EVERYDAY WITH PRACTICAL ELECTRONICS

OCTOBER 1993

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.95

MULTI-PURPOSE AUDIO SYSTEM – 1

SIX CHANNEL STEREO MIXER

RIAA PRE-AMP,
MIC PRE-AMP,
CONTROL UNIT,
AMPLIFIERS

KETTLE ALERT

BECOMING A RADIO AMATEUR

9 770262 361041 10

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

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. **Now only £4.00 ref 4P151.** Good experimenters board.
FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.
12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v.
PASSIVE INFRA-RED MOTION SENSOR.

Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**
Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R
VIDEO SENDER UNIT. Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless camera!
FM TRANSMITTER Housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R. Good range.
MINATURE RADIO TRANSCEIVERS. A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R
FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.
12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.
CAR STEREO AND FM RADIO. Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. **£19.00ref 19P30**
LOW COST WALIKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.
7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.
NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.
TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. New ed. £20.00 ref 20P32R.
GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R
FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.
FM BUG Built and tested superior 9v operation £14.00 ref 14P3R
COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.
SINCLAIR C5 MOTORS. 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £22.00 ref 20P22R. Limited stocks.
ELECTRONIC SPEED CONTROL KIT for C5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R. Potentiometer control.
SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.
ACORN DATA RECORDER ALF503. Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R
VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**
PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £22.00 REF 22P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.
12 TO 220V INVERTER KIT. As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.
WIND UP SOLAR POWERED RADIO! FM/AM Radio takes rechargeable batteries. Complete with hand charger and solar panel. £14.00 REF 14P200RA.
BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R.
FRESNEL MAGNIFYING LENS. 83 x 52mm £1.00 ref BD827R.
12V 19A TRANSFORMER Ex equipment £20 but OK.
POWER SUPPLIES Made for the Spectrum plus 2 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref Q8P3
UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.
IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.
QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!
LED PACK. 50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52
360K 5.25" DISK DRIVE. Industry standard, ideal replacement or second drive for most computers. £9.00 EACH ref: X9P1.
PPC PSU 13.8V 1.9A (not plug in). £10.00 EACH. REF: X10P1.

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.

THIS MONTHS SPECIAL OFFERS

SOLAR CELLS

10 WATT SOLAR CELL (3" x 1") 14.5v/700mA

Now available by mail order Coated with exceptionally efficient amorphous silicon these glass solar cells have an almost timeless lifespan and will not suffer with discolouration. There are possibly hundreds of uses for these cells, a few of which could be: for **Car Battery Charging**, for use on **Boats** or on **Caravans**, in fact anywhere a portable **12V** supply is required. Several of our overseas Mediterranean customers with homes in remote hilly sites, use these solar cells as a daytime power source to backup generators. The solar cells can be connected in series or parallel to give higher voltages or larger current capacity. **REF: EV34P1**

PRICED at only £33.95. PLUS an additional £2.00 special packaging charge on this item in addition to £3.00 PP charge.

OTHER SOLAR PANELS:

12V 200mA GLASS SOLAR PANEL.
12" x 12" in dimension **£15.00 EACH. ref: 15P42.**
.45V 700mA SOLAR CELL.
silicon plastic encapsulated. 95 x 65 x 7.5mm in dims.
£3.00 EACH. ref: 3P42.
.45V 400mA SOLAR CELL.
silicon plastic encapsulated. 75 x 45 x 7.5mm in dims.
£2.00 EACH. ref: 2P199.
.45V 100mA SOLAR CELL.
silicon plastic encapsulated. 45 x 26 x 7.5mm in dims.
£1.00 EACH. ref: BD631.

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

INDUCTIVE AMPS £5.00
Made for amplifying a telephone handset for the hard of hearing. However if you hold one against a piece of wire carrying a telephone conversation you can hear both sides of the conversation! It can also be used for tracing live wires in a wall or detecting cables carring mains etc. Fully cased complete with battery and fixing strap. Aprox 2.5" diameter 1" thick.
Our Price :£5.00 Our Ref :EV5P11

CTM644 COLOUR MONITOR £79.00
Refurbished monitor suitable for many home computers standard RGB input.
Our Price :£79.00 Our Ref :EV79P11

ARCHEMEDIES A3000 PSU £10.00
A compact switch mode PSU with on/off switch, selectable voltage input 110/240. NEW O/P via fly leads. GOOD STOCKS AVAILABLE.
Our Price :£10.00 Our Ref :EV10P11

ANSWERPHONES from only £18.00
Yes its true BT approved push button dialling. These are customer returned units and have two faults. We will supply you with a chip to cure one fault then you have to sort out the other problem! NON RETURNABLE.
Prices:
£18.00 each. REF: EV18P21
£60.00 PKT 4. REF: EV60P21

PORTABLE ALARM SYSTEM £17.00
'PAL' Portable Multi Beam Scanning System. Lockable Stand-alone PIR unit with removable keys (3 supplied). This unit uses a PP3 battery and when activated emits a piercing SHRILL! The unit scans the room and memorises the layout. Should this change, the alarm is triggered. There is a 60 second exit delay.
Our Price :£17.00 Our Ref :EV17P11

PIR MOVEMENT DETECTOR £15.00
Once again we have aquired stocks of this popular line and are able to offer you a very high quality and professional detector at only **£15**. Range: 20m with a 90° arc. Day and Night Mode Dims: 15cm x 9cm x 11cm. New and boxed, complete with installation guide.
Our Price :£15.00 Our Ref :EV15P21

MANY MORE SPECIAL OFFERS IN OUR REGULAR NEWSLETTERS

WE HAVE HUNDREDS AND HUNDREDS MORE STOCK LINES - TOO MANY TO LIST IN ONE ADVERT ! CHOOSE FROM

AERIAL AMPLIFIERS	FANS
AEROSOLS	FUSES
ALARMS	GLUE GUN AND GLUE
AMPLIFIED SPEAKERS	HEADPHONES
ANALOGUE MULTIMETERS	HEATSHRINK SLEEVING
APPLIANCE LEADS	HI FI SPEAKERS
BATTERIES AND HOLDERS	IONISERS
BATTERY CHARGERS	LED's
BOOKS	LASERS AND LASER PSU's
BOXES AND CASES	LOGIC PROBES
CAMCORDER BITS	LOUD AND MARINE SPKRS
CAPACITORS	MICROPHONES
CAR AMPS, RADIOS & SPKRS	PIR LIGHTS AND DETECTORS
CB SPEAKERS AND PSU's	POWERS SUPPLIES
COMPUTER BITS	POWER AMPLIFIERS
CONNECTORS	RADIOS
DESOLDER PUMP	SERVICE AIDS
DIGITAL MULTIMETERS	SOLDERING EQUIPMENT
DISCO LIGHTING	STEAM ENGINES
DISPLAYS	TRANSEIVERS
DUBBING KIT	TRANSFORMERS
DRILLS	WIRELESS MICROPHONES

IN SUSSEX?
CALL IN AND SEE US!!

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

MUCH MUCH MORE IN OUR 1993 **CATALOGUE**. PLEASE SEND 41P , A4 SIZED SAE FOR YOUR FREE COPY.

EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

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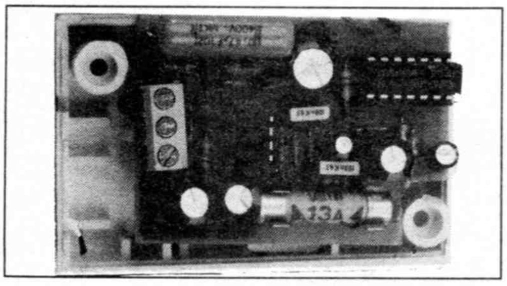
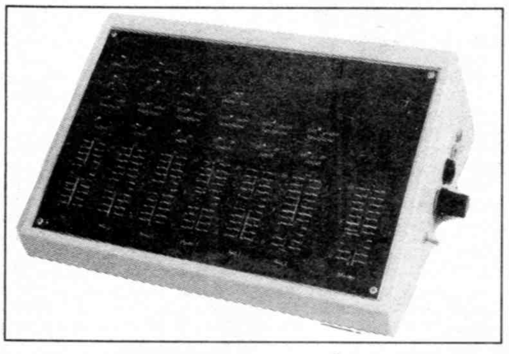
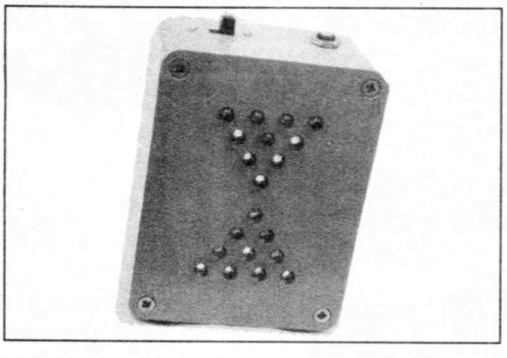
The No. 1 Independent Magazine for Electronics, Technology and Computer Projects

