, if a key is now HIGH when it was previously LOW then a keypress (the rising edge of a keystroke) will be recognised.

Every time the hardware detects an interrupt the program counter is loaded with the address where the TIMER interrupt routine is located. This is $03F8. TIMER sets a keyflag in 'flags' (depending on which interrupt was generated – RTIFLG or TOFFLG). "Flags" is our own creation. (We could have called it "Fred". It is just a byte we created in RAM to store the 7 bits which we define it to contain. Then we give it a name we will remember.) It contains information needed to run the program. When the program returns to the MAIN loop from servicing the interrupt it immediately finds that a flag has been set and it branches to the subroutine indicated – either DOBEEP or DOKEYS.

DOBEEP handles the timing beeps. The three types of timing beeps are:

When the counter reaches zero.
When the count is less than ten.
Every multiple of ten seconds.

DOKEYS checks if any key flags have been set. There are two functions for each key, one when the unit is counting down and the other when it is not.

Key A (S1): If counting down stop counting and reset to default count down time. If not counting down toggle the default time.

Key B (S2): If counting down pause. If not counting down, resume counting.

Sixty seconds after the count down or being paused the K1 goes to a powered down state.

Do not confuse flags with interrupts. Some of the routines in TIMER could have been put in DOKEYS or DOBEEP. And, alternatively, some of the routines in DOKEYS or DOBEEP could have been put in the interrupt routine. The choice is determined by the programmer and where a particular routine is best suited. What is important here is that both methods have been demonstrated.

It is difficult to remember binary bit patterns and hexadecimal addresses when you write code. It is far easier to remember mnemonic names for register addresses and bit positions. Using these names also makes the program easier to read. K1def consists entirely of EQUate directives. These associate a label with a binary number or address. Note that this is a

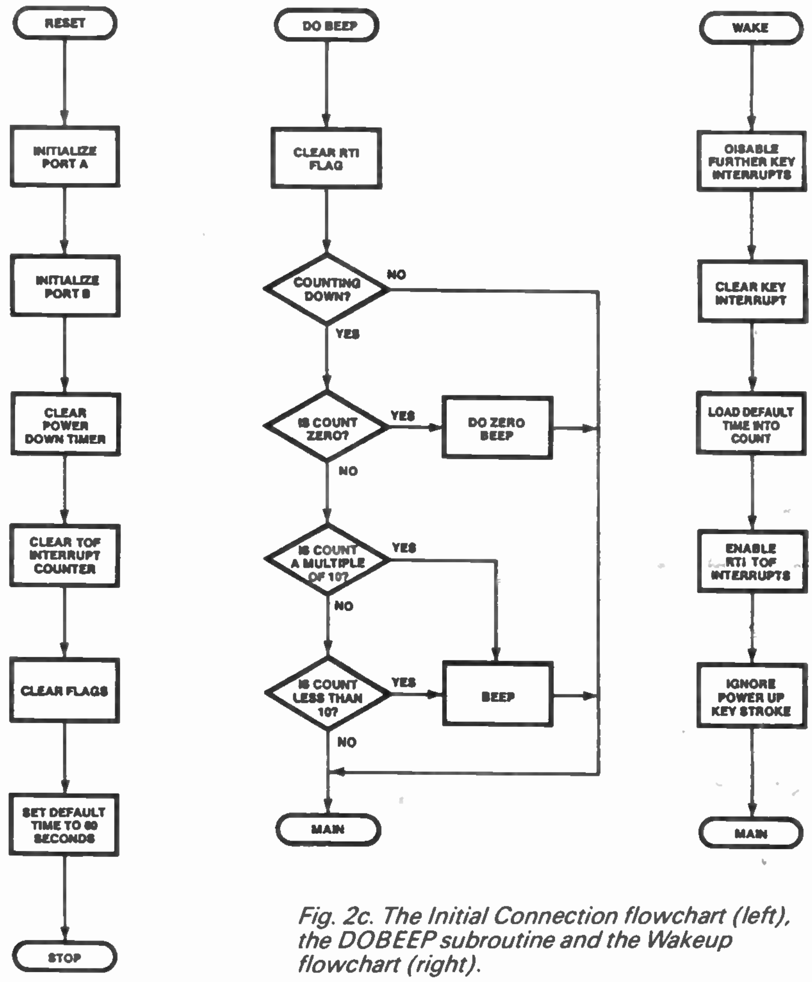


Fig. 2c. The Initial Connection flowchart (left), the DOBEEP subroutine and the Wakeup flowchart (right).

COMPONENTS

Resistors

R1	4k7
R2	27k ¼W metal film ± 1%
R3	9k1 ¼W metal film ± 1%
R4 to R6	4k7 (3 off)
R7	100

All ¼W carbon film ± 5% except where stated.

Capacitors

C1	100p ceramic
C2	10µ elect. 10V
C3	100n ceramic

See SHOP TALK Page

Semiconductors

TR1 to TR3	BC547 *npn* transistor (3 off)
IC1	68HC705K1 programmed microncontroller – see *Shop Talk*
IC2	CD14511 seven segment display driver
IC3	LM2936Z-5 5V regulator
X1, X2	CM1-5615 seven segment display (2 off)

Miscellaneous

WD1	Miniature d.c. operated 5V buzzer
S1, S2	p.c.b. mounting push switch single pole, push to make (2 off)

9V battery and battery clip; plastic box approx 82mm x 53mm x 28mm; p.c.b. – see *Shop Talk;* software on disc; 16-pin d.i.l. socket (2 off).

Approx cost guidance only **£38**

general purpose header file. Not all labels defined are used in Timeout. You may use K1def when you write your own K1 programs.

Note that K1def.asm is called by timeout.asm using the *$include* directive when timeout is assembled.

CONSTRUCTION

The complete unit is housed on one small printed circuit board (p.c.b.) as shown in Fig. 3. Commence construction by fitting the smallest components first and working up to the displays, i.e. sockets switches and sounder. Take care when fitting the buzzer, C2, TR1, TR2, TR3 and the i.c.s, make sure that they are correctly oriented. The displays must have the decimal point in the bottom right hand corner.

The microcontroller for this project is the one time programmable version (OTP) of the 68HC705K1 which has been programmed with the Timeout software. There is no window in this chip and the program cannot be erased. An EPROM version can be used but this is more expensive.

The p.c.b. can be mounted in place of the lid of a small plastic box. The display and switches (together with the other components) are then displayed. The battery leads should be soldered to the back of the p.c.b. so that the battery is housed inside the box.

Poor soldering is the most likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the p.c.b., especially the two i.c.s, electrolytic capacitors, and the two displays. If you have an oscilloscope check the oscillator. Also check that the 5V/9V supply is going to the correct places.

LEARNING CODE

The main purpose of this project is to introduce you to a microcontroller and how to program it. You will need the following items to learn the programming code:

Printout of *timeout.lst* and *k1def.lst*
The six flowcharts of Timeout

Try to buy the K1 KICS kit from Motorola or their distributors. This was an introductory offer in 1993. It is excellent value for money. It contains the Technical Manual, an excellent book *Understanding Small Microcontrollers* specifically with reference to the K1, plus an in-circuit simulator and all the software to go with it.

If you cannot buy the KICS kit then buy the K1 in-circuit simulator, K1 assembler to use on a PC and get a copy of the *MC68HC705K1 Technical Data* manual.

Try to buy the "Understanding" book.

Make sure you get an EPROM version of the K1.

Try to buy another slightly more advanced book from Motorola, *M68HC05 Microcontroller Applications Guide*. This also has a lot of general discussion and microcontroller explanation in it.

You will need a quiet space to work, good light and a few uninterrupted hours.

We have found that the following practical considerations apply to learning microcontroller code:

You are not going to learn everything in one or even ten sittings. You will soon find code fragments you do not understand. Looking in the manual may not help. However we can assure you that the answers to most things are, in fact, in the book – it is just that they are cryptic or may not be "obvious". (This is why the "Understanding" book is so good. Compare it with the Technical Manual on the discussion of the Multifunction Timer, for example.) Make a list of your problems and then move on.

Try to get someone to help you. Note that some programmers are most reluctant to share their knowledge with beginners. (They learnt their knowledge the hard way and tend to be very jealous of it.) Our advice is to forget these people. Try to find someone who knows where you are at and will anticipate your problems before you know them yourself.

There are many ways to do the same thing in software. When milliseconds are not important any way to get the job done is OK. However, at the same time think about the logic of what you are trying to do. Clear logical thinking in your early programs will lead to simpler code in your later work.

Start to write and practice immediately. The simplest way to start is to write your code on a PC, assemble it using an assembler program available for free from Motorola, program a EPROM K1, put it into the target hardware and run it. Then when a mistake is found, erase the K1 and repeat the cycle.

There are software and hardware tools to help you in code development. We think that software simulators which run as a program on a PC are probably a waste of time and effort. They are tedious to use, can only find gross errors and cannot deal with the main functions of microcontroller which are timing and I/O. The in-circuit simulator like the KICS allows some debugging and is less tedious to use. Break your program down into small individual routines and use the simulator to verify their correct operation. Thus build up the total program in small steps. Then program a EPROM K1 for final testing.

Best, but most expensive to use, is the full, real-time emulator. Get practice and advice on all methods.

FURTHER READING

There are a whole range of microcontrollers available from Motorola with increasing memory and different peripherals on them suited for different jobs. Do not be put off by the size of the list. Only a few of them are suitable for the beginner. (The rest are for mass production use.) The ones you need have a "7" in them. These are the microntrollers with EPROM – P3, C4, C8.

As with the K1, the programming tools to use these devices are low cost and readily available compared to other microcontroller families. Each of these device has a Manual, Technical Manual or Data Book.

FOX REPORT

by Barry Fox

New Dimension?

"Stunning 3D" promised the BBC for its week of "New Dimension" progammes at the beginning of December. The BBC was planning to celebrate thirty years of *Doctor Who* with two new episodes shot in a way which gives an illusion of depth to viewers who pay 99p for a pair of coloured spectacles. The BBC also had 3D versions of several other programmes (including *Children in Need, Blue Peter* and *Top of the Pops*) lined up for transmission using the same technology.

Most important, the BBC promised that viewers without the special spectacles would see "a normal television picture".

This promise brought back memories of 1982, when TVS, the TV station then serving Southern England, promised full colour TV in 3D from a new and highly secret process. The secret system turned out to be yet another variation on the age-old anaglyph theme, with left and right eye images overlapping on screen and colour fringing to distiguish them.

Viewers with the special spectacles, which put a red filter over one eye and a blue filter over the other, got an illusion of depth and a degree of colour. But the millions of other viewers who watched the cowboy feature film *Fort Ti*, which TVS broadcast at peak hours, saw drunken double images. They jammed the switchboards of both TVS and the Independent Broadcasting Authority with complaints and all broadcasters have been very wary of 3D ever since.

Moving Depth

What the BBC did not say was that the effect of depth would only be seen on moving objects, or in scenes where the camera is moving. So viewers without spectacles may well have been left wondering why there was so much motion on the screen. Although the BBC's programmes were to be marked with a 3D logo, viewers can still see similar effects if they wear the same spectacles to watch any programme in which there is motion. Viewers can make their own spectacles too, although with the BBC promising that the *Children in Need* fund would get 25p from every pair sold, it seems a pity to do so.

By now the BBC's week will have come and gone, and viewers will have had a chance to judge the effect for themeselves. Good or bad I will bet that a lot of viewers were left wondering how the sytem worked. The publicity material put out was vague, bordering on gibberish, so the national press had little hope of explaining it.

Nuoptix

The system used is called Nuoptix. Although described as patented, it relies on the old and well-known optical phenonemon, called the Pulfrich effect. If both eyes see the same 2D view, but one eye is given a dimmer image than the other, moving objects will stand out a little. This is because the brain takes longer to process the dimmer image and thus registers diffferent perspectives of a moving object for each eye.

The effect can be seen by putting a neutral filter, like a sunglass lens, over one eye only and watching TV. A particularly dramatic effect is seen if the aerial to the TV set is disconencted, so that the screen displays only a swirling mass of white snow "noise". Anyone wearing a dimming filter over one eye will see the swirl appear in 3D.

For Nuoptix to work with ordinary TV programmes, there must be relative movement beween the camera, scene and actors. The camera can move in an arc or circle round the actors or track alongside them. Or it can pan and turn on its own axis. Alternatively the actors can keep moving backwards and forwards in front of the camera. Or the image can be manipulated by a digital special effects system, as used for pop videos.

Green and Purple

The spectacles sold for the BBC week use a new idea which Beard has licensed to Telecast International of Munich. Instead of making one eye lens clear and the other a neutral grey, one lens is a very light green and the other a dark purple. This colouring, claims Beard in his patent, is chosen to match the spectral emission characteristics of the phosphors used in a colour TV screen.

These phosphors have emission peaks in the purple-blue, yellow-green and red-orange regions, and the dark filter colour is tuned to block at these peaks. So the spectacles create a large difference in apparent brightness between the two eyes when looking at a TV screen, while creating less of a difference when the wearer looks round the room in ambient light.

US Sports

The system has already been used in the US for sports matches, where there is naturally a lot of movement on screen. But as the depth effect reverses when the direction of motion reverses, with players standing proud of the background one moment and then receding behind it the next, viewers may quickly lose interest. Programmes shot in a studio can be structured to keep the effect more constant.

If you see some spectacles around, perhaps being sold off cheaply, buy a pair and try watching any programme that contains a lot of motion. If you cannot buy the coloured spectacles, just knock one lens out of a pair of dark sunglasses and put them on when you watch TV.

Constructional Project

BATTERY TO MAINS INVERTER

AND UNINTERRUPTABLE POWER SUPPLY

MARK DANIELS

Part Three

A 250W to 600W design with pulse width modulation for voltage control and an uninterruptable supply add-on. It can also be built for 50Hz or 60Hz operation.

THE mains electricity supply, though considerably more reliable than in its early years, is not infallible and for some critical applications, such as computing, needs occasional support from a secondary power source. Traditionally mains back-up has been by petrol or diesel generators which require a somewhat lengthy start-up period of several seconds, by which time a computer will normally have suffered terminal amnesia.

Any data not saved to disk prior to the power outage will be totally irrecoverable, though that which was successfully saved will normally be intact. A power failure which occurs during a write to disk will completely trash the current file, and unless the program uses two separate files for successive writes, all data will be lost from the disk as well as memory.

To preserve power (and sanity) an Uninterruptable Power Supply (U.P.S.), which derives its power from batteries, may be inserted between the national grid supply and the computer equipment. With mains electricity available the U.P.S. just sits there charging its batteries, but the instant a power cut occurs it draws on its reserve of energy stored in the accumulators and produces an independent mains voltage supply.

Obviously the energy stored in the accumulators cannot keep the computer running indefinitely, but will allow sufficient time for adequate back-ups of data to be made before shutting down, or to allow an auxiliary generator to be started and come "on line". Short duration drop outs of a few seconds or minutes will be ridden over by the reserve energy with no user intervention and operations will carry on as normal.

So far the use of a U.P.S. has been discussed only in connection with computers, this being by far the most popular application and one which requires only short duration autonomy of the supply. Larger (external) storage batteries will lengthen the independent operation time of the U.P.S. for applications such as video recording of broadcast material or for more general use with lighting and power circuits.

Additional Specifications for U.P.S.
(See Part 1 for Inverter spec.)

Type	On Line
Mains Input Voltage	200 to 260 volts
Max Input VA	625VA
Autonomy at full load	10 mins from internal battery
Transfer Time	Zero
U.P.S. Failure Protection	Relay bypass to mains
Recharge Time	< 12 Hours to 80% capacity
Weight Including Battery	18kg approx.
Design M.T.B.F.	> 20,000 hours

U.P.S. TYPES

There are basically two types of U.P.S., the change-over variety and the on-line version, each with features that make them more viable for some applications than others.

The change-over type uses a relay to switch the load between the mains and an inverter derived supply in the event of mains failure. There is normally a brief delay between loss of power and the inverter starting up and taking the load. In many applications, such as emergency lighting, this is perfectly acceptable, but some critical systems, such as computers, may not even tolerate a very short break, rendering this solution unsuitable.

The obvious alternative to this is to run the inverter continuously, with the mains battery charger supplying the power for the inverter in addition to charging the accumulators. The block diagram, shown in Fig. 1, appears very simple, comprising only a charger, battery and inverter. These are the only essential components for a functional system, but in practice a number of other features are added for increased reliability and functionality.

It does offer a number of advantages over the change-over type, including a zero transfer time at mains failure as the batteries take over the load. The isolation of the load from the mains and any transients imposed on it by motors, ensures that it will be unaffected by these undesirable conditions.

BATTERY CHARGING CIRCUITS

The U.P.S. is intended to be used in conjunction with a sealed lead acid accumulator as its reserve source of electrical energy. In a float charging application the charger should maintain a constant potential of 13·8 volts across the terminals of a nominal 12 volt accumulator, with less than 10mV of ripple.

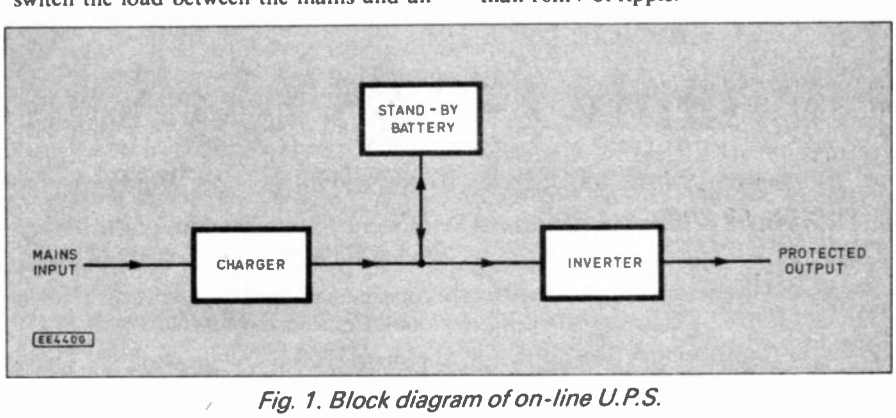


Fig. 1. Block diagram of on-line U.P.S.

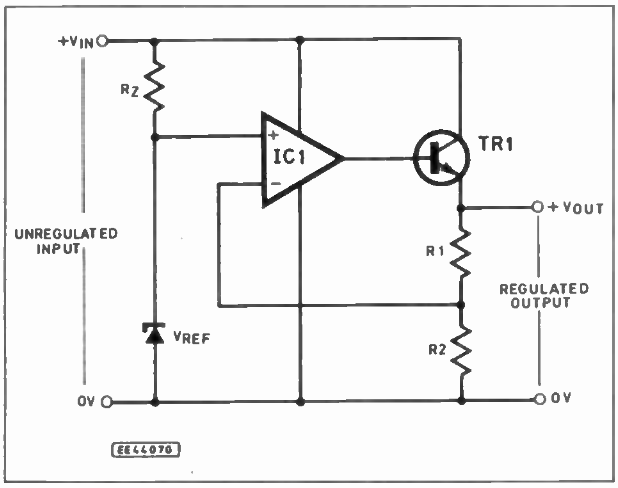


Fig. 2. Simple regulated linear p.s.u.

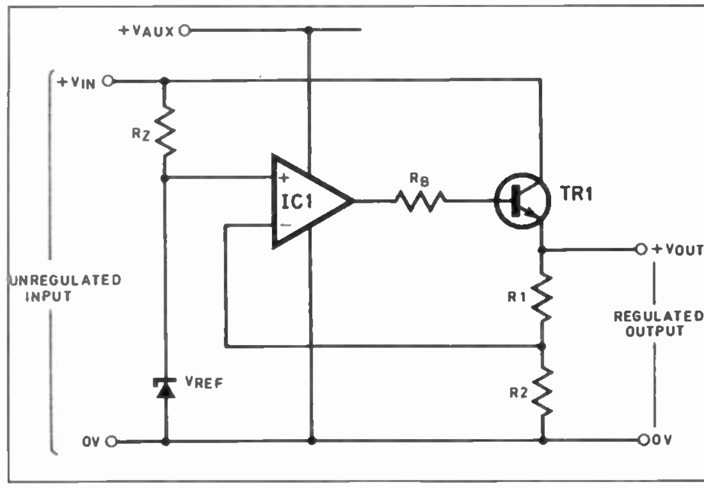


Fig. 3. Low loss linear regulator.

The charger in an on-line U.P.S. has not only to provide the charging current for the stand-by batteries, it must also deliver the power required by the inverter to drive the connected load. This places very much greater demands on the charging circuit, requiring it to be virtually 100 per cent reliable whilst operating under, at times, very arduous conditions.

Unavoidable inefficiencies in the power circuits of both the inverter and charger will contribute to a significant operating temperature rise, which for obvious reasons it is desirable to minimise. A significant reduction in these losses may be achieved through careful design of the charger. There are a number of design possibilities which may achieve this and these will be discussed below.

Since a constant charging potential is required as outlined above, external regulation must be employed to maintain a steady 13·8 volts. Regulation, however, always implies energy losses and an attempt must be made to keep these losses as small as possible. Switched mode control, where the unregulated supply is chopped with a switching transistor and then integrated by an output filter comprising chokes and capacitors, is the most efficient method available to us and would appear on the list of likely candidates.

Switching supplies, although very efficient and light weight, are notoriously difficult to design and set up, particularly when very high output currents are involved, as here. Further, a high current switcher such as required for this application would normally entail rectification of the mains with the switching transistors operating at 340 volts. This makes the circuit undesirable for home construction.

The alternative is our old friend the linear supply, along with its undesirable attributes of low efficiency and high weight. The weight can be significantly reduced by using a toroidal mains transformer, rather than a conventional laminated type. At first glance there appears to be little we can do about efficiency, since all linear regulators demand a higher input voltage than that required at the output.

LINEAR POWER SUPPLIES

A basic linear design using a "discrete" operational amplifier (as opposed to a dedicated regulator i.c.) with feedback to control the output voltage is shown in Fig. 2.

The op-amp is used in its non-inverting mode with negative feedback. A portion of the output voltage at the junction of R1 and R2 is compared by the op-amp with the stable reference voltage, V_{ref}, across the Zener diode and the output is adjusted until the two are identical. The voltage is thus maintained, so long as the supply voltage does not fall below a certain limiting value, at which point regulation will be lost. Normally the input voltage to the regulator must be several volts higher than the required output, the excess being dropped by a pass transistor, TR1 in this example.

In low current supplies this presents no problem as such, the mains transformer being selected to provide sufficient "headroom" for satisfactory operation. However, this requires the output transistor to dissipate the excess as heat and, with high current supplies, there could be a lot of it.

A typical high current, low voltage supply may have three output transistors connected as a Darlington (or super-alpha) emitter follower configuration to provide sufficient current gain. Each transistor in the chain will drop a minimum of 0·7 volts, possibly one volt or more at high currents, requiring a minimum overhead of three volts, but preferably more.

The output of the op-amp driving the transistors will normally only swing to within about two volts of the positive supply rail and a further couple of volts must be allowed for ripple on the rectified and smoothed d.c. input from the transformer.

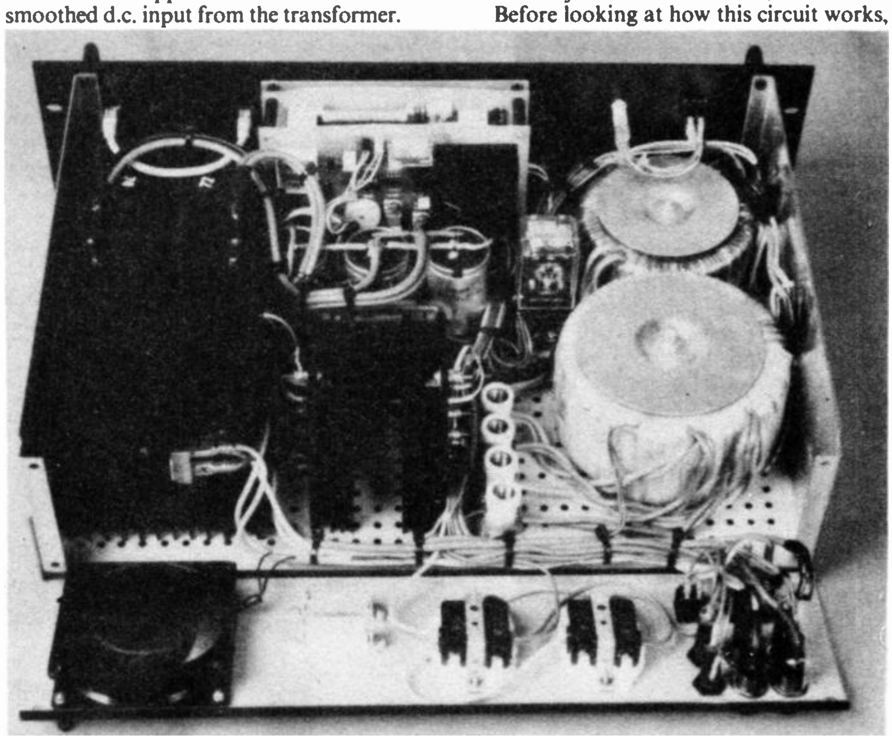
A grand total of seven volts represents our minimum operating headroom for a simple linear supply of this type. With a continuous operating current of 25 amps the power lost in the regulator could exceed 175 watts. Compare this with a switch mode supply offering an efficiency of 85 per cent, its total losses would be just 53 watts at 12 volts output.

AN ALTERNATIVE LINEAR

The main reason for the high unregulated supply voltage is to allow the op-amp to drive the base of the output Darlington up to three volts above the desired output voltage. The collector of the output device does not need to be at this same high voltage, as long as we drive the base of the first stage transistor with a sufficiently high voltage. The only places at which a high voltage needs to be present then is in the low current stages, which should reduce dissipation significantly, raising overall efficiency by a considerable degree.

The basic circuit required to do this is shown in Fig. 3. Here the op-amp is driven from an auxiliary supply of nominally 24 volts d.c. enabling its output to rise to 22 volts if required. A two stage Darlington output stage buffers the low current output of the op-amp and takes its supply from a separate, unregulated and lower voltage source of just 18 volts nominal, off load.

Before looking at how this circuit works,



let us consider what the likely losses are and compare them with the simple linear design described above. Under load the unregulated 18 volt supply is likely to drop, possibly to 15 volts, hence we have just 3 volts to drop across the pass transistor this time. The output stage power loss will be just 75 watts in this case (3V × 25A), considerably less than a conventional linear and not significantly more than the switch mode example.

At low output currents the circuit of Fig. 3 works in the same manner as the basic regulator in Fig. 2, with the output stage driven in emitter follower mode, dropping up to one volt (for each transistor) from its input to its output. However, as the load increases the supply voltage to the transistor collector will fall and will ultimately reach the point where there is insufficient voltage available for an emitter follower to work. Once this occurs in the conventional linear regulator regulation is lost as the transistor maintains this volt drop and its emitter sits at up to one volt below the collector voltage.

In the modified circuit, as this point is reached the op-amp is able to take advantage of its higher output voltage capability to drive TR1 base harder, forcing it into common emitter mode where the voltage dropped across the collector and emitter may fall to a small fraction of a volt. The transistor is ultimately driven into saturation, dropping the smallest possible voltage. A base resistor R_B limits the base current in this situation.

Obviously this will have even greater effect with multiple stage Darlingtons, since this is where the larger voltages are dropped in emitter follower mode, whilst the common emitter mode still allows the same small voltage as with a single transistor.

CIRCUIT DESCRIPTION

The full schematic for the battery charger is given in Fig. 4 A conventional 50Hz power transformer T101 (the component designations are 100+ or 200+ numbers to distinguish them from those in the Inverter circuit), is employed to transform the 240 volt a.c. mains to suitable lower voltages and higher currents as required. The supply to the transformer is filtered by the network comprising various chokes, capacitors and varistors, L101, L102, C101, C102 and VDR101 to VDR104, removing the majority of the spikes which may be present on the mains.

A relay RLA, with a single changeover contact RLA101, selects one of two primary winding taps, thus determining the voltages present across each of the secondary windings. The relay coil is energised by transistor TR102 when S1 (on the Inverter) is switched on (R103 is connected to D2 cathode in the Inverter). Resistor R104 is necessary to run the 12 volt relay coil from the 19·3 volt auxiliary supply.

When the Inverter is switched on, energising the relay, T101 primary tap Orn (orange lead) is selected increasing the number of primary winding turns in circuit and hence the primary to secondary turns ratio, reducing the output voltage in proportion. Conversely, when RLA is de-energised the pink tap (Pnk) is connected and the output voltage increases. The reason for this will become apparent later.

HIGH CURRENT

In order to obtain the very high output currents necessary for driving the Inverter at full load without incurring severe cost penalties in the transformer and rectifiers two separate circuits are used for parts of the high current path. Significantly, two separate 13·2 volt 22·5A secondary windings on the transformer allow this to be achieved in a simple manner. Each of the 13·2 volt secondaries are double wound to enable use of thinner winding wire.

Fusing, via FS102 and FS103, provides a degree of protection for the transformer and rectifiers. Two separate encapsulated bridge rectifiers, BR102 and BR103, applied separately to each of the fused high current secondaries, provide the raw d.c., being cheaper than four high current stud devices. This, until the output of the rectifiers, keeps the two circuits essentially separate.

Parallel connection of the rectified outputs is only possible by virtue of the series resistance provided in each circuit by the two separate matched secondary windings and their respective fuses, which ensures proper current sharing by the bridge rectifiers. Without this, one of the rectifiers would pass significantly more current, heating it up which would cause its resistance to drop and allow it to pass more current (so called "avalanche" effect) until eventually it was destroyed. This would leave the surviving rectifier handling more current than it was designed for and it too would fail, extremely rapidly!

Smoothing is provided by two large can electrolytic capacitors C105, C106, this gives an off-load unregulated voltage of approximately 17 to 18 volts d.c.

ERROR AMPLIFIER

The supply for the error amplifier, IC101 is derived from an auxiliary 20 volt secondary winding on the power transformer and is rectified and smoothed by

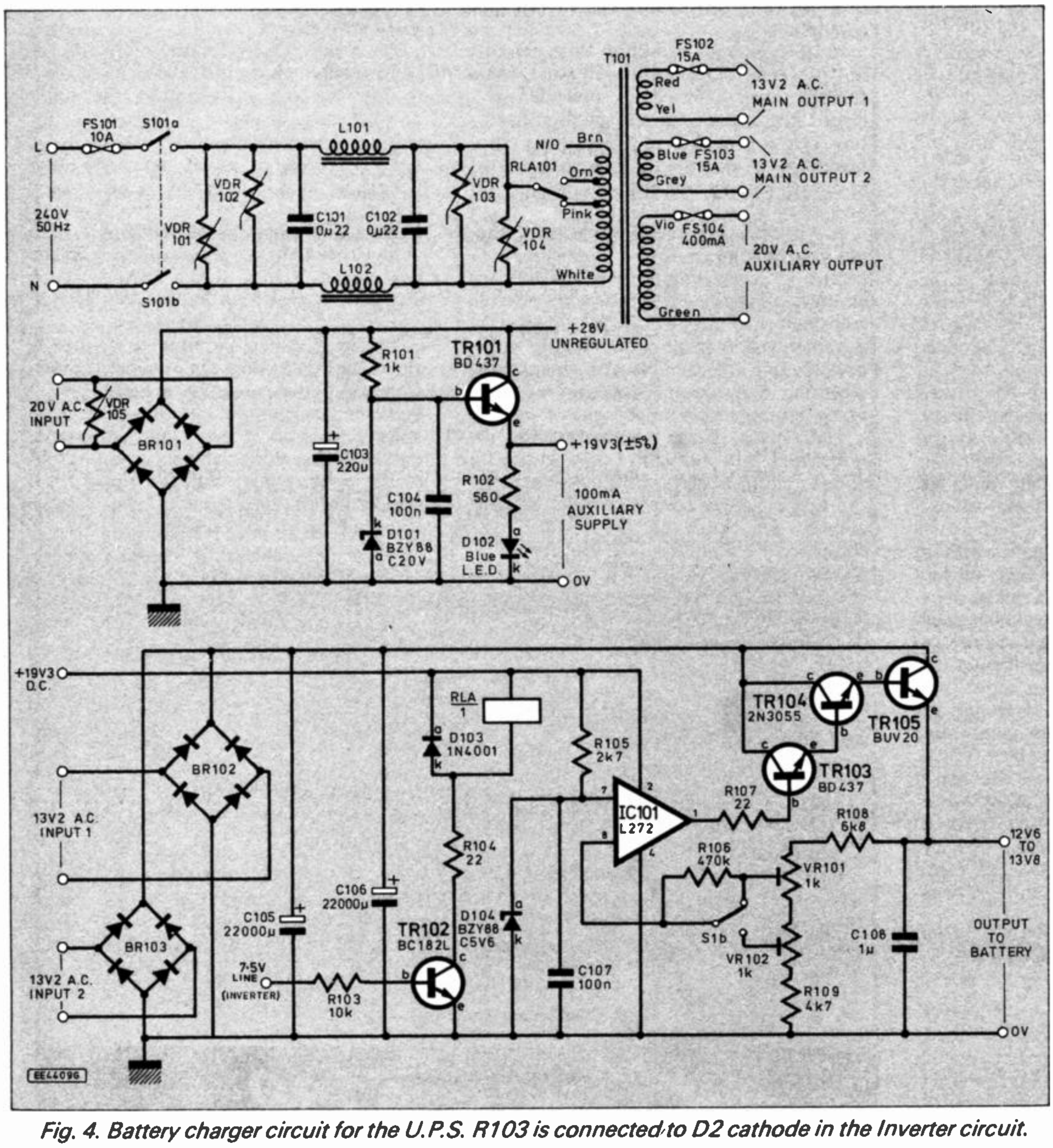


Fig. 4. Battery charger circuit for the U.P.S. R103 is connected to D2 cathode in the Inverter circuit.

a small encapsulated bridge rectifier BR101 and capacitor C103. A Zener diode D101 provides the voltage reference for a series regulator constructed around a small power transistor TR101. D102, a 5mm blue l.e.d., provides indication of mains power.

A second Zener diode D104, a 5·6 volt device, is used as the voltage reference for the error amplifier. R105 limits the Zener current to approximately 5mA and C107 suppresses Zener noise. The amplifier, IC101, is a small power op.amp capable of handling output currents of up to one amp and dissipating one watt, this device actually contains two such op.amps, only one of which is used here.

The power op.amp is used in the non-inverting mode and has negative feedback applied by the network of resistors and preset potentiometers R108, R109, VR101 and VR102, connected across the output of the power stage. S1b, the spare pole of the on/off switch of the Inverter, selects the appropriate tapping point on the potential divider, providing regulation at 12·6 volts for running the inverter or 13·8 volts for charging the battery. Resistor R106 ensures that even during operation of S1 feedback is always applied. Without this the output voltage could rise uncontrolled and cause damage to connected circuits.

The error amplifier, as already indicated, is capable of handling a maximum output current of just one amp. To cater for the expected currents of 25 to 30 amps considerable buffering is required. This is provided by transistors TR103 to TR105, connected in a Darlington configuration and normally operating as a unity gain emitter follower. However, IC101 is capable of providing sufficient output voltage (by virtue of its higher supply voltage) to drive them into a quasi common emitter mode when the situation demands. To prevent damage to the i.c. or transistors when operating in this mode a base resistor R107 is provided to limit the maximum base current available.

A capacitor, C108, connected across the output removes noise and reduces any tendency towards instability.

FAILSAFE

Obviously there is a very real possibility that either the Inverter or the battery charger may eventually fail, although this should not happen for a very long time, but it does depend very much on the quality of construction. To cater for this eventuality a mains failsafe switching circuit is employed. The schematic of this simple, but effective, circuit is provided in Fig. 5.

Relay RLB is a three-pole changeover relay and has its coil connected across the secondary of the Inverter transformer T1 (see Part One). Under normal operating conditions, with mains present and the Inverter running, RLB coil is energised connecting the load to the secondary of T1 via contacts RLB1 and RLB3. An auxiliary contact RLB2 connects the cooling fan to the mains whenever both the charger and Inverter are running to provide necessary extra cooling capacity to the heatsink fitted to the power transistor TR3 and rectifiers BR102 and BR103.

If the output from the Inverter is lost, for whatever reason (including switching it off via S1), RLB de-energises, the contacts revert to their "at rest" positions as in the diagram and the load is connected directly to the mains after a very brief delay of less than 20 milliseconds. The only warning of this is the neon LP1 extinguishing and a change in tone of the U.P.S.

COMPONENTS

CHARGER

Resistors

R101	1k
R102	560
R103	10k
R104	22 1W metal film
R105	2k7
R106	470k
R107	22 0·5W metal film
R108	6k8
R109	4k7

All 0·25W carbon ± 5% except where stated.

See SHOP TALK Page

Capacitors

C101, C102	0μ22 250V a.c. Class X mains rated polyester (2 off)
C103	220μ radial elect. 63V
C104, C107	100n boxed polyester, 5mm pitch (2 off)
C105, C106	22,000μ (minimum) can elect. 25V (2 off)*
C108	1μ polyester layer, 10mm pitch

*A single capacitor of 47,000μ (minimum) may be substitued if desired.

Semiconductors

D101	BZX88C20V 20V 400mW Zener diode
D102	5mm bright blue l.e.d.
D103	1N4001 1A 50V rectifier
D104	BZX88C5V6 5·6V 400mW Zener diode
BR101	WO1 1A 100V encapsulated bridge rectifier
BR102, BR103	KO1 25A 100V encapsulated bridge rectifier (2 off)
TR101, TR103	BD437 *npn* transistor (2 off)
TR102	BC182L *npn* transistor
TR104	2N3055 *npn* transistor
TR105	BUV20, *npn* transistor
IC101	L272 dual power op.amp

Miscellaneous

VDR101, VDR102	V275LA15 275V metal oxide varistor (2 off)
VDR103, VDR104	V250LA15 250V metal oxide varistor (2 off)
VDR105	V33ZA5 20V metal oxide varistor (optional)
T101	625VA Charger transformer, Jaytee 9E 284
L101, L102	4μH 3A axial choke (2 off), JPG Electronics
FS101	10A 20mm fuse
FS102, FS103	15A 32mm fuse (2 off)
FS104	400mA 20mm fuse
S101	miniature d.p.d.t. mains 10A rocker switch
SK101	6A I.E.C. panel mounting mains inlet connector
SK102, SK103	2-way socket housing for p.c.b. locking connector (2 off) with terminals
SK104	3-way socket housing for p.c.b. locking connector with terminals
PL101, PL102	p.c.b. plugs to match SK102, SK103 (2 off)
PL103	p.c.b. plug to match SK104
TB101	2-way 10mm pitch (or 3-way 5mm) p.c.b. mounting screw terminal connector
TB102	4-way 5mm pitch p.c.b. mounting screw terminal connector
TB103	5-way 5mm pitch p.c.b. mounting screw terminal connector
RLA	s.p.s.t. p.c.b. mounting 8A "flat" relay, 12 volt coil
RLB	3.p.d.t. standard industrial round base power relay, 240 volt a.c. coil, and socket
M101	90mm Mains 240V axial fan
B101, B102	6V, 10AH sealed lead acid acumulators (2 off)

32mm screwdriver release panel mount fuseholders (2 off); 20mm screwdriver release panel mount fuseholder; 20mm p.c.b. mount fuseholder; heatsink for TR104, 2·9°C/W; heatsink for TR105, BR102, BR103, 0·5°C/W; 30mm p.c.b. pillars; small heatsinks for TR101, TR103; connecting wire mains rated 0·75mm², blue, brown and green and yellow, thin low voltage assorted colours, 2·5mm², red, yellow, blue and black, 6mm² black and red; heat shrink sleaving, various sizes; TO3 silicone isolating kits with bushes (2 sets off); cable ties; M3 panhead screws (12mm, 20mm, 30mm), plain washers, spring washers and nuts; M3 solder tags (10 off). P.C.B. available from the *EPE PCB Service*, order code 862.

ALARM

Resistors

R201	470k
R202	1k
R203	10k
R204	4M7
R205	68k

All 0·25W carbon ± 5%

Capacitors

C201	2μ2 radial elect. 15V
C202	4n7 boxed polyester, 5mm pitch

Semiconductors

TR201	BC182L *npn* transistor
IC201	4011B quad two input NAND gate

Miscellaneous

WD201	Piezo electric sounder p.c.b. mounting

Approx cost guidance only **£140** *excluding batteries*

ALARM

An optional audible alarm, shown schematically in Fig. 6, may be fitted to the U.P.S. on the charger p.c.b.

The circuit is extremely simple and is based around a single CMOS integrated circuit. Of the four NAND gates contained in the chip, two, IC201c and IC201d, are connected as a gated astable oscillator running at around 2kHz as set by timing components R205 and C202 (the actual frequency obtained will vary considerably due to manufacturing tolerances in the CMOS i.c.). Reducing the values of either C202 or R205 will reduce the operating frequency and conversely raising their values will have the opposite effect. WD201, a piezo-electric transducer, converts the alternating signal produced by the oscillator into sound.

A monostable, short period, timer is constructed from the two remaining NAND gates IC201a and IC201b in the same package to cut the alarm off after a pre-determined short delay of around ten seconds. Again, this period will vary from one i.c. to another, and may be increased by raising the values of C201 or R204 (or decreased by reducing either of these components values).

The alarm is triggered when TR201 is turned off as the 19·3 volt supply rail drops to zero. Resistor R202 then takes pin 1 of IC201a high and also supplies power to the chip, enabling it and starting the timing sequence.

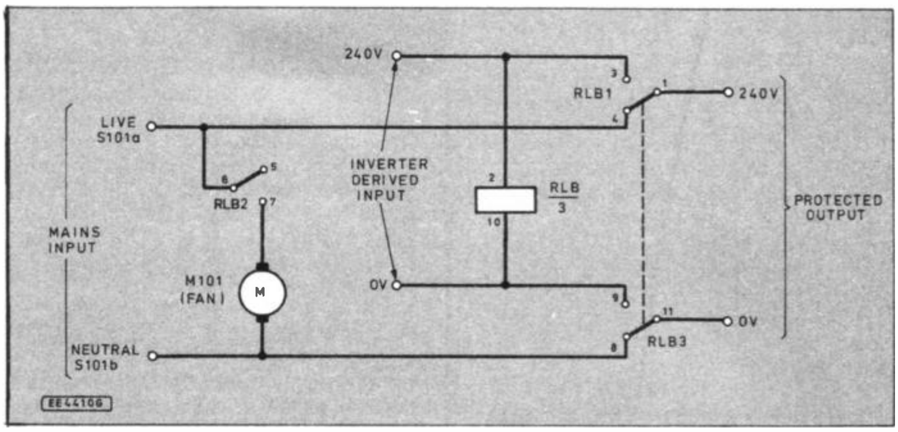


Fig. 5. Failsafe switching circuit.

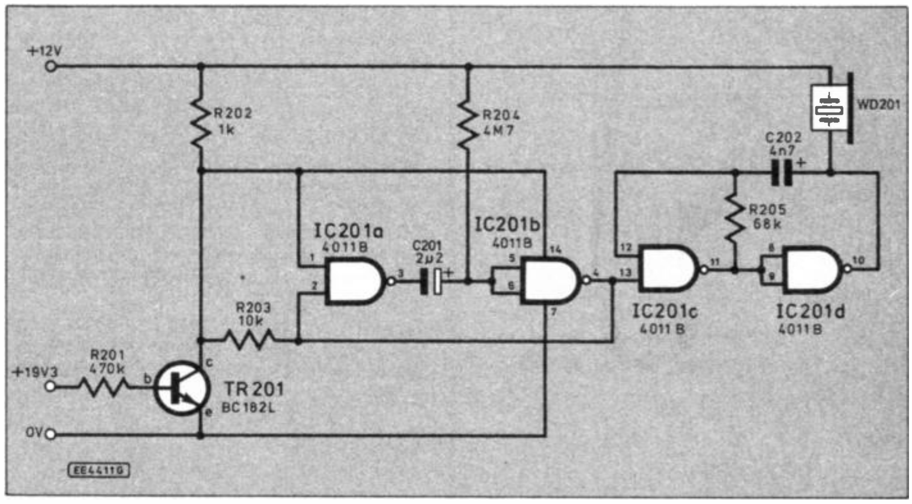


Fig. 6. Mains failure alarm circuit.

P.C.B. ASSEMBLY

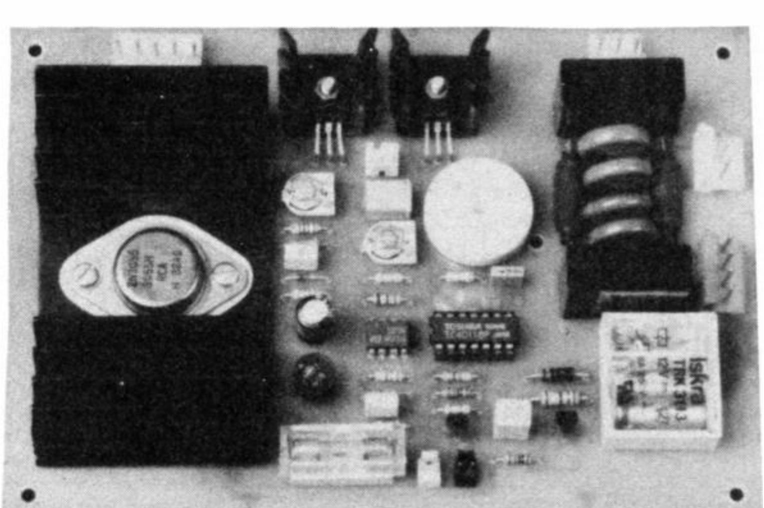
The majority of the small charger and alarm components are assembled on a single-sided p.c.b., available from the *EPE P.C.B. Service*, code 862. The foil pattern and component overlay are shown in Fig. 7.

The following order of assembly is recommended: small passive components, socket for IC201, connectors and fuseholder, large passive components, small semiconductors. IC101 should be soldered in place, with the minimum amount of heat. Do *NOT* use a socket as this may reduce the reliability of the completed unit as the contacts oxidise.

Pre-form the leads of TR102 and TR103 before bolting them to the p.c.b., with their heatsinks, metal side down. TR104 should be mounted on a heatsink using a silicone gasket for thermal transfer and the assembly bolted to the p.c.b. with M3 × 12mm set screws. Ensure that both the fixings make good electrical contact with both the p.c.b. and the transistor case as this forms the collector connections. Spring washers should be used under the nuts to prevent them loosening from vibration.

All thick tracks associated with heavy current paths, i.e. those around TR104 and the mains voltage components, should be heavily tinned to reduce track heating and aid reliability.

If the alarm function is required IC201 may now be fitted in its socket. If not, it and all associated components in the Alarm Components List may be omitted.



MAIN ASSEMBLY

All the case preparation details were given in part two last month, and the remaining parts may now be fitted to the back panel in accordance with Fig. 8.

A metal finger grille should be fitted on the outside of the back panel over the fan M101 using the fan fixings. Ensure that the connections on the fan are oriented for ease of connection at a later stage.

The majority of components may be mounted using the pre-punched holes in the lower case panel (if the recommended case is used). Exercise care when bolting down the toroidal power transformer T101, since over-tightening the mounting bolt can stress the winding insulation, causing breakdown and premature failure of the transformer. Also ensure that the bolt cannot contact the lid of the case as this will effect a shorted turn and cause subsequent overheating of the transformer.

The simplest way to secure the batteries in placed whilst allowing easy removal, is to use self-adhesive Velcro. Stick a strip of the "loops" at either end of the underside of each battery and fasten a similar length of the "hooks" to each piece. Remove the protective backing and lower the battery into place, bonding will be instantaneous, so ensure correct positioning before contact is made.

Drill the large heatsink to accept TR105 and the two high current bridge rectifiers. De-burr all the transistor mounting holes on both sides of the heatsink to prevent damage to the transistor insulating com-

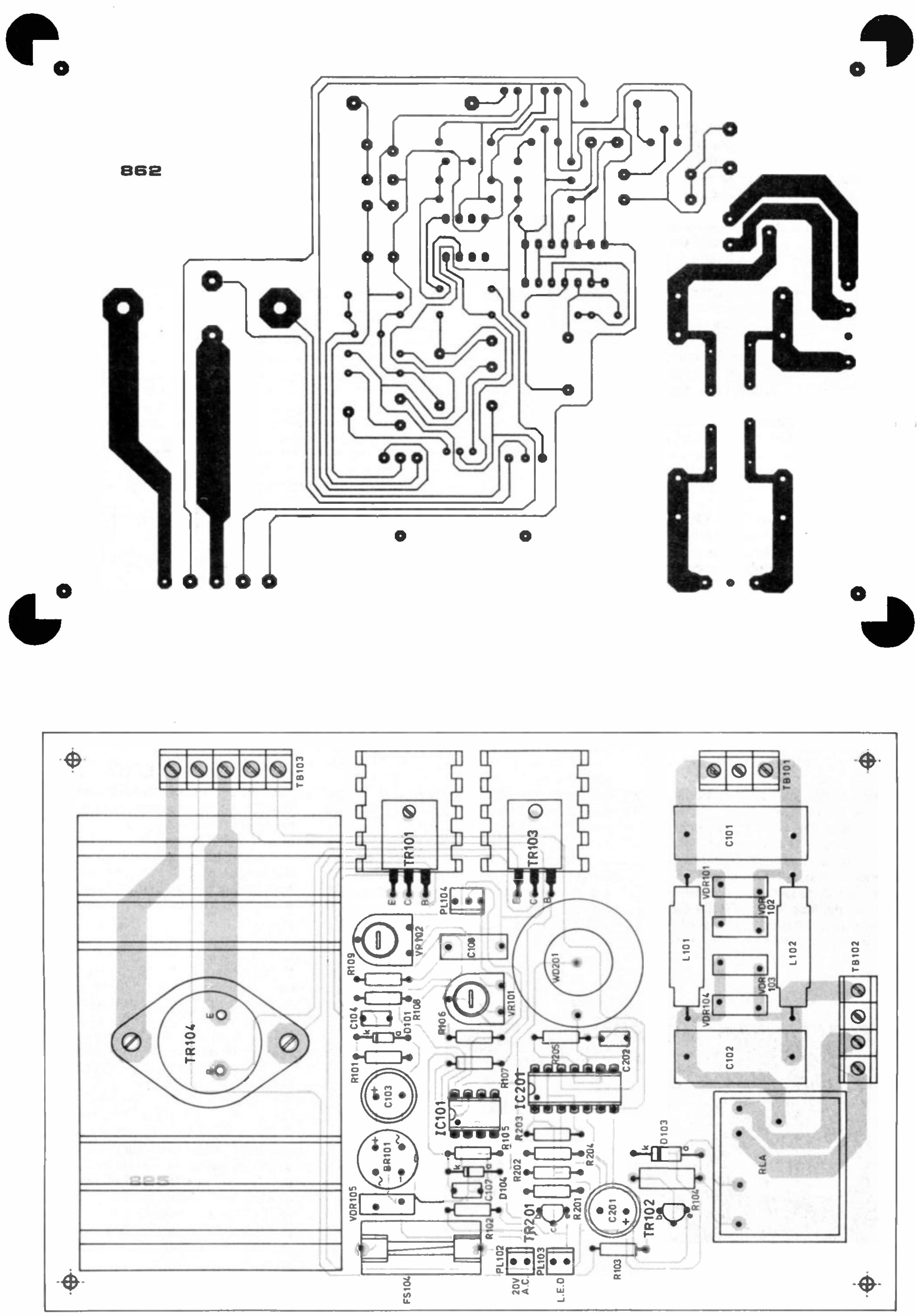
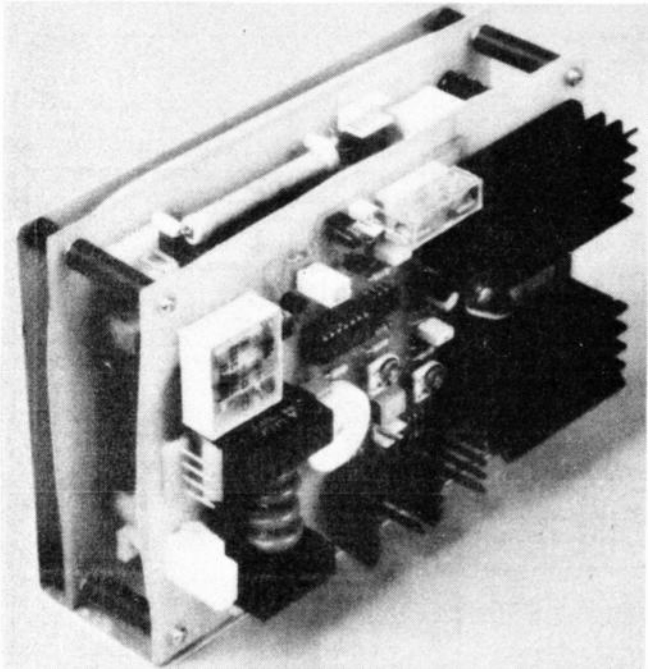


Fig. 7. P.C.B. component layout and copper foil master for the charger and alarm circuit.



ponents. Fit a silicone gasket to TR105, crimp and then solder two uninsulated butt connectors to its pins (see Part Two last month) insulating them to within 5mm of their ends with heatshrink sleeving or insulating braid.

Fit long top-hat insulating bushes in the heatsink to accept M3 × 30mm set screws and fasten the transistor down with the nuts on the same side of the heatsink as the transistor pins. Use a plain washer under both screw head and nut with a spring washer under the nut. Apply a thin film of heatsink compound to the mounting surface of each bridge rectifier before bolting to the heatsink with M4 hardware.

The assembled and wired heatsink is ultimately mounted with the component mounting platform vertical as shown in Fig. 8. This allows more effective fan cooling of the assembly.

LOW CURRENT WIRING

All the low current wiring for the U.P.S. is shown in Fig. 9 and should be wired using 0.5mm wire. Refer to Fig. 10 for transistor pinouts as necessary. The majority of the low current wiring is straight forward and should not pose any problems. Sensible use of colour coding at this stage will ensure that if fault finding becomes necessary it is a much simplified matter.

The terminals for the small p.c.b. connectors should be crimped or soldered to the wires before inserting them into their respective plastic shells, ensuring that they latch firmly in place.

The base connection to TR105 is made via a solder tag which should be slipped over the butt connector already fitted to the transistor and soldered in place. A large soldering iron would be a definite advantage here, as the smaller irons will not be able to heat the connection adequately.

The collector connection is also made via a solder tag and is simply fitted to one of the transistor mounting bolts between two washers, a spring washer and nut securely clamping it in place.

Do not make the battery connections at this stage as these are made to the main battery leads, fitted later.

POWER WIRING

There are two types of power wiring involved in this project, both of which present their own kind of hazard. The danger of the 240 volt mains supply should be apparent to all constructors. The second is perhaps not so obvious: low voltage supplies operating at high currents.