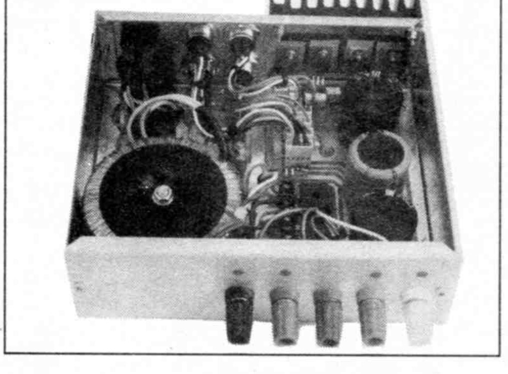
ISSN 0262 3617

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









Projects

Series

Features

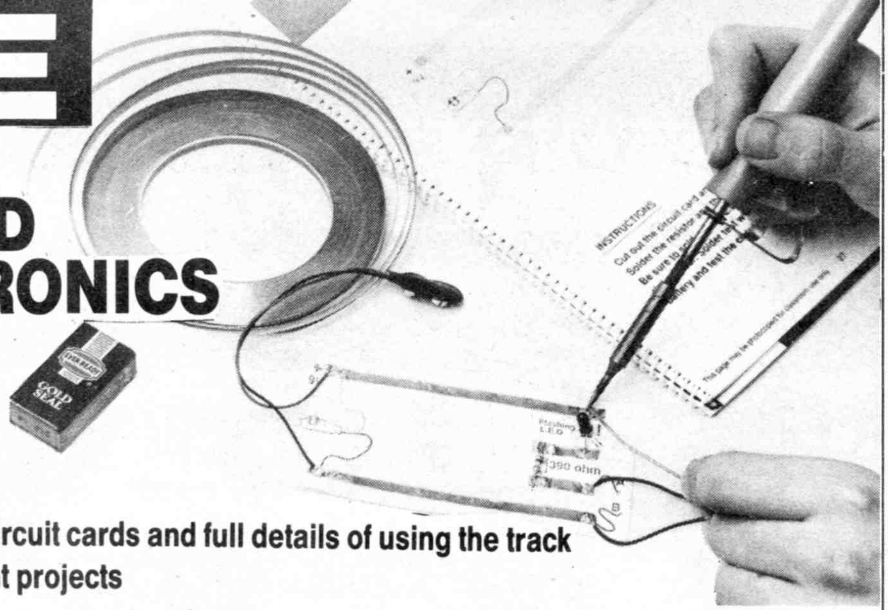
FREE WITH THIS ISSUE – MARCO '94 CATALOGUE Banded to the magazine

Our November '93 issue will be published on Friday, 1 October 1993. See page 715 for details.

NEXT MONTH

FREE

COVER MOUNTED TRACKTRONICS COPPER CIRCUIT TRACK



Together with three circuit cards and full details of using the track to build three different projects

SPECIAL SUPPLEMENT

ELECTRONICS PRINCIPLES

Describes a new software package that EPE is marketing. Full details are given together with information on how to obtain a special minimal cost demonstration disc. If you are interested in teaching or learning about electronics don't miss this important innovation.

MINIGUARD

A portable PIR alarm – take it wherever you go!

This passive infra-red intruder alarm is a miniature version of the larger system now often found in homes and commercial premises. However, Miniguard differs from its larger counterpart in being totally self-contained with integral batteries and sounder. It is therefore entirely safe in operation and may be carried from place to place as the need arises. Arming and disarming is carried out by means of a key-operated switch on the unit and there are built-in time delays which allow this to be carried out without the user setting it off.

Miniguard operates a siren when a person walks into the protected zone. The detection range is at least eight metres (26ft approximately) which should be sufficient for most purposes.

20 METRE RECEIVER

An article describing a direct conversion receiver for the 80 metre amateur band appeared in the June 1990 issue of Everyday Electronics. *The project to be featured next month is firmly based on that design, but it has been modified for operation on the 20 metre amateur band.*

Reception on the 20 metre band is in many ways the opposite of 80 metre reception. During daylight hours the radio waves are reflected from the upper atmosphere, and long distance reception is possible. The signals are reflected from a very high layer of the atmosphere, enabling very long distances to be covered on each bounce. The groundwave tends to be absorbed by the earth, giving little reception of signals via the direct route. Distances of several thousand miles can usually be covered, and even with quite simple receiving equipment it is often possible to pick up stations on the other side of the world.

EVERYDAY WITH PRACTICAL ELECTRONICS

NOVEMBER ISSUE ON SALE FRIDAY, OCTOBER 1ST

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 REGS
7812/7805/7912/7905 all 35p each, any 4 for £1.20
AD592An Temperature Sensor i.c. mounted on 1.5m screened lead complete with data and application notes £1.50 each
LM3914/LM3915 Bargraph ics £2.95 each
78512 12V +VE 2amp regulator 50p each
78505 5V +VE 2amp regulator 50p each
MICRO IC'S –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

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

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

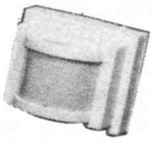
10 or 20 minute bell cut off +ve or −ve trigger* timed relay contacts. £4.96

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.
PRICE COMPLETE WITH FULL INSTRUCTIONS £8.95

SIREN
12 volt dc for external use 115db £8.95

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



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

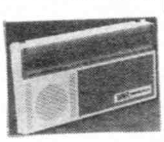
DOOR/WINDOW CONTACTS
Surface or flush mounting, white £1.10 each
JUNCTION BOX
white 6 way 60p

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

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

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

BREADBOARDS – CAPACITORS – SOLAR CELLS – HEATSHRINK – ETC

SOLAR CELL 2 volt 150mA max, size 60 x 100mm £1.35 each 5 for £6
BNC SOCKETS 50 ohm single hole fixing 50p each 10 for £4.00

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

BREADBOARD
173 X 65mm 840TP £5.25 each
TEXTOOL ZIF SOCKET
28 pin zero insertion socket £5.95 each

6 VOLT NI-CAD PACK 5AA NI-CADS, fast charge type £3.95
CAPACITOR 10,000 mfd 25 volt with fixing clip 60p each
EPROMS 27C256 – 30 27C512 – 25. Once programmed but never used eprom. Mounted on a plastic carrier, can easily be removed from the carrier or used with a low insertion force socket.
27C256 £1.00 each 6 for £5.00 **27C512** £1.20 each 5 for £5.00
Suitable low insertion force socket 28 pin 40p each 3 for £1.00
MULTITURN PRESETS 20mm RECT, 500R, 1K, 5K, 10K, 20K, 50K, 100K 1MO. 40p each, 3 for £1.00
CAR CIGAR LIGHTER ADAPTER (DUAL SIZE)
mounted on two metres of cable £2.00 each
100db PIEZO SOUNDER
2KHz note, 3-12V d.c. 40Ma, 45mm dia. x 26mm £1.76 each
VIBRATION SENSITIVE ALARM BOARD WITH PIEZO SOUNDER
Originally a bike alarm. There is a short delay after activation then the piezo sounder operates for a preset period. £3.76 each
or the above alarm board with custom designed case, fixing clip and keyswitch £9.95
INFRA-RED BREAK BEAM Transmitter and receiver p.c.b. with 2 lens assemblies. 12V d.c. supply. These are ex-installation units and are not guaranteed to be working. £4.96 pair
RECHARGEABLE BATTERIES £7.64 each

AA (HP7) 600 mAH	£1.02 each	C (HP11) 1200 mAH	£2.29 each
D (HP2) 1200 mAH	£2.40 each	PP3 8.4V 100 mAH	£4.77 each

FLOURESCENT LIGHT INVERTOR. Drives an 8 watt tube directly from 6V d.c. Data supplied £4.50 each

£1.00 BARGAIN PACKS

SUB-MINIATURE TOGGLE SWITCHES

P.C.B. Mounting

BO1 S.P. on 4 for £1.00
BO2 D.P. on 3 for £1.00
BO3 3 x D.P. 3 pos, centre off
BOO4 **DIL SWITCHES** 4-way S.P. on 3 for £1.00
BOO5 **DIL SWITCHES** 8-way S.P. on 2 for £1.00
BOO6 **DIL SWITCHES** 12-way 90° sp on 2 for £1.00
BOO7 **12 x PP3 BATTERY SNAPS**
BOO8 **1 x CAPACITOR 1 FARAD 5.5 VOLT** 20mm dia. x 7mm high
BOO9 **INSTRUMENT KNOBS (0.25" SHAFT)** High quality grey plastic knob, collet fixing 15mm dia, 5 for £1.00
BO10 as above but 29mm dia, 3 for £1.00
BO11 **4 x MAGNETIC EARPIECE** 8 ohm with 3.5mm plug
BO12 **4 x 28-WAY TURNED PIN DIL SOCKET**
BO13 **15 x 12 VOLT WIRE-ENDED LAMPS**
BO14 **8 x 2 PIN DIN PLUGS** screw terminal connection
BO15 **2 x LIGHT DEPENDENT RESISTOR** Less than 200 ohms in daylight, greater than 10 megohms in darkness
BO16 **1 x KEYPAD** 20-key in 5 x 4 matrix bubble type switch contacts
BO17 **2 x PIEZO BUZZERS** approx 3 to 20 volt d.c.
BO18 **5 x 78M12 VOLTAGE REGULATORS** positive 12V 500mA
BO19 **4 x TL082CP** bi-fet op-amps
BO20 **20 x ASSORTED LEDS** full spec. various shapes and sizes
BO21 **3 x INFRA-RED DIODE TX/RX PAIRS** made by Honeywell(no info)
BO22 **4 x CONSTANT CURRENT LED** 5mm round, red 2-18V d.c. or a.c. nominal 14mA
BO23 **50 x IN4148** diode
BO24 **2 x INFRA-RED TRANSISTOR FPT5133**
BO25 **5 x DIACS**
BO26 **3 BDX33C** 10 amp 100V npn transistor
BO27 **12 x 2N3702** Transistor
BO28 **12 x 2N3904** Transistor
BO29 **12 x BC337** Transistor
BO30 **4 x LM317T** Variable regulator mounted on a small heatsink
BO31 **2 x MAN6610** 2 digit 0.6" 7 segment display Com anode, amber
BO32 **3 x PHONO TO PHONO LEAD** 63cm long
BO33 **15 x RECTANGULAR RED LEDs** 6 x 6 x 2mm stackable
BO34 **1 x PHOTO SENSITIVE SCR** mounted on a PCB, data sheet supplied
BO35 **4 x IEC Panel Mounting Mains Plug** Snap fix
BO36 **5 x ASSORTED PIEZO TRANSDUCERS**
BO37 **5 LENGTHS OF HEATSHRINK SLEEVING** 8mm dia. 400mm long
BO38 **25 x CERAMIC DISC CAPACITORS** 0.1 mfd 63V
BO39 **15 x MONOLITHIC CERAMIC CAPACITORS** 0.1 mfd 63V, in a dil package
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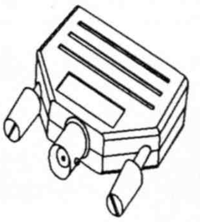

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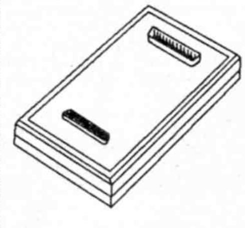

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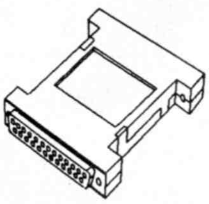
ADC-11



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- Digital output
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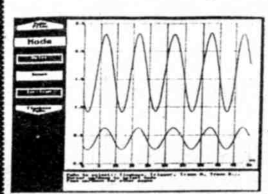

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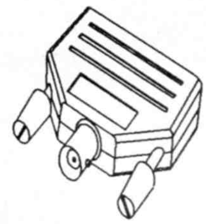

- Up to 18kHz sampling rate
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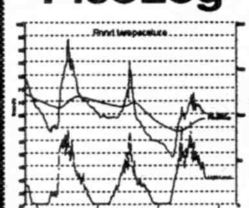

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Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●		●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
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1.0	–	–	£0.05	£0.06	£0.15
2.2	–	–	£0.05	£0.06	£0.18
4.7	–	–	£0.05	£0.08	£0.30
10	£0.05	£0.05	£0.06	£0.08	£0.48
22	£0.05	£0.05	£0.09	–	–
47	£0.06	£0.06	£0.11	–	–
100	£0.06	£0.09	£0.11	–	–
220	£0.09	£0.12	£0.31	–	–
470	£0.15	£0.19	£0.57	–	–
1000	£0.22	£0.29	–	–	–
2200	£0.37	£0.57	–	–	–
4700	–	£1.11	–	–	–

ELECTROLYTIC AXIAL CAPACITORS

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1.0	–	–	£0.10	£0.10	£0.19
2.2	–	–	£0.10	£0.10	£0.22
4.7	–	£0.09	£0.10	£0.10	£0.34
10	–	£0.12	£0.12	£0.12	£0.48
22	–	£0.09	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	£1.33
100	£0.10	£0.13	£0.21	–	£2.46
220	£0.13	£0.18	£0.42	–	–
470	£0.21	£0.24	£0.69	–	–
1000	£0.33	£0.40	£1.05	–	–
2200	£0.52	£0.64	–	–	–
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ICM7556	£0.96
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LM3900	£0.72
LM3914	£2.70
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This issue sees the start of our annual autumn promotion period. This year there will be a number of free catalogues plus a free cover-mounted gift which we are working on now. Regular readers will know that we are often able to include catalogues with the issue and these are always well received. They often represent excellent reference material and even if you don't need anything immediately they are well worth hanging on to for future reference.

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A special demonstration disc will be available at minimal cost to readers so that everyone can sample the package for themselves. When Mike reviewed the software for us he made the following comments:

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"When I started to use the package my views changed. Indeed, I was so impressed with it that I quickly came to the conclusion that *Everyday with Practical Electronics* readers should have an opportunity to try the package for themselves."

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Mike Kenward

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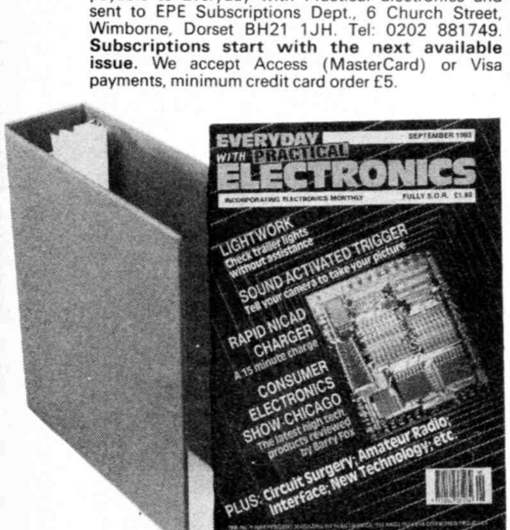

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Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.00 (£2.50 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only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

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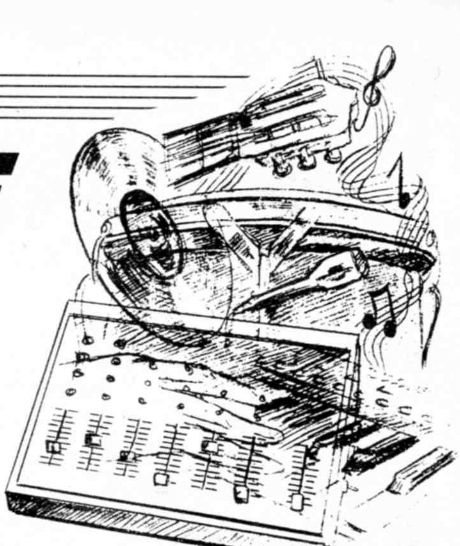


MULTI-PURPOSE AUDIO SYSTEM

Part 1 – SIX-CHANNEL, LOW NOISE STEREO MIXER

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.

THIS short series features a number of audio modules which will enable the constructor to produce a tailor made system. All the modules will operate alone, but are compatible with each other, and are designed to run on 12V d.c.

The system block diagram is shown in Fig. 1 and includes the following modules:

Module 1: 6-Channel, Low Noise Stereo Mixer
Module 2: RIAA Stereo Pre-Amp (for Record Decks)
Module 3: Microphone Pre-Amp
Module 4: Bass/Treble/Volume/Balance Control Unit
Module 5: One watt Stereo Amplifier
Module 6: 10 + 10 Watt Amplifier and P.S.U.

Note: The main mixer p.c.b. includes two Module 2's and two Module 3's. Separate p.c.b. layouts are also included for Modules 2 and 3 (next month).

Having now settled on our preferred line-up, we shall start by describing the 6-Channel Stereo Mixer module, followed by Modules 4 and 5 and finally the 10 + 10 Amplifier – Module 6. Being the "brain" of the system – accepting incoming signals, analysing, mixing and generally directing them to their designated "location" – the introduction and description is naturally fairly lengthy (and will be spread over two issues).

OVERVIEW

A stereo six channel mixer – i.e. 12 channels in all – provides many possibilities and the proposed system, as shown in Fig. 2, comprises.

Channel 1:– AUX or MICrophone 1
Channel 2:– AUX or MICrophone 2
Channel 3:– AUX or PHONO 1
Channel 4:– AUX or PHONO 2
Channel 5:– AUXiliary 1
Channel 6:– AUXiliary 2

CHOICES

The size of the final printed circuit board (p.c.b.) is determined by the layout of the slider potentiometers. It seemed wise therefore to include the microphone pre-amplifiers and the RIAA pre-amplifiers on the same board.