Great care should be taken not to short circuit the secondary of the power transformer as this may cause an arc, which will constitute a fire risk and also may cause

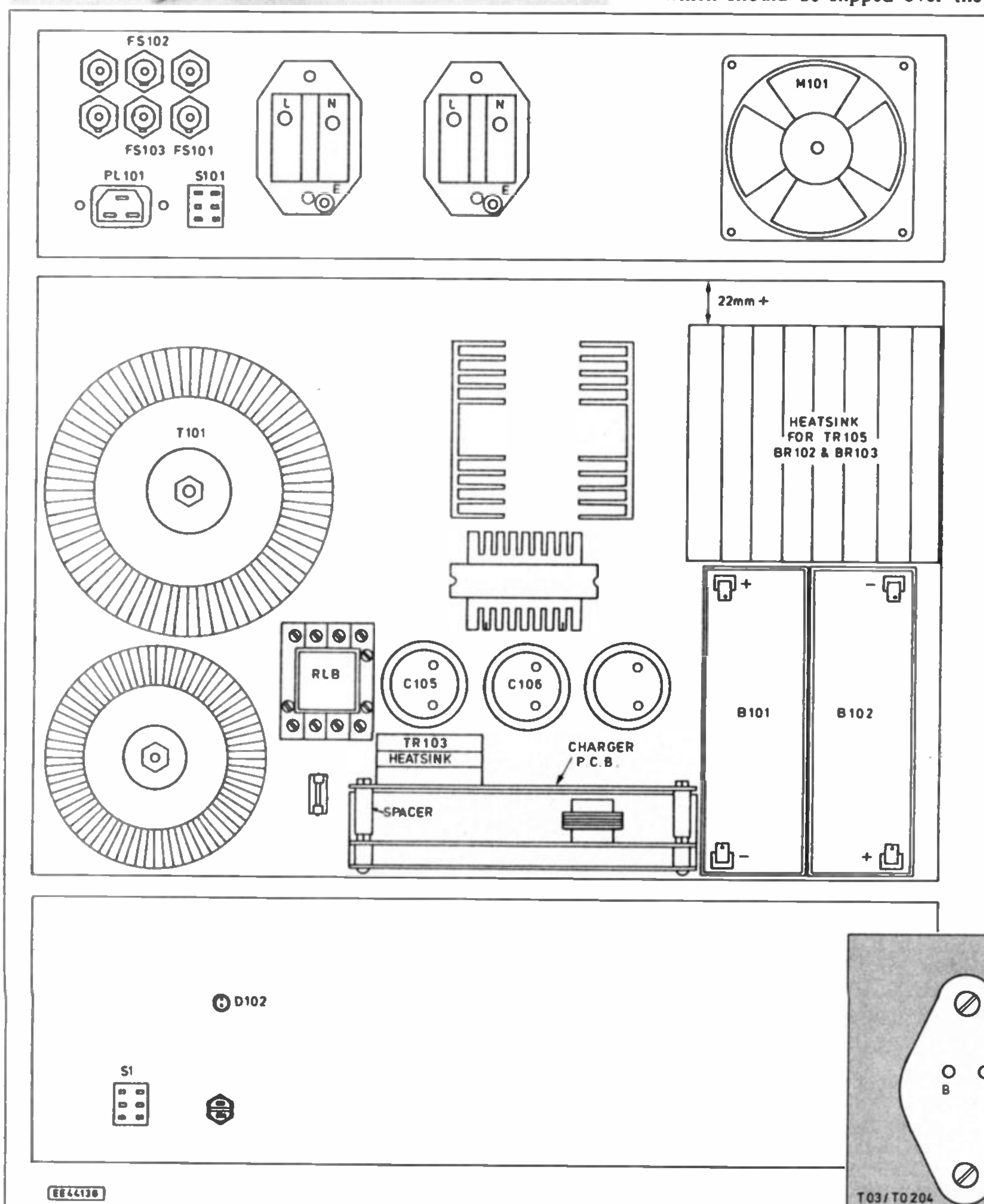


Fig. 8. Case layout showing the existing Inverter components (unlabelled) and additional U.P.S. components.

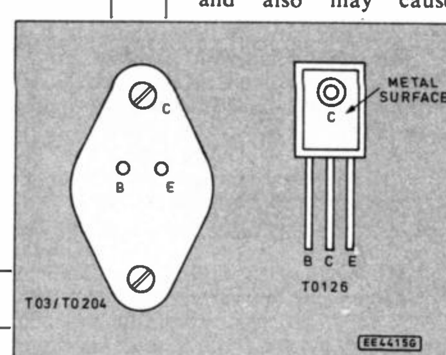


Fig. 10. Transistor connections.

damage to eye sight if viewed for a prolonged period without adequate eye protection. The transformer and associated wiring will also become very hot. **Always disconnect the mains supply before working on the unit,** whether on the mains side or the low voltage side. (Constructors should also read the *Safety* section in Part One).

If the Inverter was built as described in parts 1 and 2 the wiring associated with TB2, L3, SK1 and SK2 will need altering in accordance with Fig.11 of this part. All wiring connected to the mains or Inverter output should be rated for mains operation and be capable of safely carrying the full load current of 1·5 amps for the inverter. The mains wiring to the charger transformer should be rated at 10 amps or more to allow fusing at 10 amps to cope with the surge into the transformer at switch on. All connections should be adequately insulated, either with heat shrink sleeving or receptacle covers in the case of the push on terminals for PL101.

The secondary leads of T101 are solid copper and quite thick, making them very difficult to work. To

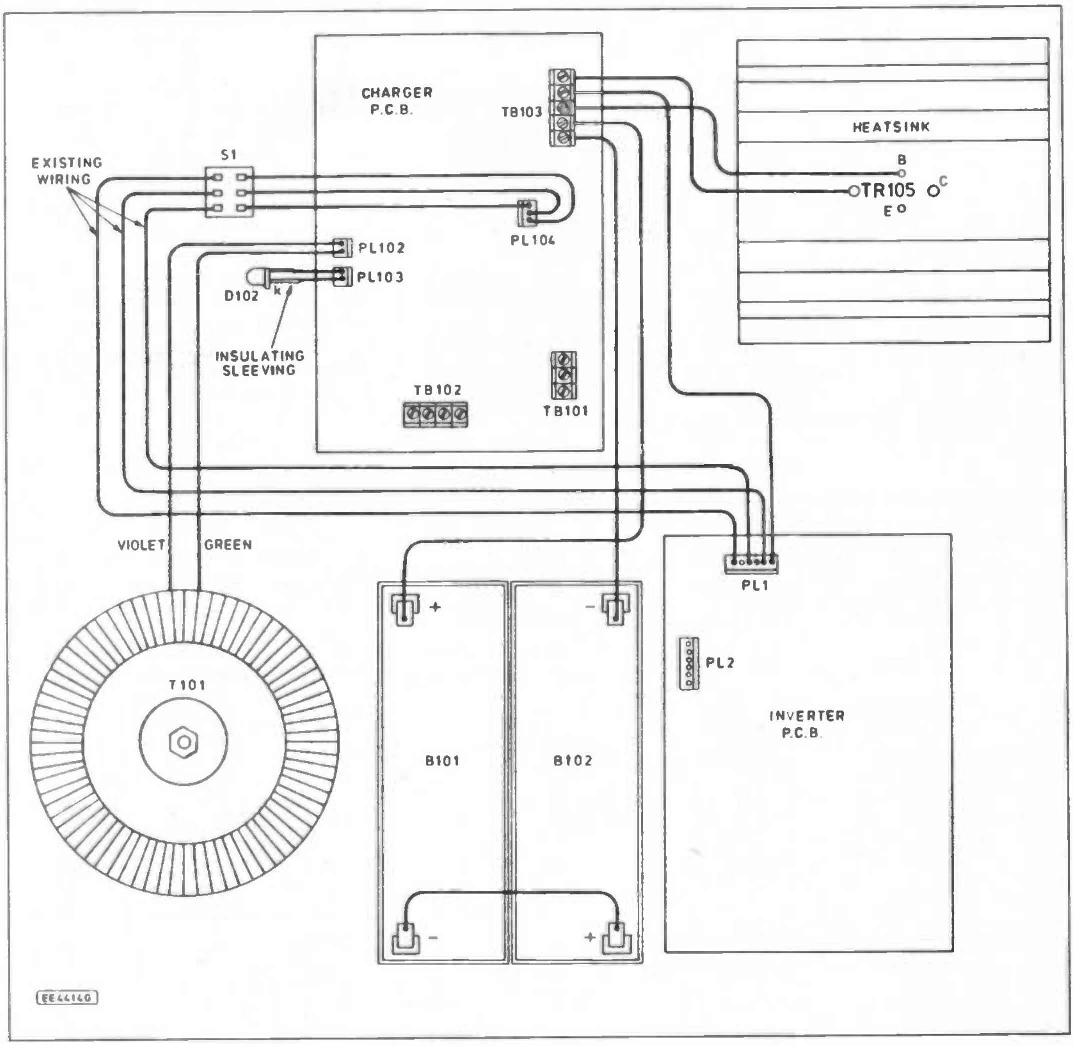
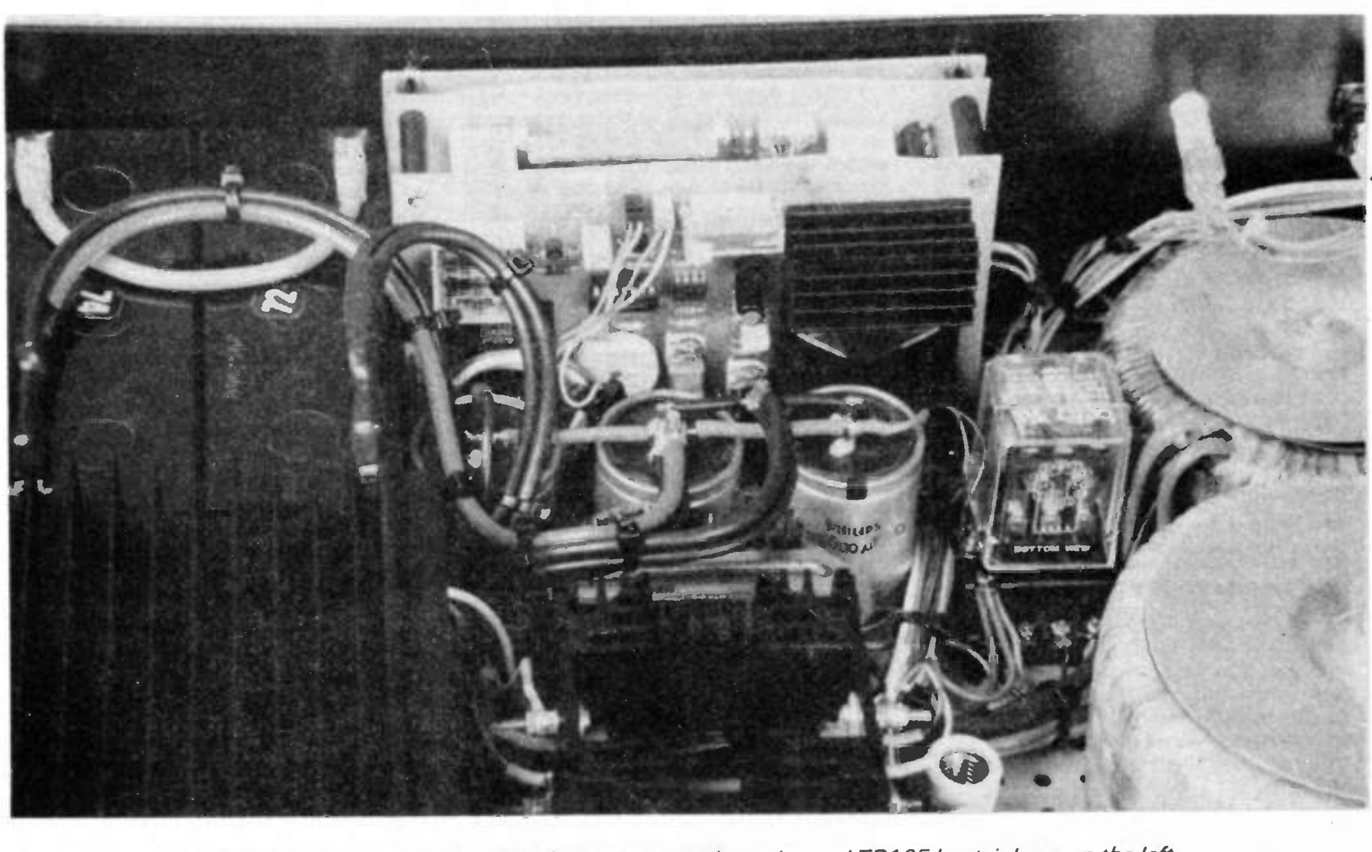


Fig. 9. Signal wiring for the U.P.S.



Layout and mounting of the U.P.S. components; batteries and TR105 heatsink are on the left.

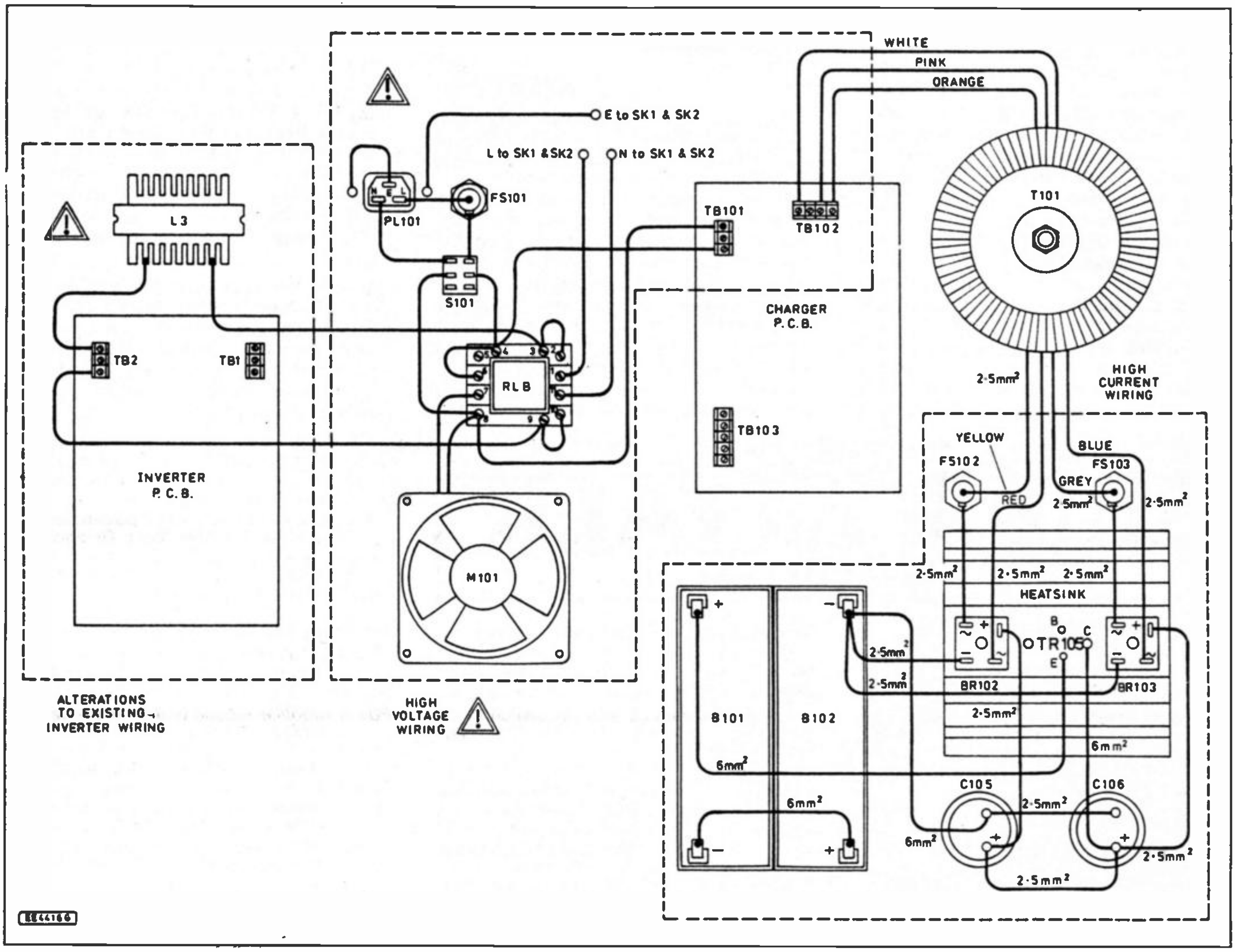


Fig. 11. High voltage and high current wiring for the U.P.S.

simplify connections to the transformer extend the leads with 2·5mm² flex, making the joins with 30 amp connector blocks or solder and insulate with heat shrink sleeving. The connections to the bridge rectifiers should be made with 0·25 inch insulated female receptacles, properly crimped or soldered to the leads.

An eye crimp is used to facilitate the connection to TR105 emitter. After crimping to the 6mm battery lead it should be slipped over the the butt connector already fitted to the transistor and soldered in place. Ensure that this joint and all other high current joints are properly made, since these are potential weak points which may later cause the unit to fail.

The remainder of the wiring is carried out using the methods described above, following the wiring diagram and using the appropriate wire sizes indicated on the drawing.

BATTERY CONNECTIONS

There are several leads to be connected to the battery terminals and this may pose problems. The method outlined below was used successfully in the prototype and should prove extremely reliable in operation over many years.

Cut the 6mm² battery leads to length and strip 50mm of insulation from the ends of each. Twist the strands together and crimp a yellow insulated (6mm²) 0·25 inch female receptacle to the very end of the wire, ensuring that the joint is electrically and mechanically sound. Use a proper crimping tool for the job, these are inexpensive and do a much better job than pliers.

Collect together the remaining wires which need connecting to the same battery terminal and strip 60mm of insulation from each. Align the insulation with the pre-terminated lead and twist the strands tightly around the exposed conductor of this lead. Repeat with the remaining leads before soldering the completed termination and insulating with heat shrink sleeving.

The lead connecting the two batteries in series is made up in the normal manner with 6mm² wire and crimp terminals.

SETTING UP AND TESTING

Remove RLB from its socket and remove FS102 and FS103. Ensure that FS101 is fitted and rated at 10A. Switch off S101 and connect the mains supply. Connect a multimeter to one of the 13·2 volt windings of T101, set to read a.c. volts on a suitable scale (e.g. 25V) and switch on, keeping hands well clear, the meter should indicate 14 to 15 volts. Switch off before repeating the test on the second winding.

Check all wiring around the mains side of T101 if the measured voltages are significantly different from those given. If the two voltages are not identical check secondary wiring.

Once the correct results are obtained disconnect the battery, fit 5 amp fuses in FS102 and FS103 positions and reapply mains, with a meter set to read 25 volts d.c. connected across C105 or C106. A reading of 18 to 20 volts should be accepted as normal, though variations of two or three volts either side may be obtained, depending on the mains voltage present. Check the output from the regulator by connecting the meter across the disconnected battery leads and adjust VR102 to obtain exactly 13·8 volts.

Re-connect the battery, replace the 5 amp fuses with 15 amp ones and fit RLB. Ensure that the Inverter is switched off by S1 and switch the charger on, with the meter still connected across the battery. Check that the battery voltage eventually rises to 13·8 volts, this may take quite a while if the battery is in a poor initial state of charge.

Disconnect the battery positive lead with the meter connected to the leads and switch on the charger, the voltage should rapidly stabilise at 13·8 volts. Now switch on the Inverter, the fan should start running and the measured voltage should fall. Adjust VR101 to obtain 12·6 volts. The battery may now be re-connected.

Check the a.c. voltage across the high current secondaries of T101, with the Inverter switched on and then off. The voltage should fall when the Inverter is switched on. If it does not check that RLA is operating correctly.

If the alarm is fitted it should operate for a few seconds every time that the mains is switched off, or the unit unplugged.

LOAD TESTING

Operate the U.P.S with a 200 watt, or larger, load connected and check all heatsinks for excessive temperature rise. The large fan cooled heatsink fitted to the rectifiers and TR105 will get quite warm after a long period of running. The others should remain quite cool.

Check all high current connections for signs of overheating, especially TR105 emitter connection since this is the most heavily stressed joint.

With the case lid in place cooling of the main heatsink will be much more effective as this ducts the air more efficiently. In normal operation the unit should only be run with the case fully assembled, not only for cooling, but for safety as well.

Note that the supply to the load should be maintained at all times with either the Inverter or the charger switched off. Only when both are switched off will the supply be interrupted.

FAULT FINDING

The circuit, although moderately complex, is fairly simple to diagnose. Many of the relevant circuit voltages are marked on the diagram or noted in the text.

If the measured voltage across either of the Zener diodes is around 0·6 volts, instead of its marked voltage, then the device is incorrectly polarised and should be removed and refitted correctly.

No voltage across the reservoir capacitors C105 and C106 may indicate ruptured or missing fuses. FS101 is most likely as this has to take a large surge at switch on and may fail prematurely. An anti-surge fuse may be the solution, but with a 10 amp rating these appear only to be available in 32mm types.

Errors around RLB are fairly likely since this is hand wired. Check it carefully against the wiring diagram and Fig. 5. Only the specified components should be used for RLA and RLB since these both have cadmium flashed silver oxide contacts. Other contact materials, as used in cheaper relays will fail prematurely with the high inductive currents being switched here, causing the contacts to be welded together.

If fault finding does become necessary, a systematic approach will pay dividends in reduced time and increased success rates. Follow the circuit through from input to output with the schematic, Fig. 4, in front of you, along with the relevant wiring and layout diagrams. □

SHOP TALK

with David Barrington

250W/600W Battery to Mains Inverter

Once again, we should like to stress that anyone undertaking the task of building the *Battery to Mains Inverter* project should be skilled in construction work. Also, it is ***most important*** that the "Safety Panel," published in part one, be read ***before*** commencing any practical work.

This month we tackle the *U.P.S.* or Uniterruptable Power Supply section and some of the components need to be selected very carefully. The 8A "flatpack" 12V relay, with cadmium oxide flashed silver changeover contacts, is the **Maplin** (☎ ***0702 554161***), code HY20. The high power, round octal base, industrial standard relay is the 240V a.c. 10A 3-pole "double-throw" (3PDT) type, with 11-pin base, also from the same source, codes JG64 and JG53.

The 4µH 3A choke was purchased from ***JPG Electronics*** (☎ ***0264 211202***). The main heatsink is an RS device and was purchased through their mail order outlet, **Electromail** (☎ *0536 204555*) order code 401-958.

Now for some further clarification on the two types of recommended toriodal transformers. The toriodals have been specially made up by **Jaytee** (☎ *0227 375254*) and the 9E284 (600VA) has been designed to function as both the step-up transformer in the 600W Inverter and also as the charger transformer in the U.P.S., with a 7E283 (300VA in the inverter section.

Obviously, it must be connected differently in each case, since in the inverter it is used as a step-up transformer, whilst in the charger it steps the mains input down. The wiring diagrams in parts two and three should clarify this.

Also, constructors should refer to the data sheet supplied by Jaytee with the transformers which gives full details of the windings, including which are used as primary and secondary in each case. It is advised that the instructions are read carefully before connecting this transformer, it could save you a lot of time and trouble!

The 7E283 300VA toriod cost £32.50 and the 9E284 625VA toriod cost £49, both inclusive of VAT and post/packing.

The 19 inch rack-mounted case used in the prototype is the Maplin XM70, some other rack cases do not appear to be deep enough (front to back) for all the parts to fit, check this out before buying, minimum internal dimensions must be 432mm x 120mm x 293mm.

The U.P.S. charger printed circuit board is available from the *EPE PCB Service*, code 862 (see page 171).

Whistle Controlled Light Switch

Only two items called up in the "comps list" for the *Whistle Controlled Light Switch* prompted further comment. These concern the whistle switch i.c. and the switch plate, which takes the p.c.b. and replaces the standard light switch.

The UM3763 whistle switch i.c. is a special "custom" device and when we first published a design using this device over a year ago we found that stocks rapidly dried up. Further investigations at the time resulted in the information that the chip was no longer being manufactured and new supplies would not be forthcoming.

However, the good news is that the designer had purchased over 500 whistle switch i.c.s and is offering these for sale to readers together with the switch plate. Incidently, it is recommended that the specified switch plate be used as the standard types are not considered deep enough and can result in components touching the earthed metal wall box.

The UM3763 i.c. and switch plate are available, *Mail Order only*, from **B. Trepak, Dept EPE, 20 The Avenue, London, W13 8PH** for the sum of £6.50, inclusive for the pair. Cheques or Postal Orders should be made out to B. Trepak.

The two terminal microphone insert is an *Altai* type and should be available from most of our component advertisers. Alternative types may be offered by suppliers and these should work in this circuit but they have not been tried in the model.

The small printed circuit board fits on the specified switch plate and is available from the *EPE PCB Service*, code 860.

Warning: This unit carries mains voltages and any reader who is not certain of being able to install it safely is strongly advised to seek professional advice and help. Remember to ***switch off*** the household mains supply when replacing the light switch.

Introduction to Microntrollers – Timeout

For those readers taking their first steps into the world of microcontrollers, the package put together by Greenweld for the *Timeout* project could not be better, (except of course our "Micro Lab" board produced as part of our recent *Teach-In '93* Series – but we are obviously biased).

The complete kit for the Timeout project, with programmed 68HC705K1 microcontroller plus all other components including p.c.b. and plastic box, but excluding the battery, is available from **Greenweld** (☎ ***0703 236363***). The kit also includes a PC compatible disc containing the labelled software used in the chip and a copy of the Motorola Instruction Set for the microcontroller.

The kit costs £37.80 plus £3 p&p inclusive of VAT and is available from Greenweld Electronics, Dept EPE, 27 Park Road, Southampton, SO1 3TB. Phone: 0703 236363; Fax: 0703 236307.

Reviving The Valve Sound – Quad II Power Amplifier

It is difficult to point readers towards one direction for components for the *Quad II Power Amplifier* rebuild project as the variation in supplies of the "old" and "new" parts seem to vary, i.e. they may stock the valves but not the XLR sockets or specified capacitors. To this end, we include a list of possible contacts as supplied by the author.

Also in the components list stock codes for RS components have been included. Any *bona-fide* stockist will be able to order these for you.

Obviously, the most important contact address is Quad themselves and they can be found at: **Quad Electroacoustics Ltd, Dept EPE, Huntingdon, Cambs, PE18 7DB.** ***Tel: 0480 52561.***

One specialist valve supplier with a very good reputation and who advertises in this magazine is the **Chelmer Valve Company** (☎ ***0245 265865***) and is certainly worth giving a call. **Chelmer Valve Company, Dept EPE, 130 New London Road, Chelmsford, Essex, CM2 0RG.** Another advertiser who stocks the specified valves is **Cricklewood Electronics** (☎ ***081 452 0161***).

Other usefull contacts are: Electro Supplies ☎ 061 477 9272 (sells surplus smoothing capacitors, valves and holders); Maplin ☎ 0702 554161 (valve components, but are expensive); ESD Electronics Services ☎ 0279 626777 (good for caps, resistors and connectors); Colomor (Electronics) Ltd ☎ 081 743 0899 (cheap valves); Electromail/RS ☎ 0536 201 234 (0·5W metal film resistors) and finally Falcon Acoustics ☎ 0508 78272 (good selection of valve publications).

Balance Stereo Microphone Preamplifier

We do not expect any component purchasing problems to be encountered when shopping for parts for this month's audio module in the *Multi-Purpose Audio System*. The *Balanced Stereo Microphone Preamplifier* is based on the relatively new SSM2017 audio pre-amp i.c. and currently only appears to be available from **Maplin**, code CP89W. They also carry a reasonably priced range of XLR connectors.

Before purchasing the metal screening box you should check that the p.c.b. will fit inside, in some instances it did not. The one in the model is the **Rapid** box, code 30-0305.

The two small printed circuit boards are available from the *EPE PCB Service*, codes 858 (pre-amp) and 859 (power supply).

INTERFACE

Robert Penfold

THIS month we continue our discussion of EPROM programming with an in-depth look at programming the 27*** series EPROMS using a computer based system. Pinout details for the 2764 and 27128 were published in a previous *Interface* article, but as this was several months ago the relevant diagram is reproduced again in Fig.1.

In Control

Apart from the supply lines and VPP (the programming voltage), all the other pins of the EPROMs must be controlled by the programmer. For a computer based programmer the obvious solution is to have an add-on parallel port which provides numerous input and output lines. Each pin of the EPROM is then fed from an input or output line, as appropriate.

There is an obvious disadvantage to this approach in that it requires about two dozen or so input and output lines. In practice the parallel port would probably have to provide more lines than this, since there would almost certainly be some inefficiency in the system. For example, you might have to commit an eight bit port as eight outputs, even though there was only one input of the EPROM left to control.

It would probably be possible to control a 2764 EPROM from the 24 lines of an 8255 parallel I/O board, but the 25 input/output terminals of a 27128 would seem to necessitate a second 8255, or perhaps the addition of a simple TTL output port. Alternatively, the interfacing can be rationalised in order to reduce the number of input/output lines required.

Counting Up

One advantage of controlling each terminal of the EPROM from an individual input/output line is that it is possible to access any address at any time. Simply set up the appropriate binary pattern on the address lines (A0 to A12 or A0 to A13) to almost instantly access the required address.

When I first experimented with EPROMs some years ago I found that a binary counter (or "ripple" counter as they are often called) provided a simple but effective means of driving the address inputs. This remains my preferred method of controlling the address bus. No matter how many address inputs the EPROM has, only two control lines from the computer are required. These are both outputs.

One output from the computer controls the "reset" input of the counter, and this is initially pulsed high to ensure that the counter starts out at a known value (zero). The other output drives the counter's "clock pulse" input. The count is incremented by one each time a complete pulse (i.e. a set of low - high - low transitions) is supplied to the clock input of the counter.

There is clearly a drawback in this system in that it is rather cumbersome. There is no instant way of randomly accessing addresses. However, you can access any desired address simply by resetting the counter and supplying the appropriate number of clock pulses to the counter. To access address 24987 for example, it would just be a matter of resetting the counter, and then using a software loop to produce 24987 clock pulses. This is not very difficult from the software point of view, and assuming a fast programming language is used, it is possible to access any address quite rapidly.

In practice it is not often necessary for an EPROM programmer to randomly access addresses anyway. In the normal course of events the EPROM is first checked to see that all the memory stores are blank (set to 1). This is just a matter of going through the addresses one-by-one, in sequence, reading each byte to ensure that a value of 255 is returned. Then the EPROM is taken back to address 0, and each address is programmed with the new data, in sequence.

Binary Counter

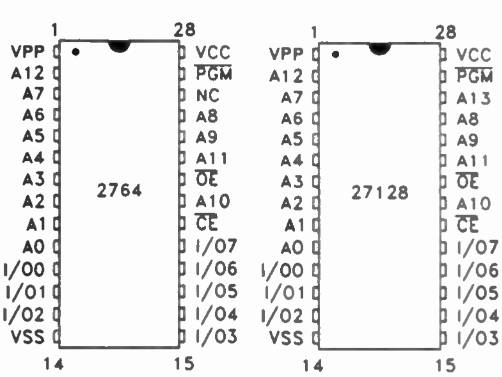
Using a binary counter to drive the address inputs is very convenient when checking the contents of an EPROM and during programming. The basic course of events is much the same in both cases. The counter is reset to zero, and then the first address is read or programmed. Then the counter is incremented by one, and the next address is read or programmed. This sequence of events is continued until all the addresses have been checked or programmed.

There are several CMOS binary counters which look promising for use in the present application. In practice there is a problem with some of these counters in that they do not give access to the output of every stage. Some of the longer dividers do not provide access to one or more of the early divider stages.

A two chip counter made up from two 4024BEs or 74HC4024s connected in series is probably the cheapest way of driving the 13 address inputs of a 2764, or the 14 address inputs of a 27128. The 4024BE is a seven stage binary counter, so using two in series provides up to 14 outputs. Fig.2 shows the circuit for a 14-bit counter based on two of these chips. Of course, when this circuit is used with a 2764 the A13 output is not needed. However, this output can be left connected to pin 26 of the 2764 EPROM as this pin is not connected to anything internally.

Control Inputs

The general scheme of things so far is to have the address lines controlled by two outputs of the computer port via a binary counter, and VPP fed from a suitable stabilised supply (usually with a potential of 12·5 volts). The eight input/output lines are used to write data to the EPROM when programming, and to read back data once the device has been programmed. Although it might at first seem as though these lines could be



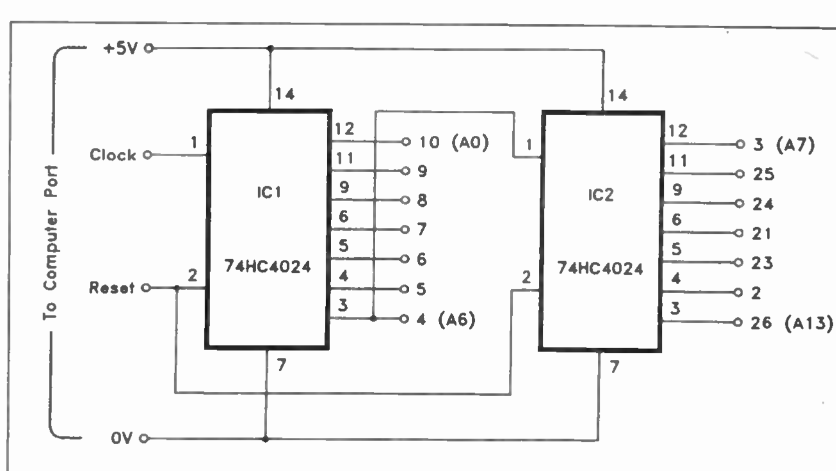


Fig. 1. Pinout details of the 2764 and 27128 EPROMs.
Fig. 2. (right). Using a 14 stage ripple counter to drive the EPROM address bus.

driven from output lines, in practice it is essential to read data from the EPROM during programming.

As already pointed out, it is normal to check that an EPROM is blank before reprogramming it. It is also essential to check that programmed devices have been programmed correctly. Therefore, in practice the input/output terminals must be fed from eight lines that are capable of operating as inputs and outputs. A port of an 8255 is capable of being switched to operate as an input type under software control, and is therefore perfectly suitable for this application. Other PIA chips (6522, 6821, etc.) also seem to be capable of this bidirectional operation.

This still leaves three terminals of the EPROM to contend with, and these are all inputs. Pin 20 is the chip enable ("CE") input, and this must be taken low in order to make the EPROM active. With this pin taken high the EPROM is effectively switched off, and it is not possible to read from or write to the device. This input is needed when the EPROM is used as one of the chips in a multi-chip memory bank. It does not serve any obvious use when the EPROM is being programmed. This input could be fed from an output line of the computer, but there is probably no disadvantage in simply wiring it to the 0 volt supply rail.

Pin 22 is the output enable ("OE") terminal, which controls the tristate buffers at the data inputs/outputs. This terminal is taken low to activate the tristate buffers, and it must therefore be taken low when reading from the EPROM. Obviously the tristate buffers must be inactive during programming, which means that pin 22 should be high when programming. When programming a 2764 or 27128 pin 22 effectively becomes the read/write input (low to read - high to write).

Finally, the PGM input at pin 27 effectively switches the programming voltage at pin 1 on and off. An EPROM is based on field effect transistors having charge storage capacitors at their inputs. Normally each bit of memory is set at logic 1, and the very high insulation resistances in the circuit prevent the charge voltage from leaking away and setting some bits to logic 0. This is actually a slight exaggeration, since the charges will eventually change due to minute leakage currents, but a properly cared for EPROM should not suffer from amnesia for at least ten years. The programming voltage is used to break down the insulation in the EPROM, and alter the charges on certain capacitors so that their bits are set to logic 0.

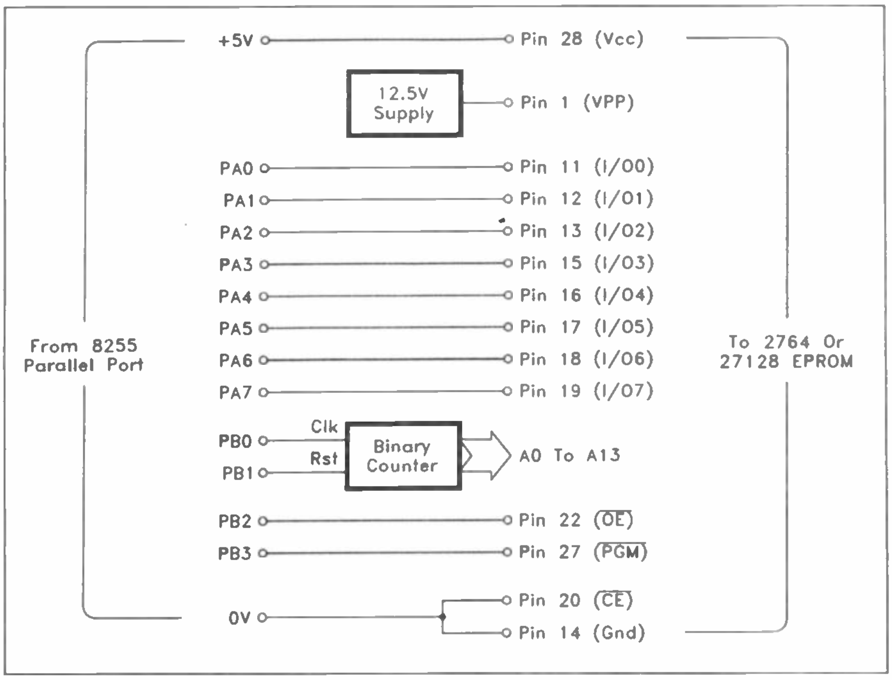


Fig. 3. Suggested method of controlling an EPROM via an 8255 or similar PIA.

Programming Voltage

An important point to note here is that the programming voltage must only be applied to each memory cell for 78·75ms or less. Applying the programming voltage for longer than this could result in the EPROM being damaged. Pin 27 is pulsed low to apply the programming voltage to the eight memory cells at the currently selected address.

If any bits of the data bus are set to 0, the appropriate memory cells will be altered to suit. Another important point to note is that memory cells can only be altered from 1 to 0, and not the other way round. If even one bit is incorrectly set at 0, this can only be corrected by erasing the EPROM and completely reprogramming it.

PGM can be fed from any spare latching output line of a parallel port, or it can be driven via a monostable having a suitable pulse duration. A monostable provides a means of giving an output pulse of the precisely the required duration, and avoids the need to find a reliable method of obtaining accurate software timing. Using a monostable is a safer approach, but it precludes the use of fast programming techniques.

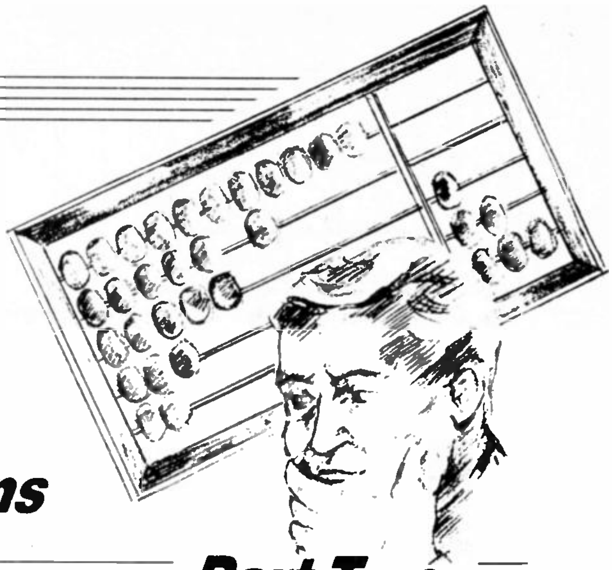
Basic Programmer

A basic computer based EPROM programmer could therefore consist of something along the lines of Fig.3. Port A of an 8255 is used to provide the eight input/output lines which are used to write data to the EPROM and read from it. Two lines of Port B are used as outputs to control the address inputs via a binary ripple counter, and two more outputs of Port B are used to drive the output enable and PGM inputs.

The chip enable input is simply connected to the 0 volt supply rail. This enables the EPROM to be controlled via just eight bidirectional lines and four outputs, which requires only half the capacity of an 8255. Although the EPROM is shown as being controlled via an 8255, the same method applies equally well to ports based on the 6522, 6821, etc.

Next month we will continue on the same theme with a detailed discussion of the programming cycle.

Special Series



CALCULATION CORNER

Ohm's Law and its applications

STEVE KNIGHT — **Part Two**

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.

A NUMBER of formulae turn up in this month's offering. Don't be put off by this and don't just give time to memorising formulae. That is not the way to master things. The way ahead is to understand the principles from which such formulae are derived. Constant usage of the principles then fix the formulae without conscious effort.

RESISTORS IN SERIES

When resistors are connected in series, as in Fig. 2.1 the **same current** passes through each of them and the applied e.m.f. divides between them as a series of potential differences or **voltage drops**. These are the important characteristics of a series circuit.

The sum total of the individual p.d.'s must be equal to the applied e.m.f., therefore, from Fig 2.1 we can say

$$E = V_1 + V_2 + V_3$$

Suppose now that the total equivalent resistance of the circuit is R_e ohms. Then the current passing through R_e would be I and the voltage across it would be E. Applying Ohm's law to this equivalent circuit gives us $E = IR_e$, hence from the above

$$IR_e = V_1 + V_2 + V_3 = IR1 + IR2 + IR3$$

Cancelling out the common current I, gives us

$$\mathbf{R_e = R1 + R2 + R3}$$

In words, the total equivalent resistance of a series circuit is simply the sum of the individual resistances. This arrangement (which applies to any number of resistors) gives the greatest possible total resistance.

RESISTORS IN PARALLEL

When resistors are connected in parallel, as in Fig. 2.2, the **same voltage** is present across each of them and the **current divides** between them. These are the important characteristics of a parallel circuit. From the figure we can see that the total circuit current I must be equal to the sum of the currents flowing into the individual resistors (this is actually **Kirchhoff's law**, of which more later), so

$$I = I_1 + I_2 + I_3 = \frac{E}{R1} + \frac{E}{R2} + \frac{E}{R3}$$

by the application of Ohm's law to these currents.

If now the total equivalent resistance of the circuit is R_e ohms, then the current passing through it would be I and the voltage across it would be E. Hence for this equivalent circuit $I = E/R_e$ and from the above

$$\frac{E}{R_e} = \frac{E}{R1} + \frac{E}{R2} + \frac{E}{R3}$$

Cancelling out the common e.m.f. E, gives us

$$\mathbf{\frac{1}{R_e} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

This arrangement (which applies to any number of resistances) always gives an equivalent resistance which is *smaller* than the *smallest* individual resistance used in the arrangement.

A simplification in calculation comes along when only two resistors are wired in parallel. For we then have

$$\frac{1}{R_e} = \frac{1}{R1} + \frac{1}{R2} = \frac{R1 + R1}{R1 \times R2}$$

Then

$$R_e = \frac{R1 \times R2}{R1 + R2} \text{ or } \frac{\text{Product}}{\text{Sum}}$$

It is important to keep in mind that this holds good for only *two* resistors.

Armed now with all the forms of Ohm's law and the equivalent resistance of series and parallel combinations, the following worked problems shouldn't give you any difficulties in understanding how the calculations are made.

1. Two resistors of 2·7Ω and 5·6Ω are wired in parallel across a 1·5V source. Find the equivalent resistance and the current drawn from the source.

As there are two resistors here, we can use the product/sum rule to find R_e:

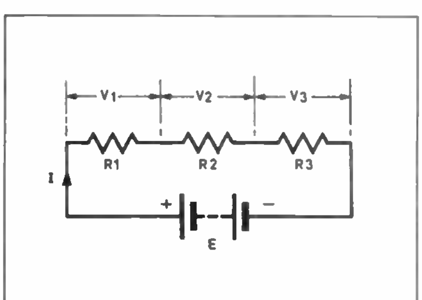


Fig. 2.1. A series circuit where I flows through each resistance and $E = V_1 + V_2 + V_3$.

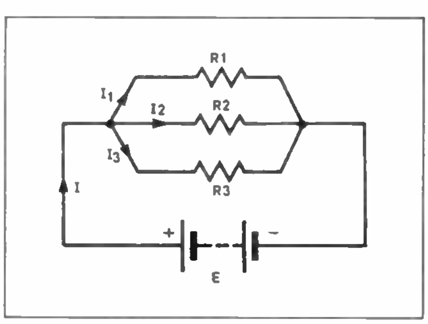


Fig. 2.2. A parallel circuit where E volts is applied to each resistance and $I = I_1 + I_2 + I_3$.

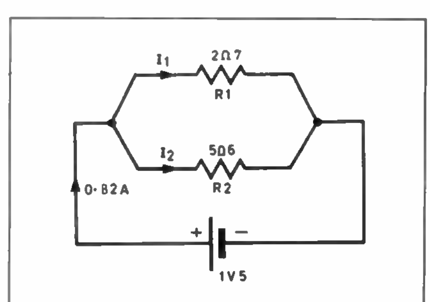


Fig. 2.3. How does the current divide in this circuit?

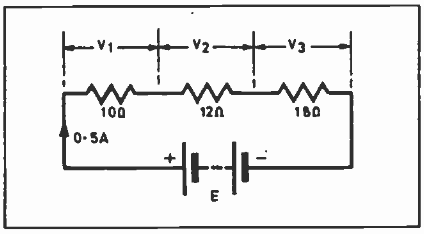


Fig. 2.4. Here we to have to find the total resistance, the e.m.f. E and the Voltages V_1, V_2 and V_3.

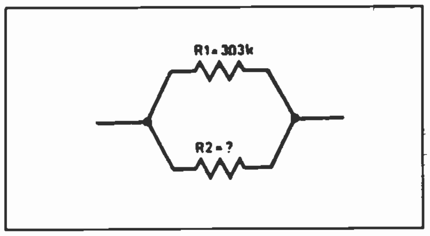


Fig. 2.5. What should R2 be so that the total resistance is 1·5kΩ?

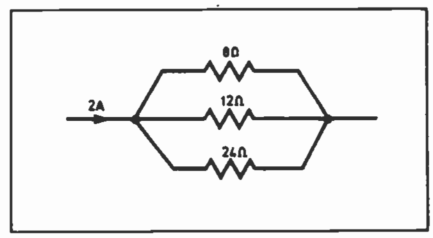


Fig. 2.6. Which is the best way of solving the current distribution – by resistance or conductance?

$$R_e = \frac{2{\cdot}7 \times 5{\cdot}6}{2{\cdot}7 + 5{\cdot}6} = \frac{15{\cdot}12}{8{\cdot}3} = \mathbf{1{\cdot}82\Omega}$$

The current drawn

$$I = \frac{E}{R_e} = \frac{1{\cdot}5}{1{\cdot}82} = \mathbf{0{\cdot}82A \text{ or } 820mA}$$

2. How does the current divide between the two resistors of the previous problem?

Well, looking at Fig. 2.3, each resistor has 1·5V across it, so the currents will be given by the application of Ohm's law once again:

$$I_1 = \frac{E}{R1} = \frac{1{\cdot}5}{2{\cdot}7} = 0{\cdot}55A \text{ or } \mathbf{550mA}$$

$$I_2 = \frac{E}{R2} = \frac{1{\cdot}5}{5{\cdot}6} = 0{\cdot}27A \text{ or } \mathbf{270mA}$$

Adding these two branch currents as a check, we find that 0·55 + 0·27A = 0·82A which agrees with the total circuit current found earlier.

3. Three resistors, 10Ω, 12Ω, and 18Ω respectively are wired in series across a battery of e.m.f E volts. If a current of 0·5A (500mA) flows from the battery find (a) the total circuit resistance, (b) the e.m.f. of the battery, (c) the voltage across each resistor.

The circuit is shown in Fig. 2.4. Get into the habit of sketching a circuit in this way; this avoids any confusion between the various units, resistor numbering and so on.

(a) $R_e = R1 + R2 + R3 = 10 + 12 + 18 = \mathbf{40\Omega}$

(b) E.m.f. $E = IR_e = 0{\cdot}5 \times 40 = \mathbf{20V}$

(c) The same current (0·5A) flows through each of the resistors, so we can say

$$V_1 = IR1 = 0{\cdot}5 \times 10 = \mathbf{5V}$$
$$V_2 = IR2 = 0{\cdot}5 \times 12 = \mathbf{6V}$$
$$V_3 = IR3 = 0{\cdot}5 \times 18 = \mathbf{9V}$$

As a check on our working, the sum of the individual p.d.'s should equal the e.m.f. E: 5 + 6 + 9 = 20V which they do.

4. What would you parallel with a 3·3kΩ resistor to give you an equivalent resistance of 1·5kΩ? Fig. 2.5 shows the situation; when we add R2 to the 3·3kΩ resistor we should finish up with a 1·5kΩ resistor. We know that a simple rearrangement of the parallel formula for two resistors we shall have

$$\frac{1}{R_2} = \frac{1}{R_e} - \frac{1}{R1} = \frac{R1 - R_e}{R1 \times R_e}$$

from which

$$R2 = \frac{R1 \times Re}{R1 - Re} = \frac{\text{product}}{\text{difference}}$$

Going back to the problem, and treating R_2 as the resistance we need to find, we write

$$R2 = \frac{3{\cdot}3 \times 1{\cdot}5}{3{\cdot}3 - 1{\cdot}5} = \frac{4{\cdot}95}{1{\cdot}8} = \mathbf{2{\cdot}75k\Omega}$$

Notice here that we are working in terms of kilohms, so that the answer will be in kilohms. Don't complicate things by using the values in ohms in a case like this; this leads to large and awkward numbers where mistakes can be more easily made.

The answer 2·75kΩ is not a preferred resistor value but with normal tolerances, a 2·7kΩ would doubtless do the job.

USING CONDUCTANCES

We introduced conductance in Part 1 of this series and saw that

$$\text{Conductance (G)} = \frac{1}{\text{resistance (R)}} \text{ Siemens (S)}$$

This provides us with a very convenient method of finding the equivalent resistance of a number of resistors in parallel and is suited to calculators with a reciprocal (1/x) key. What we really have in the formula for resistances in parallel is the sum of conductances, that is

$$\frac{1}{R_e} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \text{ is the same as } G_e = G_1 + G_2 + G_3$$

Hence, the *sum* of the conductances gives us the total equivalent conductance, G_e, which, being inverted, provides the equivalent resistance. Here is an example:

$$\text{Let } R_1 = 15\Omega, \text{ then } G_1 = \frac{1}{R1} = \frac{1}{15} = 0{\cdot}0667\text{ S}$$

$$\text{Let } R_2 = 75\Omega, \text{ then } G_2 = \frac{1}{R2} = \frac{1}{75} = 0{\cdot}0133\text{ S}$$

$$\text{Let } R_3 = 150\Omega, \text{ then } G_3 = \frac{1}{R3} = \frac{1}{150} = 0{\cdot}0067\text{ S}$$

$$\text{Then } G_e = G_1 + G_2 + G_3 = 0{\cdot}0667 + 0{\cdot}0133 + 0{\cdot}0067 = 0{\cdot}0867\text{ S}$$

$$\text{Hence } R_e = \frac{1}{Ge} = \mathbf{11{\cdot}53\Omega}$$

DIVISION OF CURRENT

Looking back at Problem 2 above, we learned there a method of finding the current in each branch of a parallel circuit. Only two resistors were involved, but the method can clearly be applied in exactly the same way for any number.

We can illustrate an alternative method by thinking in terms of conductance: the branch with greatest conductance (the smallest resistance) will take the greatest share of the current, and conversely. Once we have found the shares, the current can be readily split up into them.

In Fig. 2.6 we have three resistors in parallel. The current flowing into this circuit divides inversely as the resistances but *directly* as the conductances. So if the resistances are R_1, R_2 and R_3 respectively, the current divides among them in the ratio 1/R1, 1/R2 and 1/R3, or as G_1, G_2 and G_3. Hence we can say

$$I_1 : I_2 : I_3 :: G_1 : G_2 : G_3$$

We will illustrate this method by an example. Of course, if you are working out problems of this sort for yourself, use whichever method you feel happiest with.

6. The resistors of Fig. 2.6 are respectively 8, 12 and 24Ω. If the total current is 2A, find the current in each branch.

The current is shared in the ratio of the conductances:

$$\frac{1}{8}:\frac{1}{12}:\frac{1}{24} :: \frac{3:2:1}{24}$$

Therefore the *total* number of shares is 6, and the current divides as follows:

$$\text{current in the } 8\Omega \text{ branch} = \tfrac{3}{6} \text{ of } 2 = \mathbf{1A}$$

$$\text{current in the } 12\Omega \text{ branch} = \tfrac{2}{6} \text{ of } 2 = \mathbf{0{\cdot}67A}$$

$$\text{current in the } 24\Omega \text{ branch} = \tfrac{1}{6} \text{ of } 2 = \mathbf{0{\cdot}33A}$$

This method does save a bit of work; there is no need to find either the equivalent resistance or the applied voltage as we did in Problem 2.

INTERNAL RESISTANCE

When a cell or battery (or any other source of e.m.f. for that matter) supplies current to an external system, then a part of the e.m.f. generated is required to drive the current through the *internal* resistance of the source itself. This internal resistance is very small in a new or freshly charged battery but increases as the battery "runs down". Because of this, the voltage measured at the terminals of the source falls as the battery ages so that eventually we either chuck it away or give it a recharge.

From Fig. 2.7 we see that for an internal resistance r ohms and a circuit current I amps, the voltage drop across r will be Ir volts and

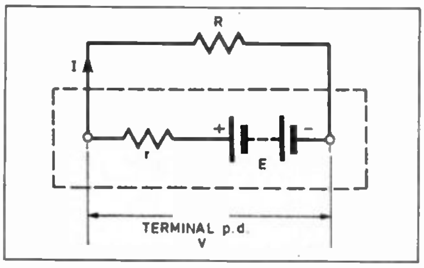


Fig. 2.7. How internal resistance affects the terminal p.d.

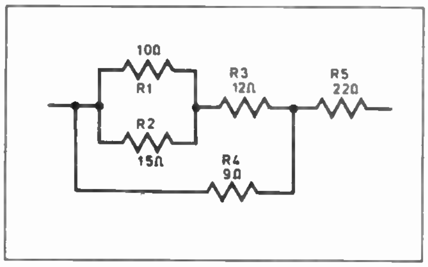


Fig. 2.8. What is the equivalent resistance of this circuit?

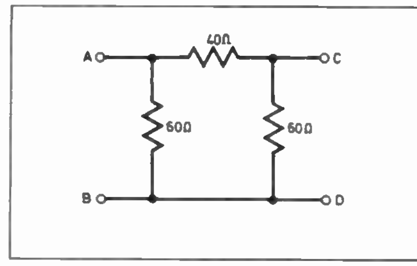


Fig. 2.9. A simple circuit with a curious property.

hence the terminal p.d. will be the e.m.f. minus the internal drop. Or in symbols $V = E - Ir$.

If no current is drawn from the battery, there is no voltage drop across r and the voltage at the terminals is equal to the e.m.f. With an external load connected, however, the greater the current drawn, the greater the internal voltage drop and the smaller the terminal p.d. becomes. As we shall see in due course, internal resistance is not simply restricted to batteries.

Here are a couple of examples so that you will be able to deal with internal resistance problems. Remember, it's just Ohm's law again.

7. A cell has an e.m.f. of 1·5V and an internal resistance of 0·05Ω. Find the terminal voltage when a load resistor of 4Ω is connected to the cell.

Here we have $E = 1{\cdot}5V$, $r = 0{\cdot}05\Omega$. Then the total circuit resistance (from Fig. 2.7) is $4 + 0{\cdot}05 = 4{\cdot}05\Omega$ and the circuit current will be

$$I = \frac{E}{R_e} = \frac{1{\cdot}5}{4{\cdot}05} = 0{\cdot}37A$$

Hence the terminal p.d. will be

$$V = E - Ir = 1{\cdot}5 - (0{\cdot}37 \times 0{\cdot}05)V$$
$$= 1{\cdot}5 - 0{\cdot}0185$$
$$= \mathbf{1{\cdot}48V}$$

8. When a battery is connected to an external resistance of 4Ω the circuit current is 1·5A, and when it is connected to 9Ω it is 0·75A. Find the e.m.f. and internal resistance of the battery.

We can use the formula $E = I(R + r)$ here. With the 4Ω resistor connected we have $E = I(R + r) = 1{\cdot}5(4 + r)$, and with the 9Ω resistor connected we have $E = 0{\cdot}75(9 + r)$. Hence we have two equations and two unknown quantities. Since both of these equations are equal to E, their right-hand sides must also be equal, so we get

$$1{\cdot}5(4 + r) = 0{\cdot}75(9 + r)$$

and multiplying out $6 + 1{\cdot}5r = 6{\cdot}75 + 0{\cdot}75r$

Therefore $1{\cdot}5r - 0{\cdot}75r = 6.75 - 6$

or $0{\cdot}75r = 0{\cdot}75$

Therefore $\mathbf{r = 1\Omega}$

Substituting this value for r back into *either* of the original equations we find that $\mathbf{E = 7{\cdot}5V}$.

SERIES-PARALLEL CIRCUITS

Circuits made up of series and parallel combinations of resistors do not often turn up in practical designs, but they do in some examination papers and we conclude this month's subject with methods of dealing with them.