If these are not required a simple wire link can be inserted to bypass that section of the p.c.b. Also, separate microphone and RIAA pre-amp p.c.b. layouts are provided in case the constructor wishes to include six microphone inputs or six phono inputs or any other combination.

MICROPHONE INPUTS

Since all inputs are stereo, the microphone inputs can be "joined" by means of switch S1 (and S2) to connect the left and right inputs together, see Fig. 2, enabling an ordinary microphone to mix into both left and right channels at the same time. If a stereo pair of microphones is required they could be connected to the right and left inputs of say Channel 1. Note that the left and right channels are controlled by a single slider; if independent control is required the left microphone could be connected to Channel 1 and the right microphone to Channel 2.

If full independent control of four microphones is required a variable resistor (potentiometer) could be fitted to one or both channels of each microphone pre-amp. This is described in the relevant section.

The microphone inputs, Fig. 2, are amplified before being fed to slider control VR1 (and VR2). Switches S3 and S4 may be used to bypass the microphone pre-amps if devices such as CD players or tape recorders are used with Channel 1 and/or Channel 2.

PHONO INPUTS

"Phono" is a term used to imply that the input is suitable for use with a magnetic cartridge – as fitted to most good quality record decks. The term should not be confused with the type of connector known as a "phono" plug or socket.

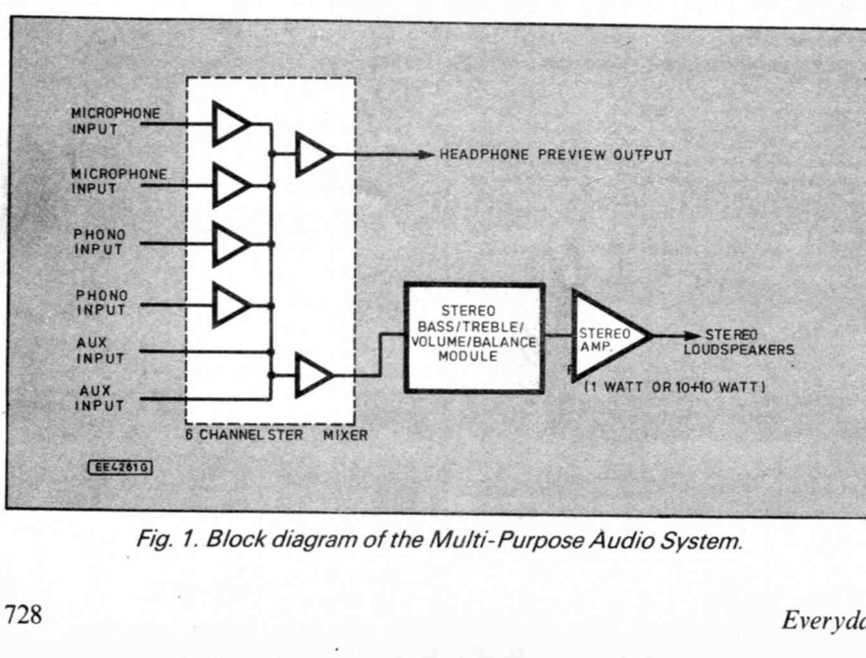


Fig. 1. Block diagram of the Multi-Purpose Audio System.

The phono or gramophone input requires amplification and frequency correction. The type of correction required is known as *RIAA* equalisation, and is described fully later.

Like the microphone pre-amps, the RIAA pre-amps can be bypassed by means of switches S5 and S6 to enable Channel 3 and/or Channel 4 to be connected to devices other than record decks.

AUX (AUXILIARY) INPUTS

Channel 5 and Channel 6, the AUX inputs, can only be used with equipment which does not require a pre-amp or frequency correction. Such equipment includes CD players, tape decks, tuners and video recorders.

There is no reason why external microphone pre-amps or RIAA pre-amps could not be connected to Channel 5 and/or Channel 6. It is also a fairly simple matter to convert a RIAA pre-amp to a microphone pre-amp, and this is described in the RIAA pre-amp section.

SLIDER/SWITCH CONTROLS

Potentiometers VR1 to VR6 are stereo "slide"/"fader" controls which enable the various sound inputs to be mixed at suitable levels. Switches S8, S10, S12, S14, S16 and S18 enable the inputs to be connected to the main mixer.

The odd number switches S7 to S17 allow the inputs to be monitored and/or previewed on headphones, via the headphone mixer. These switches are two way "centre off" types which allow monitoring at full volume or via the faders.

MAIN MIXER

The main mixer circuit and the headphone preview mixer are identical although for convenience in the p.c.b. design, different pins of the i.c. are used for the left and right channels. The circuit diagrams for audio mixer and headphone preview mixer are shown in Fig. 5 and Fig. 6 respectively.

The main mixer is based on an i.c. type NE5532. This chip includes two ultra low noise op-amps, which allow a simple yet effective high quality sound mixer to be realised. The mixer circuit is designed for a single rail supply (i.e. a normal 9V or 12V battery or power unit), and provides a gain of unity (i.e. the output is equal in magnitude to the input).

The printed circuit board allows up to six stereo channels (i.e. 12 channels in all). The constructor need only build the channels required – most of the cost of each channel being the slider potentiometer and switches.

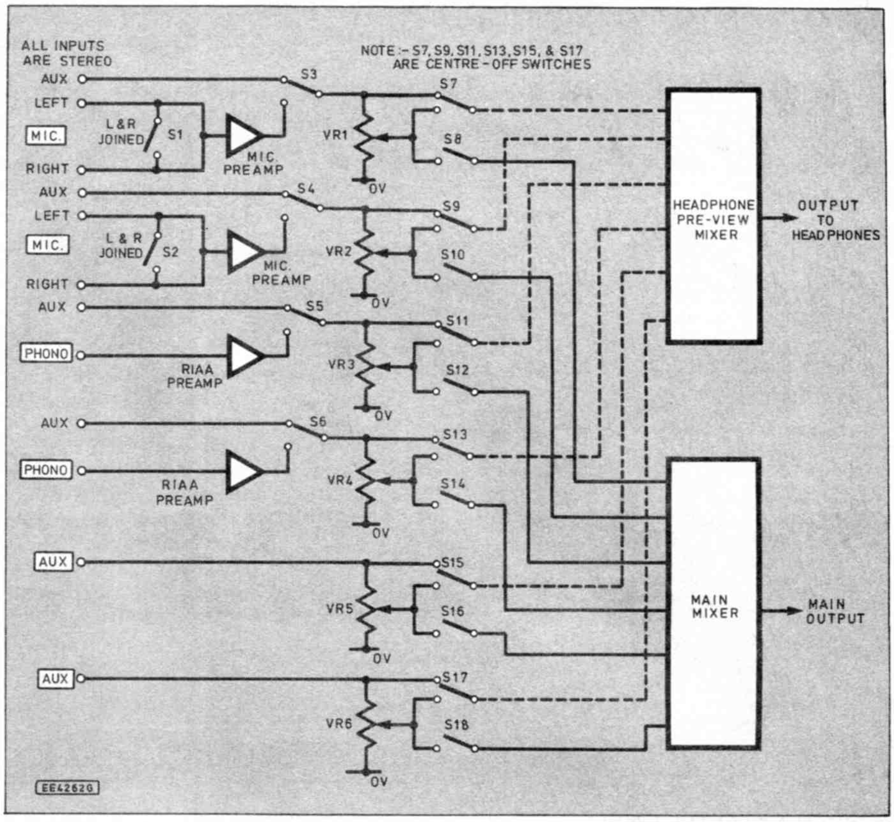
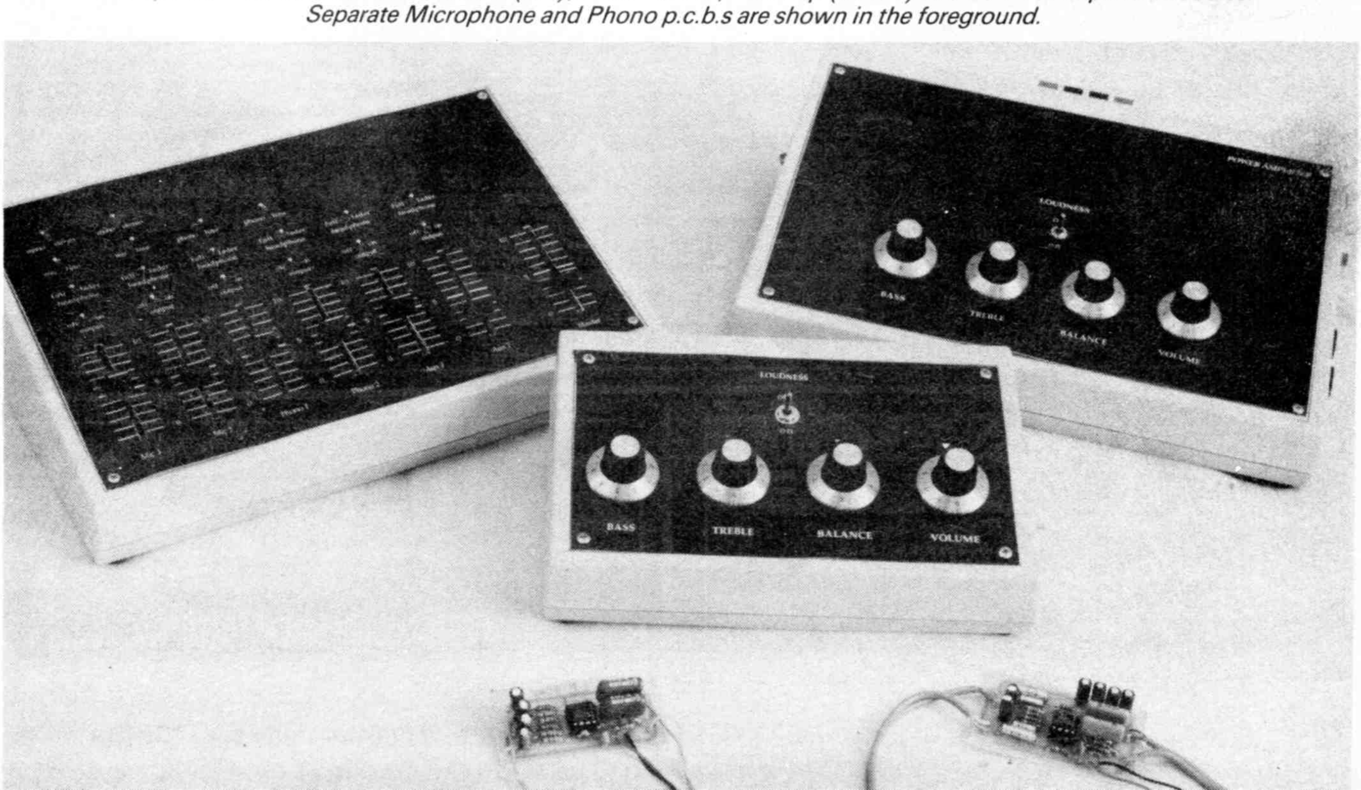


Fig. 2. Block diagram for the 6-Channel Stereo Mixer. Note: All lines, switches etc are stereo pairs.

INPUT CONTROLS

The sound input level controls (VR1 to VR6), Fig. 2, are the most obvious part of any mixer unit, and sliders were chosen since they provide the more professional finish, and visual comparisons between sound levels are more obvious than with rotary controls. However, sliders are more expensive and more difficult to mount in a case. The complexity of wiring up stereo sliders, and the availability of miniature types pointed toward their inclusion on the p.c.b. design.

The System – Six Channel Stereo Mixer (left), Tone Control/1W Amp (centre) and 10 + 10 Amplifier Modules. Separate Microphone and Phono p.c.b.s are shown in the foreground.



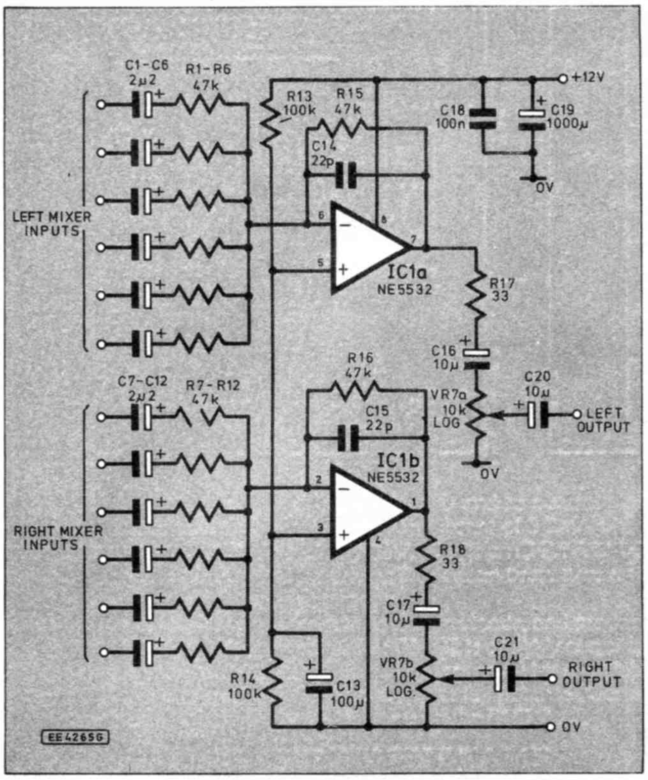


Fig. 5. Circuit diagram for the Main Mixer.

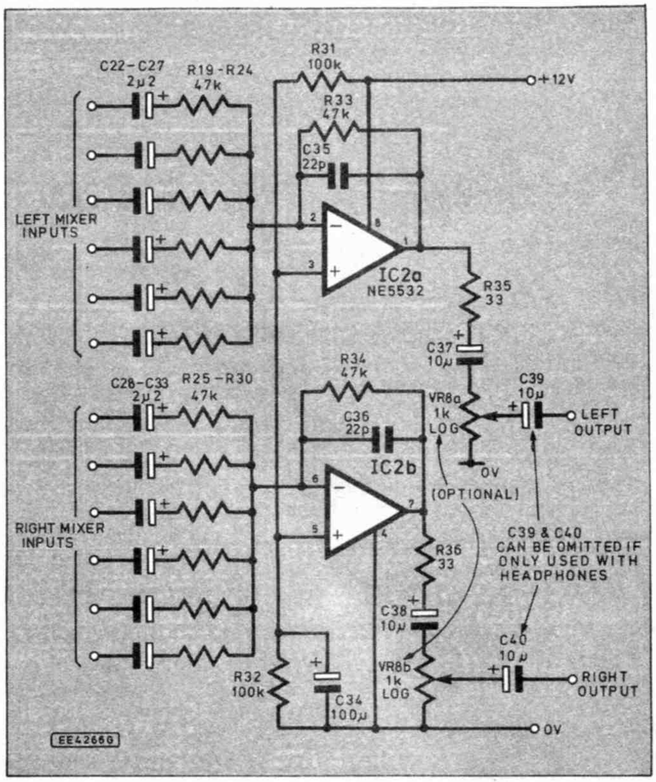


Fig. 6. Headphone Preview Mixer circuit diagram.

Pin 8 and pin 4 are the power supply pins, and capacitor C19 decouples the supply, providing a smooth d.c. supply for all the modules in the project. Capacitor C18 removes any voltage spikes on the supply in the vicinity of IC1. Since the two stereo halves IC1a and IC1b are identical, only the left channel will be described.

The non-inverting input (pin 5) is held at half the supply voltage (i.e. 6V) by the potential divider formed by resistors R13 and R14. Output pin 7 will also assume 6V since it is connected to inverting input pin 6 via R15. Pin 6 is also held at 6V, since any change in the d.c. level at the output will feed back to the inverting input and be self cancelling.

INPUT IMPEDANCE

The a.c. audio single is applied to inverting input pin 6 via capacitor C1 (or C2 etc.) and resistor R1 (or R2 etc). The input capacitors are required to prevent the flow of d.c. away from pin 6 (which remember is at 6V) to ground via the input potentiometer VR1 (Fig. 2).

The inverting input pin 6 acts as "ground" as far as audio a.c. signals are concerned, and therefore the effective input impedance at this stage is the value of resistor R1. Since pin 6 acts as an a.c. ground, no a.c. signals can flow back through any of the other input resistors (i.e. R2-R6). This ensures that the various input sources (CD player, tape deck etc) are truly independent.

GAIN

The gain of the circuit for Left Channel 1 is given by R15/R1, i.e. unity. Note that the output will be out of phase with the input. Capacitor C14 is required to remove any very high frequencies which may cause unwanted oscillations.

OUTPUT

The output from pin 7 is fed via a 33ohm resistor (R17), which protects the output if it is accidentally shorted to ground. Capacitor C16 prevents the flow of d.c. from the output of the i.c. to 0V, but allows the a.c. audio signal through to the Master fader (VR7a) control.

The master fader is a dual (i.e. stereo) slider potentiometer identical to the other slider potentiometer. No balance control is provided since this is included within the tone control module (a separate article).

HEADPHONE PREVIEW MIXER

The circuit diagram for the Stereo Headphone Preview Mixer stages is shown in Fig. 6. Note that for the left hand channel, pins 1, 2, and 3 of the i.c. are used instead of pins 5, 6 and 7. This aided the p.c.b. design. Otherwise the headphone mixer is identical to the main mixer except that the output capacitors C39 and C40 (in the main mixer) are not required in the headphone mixer.