A combined arrangement of this type is shown in Fig. 2.8. The total equivalent resistance R_e of such circuits can be found by progressively reducing all the parallel parts to a single equivalent, then adding together any series parts remaining. You may have to do this a number of times, but the circuit can always be reduced to a single equivalent in the end. Though perhaps it is fair to say that for some circuits, techniques beyond those we have studied here must be used!

Turning to Fig. 2.8, to resolve this we first of all eliminate the parallel group of R1 and R2. Using the product/sum rule, we find that 10Ω and 15Ω in parallel come to 6Ω (be sure and try this for yourself); this 6Ω is now in series with R3 which is 12Ω making a total of 18Ω, which itself is in parallel with R4. Again using the product/sum rule, we find that 18Ω in parallel with 9Ω gives us 6Ω. Finally we have 6Ω in series with R5, 22Ω, making a final equivalent equal to 6 + 22 = 28Ω.

As an exercise, make a circuit sketch for each of the steps outlined in the text above.

Now here are last month's solutions and a further set of self-assessment problems for this month.

1. Find the equivalent resistance of 9, 18 and 36Ω in parallel.
2. In Fig. 2.9, what is the resistance between terminals A and B? If a 9V battery is connected to A and B, what will be the voltage between C and D?
3. If N resistors, all of the same value RΩ, are wired in parallel deduce that the equivalent resistance is R/NΩ.
4. Six 120Ω resistors are wired in parallel. What is the equivalent resistance?
5. How many 1MΩ resistors must be connected in parallel to give an equivalent resistance of 200kΩ?
6. If the resistance ratio of two resistors wired in parallel is 1:2, then the current ratio is 2:1. Is this a true statement?
7. The transistor shown in Fig. 2.10 draws a current of 2mA from the 9V supply. What would a voltmeter connected as shown read?

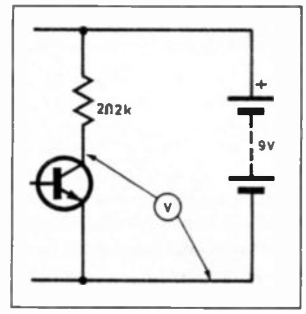


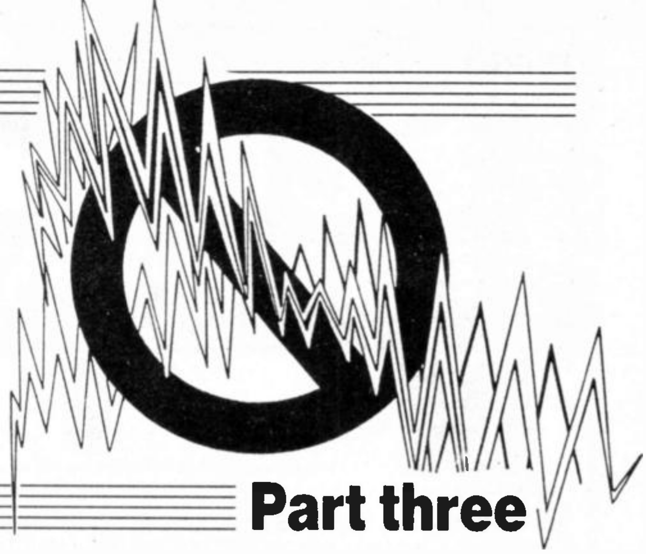
Fig. 2.10. What is the voltage at the collector?

8. If a 30Ω resistor is connected between terminals C and D in Fig. 2.9, what resistance will be measured between A and B? Do you notice anything "curious" about your answer?
9. A circuit has two resistors of 20Ω and 30Ω connected in parallel. This group is then joined in series with a third resistor of 18Ω. What is the equivalent resistance and what current flows in each resistor when the circuit is connected to a 6V supply?
10. A cell has an e.m.f. of 1·45V and an internal resistance of 400milliohms (mΩ). It supplies a current of 350mA to an external circuit. Find (a) the terminal p.d. (b) the external resistance.

Last month's answers: 1. The coulomb; 2. $1{\cdot}58 \times 10^{-19}$C; 3. 180 secs; 4. 0·021S; 5. 8Ω; 6. 11·75V, p.d.; 7. (a) 15×10^{-3}A (b) 256×10^{-6}V (c) $8{\cdot}2 \times 10^6\Omega$ (d) 3·185S (e) 650×10^{-6}C; 8. I = VG, V = I/G, G = I/V.

Next month: Work, energy and power.

Special Series



SAFETY FIRST!

T.R. de VAUX-BALBIRNIE

Part three

Staying alive with electrical equipment

THIS is the third article in a four-part short series concerned with household electrical safety. Over the last two months, we have discussed the danger of electric shock, the theory and some life-saving first-aid procedures. This month and next, we shall look at some other dangers arising from the use of electricity – *over-heating* and *fire*.

HOOKED ON CARAVANS

However, following-on from last month, we shall first look at some safety aspects in the use of mains hook-up facilities in touring caravans. This may be helpful to some readers.

There will be no problem if the user is content to use only a rechargeable (car-type) battery to provide an extra low-voltage (12V) supply for lights, water pump, etc. This is too low to present a shock hazard. However, although such a supply is adequate, there is often a wish to operate *mains* appliances and this has certain advantages, chief of which is that electricity may be used more liberally. On the other hand, mains hook-up installations can be dangerous if not correctly installed and maintained.

A caravan amounts to a metal box which is normally isolated from the ground due to the insulating effect of the rubber tyres. When hooking-up to the mains it will be necessary to Earth the caravan (see Fig. 1). If this is not carried out and the live (L) wire touched a metal part of the structure, then a person touching the caravan and having some contact with the ground would receive an *earth-loop shock*. This type of electric shock was considered in some detail last month. Since the ground could be wet, such a shock could easily prove fatal.

If the caravan became live with its structure earthed, a large current would flow from live to earth and complete the circuit to neutral. This would blow a fuse immediately so isolating it from the supply. The following information covers the main practical points but readers requiring further guidance should seek specialist advice at a reputable caravan centre.

ROUND-PIN SOCKETS

Mains hook-up supplies at caravan pitches terminate in special 16A round-pin sockets providing live (L), neutral (N) and earth (E) connections. For some reason, the live and neutral connections are the opposite way round compared with a standard UK socket. Each has a fuse or other over-current protection and groups of sockets are protected by an RCD (Residual Current Device).

Regulations state that there should be no more than 20m (66ft approximately) between a supply socket and any caravan intending to use it. Also, in the UK, no more than one caravan may use the same outlet.

A matching inlet *plug* fitted with a waterproof cover is fitted on the side of the caravan (see photograph). This is linked to the supply using a line socket and a length of up to 25m (82ft approximately) of three-core flexible cable. This will have 2·5mm^2 conductors providing a maximum loading of 16A which is more than adequate in practice.

The Live, Neutral and Earth wires inside the caravan lead to a small consumer unit. This has a double-pole main switch, an RCD and a separate fuse for each circuit. A thick wire is securely attached to the caravan chassis and is connected to the earth pin on the plug. There will be a notice with standard wording attached near the main switch – this provides the user with information concerning safe use of the system.

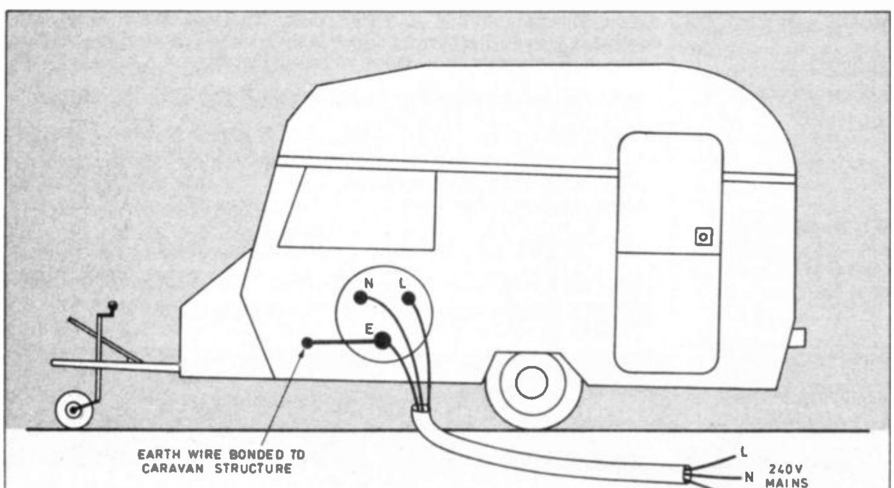


Fig. 1. The caravan body and chassis must be earthed.

It is essential for the caravan installation and flexible lead to be tested at a caravan centre every three years – more if it is used often. Note that, when in use, the lead *must be fully uncoiled* from any reel on which it is stored to prevent any possibility of overheating (see later).

We now go on to the main part of this month's work – *danger of overheating and fire.*

FIRE!

In the UK there are some 55,000 accidental fires each year killing 650 people and injuring a further 8,000. Many thousands of incidents are not reported because they cause only slight damage and minor injuries. A large proportion of fires are caused by electrical faults and misuse of electrical equipment but almost all could have been avoided by exercising simple precautions. Every household should have a fire extinguisher – even a simple dry powder one is adequate for minor fires but, remember, *never use a water-type extinguisher on an electrical fire.*

The electrical installation in a house does not remain in good condition for ever. Householders are advised to have it checked professionally every 15 years and certainly before moving into a house where there is evidence of amateurish additions to the system.

One sign that re-wiring is necessary is the existence of round-pin sockets and old-fashioned surface-mounted light switches. Fixed-wiring jobs are best left to the professionals unless you are certain that you know what you are doing. Amateurs installing mains wiring accounts for a high proportion of all fires since they often choose a cable having too low a current rating for the job.

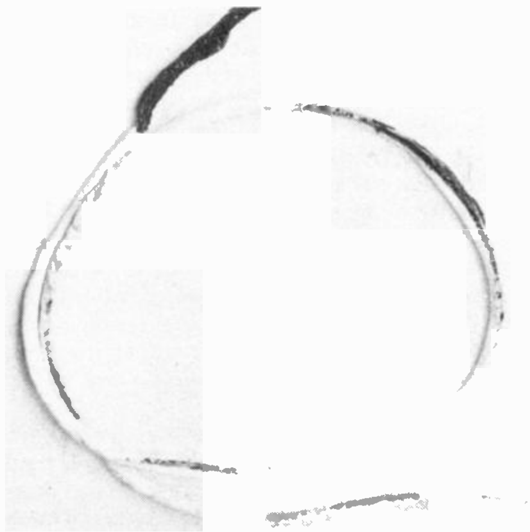
If you are unfortunate enough to have a fire at home, follow this procedure. Note that further information may be obtained from your local Fire Brigade.

Procedure in the event of fire

- Decide if you can safely tackle the fire yourself. Never use water or a water-type fire extinguisher on an electrical fire.
- If you cannot deal with the fire yourself, *get out of the room* and *close the door.* This will delay the spread of fire. Ordinary doors are effective in containing fire until the Fire Brigade arrives.
- Get everyone out of the house and *dial 999* from a neighbour's house or public telephone. *Never go back into the building.*

BASIC THEORY

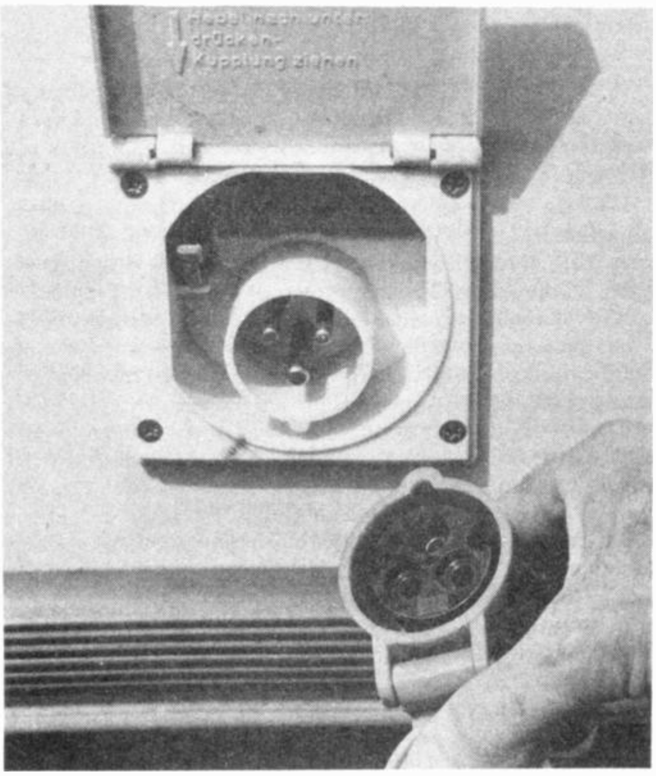
When an electric current flows through a wire, heat is produced. This effect is put to good use in an electric fire, soldering iron or light bulb. In other situations, it is a nuisance and wastes energy. Where the heat is produced in a connecting wire, it is important that it is thick enough to carry the current safely so that there is no excessive rise in temperature.



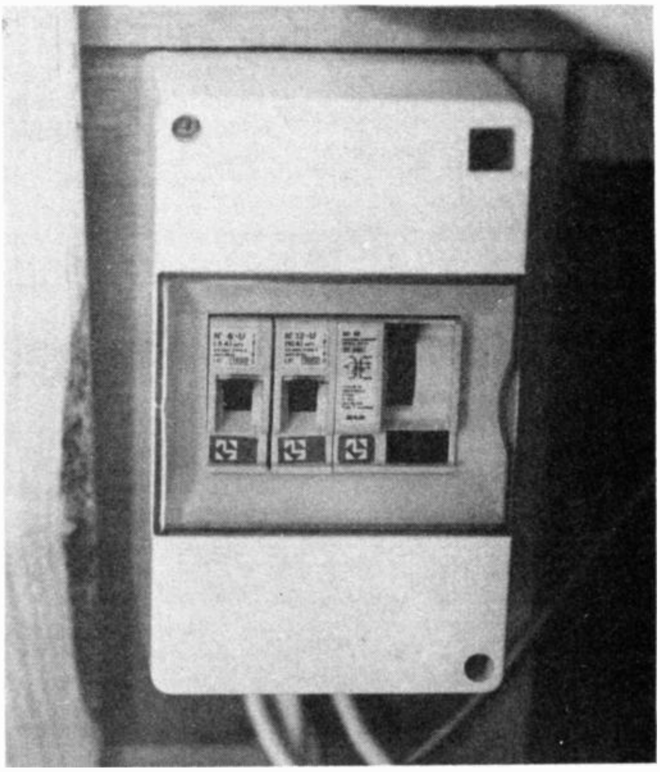
Never use underrated cable. The overheating of the wire will melt the insulation and it may even burst into flames causing a major fire.

Using wire of a thinner type than needed – perhaps for an extension lead – is a common cause of fire. Suppose a piece of wire rated at 6A is used for an electric fire requiring 13A. The copper conductors would soon overheat, the plastic insulation melt and begin to burn (see photograph). If there was combustible material nearby this could cause a major fire.

If some copper strands are lost when the insulation is removed from the end of a piece of wire – probably to fit a plug – this can lead to local overheating when it is operating near to its maximum current capacity. This is because the wire is made effectively thinner and the current-carrying capacity reduced.



Caravan site mains "hook-up" 16A round-pin outlet socket and matching caravan plug, with waterproof flap.



Caravan consumer unit. This has a double-pole switch, an RCD trip and a separate fuse for each circuit.

Ideally, the heat should be free to leave the surface of a wire and be carried off into the air. Particular care must be taken when using a cassette-type extension lead of the type which winds into a plastic casing (see photograph). Suppose the wire is rated at 13A. This figure is quoted for use in *free air*. For this reason, when carrying a high current, the wire must be fully uncoiled. If it is partially wound into the cassette, the wire will not be able to rid itself of the heat so effectively, possibly overheat and cause a fire.

Commercial extension leads are usually fitted with a thermal cut-out but this cannot be relied on. For a capacity of 13A when unwound, a typical rating is only 6A when wound in – figures such as these will be inscribed on the plastic case (see photograph) *and must never be exceeded*.

There is some confusion because the general public cannot easily relate current (*amps*) with the more familiar *wattage* (power rating) of an appliance. This involves using a simple formula (see below). Readers who have been following the series will recognize it as the same one used in Part 1 to predict *Electric shock current:*

$$I = P/V$$

Where I is the current in amps, P the power of the appliance (in watts) and V, the voltage of the supply.

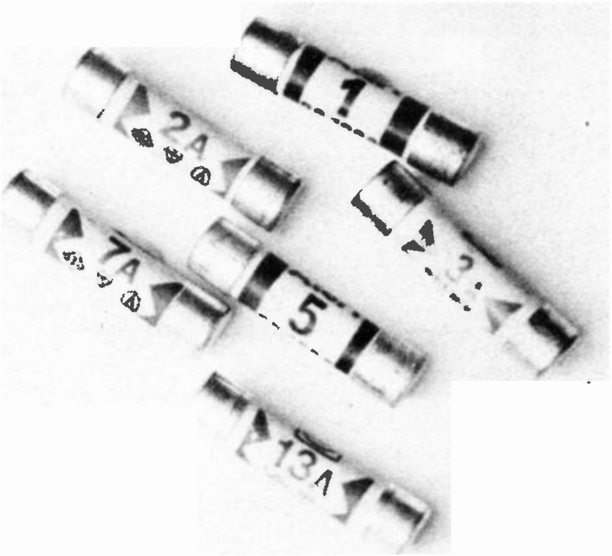
By dividing power by voltage, the current if found. Suppose the extension lead above were to be used for a 2kW (2000 watt) electric fire operating from 240V mains. Using the above formula:

$$I = P/V = 2000/240 = 8{\cdot}33\text{A}.$$

This shows that it would be safe to operate the fire with the extension lead fully unwound but the wire would overheat if it were left wound on its cassette. On the other hand, if a soldering iron of rating 15W on 240V mains were to be used with the same extension lead, a similar calculation shows that the current would be only 0·063A (63mA) and so safe to use with the wire fully wound on the reel.

BLOWING A FUSE

People frequently buy extension leads having a current rating only just sufficient for their immediate needs – probably because it is cheaper. If you buy one which is rated at 6A, it will be necessary to prevent someone using it with an appliance which requires a higher current. This would involve fitting a 5A fuse in the mains plug. This would blow straight away if the rating was exceeded.



A selection of cartridge fuses from 1A to 13A.

A commercial extension lead showing the coiled (6A) rating and the fully unwound (13A) rating inscribed on the cable housing.

Incidentally, all the following plug fuse values are available: 1A, 2A, 3A, 5A, 7A, 10A and 13A. However, if buying locally you will probably have to be content with a limited range. People often leave the 13A fuse in the plug because it was there when they bought it. This is *dangerous* because it provides no safety in the event of overload.

A fuse is just a thin piece of wire – usually copper – which is protected by a heatproof case. The fuse is meant to be the weakest (that is, most easily melted) part of a circuit and will "blow" before there is any danger. A standard UK plug fuse has a case made of *high-rupture ceramic*. This is strong enough to contain the flying pieces of red hot copper which are produced when a fuse blows violently.

The thickness of the wire in the fuse is carefully selected so that any current up to its rated value can be accommodated but the wire will become hot, melt and break the circuit very quickly in the event of an overload. *Never bridge the fuse clips inside a plug with a piece of wire or aluminium foil to make a temporary fuse.*

CHOOSING THE CORRECT FUSE

When a piece of equipment is purchased, the correct plug fuse value will be advised in the instructions. However, this may not be known for appliances which have been in the house for a number of years. The formula used previously may then be used to find the correct value. Note that the power rating is usually given on a metal plate or piece of tape located on the back or underside of the appliance.

Example: *A toaster is rated at 800W and is connected to the 240V mains supply. What is the correct value of fuse to use in the plug?*

Using: $I = P/V = 800/240 = 3{\cdot}3\text{A}$.

A 3A fuse would be unsuitable. The next easily-obtainable value is 7A which is satisfactory but a 5A fuse, if available, would be an even better choice.

Example: *A soldering iron is rated at 25W. This is connected to the 240V supply mains. What is the correct value of fuse to use in the plug?*

Using : $I = P/V = 25/240 = 0{\cdot}104\text{A}$

It is likely that a 3A fuse will be the lowest value which can be obtained locally but a 2A or 1A fuse would be better.

Sometimes, where *inductive* loads such as motors are involved, the theoretically "correct" fuse keeps blowing because of the current surge which occurs on switching on. If this happens, refer to the instructions or contact the manufacturer. Everyone should do a plug fuse check in their home. It is likely that you will find 13A fuses in many of the plugs where a lower value would be much better.

NEVER REFUSE

A fuse must never be replaced with one of a higher rating without competent advice. It has been known for a householder to replace a fuse in the main fusebox with a thick nail in an attempt to prevent it from blowing. Obviously, the nail will withstand an enormous current – hundreds of amps – and will no longer be the weakest part of the circuit. Some section of the wiring is now likely to overheat and cause a fire. In one sad tale, the wire ran close to a lead gas pipe which melted and released gas. The resulting explosion totally destroyed the house.

A fuse does sometimes blow due to "old age" especially when being used near the limit of its rating. However, do not replace a fuse until you have investigated possible causes. If you cannot find the cause, replace the fuse *once*. If it blows again, *seek professional advice*.

It often happens that people join together pieces of wire of differing thicknesses to make one long extension lead. This is asking for trouble. The combination can only handle the current of the thinnest wire.

Twisted and taped joints are another cause of trouble. Where wires are joined together by twisting, the contact between the pieces of conductor will not be perfect and the joint is likely to have a higher resistance than the rest of the wire. This may lead to local overheating and possible fire. Also, a twisted joint is mechanically weak so, with an accidental pull, the bare conductors may be exposed and give rise to a risk of electric shock.

Ideally, wire should not be joined at all but bought in one length. However, if it has to be joined, a proper flex connector having cable clamps may be used. These connectors are often of less than 13A rating so the plug fuse should be chosen to take account of this as well as the rating of the wire itself (whichever is the lower). Readers who have not been following the series should note that further information was given about the safe use of flex connectors and extension leads last month.

MULTIPLE ADAPTORS

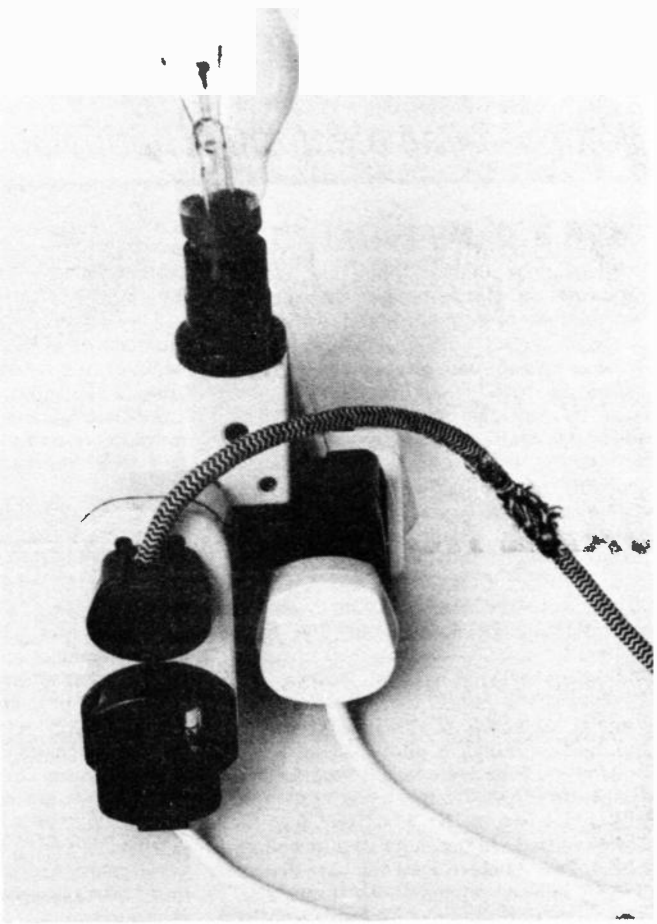
People forget that the maximum current which can be supplied through a multiple adaptor is 13A ***total***. Unfortunately, these do not generally have an internal fuse which would be a safety measure.

Suppose a double adaptor were used for a kettle requiring 13A and a fire needing 8A – a total of 21A. The fuse at the main fusebox will be appropriate for the whole ring-main – usually 30A. This will not blow but it is likely that the adaptor itself will overheat and possibly cause a fire.

Multi-way adaptors are sometimes necessary and can be acceptable if used within their rating. Multiple adaptors riding piggy-back on further adaptors to increase the number of outlets (see photograph) is asking for trouble. The popular type of 4-way or 8-way distribution sockets are better but must, again, be used with caution – the total loading must not exceed 13A and less if the connecting wire has a lower current rating than this. These sockets have an internal fuse which should be appropriate to the wire being used.

CURRENT SITUATION

Returning to the "Power Equation", it can be seen that low voltage supplies require a larger current for a given power compared with a high voltage. To illustrate this, compare the current passing through the connecting wires of a 12V 48W car headlight bulb and a 100W light bulb connected to the 240V mains.



Using multiple adaptors, "piggy-back fashion", on a single outlet is asking for trouble and ***must be avoided.***

In the case of the headlamp, the current is:

$$I = P/V = 48/12 = 4A$$

But in the case of the 100W mains bulb, it is:

$$I = P/V = 100/240 = 0{\cdot}42A$$

This seems surprising. The car headlight has a lower power rating than the mains bulb yet more current flows in the circuit. In practice, this means that automotive wiring is generally fairly thick to carry the large currents involved. When wiring-up car accessories it is essential to use proper auto-type wire of the appropriate rating.

Vehicle fires are often caused by amateurs using thin mains-type wire or light-duty "bell wire" to connect high-powered accessories. Consider a pair of spotlights rated at 200W total. The current in the feed wires will be:

$$I = P/V = 200/12 = 17A \text{ approximately}$$

If mains-type wire of 3A rating were used, the result could be catastrophic. A similar cause of fire is plugging a "power" appliance into the household lighting circuit. This will be looked at in more detail next month.

For complete safety, all electrical appliances should be switched off at night and unplugged from the mains. This may have been easy years ago but it is more difficult today in the world of video recorders and digital clocks.

Unplugging these is impractical and they have been designed to be powered continuously. However, overheating will occur if the ventilation holes are covered up or the air flow restricted in some other way. Check how warm the case feels every so often and disconnect the appliance if there is any sign of an abnormal rise in temperature.

That's all for this month. Next time we shall complete the series by continuing with our discussion of fire. We shall look particularly at the use of car batteries and examine some other sources of danger – Direct and Indirect Burns and some Chemical Hazards.

Home Base

Jottings of an electronics hobbyist – Terry Pinnell

Who Makes What?

Where does all that solder and circuit board end up? Not to mention those countless millions of components? It would be interesting to see a really thorough survey of what we hobbyists actually construct. If there has been one, then I've missed it.

Of course, the construction mix has changed significantly over the years. Nowadays, for example, there are probably many more digital circuits getting built than analogue, and I expect computer-orientated projects in particular feature strongly. But over the last decade or so I wonder if the average constructor's output would be much different from the sort of things I've turned out? I've been doing a little analysis of my own projects, and the pie chart in Fig.1 boils it down.

I have my Finished Circuits Binder to thank as the source of this data. I used to find that, although a circuit seemed obvious at the time I made it, I would soon completely forget how it worked, even after only a few weeks. So I started keeping written records, in the shape of a loose-leaf binder. I'd scribble at least the bare details of every finished project on A4 sheets, give it a name – hopefully one I'd recall months or years later – punch some holes in it and just file it alphabetically. The set now consists of three separate thick binders and contains some 145 different projects, split over nine broad categories.

What's in a Name?

There are clearly lots of ways you can classify circuits, depending on how your mind works and on what you want to do with the results. My nine categories are an admittedly arbitrary choice, made recently I hasten to add, not selected way back and sustained throughout the years. Not that I didn't give it some thought before homing in on this particular set. One of the problems was that useful labels are often not mutually exclusive. Is a burglar alarm for the house best pigeon-holed in the Domestic or Alarm category? After all, any project used indoors could logically be classified as Domestic.