The headphone Volume control VR8 (if required) is a one kilohm "log". dual rotary potentiometer. Note that C39, C40 and VR8 are not included on the p.c.b. since the capacitors are unlikely to be required, and VR8 may be mounted at the side of the case.

Rear view of the mixer console showing the layout of the input and output sockets.

STEREO MICROPHONE PRE-AMP

The Stereo Microphone Pre-Amplifier is based on the NE5532 i.c. as used in the mixer. The basic principal of operation is shown in Fig. 7 and the circuit diagram in Fig. 8. The component references in brackets in Fig. 8 refer to the second microphone preamplifier (MIC 2).

This time the op.amp is used in its non-inverting mode, where the input is connected to the *non-inverting* input (see Fig. 7), and the output is in phase with the input. The reason for this arrangement is that the gain can be quite high, without reducing the input impedance of the circuit. The input impedance and gain are described below; note how (unlike the previous *inverting* circuit) the two are not related.

CIRCUIT DESCRIPTION

One half of the circuit (Fig. 8) will be described, the other stereo half being identical. As with the mixer, this circuit is designed to operate on a single 12V supply, and it is necessary to hold the input and output at half the supply voltage (i.e. 6V) in order to accommodate the a.c. audio signal.

The non-inverting input pin 3 is held at 6V by the potential divider formed by resistors R37 and R38. The output pin 1 also remains at 6V since it is connected to inverting input pin 2, via resistor R41. Any change of d.c. level at the output will tend to self cancel.

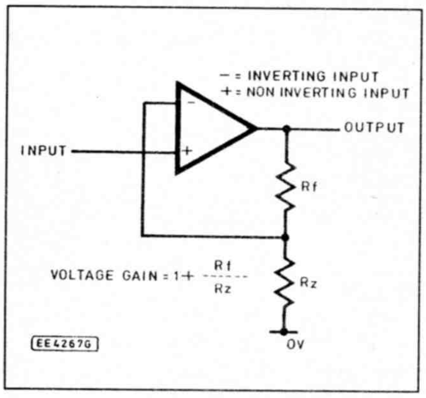


Fig. 7. Op.amp in non-inverting mode.

INPUT IMPEDANCE

Having set the d.c. levels, the a.c. audio signal input is supplied via d.c. blocking capacitor C41 to pin 3. The effective input impedance of the circuit is determined by the resistance to a.c. between the input and ground.

As far as audio frequencies are concerned, the two supply rails both act as grounds and the input impedance is therefore given by resistors R37 and R38 as if in parallel, i.e. 50 kilohm. This may seem high considering that microphones are generally rated at a few hundred ohms, but a good microphone pre-amp should not drain much current from the microphone and a high input impedance is therefore wise, if not essential.

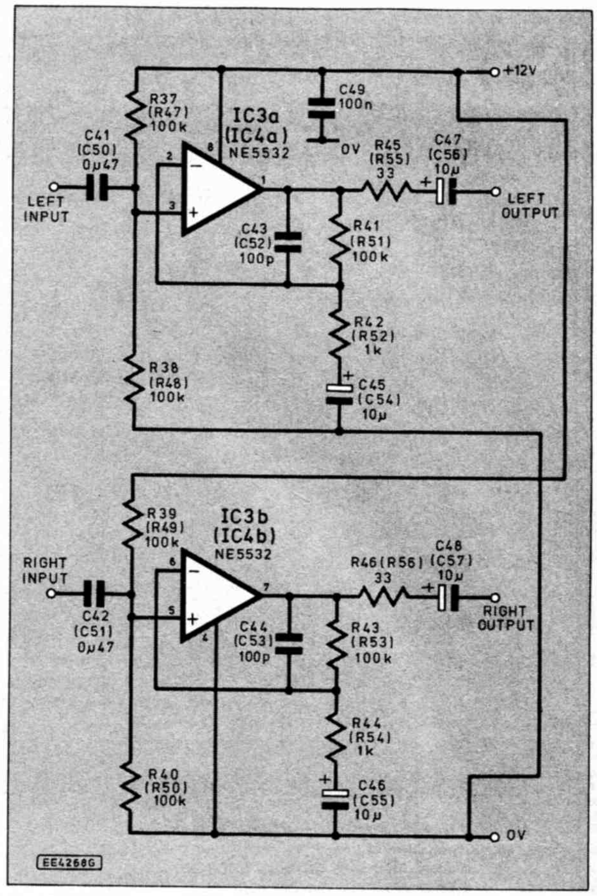


Fig. 8. Stereo Mic Pre-Amp circuit.

GAIN

The gain of the pre-amp (see Fig. 7) is given by: $1 + R41/R42$, i.e. $1 + 100k/1k = 101$. Capacitor C45 plays no part in this equation since all audio frequencies will pass through C45 as if resistor R42 was connected directly to ground. However, C45 blocks the flow of d.c. ensuring that pin 2 is effectively tied to pin 1 as far as d.c. is concerned, thus maintaining the average d.c. level of 6V. Capacitor C43 provides a low impedance path for very high frequencies, thus eliminating unwanted interference.

Individual constructors may wish to change the gain to suit their particular microphones. The gain may be increased by increasing the value of resistor R41 (and R43), or reduced by reducing the value of these resistors the result being based on the formula above. Alternatively, variable gain controls may be provided by means of potentiometers of say 100 kilohm or 250 kilohm in place of R41 (and R43), but keep the wires short (or screened), and remember that the gain cannot be reduced to zero; in other words the "pots" will not act like normal volume controls.

OUTPUT

Resistor R45 prevents any damage which might occur if the ouput was shorted to ground, and capacitor C47 blocks the flow of d.c. into the next stage of the project – in this case the potentiometer which controls the mixed input level. Capacitor C49 removes any short spikes on the supply in the vicinity of the i.c.

CUTTING CORNERS
APPLIES TO ALL SECTIONS OF THE MIXER

IT MAY have occurred to some readers that some circuitry could be saved by mixing the inputs before the microphone pre-amp or RIAA stages. For example, if a six (stereo) channel microphone mixer was required, the saving in circuitry could be considerable.

However, be warned! Mixing is best done with "line level" signals, not the tiny signals from microphones or magnetic cartridges. Potentiometers tend to produce noise (i.e. random voltages) and this will seriously reduce the quality of sound from the mixer. If the cost of the electronic components is compared with the cost of the case and slider controls, the savings made in this way are not worth the loss in quality which would result.

BEFORE BUYING THE PARTS

It is important to have a clear idea of exactly what is required from the mixer before buying the parts. A second glance at the "System Options" panel will help clarify the system required. Remember that the p.c.b. provides six stereo channels (although less could be built if preferred), and two channels are designed for Microphone or "Aux." inputs, and twoo channels are designed for Phono or "Aux." inputs.

If you require six "auxiliary" inputs, none of the pre-amps need be built, and switches S3 to S6 could be replaced by pairs of wire links inserted to bridge each *centre* switch pad to each *left*-hand switch pad viewed from the component side. The "line input" pads will then be permanently connected to the slider control.

If you require three or four stereo microphone inputs, and no phono inputs, the RIAA pre-amps can be converted to microphone pre-amps by replacing resistors R66 and R68 by wire links, fitting 100pF capacitors for C64 and C66, and omitting C65 and C67. Resistors R65 and R67 could be substituted by 100 kilohm types to match the gain of the other microphone pre-amp circuits.

The switches represent a significant part of the cost of the project, but switches S7 to S18 are necessary if you wish to preview sounds before including them in the final mix. If such previewing is not required, *all* these switches and the headphone preview mixer can be omitted. In this case, the even numbered switches S8 to S18 *must* each be replaced by a pair of wire links inserted sideways to link the pads not already joined together by copper tracks.

If all the switches are required it is worth shopping around for low cost versions. Threaded types tend to be more expensive, but have long levers. However, non-threaded types allow the front panel of the case to be seated a little lower, and fairly low cost plastic body versions are available. P.C.B. pads are provided for 2-way switches. Cheaper on/off switches may be used in many cases, as described in "System Options".

COMPONENTS

Approx cost guidance only **£70** plus case

6-CHANNEL STEREO MIXER SYSTEM

MAIN MIXER

Resistors

R1 to R12, R15, R16	47k (14 off)
R13, R14	100k (2 off)
R17, R18	33 (2 off)

All 0·25W 5% carbon film

Potentiometers

VR1 to VR7	10k min. dual (stereo) slider carbon, log. (7 off) (p.c.b. mounting type, with metal body)

Capacitors

C1 to C12	2µ2 radial elect. (12 off)
C13	100µ radial elect.
C14, C15	22p ceramic (2 off)
C16, C17, C20, C21	10µ radial elect. (4 off)
C18	0µ1 disc ceramic
C19	1000µ axial elect.

See SHOP TALK Page 743

Semiconductors

IC1	NE5532 dual low noise op.amp

Miscellaneous

S1, S2	S.P.D.T. p.c.b. mounting toggle switch (2 off)
S3 to S6	D.P.D.T. p.c.b. mounting toggle switch (4 off)
S8, S10, S12, S14, S16, S18	D.P.D.T. p.c.b. mounting toggle switch (6 off)
S19	On/Off supply toggle switch

HEADPHONE MIXER

Resistors

R19 to R30, R33, R34	47k (14 off)
R31, R32	100k (2 off)
R35, R36	33 (2 off)

Potentiometers

VR8	1k dual (stereo) rotary carbon, log. (optional)

Capacitors

C22 to C33	2µ2 radial elect. (12 off)
C34	100µ radial elect.
C35, C36	22p ceramic (2 off)
C37, C38, C39, C40	10µ radial elect. (4 off) (C39, C40 not required for headphone application)

Semiconductors

IC2	NE5532 dual low noise op.amp

Miscellaneous

S7, S9, S11, S13, S15, S17	D.P.D.T. centre off p.c.b. mounting toggle switch (6 off)

The items below are required only for the Main Mixer, apart from where indicated.

Printed circuit board available from the *EPE PCB Service,* code 845. 8-pin d.i.l. socket (also required for Headphone Mixer); knobs for slider "pots" (6 off); ¼in. mono chassis jack sockets (4 off); phono chassis sockets (18 off); ¼in. stereo chassis jack socket (Headphone Mixer only); chassis power input socket (2 off); console case (see *Shoptalk*); M3 nuts, bolts and spacers; connecting cable; solder, etc.

STEREO MICROPHONE PRE-AMP

MIC 1

Resistors

R37 to R41, R43	100k (6 off)
R42, R44	1k (2 off)
R45, R46	33 (2 off)

All 0·25W 5% carbon film

Capacitors

C41, C42	0µ47 polyester film, 100V (2 off)
C43, C44	100p ceramic (2 off)
C45, C46, C47, C48	10µF radial elect. (4 off)
C49	0µ1 disc ceramic

Semiconductors

IC3	NE5532 dual low noise op.amp

MIC 2

Resistors

R47 to R51, R53	100k (6 off)
R52, R54	1k (2 off)
R55, R56	33 (2 off)

Capacitors

C50, C51	0µ47 polyester film, 100V (2 off)
C52, C53	100p ceramic (2 off)
C54, C55, C56, C57	10µF radial elect. (4 off)

Semiconductors

IC4	NE5532 dual low noise op.amp

Miscellaneous

8-pin d.i.l. socket; unless you are building all the circuits on the main mixer p.c.b., you will also need a p.c.b. for each pre-amp. (Separate small p.c.b.s available from *EPE PCB Service,* code 846). Note that 100V capacitors are specified for C41, C42, C50, C51 due to space problems on the p.c.b. if physically larger types are used.

STEREO RIAA PRE-AMP

PHONO 1

Resistors

R57, R58	47k (2 off)
R59, R62	100k (2 off)
R60, R63	820k (2 off)
R65, R67	56k (2 off)
R66, R68	680k (2 off)
R69, R70	1k (2 off)
R71, R72	33 (2 off)

All 0·25W 5% carbon film

Capacitors

C58, C59	0µ47 polyester film, 100V (2 off)
C60 to C63, C68, C69	10µ radial elect. (6 off)
C64, C66	1n8 close tolerance polystyrene (2 off)
C65, C67	5n6 close tolerance polystyrene (2 off)
C70	0µ1 disc ceramic

Semiconductors

IC5	NE5532 dual low noise op.amp

PHONO 2

Resistors

R73, R74	47k (2 off)
R75, R78	100k (2 off)
R76, R79	820k (2 off)
R81, R83	56k (2 off)
R82, R84	680k (2 off)
R85, R86	1k (2 off)
R87, R88	33 (2 off)

Capacitors

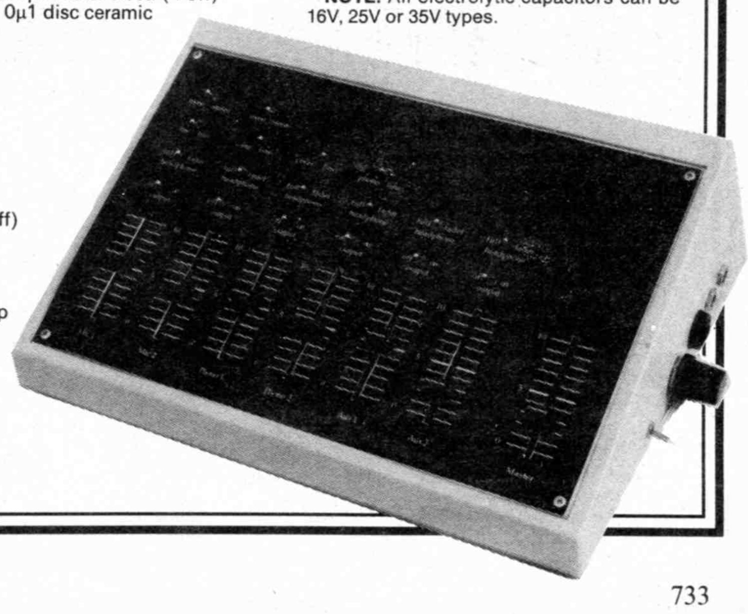
C71, C74	0µ47 polyester film, 100V (2 off)
C73 to C76, C81, C82	10µ radial elect. (6 off)
C77, C79	1n8 polystyrene, 1% (2 off)
C78, C80	5n6 polystyrene, 1% (2 off)

Miscellaneous

8-pin d.i.l. socket; unless you are building all the circuits on the main mixer p.c.b., you will also need a p.c.b. for each RIAA pre-amp. (Separate small p.c.b.s available from *EPE PCB Service,* code 847).

Note that 100V capacitors are specified for C58, C59, C71, C74 due to space problems on the p.c.b. if physically larger types are used.

NOTE: All electrolytic capacitors can be 16V, 25V or 35V types.



STEREO RIAA PRE-AMP FOR RECORD DECKS (PHONO)

The RIAA Pre-Amp is necessary because if a magnetic record deck cartridge was connected directly to the mixer there would be two problems:

1. The input signal level from the cartridge would be much too low.
2. There would be a severe lack of bass.

A pre-amp (like the microphone pre-amp) would boost the audio signal, but the bass problem would remain. A pre-amp is required which both *amplifies* the audio signal and *corrects* the frequency response of the record.

RIAA FILTER

When a record is cut, a filter circuit is used to increase the amplitude of the high frequencies and reduce the amplitude of the low frequencies. This is necessary to prevent the bass frequencies from occupying too much space on the record surface.

When replayed, a similar but opposite filter must be used to re-balance the frequency spectrum to its original level. The circuit required is known as a *RIAA filter*.

HOW IT WORKS

The circuit diagram for the RIAA Stereo Pre-Amp, for magnetic cartridge input (Phono), is shown in Fig. 9. The figures in brackets on the circuit diagram refer to the second channel or Phono 2. The RIAA filter pre-amp is again based on the NE5532 i.c., used in its non-inverting mode.

The non-inverting input (pin 5) of IC5a is held at about half the supply voltage by resistors R59, R60 and R61. The signal from the record deck is applied to pin 5 via d.c. blocking capacitor C58.

The amplified output from pin 7 is fed back to inverting input pin 6 via a resistor/capacitor filter which allows the necessary bass boost and treble cut. The overall gain of the circuit can be changed by changing the value of resistor R69. For example, increasing the value of R69 will reduce the gain.

The corrected and amplified signal is fed via R71 and C68 to the mixer. Resistor R71 prevents any damage should the output be accidentally connected to ground, and capacitor C68 blocks the flow of d.c. from the output, but conducts the a.c. audio signal.

The right hand signal is treated in exactly the same way via IC5b. Capacitor C70 removes any spikes from the supply rails in the vicinity of the i.c.