Similarly, is a gong used in a car alarm best labelled Audio or Alarm or Car? What about a headlamp-operated garage light – Car or Domestic? Not that it's a matter of earth-shattering importance anyway; I'm not going to get arrested for mis-coding anything!

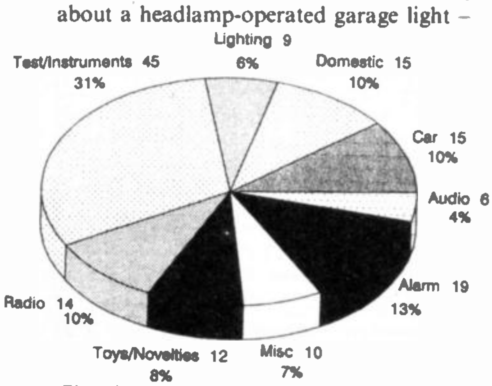


Fig. 1. A decade or so of electronics construction.

I also had some difficulty keeping the number of projects allocated to Miscellaneous to a minimum. It helped to introduce a Toys/Novelties category, reserving Miscellaneous for those projects that wouldn't even fit in that. Judge for yourself from the two lists out of the nine types.

Incidentally, I did cheat a bit in coming up with the 145; there was a handful of projects that I'd somehow left out of the binder, so those had to be added retrospectively. Of these, a few were arguably not "projects" at all, but on balance I decided to put them in.

For instance, my cupboard light would come high in a bid for the title of Most Trivial Project. It consists of a microswitch and a few lengths of wire, supplying mains voltage to an overhead bulb whenever the door to the under-stairs cupboard is opened. But as it was just about the first constructive thing I did after mastering the basic principles of electricity, I thought it deserved a place, on sentimental grounds if nothing else.

Cutting Remarks

Top place for triviality surely goes to the Polystyrene Cutter though. That is nothing more than a couple of feet of resistance wire, with hooks on either end. It's cheeky to call it a finished project, as it is really an accessory to my heavy duty battery charger, without which it doesn't do a lot. But with the wire stretched tightly between a couple of nails or whatever, and the croc-clips of my charger supplying it with an awesome 20 amps, it glows a nice red and cuts clean lines in any polystyrene you draw through it.

OK, you're probably wondering why you'd need to cut poystyrene. To be honest I can't remember an enormous demand myself. But I do recall that my Yoghurt Maker needed a biscuit tin lined with the stuff, to serve as insulation to maintain a steady temperature, which is what probably prompted the digression.

There are quite a few more candidates for that Most Trivial award. For instance, my simple attenuator consists of a four inch length of soft wood, with six nails hammered into it, and five resistors strung between them, giving four levels of attenuation (by 10, 100, 1000 and 10,000). Despite its simplicity it actually gets used occasionally too.

Another simple but much-used "project" is my CMOS tester; just a tiny plastic case with a 14 pin i.c. holder wired up to test the four gates of 4001 and 4011 chips, which I tend to use a lot. The two pins of each gate (1/2, 5/6, 13/12 and 8/9) are connected together and normally held at 0V with a 12 megohm resistor. To test whether they are working satisfactorily you just apply a logic high signal in turn to each gate and see that the outputs at pins 3, 4, 11 and 10 all go correspondingly low.

Short Waves and Sea Waves

At the complex end of the scale, I reckon that 13 of the 145 projects took me more than a month to complete. Mind you, there's no clear correlation with intricacy. For example, my house burglar alarm, built in my relatively novice period, probably took me a couple of months (plus various enhancements over subsequent years). Looking at the circuit now it seems like it should be no more than a couple of week's work.

Apart from circuit design and the personal learning curve, there's the issue of physical construction difficulty too. In that particular case, as I was using reed switches in doors and windows, a major chunk of the effort was the wiring. That was true of some of my car alarms also; getting a connection from A to B without dismantling the vehicle sometimes took an inordinate length of time. Similarly, making my sound-to-light unit in its tall, wooden, glass-fronted case proved to be more of a challenge to my poor carpentry skills than any prowess in electronics.

One genuinely complex design of which I was proud was my twelve band short wave radio. Mastering the mysteries of the superheterodyne gave me great pleasure, and at the flick of a switch the radio still works perfectly. Waves also featured centrally in another project of similar complexity, my surf simulator. A bedside toggle brings the sound of crashing breakers, complete with the deeper roar of shingle and the constant, soporific background hiss.

Unlike a tape recording (which would have been a lot easier!) it has the merit of being random – you don't know whether the next wave will be loud or soft, or whether it wll come in five seconds or thirty. Gradually it fades away, and there are controls to vary the time taken as well the overall volume. I recall one of the satisfying puzzles to solve was finding a way to make the fade-out absolutely smooth. Having gently soothed you to sleep over 15 to 30 minutes, that final click from the loudspeaker – inaudible in everyday circumstances – was just enough to wake you up again!

TOYS/NOVELTIES
Buzz bar
Electronic Safe
ElectroMagnetic Pulser (EMP)
EMP (large)
EMP (small)
Light Rifle
Metronome
Random Light Flasher
Siren
Train Controller
Xmas Tree Flasher
Xmas Tree Fader
TOTAL: 12

MISCELLANEOUS
Agitator
Capacitor Tester: BBC Micro
Computer light pen
Divider (for timer contest)
Light Trigger
Metal Detector (kit)
Mousetrap
Polystyrene Cutter
Yoghurt Maker
ZX81 Interface
TOTAL: 10

Constructional Project

MULTI-PURPOSE AUDIO SYSTEM

Part 5 – BALANCED STEREO MICROPHONE PREAMPLIFIER

MAX HORSEY — **P.C.B. Design PHILIP CLAYTON**

If you want to set up a home recording system, mix sound videos, run a disco or a small band then these modules are for you! All modules will operate alone, but are compatible with each other.

A BALANCED microphone pre-amp is essential for high quality work since most higher priced microphones are of the *balanced* (explained later) variety. The pre-amp described here is designed to electronically unbalance the signal and raise it to "line level"; in other words make it suitable for any mixer or power amplifier input which is designed for tape recorders, CD players, tuners etc. It may be connected to the Mixer described in Part 1 of this series and includes a 15V d.c. output which may be used to power the Six-Channel Stereo Mixer.

The preamplifier is based on a new i.c. type SSM2017. This i.c. boasts very low noise, wide bandwidth and low cost, and is available in an 8-pin d.i.l. package. It is particularly suitable for use as a balanced microphone amplifier, although it can be used with unbalanced microphones as well.

POWER REQUIREMENTS

The i.c. is designed for use on a dual rail supply, and since it only requires 22mA per rail, two PP3 9V batteries may be used. This is useful if the amplifier is to be operated out of doors.

Alternatively a dual rail 15V (i.e. +15V, 0V, −15V) supply is suitable and a mains driven power supply is included in this article.

BALANCED AUDIO SYSTEMS

The term "balanced input" or "balanced microphone" may be a mystery to many readers, but most higher priced microphones are "balanced", and so a few general words about balancing may be helpful. Many people will have experienced mains hum or other unwanted "noise" picked up by long microphone leads. The problem occurs because microphone signals are at a very low level, typically around 1mV or less, and the slightest magnetic interference from nearby mains cables or other equipment induces electrical "noise" into the microphone lead. Mains hum is very difficult to filter out since it is very close in frequency to bass sounds which are generally required. Fig. 1(a) illustrates the problem.

Clearly, screening the microphone lead will help reduce interference, but a far better solution – in addition to screening – is to use a pair of signal wires, one for the signal, and the other for an "out of phase" signal. This may sound complicated, but it makes little difference to the cost of the microphone since the two ends of the microphone coil are out of phase anyway. Providing neither end of the microphone coil is connected to the screen or "ground", the microphone will be "balanced". Most higher price microphones provide an output from each end of the coil, plus a screen or ground connection.

The clever part of this arrangement is that both signal wires will pick up the same interference. A balanced input amplifier is designed to respond only to the difference between the two input signals and reject common signals. Hence the wanted audio signal is amplified, but the interference which is the same on both wires (i.e. in phase) is rejected.

BASIC ARRANGEMENT

The pin connections for the SSM-2017 low-noise audio preamplifier i.c. are shown in Fig. 2. Note that the reference terminal (pin 5) is connected to ground (0V) in this application.

A simplified arrangement showing the principle of operation is shown in Fig. 3.

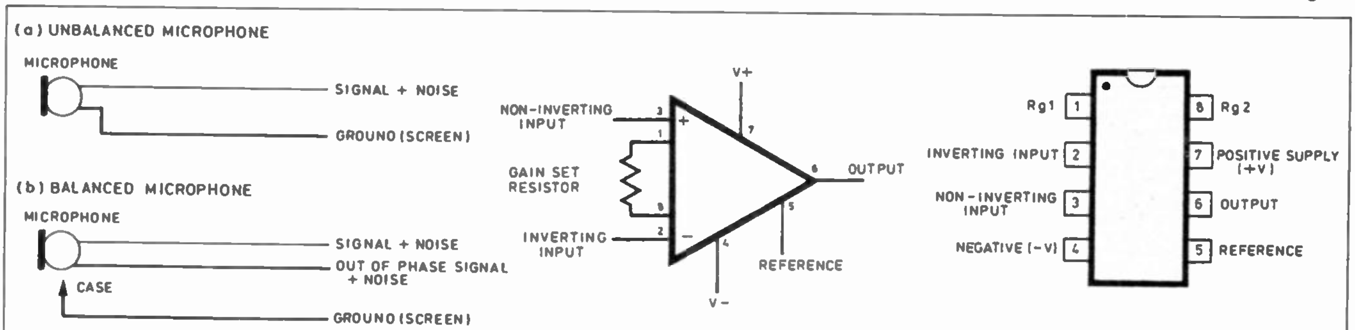


Fig. 1. Unwanted noise on balanced and unbalanced microphones.

Fig. 2. Circuit and pinout connections for the SSM-2017 low-noise preamplifier i.c.

The capacitor removes any very high frequencies which may appear at the input, and the two 6·8 kilohm resistors provide d.c. bias to keep the d.c. input voltages to within an acceptable range.

TYPES OF MICROPHONES

The circuit (Fig. 5) is capable of working with any type of microphone but it may be helpful to discuss the differing types at this stage since some components can be omitted if – for example – *dynamic* microphones are the only type to be used.

Balanced or *unbalanced* microphones may be used, but the circuit is designed for higher quality balanced microphones. The two most common types of balanced or unbalanced microphones are *Dynamic* and *Capacitor* (e.g. Electret) microphones.

Dynamic microphones work like tiny generators, generating an electrical signal whenever they receive a sound. They are robust, easy to use and can cost as little as £5 or more than £100. More expensive microphones offer a wider flatter frequency response (essential for hi-fi recordings) improved noise immunity etc. Dynamic microphones do *not* require a power supply.

Capacitor (condenser) microphones do not generate a signal, and do therefore require a power supply. The higher price types require a supply from the preamplifier circuit. This is often known as a *phantom power supply*, and Fig. 4 shows how a d.c. supply of 48V is connected to the microphone without requiring extra cables. The Zener diodes prevent damage caused by high voltages, produced when the microphone is plugged in or unplugged.

A phantom power supply may seem a lot of trouble, but the highest quality (and most expensive!) microphones are generally capacitor types.

Electret microphones are similar to normal capacitor microphones but they are generally less expensive. In fact the cheapest electret inserts (i.e. microphones without the normal case) may cost less than £1.

They require a power supply either from the circuit, or from a 1·5V battery which is often housed inside the microphone case. An electret microphone with its own internal battery should be connected to the amplifier in the same way as a dynamic microphone i.e. it does not require a phantom power supply.

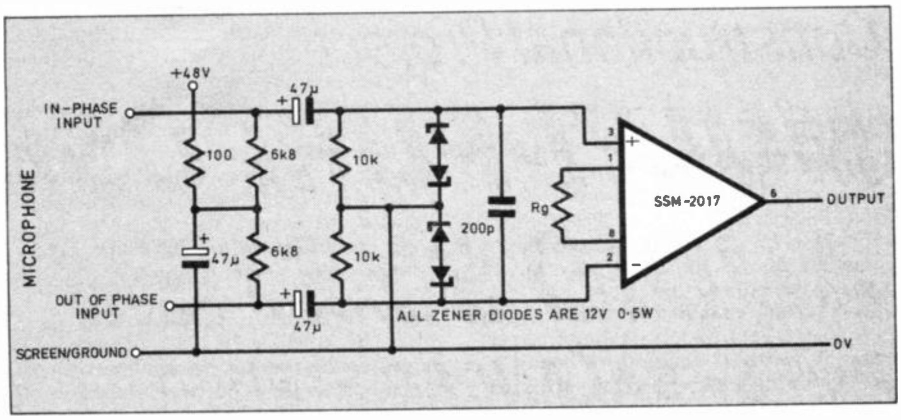


Fig. 4. Phantom powered microphone circuit diagram.

SETTING THE GAIN

Returning to Fig. 3, pins 1 and 8 of the i.c. are for the connection of a gain set resistor. The gain of the circuit is determined by the formula:

$$\text{Voltage Gain} = \frac{10\text{k}\Omega}{R_G} + 1$$

where R_G is the value of the gain set resistor.

The following table provides some typical values:

Voltage Gain	dB	Rg(Ω)
1	0	open
3.2	10	4700
10	20	1100
31.3	30	330
100	40	100
314	50	32
1000	60	10

For example, with a gain set resistor value of 330 ohms, the voltage gain is 31·3 (=30dB). A resistor value of 32 ohms produces a voltage gain of 314 (=50dB).

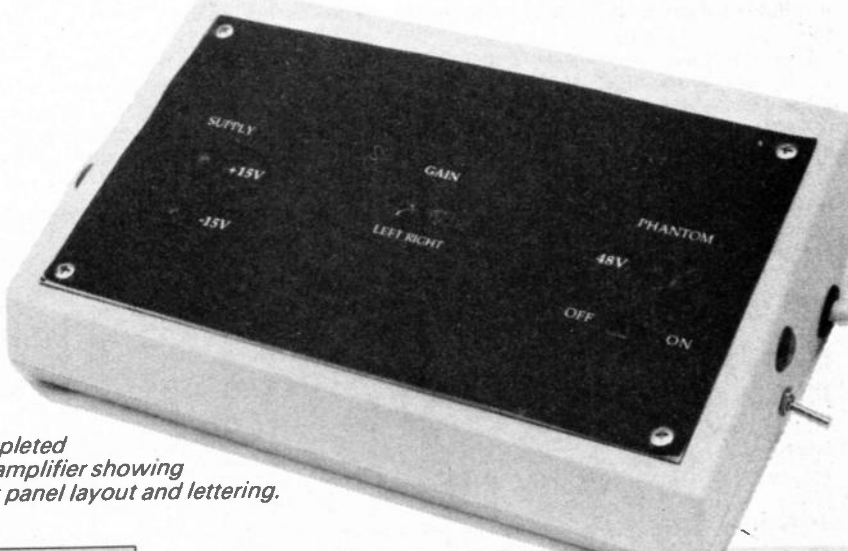
If the gain set resistor is removed, the gain will be unity (0 dB).

If the resistor value is reduced to zero, the gain will be infinite.

The maximum gain permitted is 3500, and this should be more than sufficient for most microphones. The printed circuit board has provision for a preset resistor to set the gain in each channel.

The prototype was designed so that adjustment could be made with a screwdriver through holes in the front panel. Alternatively the user could fit ordinary potentiometers (rotary or slider) if *frequent* changing of gain is required.

The bandwidth (i.e. range of audio frequencies which are amplified by the amounts quoted above) is greater than the



Completed pre-amplifier showing front panel layout and lettering.

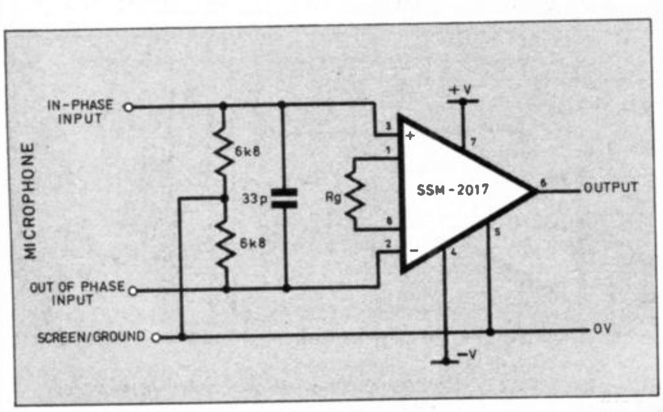
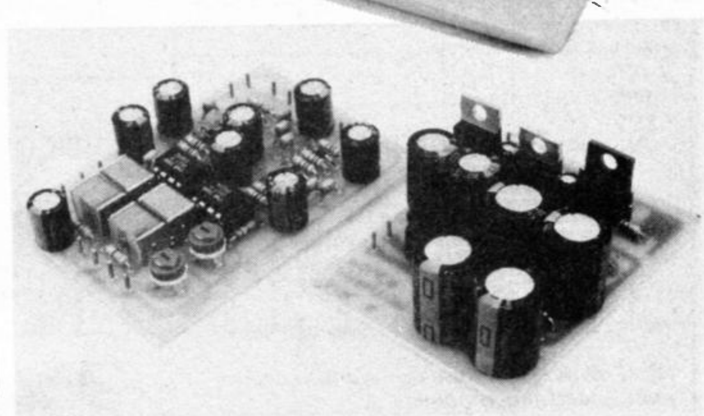


Fig. 3. Simplified circuit showing principle of operation.



human audio range. For example with a voltage gain of 1000, the bandwidth is 200kHz.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Stereo Balanced Microphone Preamplifier is shown in Fig. 5. The two stereo halves require the same circuit, and so only the left hand side will be described.

Most of the components at the input stage are required for the phantom power operating mode. If phantom powering is not required significant savings can be made as described later under "Omitting Phantom Power".

Resistor R1 couples the 48V phantom power supply to the junction between R2 and R3. Capacitors C1 and C2 ensure that electrical noise on the supply is removed. R2 and R3 feed the 48V supply equally to both balanced microphone lines. This assumes that the microphone used is designed for a +48V supply on both the in-phase and out-of-phase lines; most capacitor microphones are of this type.

Capacitors C3 and C4 allow the alternating in-phase audio signal from the microphone to flow to pin 3 of IC1. C5 and C6 do the same for the out-of-phase signal. However these capacitors block the flow of d.c., therefore preventing the 48V supply from reaching the i.c. All the electrolytic capacitors in the circuit are bridged with small 100nF capacitors since these are much better at conducting high frequency signals.

The input pins 3 and 2 of IC1 need to be referenced to 0V and this is achieved by resistors R4 and R5. These ensure that the average signal received by IC1 is 0V. Hence the output signal from pin 6 will "wobble" equally above and below 0V.

Zener diodes D1 to D4 ensure that the i.c. will not be damaged by high voltage spikes which could pass through C3 or C5 when the capacitor microphone is plugged in or unplugged. Capacitor C7 removes any high frequency noise at the inputs and capacitors C10, C11, C21 and C22 remove noise on the supply lines.

The gain set resistor is VR1. This could be a fixed resistor if you know in advance the gain required, or it could be a preset (a space is available on the p.c.b.) or it could be an external potentiometer control. Resistor R6 ensures that the total resistance cannot fall be low 3·9 ohms, otherwise the gain would be too high.

OUTPUT

The output from the IC1 is delivered via capacitors C8 and C9. These allow the a.c. audio signal to flow, but prevent the flow of d.c. which may be present. Two capacitors are used in parallel so that top quality polylayer types can be used. (These are not yet available in values of 2·2μF).

Resistor R7 prevents any damage to the i.c. if its output is accidentally shorted to ground. The value of R7 is too low to affect the output signal.

POWER SUPPLIES

The preamplifier printed circuit board (p.c.b.) (excluding the 48V supply) could be powered by two PP3 batteries, or two sets of cells arranged as shown in Fig. 6. This would be an effective supply assuming that phantom power is not required. It is important to remember to switch the circuit off when not in use – two PP3 batteries will be drained in less than 24 hours of continuous use.

A mains power supply provides a more reliable alternative, and the circuit shown in Fig. 7 provides a +15V, 0V, −15V supply in addition to a 48V supply all derived from a single mains transformer.

The current required by the balanced amplifier is about 22mA per channel. When testing, an extra 10mA was allowed, plus 10mA for the l.e.d. indicators. In other words a total of 42mA per channel.

The phantom power supply is at about 48V, and typically 2mA is required by an "average" capacitor microphone. The phantom power circuit is capable of delivering well over 10mA, plus 10mA for an l.e.d., i.e. a total of over 20mA.

SELECTING A TRANSFORMER

The maximum current required by the power supply circuit is less than about 190mA from one winding and 60mA from the other. A 6VA (i.e. 3VA per coil) transformer will therefore be sufficient since each 15V winding can deliver 200mA. A 12VA transformer will offer a higher safety margin, but in practice this is unnecessary unless several other devices are to be powered.

Another alternative worth considering is a toroidal transformer. These produce less magnetic interference, but at a higher cost. The smallest type readily available is rated at 15VA with two 15V secondaries.

It performed well in tests, but is much more expensive than a standard 6VA type. The standard 6VA transformer was therefore chosen for the prototype on grounds of cost and size. In tests it performed very well, even with the Stereo Mixer (as described in Part 1) also connected to the +15V supply.

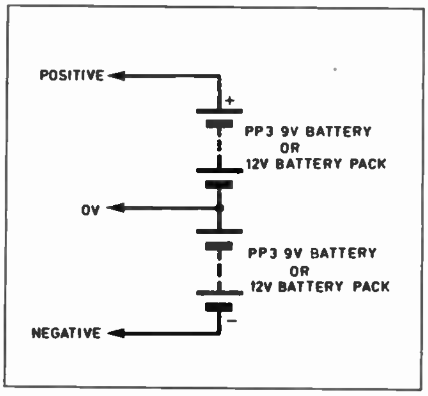


Fig. 6. Using two sets of PP3 batteries or battery packs to power the preamplifier p.c.b. (excluding the 48V supply).

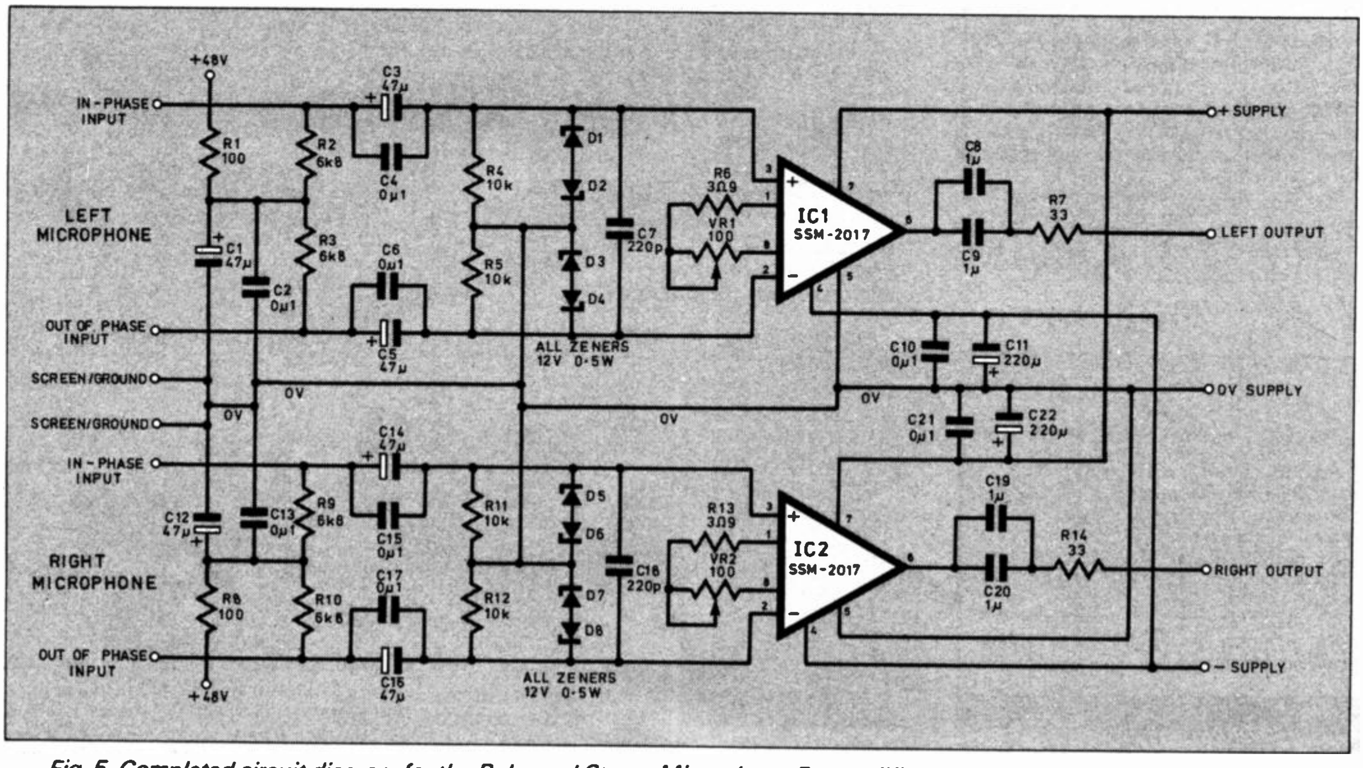


Fig. 5. Completed circuit diagram for the Balanced Stereo Microphone Preamplifier. The circuit gain is set by VR1/VR2.

POWER SUPPLY CIRCUIT

The circuit diagram for the power supply is shown in Fig. 7. The 240V a.c. mains is fed via a double-pole switch S1 to the mains transformer. The neon is connected before the switch to indicate when the unit is connected to the mains – whether or not S1 is switched on. Three l.e.d.s are employed to indicate the state of the three power supply outputs.

The transformer provides a 15V, 0V,15V a.c. supply. This is used to drive both the regulated +15V, 0V, −15V and the 48V outputs.

The bridge rectifier REC1 converts the 30V a.c. across the secondary winding of

COMPONENTS

POWER SUPPLY

Resistors
R1, R2 1k (2 off)
*R3 3k 1% metal film
*R4 82 1% metal film
*R5 6k8
All 0·25W 5% carbon, except where stated.

Capacitors
C1, C2 1000µ radial elect. 25V (2 off)
C3, C4, C5, C6 100n disc ceramic (4 off)
C7, C8 10µ radial elect. 25V (2 off)
*C9, *C10, *C11, *C12 220µ radial elect. 63V (4 off)
*C13 1µ radial elect. 63V
*C14 10µ radial elect. 63V

Semiconductors
*D1 to *D4 1N4001 50V 1A rect. diode (4 off)
D5 5mm yellow l.e.d.
D6 5mm green l.e.d.
*D7 5mm red l.e.d.
IC1 7815 +15V 1A voltage regulator
IC2 7915 −15V 1A voltage regulator
*IC3 TL783C adjustable high voltage (+1·25V to +125V) regulator
REC1 W005 50V 1·5A bridge rectifier

Miscellaneous
T1 6VA mains transformer with twin 15V 3VA per winding secondaries
LP1 Mains panel mounting neon
FS1, FS2 Panel mounting fuseholder and 500mA fuse (2 off each)
S1 Mains rated double-pole toggle switch
*S2 On/Off slide switch (optional)

Printed circuit board available from the *EPE PCB Service*, code 859; self-adhesive p.c.b. mounting plastic stand-off pillar (2 off); 3-core mains cable; l.e.d. clip (3 off); small cable ties; multistrand connecting wire; solder tag; solder etc..
Note: Components marked with an asterisk (*) may be omitted if phantom power is not required.

Approx cost guidance only **£22**

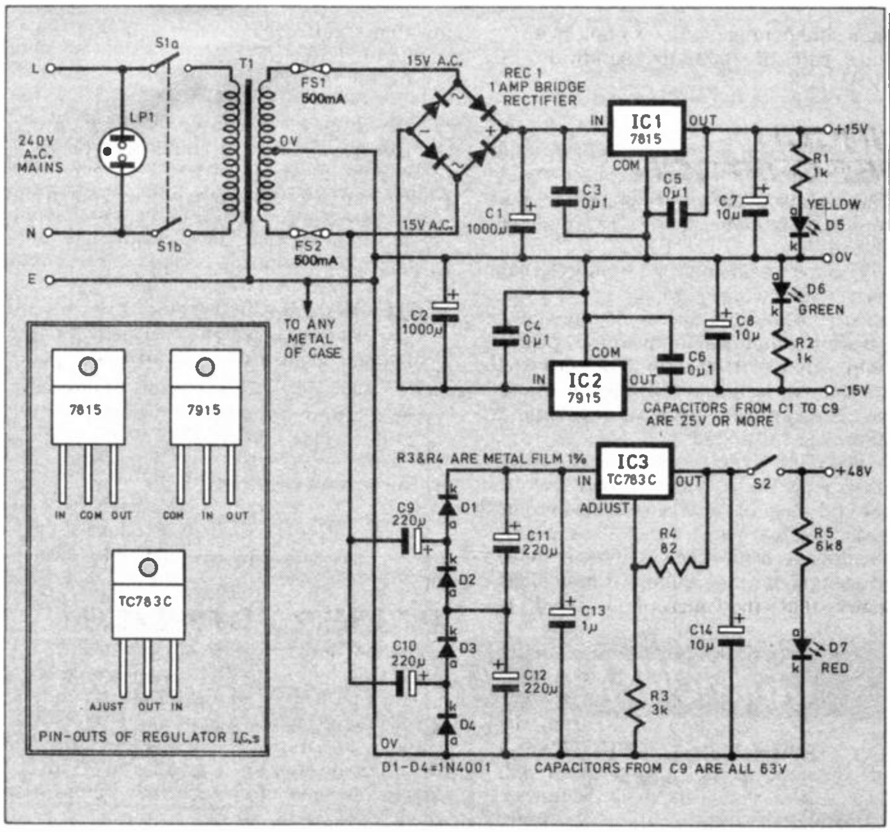


Fig. 7. Circuit diagram for a mains powered dual-supply and a 48V supply.

the transformer to a d.c. supply, and the centre tapping of the transformer provides the 0V output. Capacitors C1 and C2 smooth the d.c. and increase the average voltage to about 42V from *plus* to *minus*, in other words 21V above 0V, and −21V below 0V. The positive regulator IC1 maintains an accurate +15V output, while the negative regulator IC2 produces −15V. Capacitors C3 and C5 remove electrical noise and enhance stability for the positive supply; C4 and C6 do the same for the negative supply. Note that the way they are drawn implies that they should be connected close to their respective i.c.s for maximum effect.

Capacitors C7 and C8 provide additional smoothing and l.e.d.s D5 and D6 indicate correct operation of the respective positive and negative outputs. Resistors R1 and R2 limit the current through the l.e.d.s to a safe level.

PHANTOM POWER

The obvious way to produce a 48V d.c. output is to use a separate mains transformer. However it is possible to step up an a.c. output by a cunning arrangement of capacitors and diodes, and this was the method chosen. The array formed by capacitors C9 to C12 and diodes D1 to D4 form a diode/capacitor pump, raising the a.c. supply of 15V to about 60V.

It is vital that the 0V supply is derived from the centre tap of the transformer for all power supply outputs. In other words, the d.c. outputs of +15V, −15V and +48V are all measured with respect to the same 0V output from the centre tapping of the transformer.

The "lower" end of the mains transformer secondary winding is connected to both capacitor C9 and C10. When this end is positive, current appears to flow through C9 and C10, and hence through diodes D1 and D3, causing C11 and C12 to charge up. As the a.c. output reverses the centre tapping of the transformer will become more positive than the lower end and current will now flow through diode D4.

Whenever the voltage on one side of a capacitor changes, there will be a corresponding change on the other side. Since the right hand side of C10 is now at +15V, as the lower end of the transformer secondary becomes positive again, the right hand side of C10 is boosted to +30V. Current flows through diode D3 causing the voltage across C12 to rise to about 30V. By similar reasoning the voltage across C11 will also rise to 30V, giving a combined voltage across C11 and C12 of 60V. Capacitor C13 provides additional smoothing and the steady 60V supply is fed to IC3 input.

Integrated circuit IC3 is a high voltage regulator (type TL783C) which can be programmed to supply any voltage from 1·25V to 125V, given a suitable input voltage. In this arrangement the output voltage is given by:

Output voltage = $1{\cdot}25 \times (1 + R3/R4)$

Using a value of 3 kilohm for R3 and 82 ohms for R4, the output voltage is 46·9V.

If a different voltage is required for the phantom supply, simply change the value of R3 to produce the desired result.

Capacitor C14 ensures that a smooth supply is produced and l.e.d. D7 indicates correct functioning of the phantom supply.

OMITTING PHANTOM POWER

If phantom power supply is not required, the following components can be *omitted* from:

MAIN P.C.B.: Left Channel:
R1-R3, C1-C6, D1-D4.
A wire link *must* be inserted in place of C3 and C5.
, Right Channel:
R8-R10, C12-C17, D5-D8.
A wire link *must* be inserted in place of C14 and C16.
POWER SUPPLY PCB
R3-R5, C9-C14, IC3, D1-D4, D7, S2.

CONSTRUCTION – MICROPHONE PREAMPLIFIER

The printed circuit board (p.c.b.) top-side component layout and full size under-side copper foil master pattern for the Mic. Preamplifier is shown in Fig. 8. This board is available from the *EPE PCB Service*, code 858.

The stereo pre-amp p.c.b. is quite compact, and having fitted the i.c. sockets, it will be advantageous to begin with the smallest components and work up in size. Take care to fit the eight Zener diodes the correct way round with their light coloured bands (which indicate the cathode (k)) aligned as shown in Fig. 8.

The electrolytic capacitors must also be fitted with the correct polarity; note that the negative side is indicated on each capacitor body and the positive side has the longer lead. The 1µF (and smaller) capacitors are not polarised and may be fitted either way round.

The two presets (if used) may be fitted as shown. If fixed resistors are used, they may be mounted vertically in the two pairs of holes indicated by an X in Fig. 10. If external potentiometers are preferred, solder wires (or terminal pins) into the two pairs of holes indicated, and connect the other ends of the wires to the pots., keeping the wires as short as possible to avoid interference. Note that the pots. are not normal volume controls because they cannot reduce the output to zero.

Finally solder in terminal pins for all the external connections and insert the i.c.s into their sockets, ensuring that the notches line up correctly.

CONSTRUCTION – POWER SUPPLY

All components for the power supply except the mains transformer, fuses and "phantom supply" switch S2 (if fitted), are mounted on a separate p.c.b. This board is available from the *EPE PCB Service*, code 859.

The power supply p.c.b. is constructed in much the same way, taking care to fit the diodes and bridge rectifier the correct way round, and the electrolytic capacitors as before. The regulator i.c.s should be fitted with care, noting that each has a different pin layout.

COMPONENTS

BALANCED STEREO PRE-AMP

Resistors

- *R1, *R8 — 100 (2 off)
- *R2, *R3, *R9, *R10 — 6k8 (4 off)
- R4, R5, R11, R12 — 10k (4 off)
- R6, R13 — 3Ω9 (2 off)
- R7, R14 — 33 (2 off)

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometers

- VR1, VR2 — 100 horizontal Cermet preset (2 off)

Capacitors

- *C1, *C3, *C5, *C12, *C14, *C16 — 47µ radial elect. 63V (6 off)
- *C2, *C4, *C6, C10, *C13, *C15, *C17, C21 — 100n disc ceramic (8 off)
- C7, C18 — 220p ceramic (2 off)
- C8, C9, C19, C20 — 1µ polylayer (4 off)
- C11, C22 — 220µ radial elect. 25V (2 off)

Semiconductors

- *D1 to *D8 — 12V 0·5W Zener diode (8 off)
- IC1, IC2 — SSM2017 audio preamplifier (2 off)

Miscellaneous

Printed circuit board available from the *EPE PCB Service*, code 858 (pre-amp); metal screening box, size 75mm x 55m x 25mm; console case (with metal sloping front panel), size 190mm x 100mm x 72/33mm; 8-pin d.i.l. socket (2 off); output socket, phono (2 off); input socket, XLR-audio (2 off) – see text; terminal pins; twin screened cable; multistrand connecting wire; solder etc.

Note; Components marked with an asterisk (*) may be omitted if phantom power is *not* required, but note that *two wire links must* be inserted as described in the text.

Approx cost guidance only **£24** *plus case*

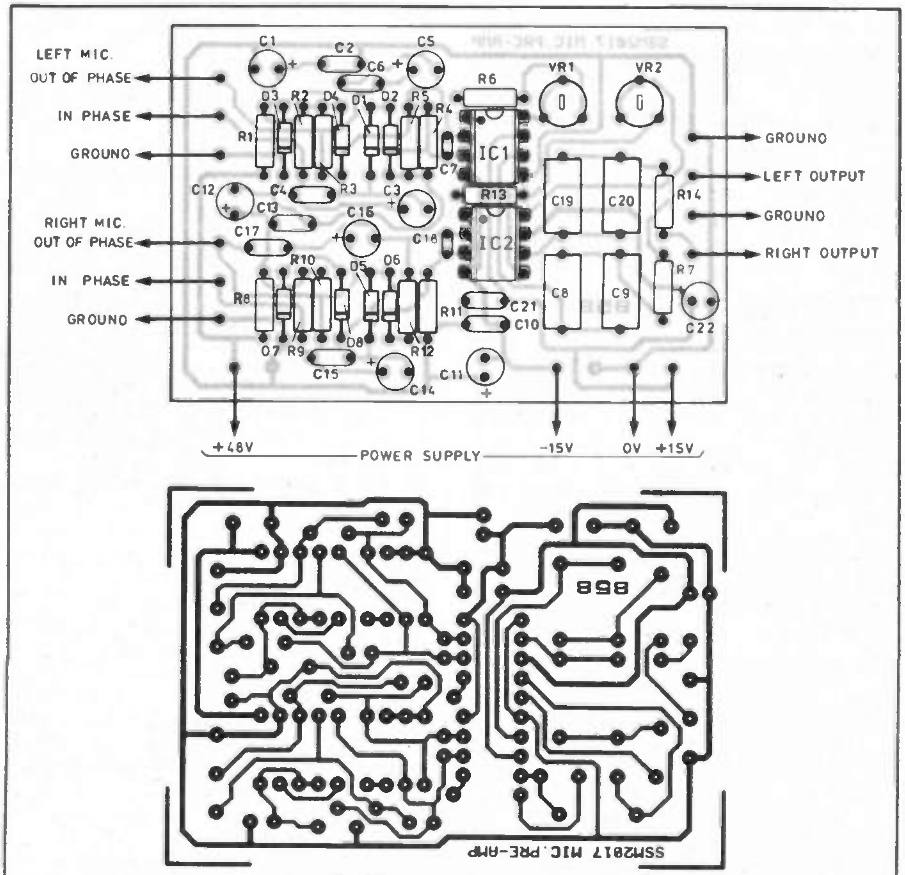
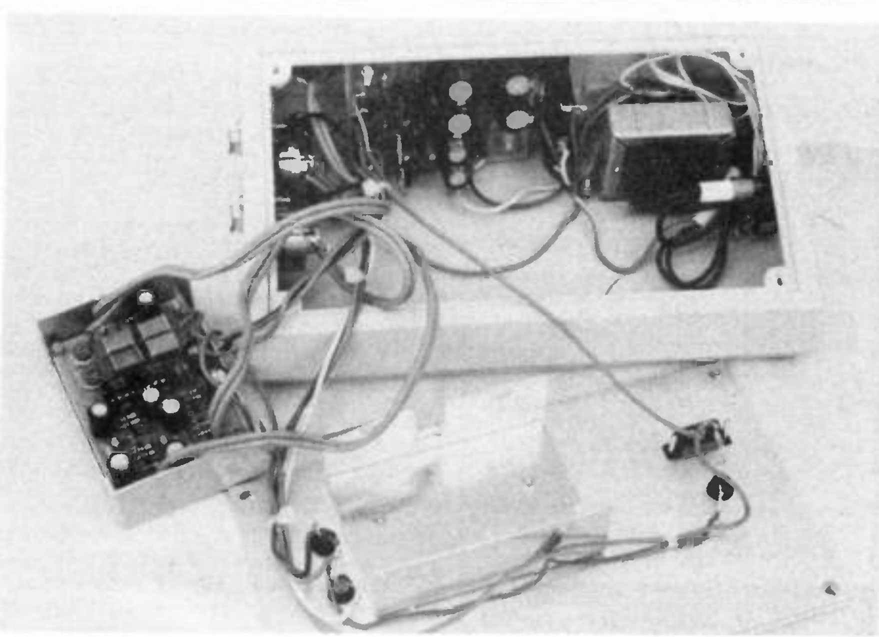


Fig. 8. Printed circuit board component layout and full size p.c.b. foil pattern.



The preamplifier removed from the screening box showing the cable entry cut out.

The l.e.d.s D5 and D6 are likely to be mounted on the front of the case, and will need to be connected via leads and terminal pins. Note that the l.e.d.s share a common 0V pin. There is provision on the p.c.b. for D7 series resistor (R5). However, if switch S2 is fitted to enable the phantom power supply to be switched off, it is more convenient to connect the l.e.d. series resistor R5 between S2 and the l.e.d. as shown in the photograph.

INTERWIRING

The external wiring to and from the off-board components may be carried out temporarily for testing, or permanently, in which case the transformer etc. will need to be fitted into the case. The two ends of the transformer secondary should be connected to the p.c.b. via fuses as shown in Fig. 13. The a.c. mains supply leads should be connected as shown having established exactly where the transformer and other main components will be located – or better still – fixing these items before completing the wiring. Remember the importance of neat wiring both for safety, and to reduce the risk of interference.

TESTING THE POWER SUPPLY

DUE TO THE PRESENCE OF MAINS VOLTAGES, CARE MUST BE TAKEN WHEN TESTING THE POWER SUPPLY.

The power supply should be tested using a voltmeter, before connecting it to the pre-amp. Connect a voltmeter to the 0V and +15V output pins. Switch on the supply and check for a correct reading. If the reading is not correct, switch off immediately and check for faults. If all is well, check the −15V supply, and the +48V outputs.

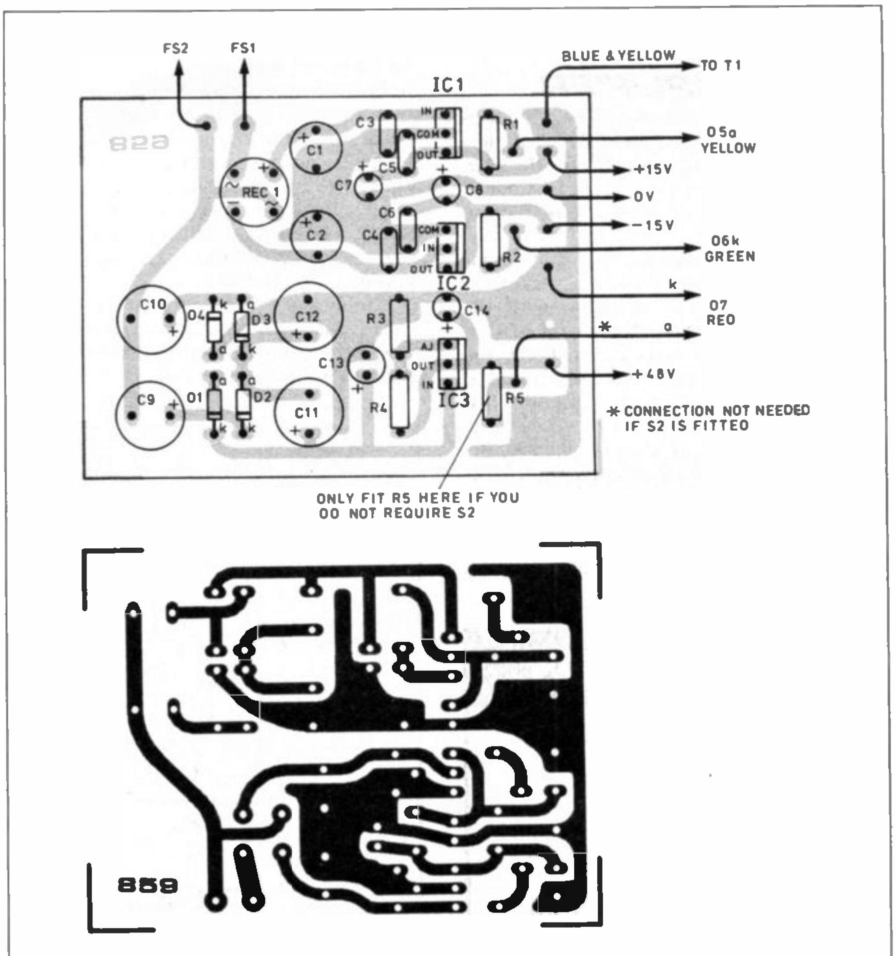


Fig. 9. Power supply p.c.b. component layout and full size copper foil pattern.

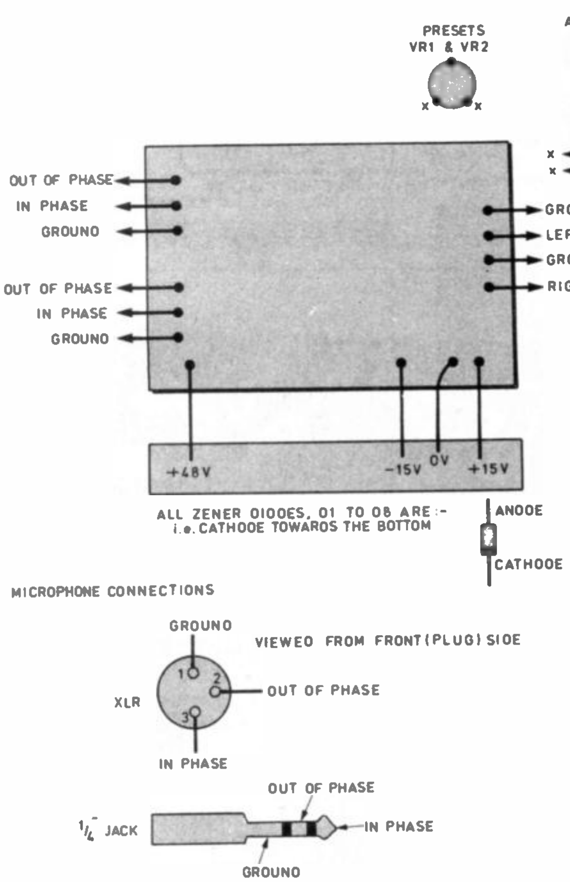


Fig. 10. Interwiring and microphone connection details for the pre-amp board.

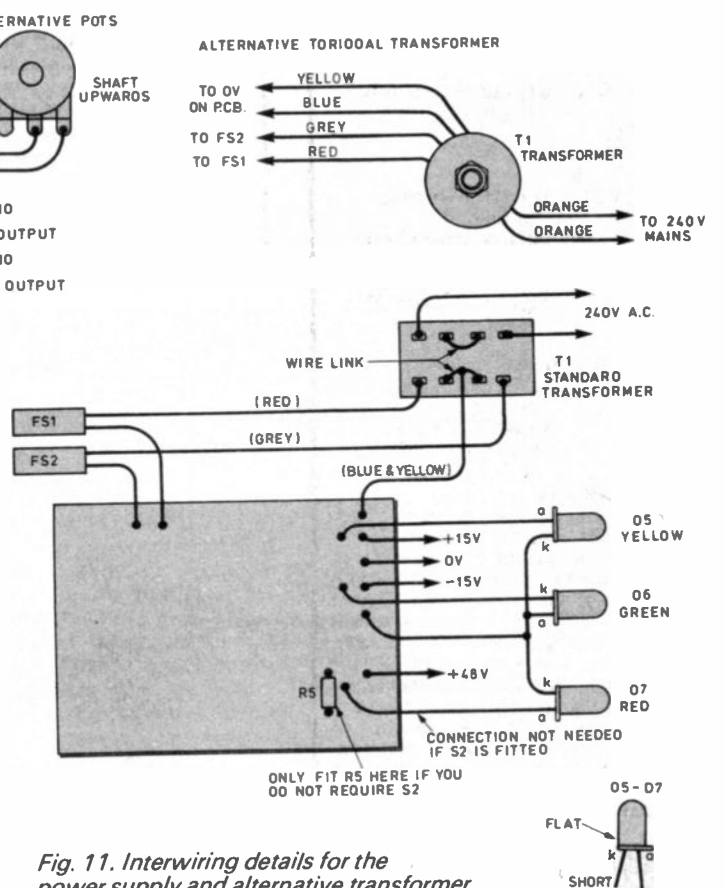
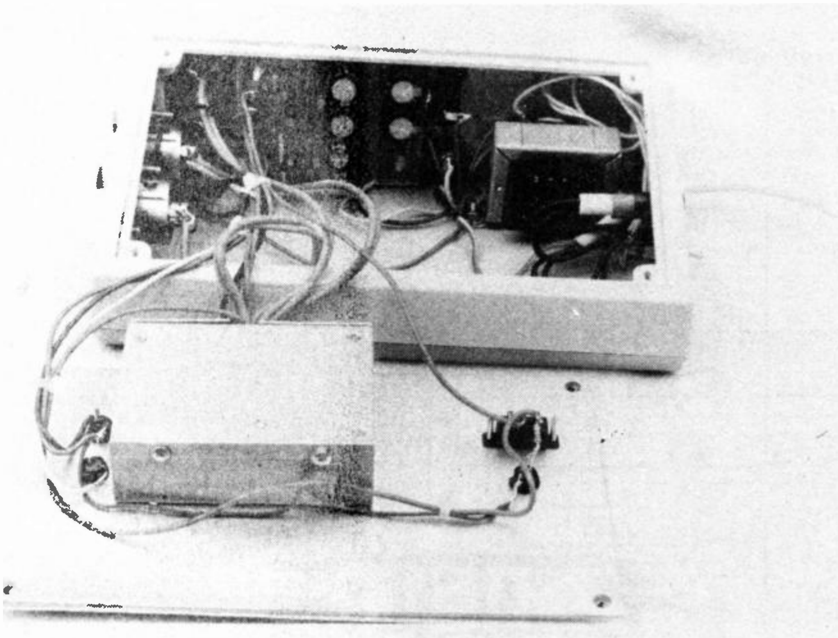


Fig. 11. Interwiring details for the power supply and alternative transformer wiring.



Completed preamplifier showing wiring to front panel l.e.d.s and on/off switch. The position of the "screening box" is also shown.

If the power supply is not working correctly, switch off immediately in case components particularly electrolytic capacitors – are the wrong way round. Having checked this, ascertain that the voltage across C1 and C2 is about 21V (it may be up to, say 10 per cent more, depending upon the regulation offered by the transformer). The reading across capacitor C13 should be about 60V.

TESTING THE PRE-AMP

Having established that the power supply unit is providing the correct voltages, it can be linked to the pre-amp p.c.b. Reasonably long wires should be used since the pre-amp will be housed in a metal "screening" case fitted inside the main case.

Testing may be accomplished using a signal generator and oscilloscope (if available) or by simply connecting a microphone and listening to the output via an amplifier/speaker, or headphones. If a signal generator is used, ensure that the signal is attenuated (turned to a low output) or the circuit will be overloaded, resulting in distortion.

Switch on the power supply, and apply a signal to the non-inverting input (pin 3) of, say the left-hand channel, not forgetting to link the 0V (ground) terminal to the input signal ground. Connect the output to the oscilloscope, again, not forgetting the 0V side. A suitable wave trace should be observed. Adjust the presets or potentiometers if necessary.

Now apply the input signal to the inverting input (pin 2). The wave trace will look similar, but if compared with the signal from the generator, it should be out of phase. Repeat the same tests with the right-hand channel.

It may be helpful for testing, or for use when balanced microphones are not available, to make provision for the use of unbalanced microphones. This may be accomplished by connecting the inverting input (leading to pin 2) to 0V. The microphone signal must then be connected to the non-inverting input, and the microphone screen to 0V.

FAULT FINDING

Hopefully, one or other (if not both!) of the stereo halves of the circuit will work. If not, check the power supply connections and diodes. Measure the voltage across pins 7 and 4 of each i.c. You should obtain a reading of about 30V.

The voltage across pins 7 and 5, (and 5 and 4) should be about-15V. Check that the four electrolytic capacitors are fitted the correct way round.

If using balanced microphones check that the signal is passing through your plug and socket arrangement successfully. The pin numbers are often marked on the XLR sockets to avoid confusion if they are viewed from the wrong direction.

THE CASE

Assuming that the pre-amp p.c.b. is to be housed in the same case as the power supply, it is wise, if not essential to house it in a separate inner metal case to provide screening – see photos and Fig. 12. The metal case should be linked to 0V (ground). When fitting the p.c.b. into the case, ensure that no parts of the circuit are touching the metal – even if painted.

If presets are used, try to install the p.c.b. so that the presets may be adjusted via small holes drilled in the inner case which also line up with similar holes drilled in the front panel. The prototype was constructed in this way and case layout and front panel layout can be seen in the photographs. The interwiring between boards and off-board components is shown in Fig. 13.

The input sockets will normally be XLR types designed for balanced microphones. Alternatively, "stereo" jacks are sometimes used. The stereo output should be via a pair of phono sockets, or a single stereo jack socket, (or both for flexibility!).

The outer case specified is identical to the case which housed the 1W amplifier and tone control i.e. a smaller version of the Stereo Mixer case. All the parts will fit into this case, but care is required with the layout. The transformer employed was the smallest 6VA type; however the larger 12VA will *just* fit (if screwed to the back of the case rather than the base), and the 15VA toroidal type will fit reasonably easily.

Note that the transformer is fitted as far away from the sensitive inputs as possible. The pre-amp p.c.b. is mounted inside a metal box which provides complete screening. This may not be essential, but there is little point in constructing a very high quality amplifier and then spoiling its performance with induced hum.

Begin by drilling holes in the plastic body of the main case for the mains cable, neon, switch S1, two fuseholders, two phono sockets, optional power output socket, and XLR (or jack) input sockets. The use of masking tape to help with marking, and to provide a non-skid surface when drilling is a great advantage.

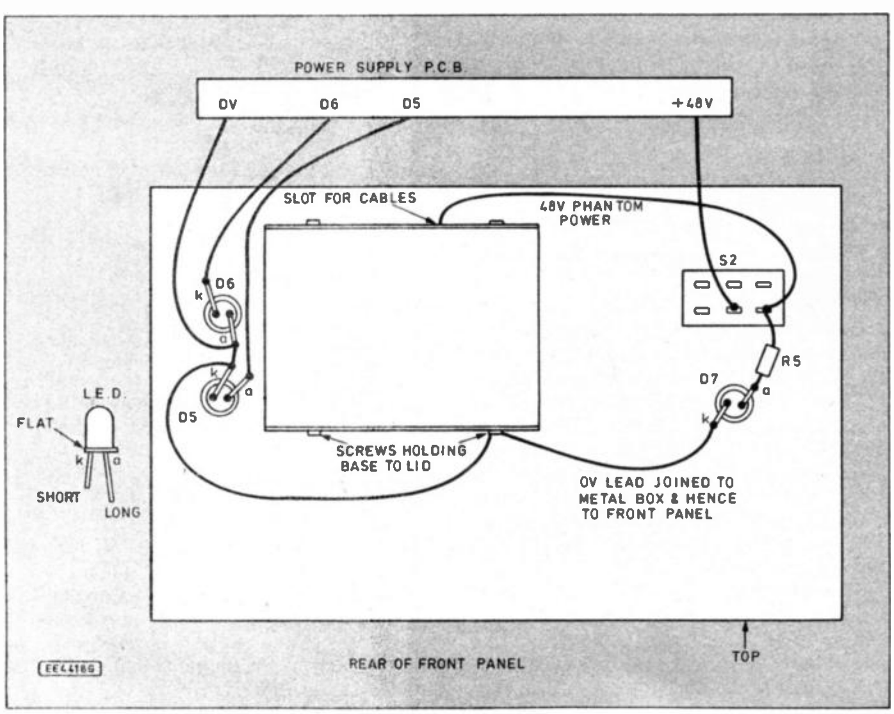


Fig. 12. Wiring to components mounted on the rear of the front panel.

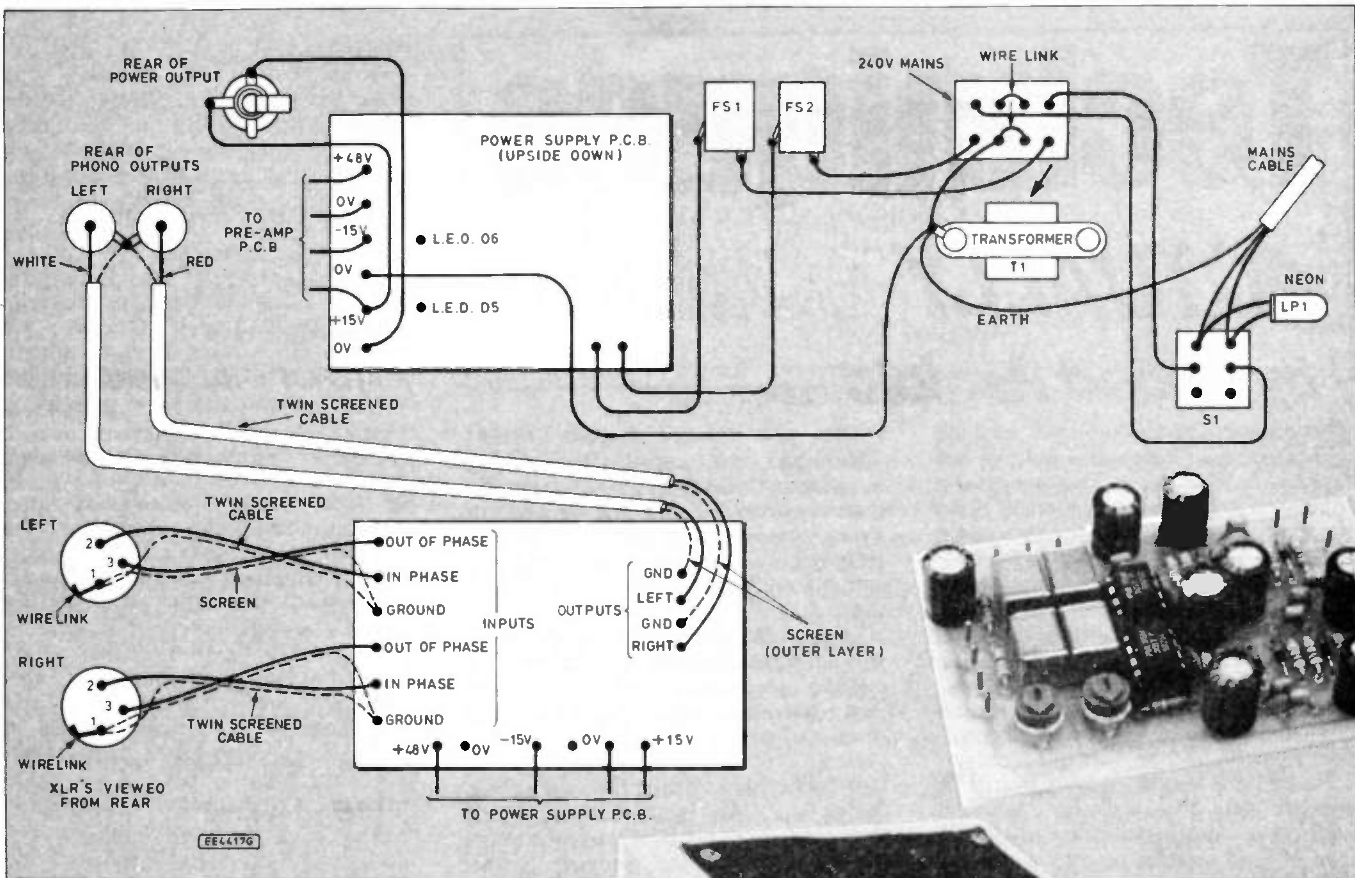
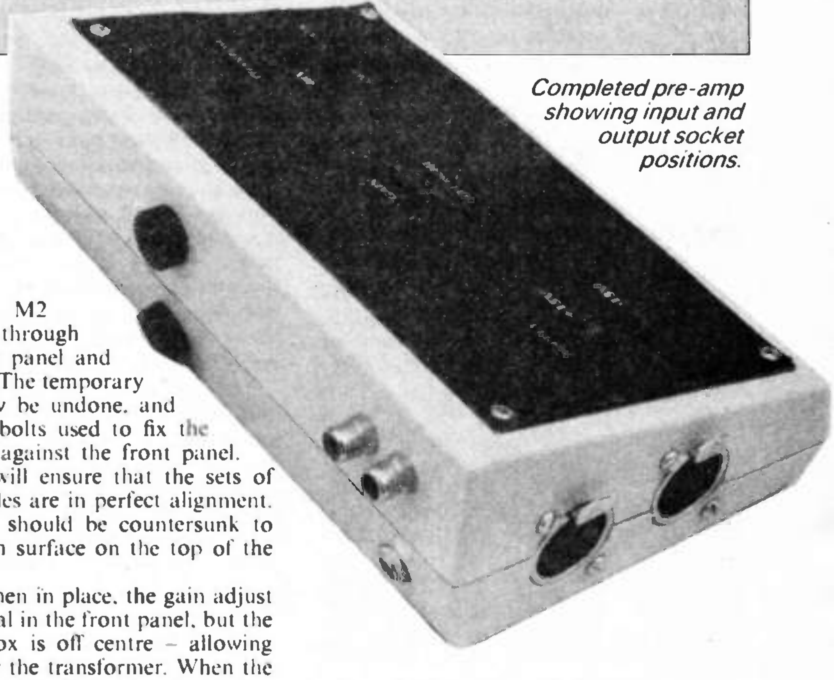


Fig. 13. Interwiring between boards.



Completed pre-amp showing input and output socket positions.

A front panel layout guide as shown in the photographs. Make two copies of the panel, one as a template for drilling and the other as a front panel cover. If possible, the front panel cover can be inverted so that the markings are in white on a black background.

Drill all the holes required in the metal front panel. The slide switch (S2) may be awkward, since a rectangular hole is required: a round toggle switch will do just as well. Do not forget the M2 holes required to mount the small metal inner case which houses the pre-amp.

METAL INNER CASE

Before working on the metal box, check the p.c.b. will fit inside. Prepare the small metal box by cutting a grove in one side as shown in photographs to allow the cables to enter the box. Alternatively a cable entry hole could be drilled; however this makes the final connections more difficult since the wires first have to be threaded through this hole.

Three or four small (M2) holes should be drilled in the pre-amp p.c.b., and in the small metal box base so that M2 nuts and bolts may be used to fasten the pre-amp in place. Ensure that the p.c.b. is well clear of the base by using insulated "spacers" such as grommets, M3 nylon nuts etc. Also, make sure that the p.c.b. is sufficiently clear of the screws which fasten the lid of the small box.

Having fixed the p.c.b. to the base of the metal box, mark and drill two holes in the lid so that a screwdriver may be inserted to turn the presets. Now fix the metal box lid firmly against the metal front panel so that all the preset gain control holes are in line. Nuts and bolts may be temporarily placed through these holes to achieve this.

Move the p.c.b.s to a safe distance to avoid contamination with metal filings, and drill two M2 holes straight through both the front panel and metal case lid. The temporary bolts may now be undone, and M2 nuts and bolts used to fix the metal box lid against the front panel. This method will ensure that the sets of gain adjust holes are in perfect alignment. The M2 bolts should be countersunk to leave a smooth surface on the top of the front panel.

Note that when in place, the gain adjust holes are central in the front panel, but the small metal box is off centre – allowing more space for the transformer. When the front panel is placed on the plastic box base, the metal box will fit neatly inside.

FINAL WIRING

Link the XLR sockets with the pre-amp p.c.b. using twin screened cable for each channel. The convention is screen for ground (0V), red for out-of-phase, the other colour (e.g. white) for in-phase. The output signal is linked via one length of twin screened cable using the convention screen for ground, red for right, other colour for left. The power supply connections should be completed, noting that a *single* 0V connection is sufficient.

Carefully lift the small metal box base so that it fits against its lid which is attached to the front panel. Once in place use the self-tapping screws provided with the box to fix the base into the lid. Check again that these screws do not touch the p.c.b.

Finally the front panel may be finished by covering the copy card with book covering material, then making holes for the l.e.d.s and gain adjust openings by means of a cork borer. A craft knife may be used to make the rectangular hole for switch S2. Position the front cover over the panel, pierce the corners to allow the front panel screws to enter and screw, gently, into place.

FINAL TESTING

Now for the final test! Connect the output of the Balanced Microphone Preamplifier to a power amplifier, switch on and check for hum or other noises. **If a *dynamic* microphone is used, ensure that the phantom power supply is *switched off*.** Connect the microphone(s) and check that the system works correctly and that the gain can be adjusted by means of the gain presets. □

Techniques

ACTUALLY DOING IT!

by Robert Penfold

Some months ago the topic of large cut-outs in cases and panels was covered in *Techniques*. This is a subject which might not be expected to bring much of a response from readers, but it did result in several letters offering useful suggestions.

We are always interested in readers reactions to practically anything related to the magazine, and my thanks are due to those who wrote in on this occasion. I will always endeavour to try out any useful tips and, where appropriate, pass them on to others via this feature.

I think it is worth making the point though, that no matter how good a method of doing something might be, it is of little interest to others if it requires access to expensive equipment or materials that are only available to those in some trade or other.

FLEXIBLE FRIEND

Most of the letters on the subject of cut-outs mentioned "Abrafiles". I used these a great deal some years ago, but have found them impossible to obtain locally in recent years. However, they are still available, and if they prove to be unobtainable locally they are available direct from mail order tool suppliers.

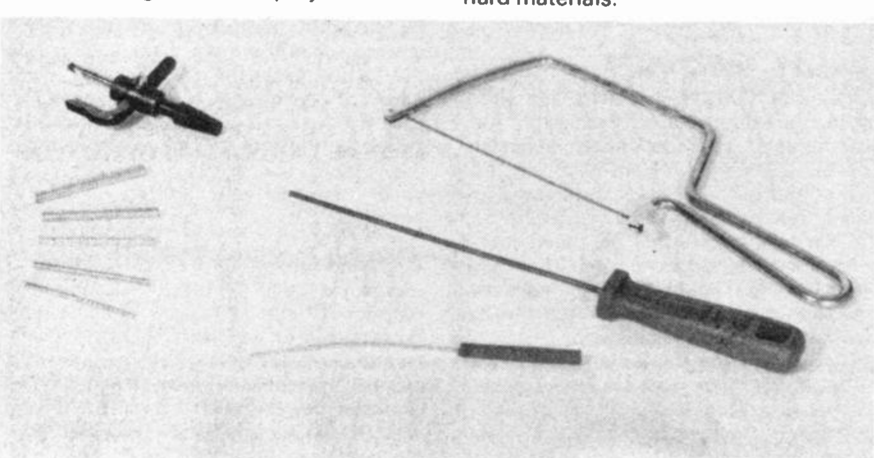
"Abrafiles" look very much like ordinary round "needle" files, but they have the unusual attribute of being bendable. The idea is that these files can be bent into shapes that enable them to reach the awkward parts that other files cannot reach. This is no doubt very useful for model makers and many other users, but I cannot honestly say that I have ever found this flexibility to be a useful property when building electronic projects.

The characteristic which makes "Abrafiles" so useful for making cut-outs is their relative coarseness. An ordinary "needle" file can be used to make cut-outs, but progress is very slow even when working on relatively soft materials such as aluminium and plastics.

These files are made primarily for smoothing purposes, and not for making long cuts. It is for this reason that I generally suggest making a ring of small holes first, and then using a "needle" file to join the holes. A large half-round file can then be used to tidy things up. This may seem to be a roundabout way of doing things, but it is far quicker than producing the cut-out using only the "needle" file.

"Abrafiles" are designed for general cutting and filing purposes, and will cut through aluminium and most plastics at a reasonable speed. They can be used to cut in any direction at any time, and can therefore be used to cut quite complex shapes. They can also be used in the middle of large panels without any difficulty. "Abrafiles" are available in three diameters (1/8, 3/16, and 1/4 inch), but it is only the smallest size which is of use in the current context.

Packs of five "mouse-tail", files are also available. These are basically just a scaled-down version of the normal type, having a diameter of about 1·5 millimetres. They are well suited to small cut-outs, particularly where intricate shapes are required. As only a very limited amount of pressure can be applied using such thin files, they cut relatively slowly, and are less than ideal for large cut-outs. They are not recommended for use with steel or any very hard materials.



Various types of Abrafile and a "tank cutter".

FRAME-UP

Probably the best "Abrafile" for making cut-outs is the framed variety. This is basically just a junior hacksaw frame, but it has a rather "taller" frame than a normal junior hacksaw. It looks rather like a cross between a junior hacksaw and a coping saw. This tool actually comes complete with a normal 6 inch hacksaw blade, but it is the other blade supplied with the frame that is of more interest. This is a tension file blade, which is basically just a 6 inch long "Abrafile" which fits into the frame in exactly the same way as an ordinary hacksaw blade.

There is an obvious disadvantage to a framed file in that it cannot reach into the middle of large panels. However, the high access frame supplied with the file has a reach of about 90 millimetres, which is adequate for all but the largest of projects. The main advantage of having the frame is that it enables much more force to be used, which means that large cut-outs can be completed very quickly. I also find that I can make cuts with a greater degree of precision when using the framed version of an "Abrafile".

The file is only about 1·5 millimetres in diameter. This means it can be used to produce quite intricate cut-outs, although it is less good in this respect than a fretsaw. The frame also provides far less reach than a fretsaw. on the other hand, the "Abrafile" has a big advantage in that it is not necessary to stop every thirty seconds to replace a broken blade!

ROTARY FILES

There is another variation on the "Abrafile" theme in the form of rotary files. These are short round files which are supplied in packs of five. The pack contains files of five different diameters ranging from 1/8 inch to 1/4 inch. They are all double-ended, and are designed for use in power drills.

For those who prefer to avoid the exertion of producing large cut-outs by hand, these rotary files would seem to offer an ideal solution. This type of tool is best suited to a drill that is mounted in a proper stand. It is then not too difficult to make cut-outs with reasonable precision, but I have always found progress to be very slow using any form of rotary file. These "Abrafiles" do not seem to be an exception, and they are better suited to their primary purpose of deburring and enlarging. When used for these purposes a handheld drill is perfectly satisfactory provided you proceed carefully.

A useful point to remember is that it is generally easier to have a panel clamped in a vertical position when working on it using something like an "Abrafile" or fretsaw. It is more comfortable and therefore less tiring working on a panel that is positioned vertically. Also, you can orientate everything so that you are not casting a shadow over the workpiece, making it easier to see what you are doing. The end result is usually a more precise cut-out and a lot less backache.

"Abrafiles" and tank cutters are available from Axminster Power Tool Centre, Chard Street, Axminster, Devon, EX13 5DZ (Tel. 0297 33656).

TANKED-UP

Most constructors make large round cut-outs (for something like a moving coil panel meter) using a fretsaw, "needle" file, etc. Most of the quick ways of making round holes are not applicable to holes of about 40 millimetres or more in diameter. Even if you can find a chassis punch of the required size, it is likely to be extremely expensive, and it will only make a hole of one size. The next time you need to cut a large diameter hole it might be necessary to buy yet another chassis punch.

There is a tool which seems to solve the problem of producing large diameter holes, and it is called a "tank cutter". I presume that its intended purpose is making inlet and outlet holes in water tanks, etc. It is a delightfully simple idea, and it is based on a twist drill of about 6 millimetres or so in diameter. There is an L-shaped cross piece which has the cutting blade at one end. This is adjustable, and enables holes from (typically) about 25 to 100 millimetres in diameter to be cut.

In order to make a hole you first set the blade for the right diameter. Then a centre punch is used to make an indentation in the panel at the centre of the required cut-out. Next the drill part of the cutter is used to drill right through the panel so that the cutting blade can be brought down onto the panel. You then just carry on drilling, except the drill now just acts as a spindle to keep the cutting blade on the correct circle.

It is the blade which actually does the cutting. Working on an 18 s.w.g. aluminium panel it literally takes no more than a few seconds to make a hole of about 50 millimetres in diameter.

IMPORTANT POINTS

Although cutting large holes using a tank cutter is very easy, there are a few important points to bear in mind. First and foremost, these tools are only intended for operation at very *low speeds* (just a few r.p.m. in fact). They should be used in a brace, and *not* in any form of power drill, or even in a heavy duty hand-drill. The workpiece must be very securely clamped in place, and the cutting should be done very slowly and carefully. It takes so little time to cut holes using this device that rushing things is completely pointless anyway.

The hole produced is nothing like as neat as one made using a chassis punch. The cut is not actually that rough either, but it does require some deburring. Therefore, it is a good idea to cut a hole that is about one millimetre too small, to allow for some slight enlargement when it is deburred.

One of the cheaper tank cutters is more than adequate for cutting through thin sheet aluminium. These cost around £7, which has to be considered a real bargain considering the ease with which holes can be made, and the wide range of sizes that can be accommodated. Using one of these tools puts quite a lot of strain on the workpiece, so it is probably best not to try one on a plastic case unless you proceed extremely carefully and gently.

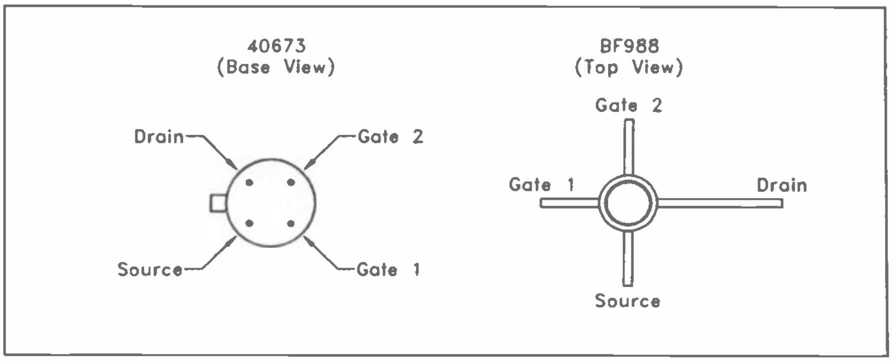


Fig. 1. Connections for the 40673 and BF988.

MOSFETs

The subject of dual-gate MOSFETs and their virtual non-availability was discussed in an *Actually Doing It* article some time ago. Two or three readers pointed out that the 3SK88 was still available from Maplin. Unfortunately, although it was in the Maplin catalogue at that time, it was definitely no longer available, and it is not in the current catalogue. However, the new Electrovalue catalogue does include a similar device, the BF988. Like the 3SK88, this is a surface mount device. On the face of it there are problems in using it in place of a 40673, which has four normal leadout wires.

In reality there is no difficulty in fitting a 3SK88 or a BF988 into a printed circuit layout designed for a 40673 or similar device. As can be seen from the pinout diagrams for these components (Fig.1), they have what is basically the same pinout arrangement.

The flat tags of the BF988 can be carefully bent through right angles so that the device can be fitted straight onto a printed circuit board designed for the 40673. There should be no need to enlarge the holes in the circuit board since the tags are less than one millimetre across. Anyone feeling adventurous could try surface mounting the BF988 upside-down on the underside of the board.

The BF988 seems to work well as a substitute for the 40673, etc. in short wave receivers, but I have not tried it beyond 30MHz. Having tried a number of different dual-gate MOSFETs over the years, I find the consistency of these devices rather surprising. Changing from one type to another seems to produce no significant change in performance, which is not the case with bipolar r.f. transistors. Swapping one of these for a different but supposedly similar device often gives either a marked loss of performance, or gross instability.

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MORE AMATEUR SATELLITES

An Ariane launch vehicle from Kourou, in French Guiana, carried seven satellites into orbit on September 26th, including a number of OSCAR amateur communications satellites.

Kitsat Oscar 25 (KO-25) is a 50kg satellite built by the Korean Advanced Institute of Space Technology, and its mission is to take CCD pictures, process numerical information, measure radiation, and receive and forward messages. Its uplink is 145·870/145·980MHz, and its downlink is 435·175/436·500MHz.

Itamsat Oscar 26 (IO-26) is a 12kg satellite built by AMSAT-ITALY and is intended to store and forward amateur radio messages. Its uplink frequencies are 145·875/145·900/145·925MHz and 145·950MHz; with downlink on 435·867MHz (primary) and 435·822MHz (secondary).

Amrad Oscar 27 (AO27) is a secondary amateur communications payload carried on Eyesat-1, a 12·5kg commercial microsat built by Interferometrics Inc. of Vienna, Virginia. The amateur equipment on this satellite was constructed by members of AMRAD, a technically orientated organisation of radio amateurs in the Virginia suburbs of Washington D.C., to meet the needs of amateurs for a platform to conduct digital satellite communications experiments. Uplink – 145·850MHz, downlink – 436·800MHz.

A further satellite is PoSat-1, awaiting a decision from Portugal on whether the amateur package on this 50kg commercial satellite will be activated, in which case it will become PoSat Oscar-28 (PO-28). Built by Surrey Satellite Technology Ltd (SSTL) of the University of Surrey, for LNETI (Portugal), its mission is to receive and transmit earth images, determine its position using GPS, make radiation measurements, and receive and forward messages. Uplink – 145·925/145·975MHz, downlink – 435·250MHz (primary) and 435·275MHz (secondary). Information from *W5YI Report*.

INTERNATIONAL EFFORT

There are now so many amateur radio satellites in orbit it would be confusing to attempt to list them, but most are the result of the work of AMSAT, the Radio Amateur Satellite Corporation, and associated organisations around the world.

In this country, AMSAT-UK co-ordinates amateur satellite activities, raises funds, and engages in the design and building of apparatus for OSCAR launches. It publishes a bimonthly journal, *Oscar News*, which contains up-to-date information on all aspects of satellite operation, including listed orbits and general advice; and has a number of useful publications and computer programs for both beginners and experienced operators.

It has an annual Colloquium at the University of Surrey with demonstrations and lectures on all aspects of amateur satellite activity, provides an information service to members and offers advice and general assistance to newcomers to this specialised field of amateur radio.

AMSAT nets, providing the latest information and news on space activities are held on the amateur bands as follows: Sundays, 1015hrs, on 3·780MHz; and 1930hrs on 144·280MHz, in most parts of the UK. Mondays and Wednesdays, 1900hrs, on 3·780 MHz. (All times local).

GETTING STARTED

To work through, or hear, an amateur satellite you need to know when it will be in a suitable position to transmit and receive radio signals to and from your particular location. This can be calculated by means of an "Oscalator" and an orbital prediction calendar, both obtainable from AMSAT-UK, or can be calculated by computer using one of the AMSAT programs.

While most satellites have either uplinks or downlinks in the 2m band, many beginners start with the Russian RS 12 satellite, which has an uplink of 21·210 – 21·250MHz, and a downlink of 29·410MHz – 29·450MHz with a beacon on 29·408MHz.

This makes satellite operation possible for any amateur who has an h.f. amateur station plus a separate h.f. receiver, or for listeners who have receivers capable of covering the amateur h.f. bands. Existing antennas will probably be quite suitable for transmitting, and a simple 10m dipole will be suitable for receiving. There is no need for any special "know-how", which can be acquired later if you get "hooked" on satellite operation. If your receiver is a bit "deaf" around 30MHz, then AMSAT-UK can supply a suitable 28-30MHz preamplifier to improve its performance in this band.

If you are busy with other things in your shack, you can leave your receiver permanently on the beacon frequency and once every 104 minutes, when it is on a suitable orbit, you will hear RS 12 come up. CW (Morse) signals should be heard in the lower part of the band while SSB (single sideband) speech signals will be heard in the the upper part.

INFORMATION PACK

An information pack about AMSAT-UK and amateur radio satellites can be obtained by sending a 9x6inch self-addressed envelope with a 29p stamp to AMSAT-UK, 94 Herongate Road, London E12 5EQ. An introductory booklet, *Satellites for Beginners* is also available, price £1.65, postpaid.

For a limited period, new members joining AMSAT-UK will receive on request a free copy of an IBM computer tracking program on 5·25inch disk. This program can also be supplied on 3·5inch disk if the member supplies his/her own formatted disk at the time of joining. An application form for membership is supplied in the information pack.

ITU RESTRUCTURING

The International Telecommunication Union, the international legislative body which, among many other things, lays down the rules for amateur radio, has been re-organised into three sectors. Of most interest to amateurs is the Radiocommunications Sector, the work of which will be conducted through World and Regional Radiocommunication Conferences and Radiocommunications Assemblies to be held every two years.

The previous World Administrative Radio Conferences, which occupied much of the time and effort of national radio societies in trying to influence their national delegations whenever amateur radio was under consideration, will no longer be held.

The new constitution, as from July 1, 1994, continues to provide for participation in the work of the ITU by recognised international organisations such as the International Amateur Radio Union, but they must now be prepared for ITU conferences on a regular two-year basis instead of sporadically as previously.

The first WRC was held in November 1993. Its only business was to develop recommended agendas for the WRCs to be held in 1995 and 1997. An ITU Voluntary Group of Experts (VGE) is developing recommendations for simplification of the Radio Regulations to be considered at a future conference, probably in 1995. *(IARU News)*.

WINTER BROADCASTS GUIDE

The International Short Wave League's *Guide to English Language Short Wave Broadcasts to Europe, Winter 1993/94*, is now available. Once again it provides invaluable assistance for SWLs with its round-the-clock format and station information, including country, frequencies and programme information.

The introduction to this issue reminds us that during the present phase of the sunspot cycle the higher frequencies are less reliable. Accordingly, international broadcasters are battling for space on the lower frequencies, sometimes causing co-channel interference and making reception difficult.

It also comments on the increase in the number of stations using AM compatible SSB transmissions, which reduce the "splatter" associated with normal AM broadcasts. To receive them clearly a receiver with SSB capability is to be preferred, although an AM-only radio can usually provide acceptable reception of these transmissions.

The Guide, which costs £1.30 (stamps acceptable) or 2xIRCs, postpaid, can be obtained from ISWL, 10 Clyde Crescent, Wharton, Winsford, Cheshire CW7 3LA. Why not ask for information about the League at the same time if you don't already know about them?

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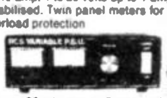

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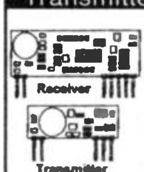

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ADVERTISERS INDEX

AITKEN BROS. & CO. 98
ANNEX SOFTWARE 145
AUTONA 173
N. R. BARDWELL 176
R. BARTLETT 145
B.K. ELECTRONICS .... Cover (iii)
BRIAN J. REED 176
BULL ELECTRICAL .... Cover (ii)
CAMBRIDGE COMP. SCIENCE 175
CHATWIN GUITARS (JCG) 173
CHELMER VALVE CO. 119
CIRKIT DISTRIBUTION 99
COMPELEC 173
COOKE INTERNATIONAL 175
CRICKLEWOOD ELECTRONICS 165
CR SUPPLY COMPANY 176
DISPLAY ELECTRONICS 90
ELECTROVALUE 119
ESR ELECTRONIC COMPONENTS 102
EUROCOM INTERNATIONAL 109
HART ELECTRONIC KITS 155
HENRYS AUDIO ELECTRONICS 96
ICS 176
INFOTECH & STREE 175
JAYTEE ELECTRONIC SERVICES 99
JPG ELECTRONICS 173
MAGENTA ELECTRONICS 100/101
MAILTECH 92
MAPLIN ELECTRONICS .... Cover (iv)
MARAPET 175
MAURITRON 175
M&B ELECTRICAL SUPPLIES 94
M&B ELECTRONICS 109
MQP ELECTRONICS 98
NATIONAL COLLEGE OF TECHNOLOGY 95
NUMBER ONE SYSTEMS 93
OMNI ELECTRONICS 96
PCL SOFTWARE 98
PICO TECHNOLOGY 97
POWERWARE 95
PROFILE ELECTRONICS 96
ROLINE SYSTEMS 126/127
SEETRAX CAE 91
SERVICE TRADING CO. 96
SHERWOOD ELECTRONICS 175
S&N ENTERPRISES 173
STEWART OF READING 98
SUMA DESIGNS 149
TSIEN (UK) 111

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