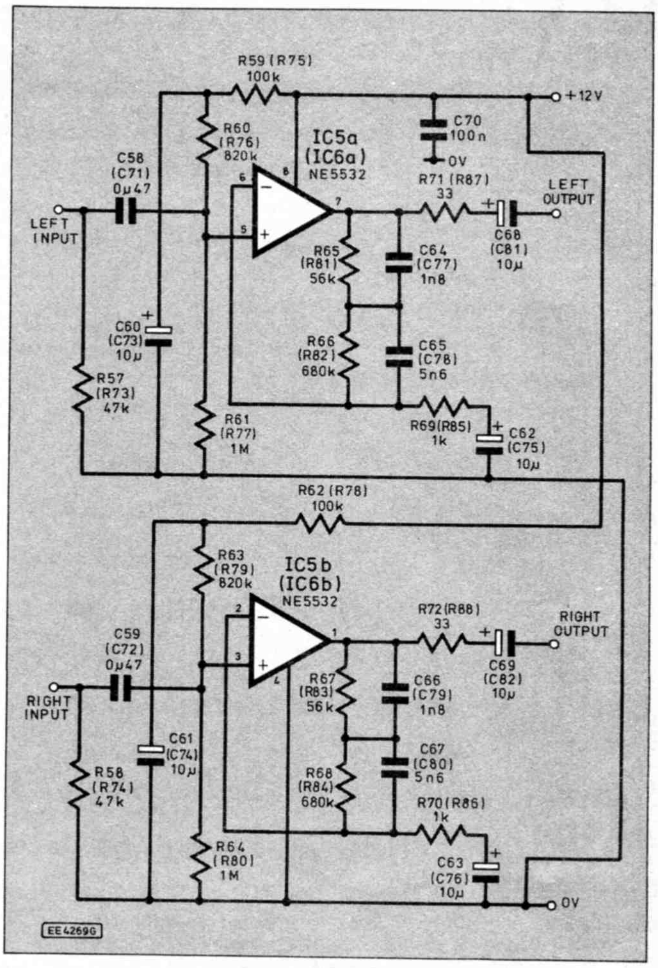


Fig. 9. Stereo RIAA Pre-Amp circuit diagram.

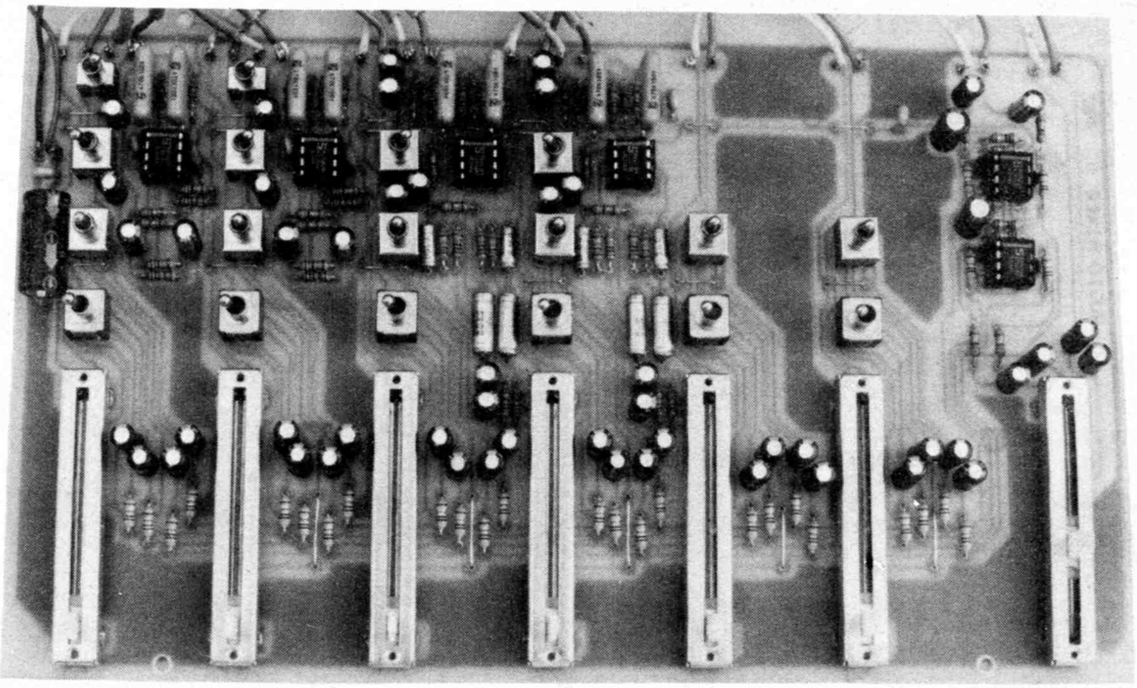
CONSTRUCTION

The Six-Channel, Low Noise Stereo Mixer module is built on a large (to take the slider controls) single-sided printed circuit board (p.c.b.). Separate p.c.b.s have also been designed for the Microphone and RIAA (Phono) Pre-Amp stages – see later. These board are available from the EPE PCB Service, codes 845 (6-Channel Stereo Mixer), 846 (Microphone Pre-amp) and 847 (RIAA Pre-amp).

The topside component layout on the large mixer board and underside copper foil master pattern is shown in Fig. 10. Begin construction by checking that the holes will accommodate the most awkward items such as the switches and slider "pots". Small holes can be enlarged by a miniature reamer if necessary.

Having established that the pots and switches will fit, begin by inserting the smallest components first, and the i.c. sockets. Check the polarity of the electrolytic capacitors; the negative side is usually marked (–), and the longer wire is on the positive side. Solder very carefully using a soldering iron with a miniature bit since some of the pads are quite closer to other pads or tracks.

Fit the stereo slider potentiometers, noting that the log scale only works correctly when the pot. is fitted the correct way up, as shown



6-CHANNEL STEREO MIXER BOARD

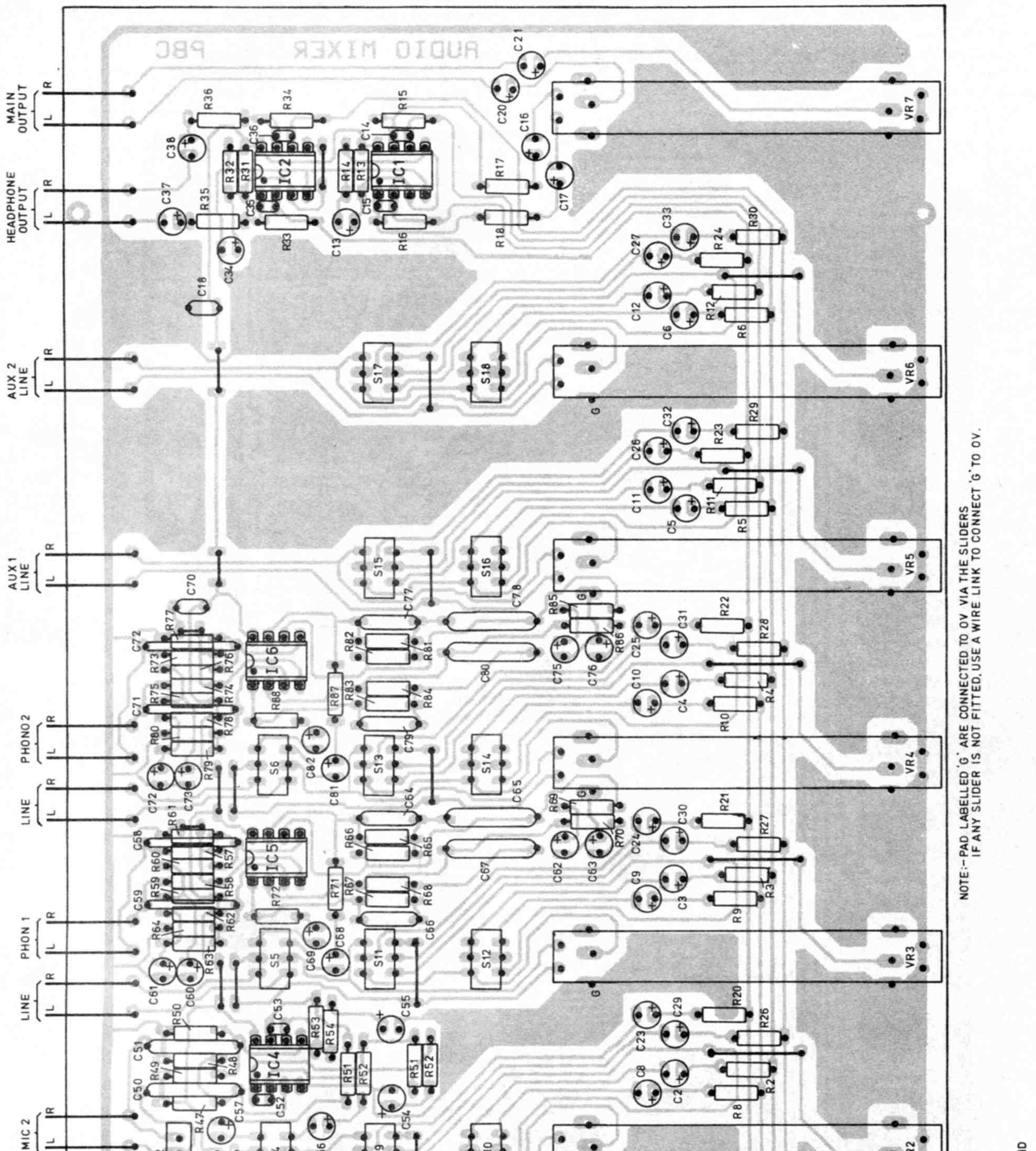


Fig. 10. Six-Channel, Low Noise, Stereo Mixer printed circuit board topside component layout. The completed board is shown opposite (left) and the copper foil master pattern appears on the next page.

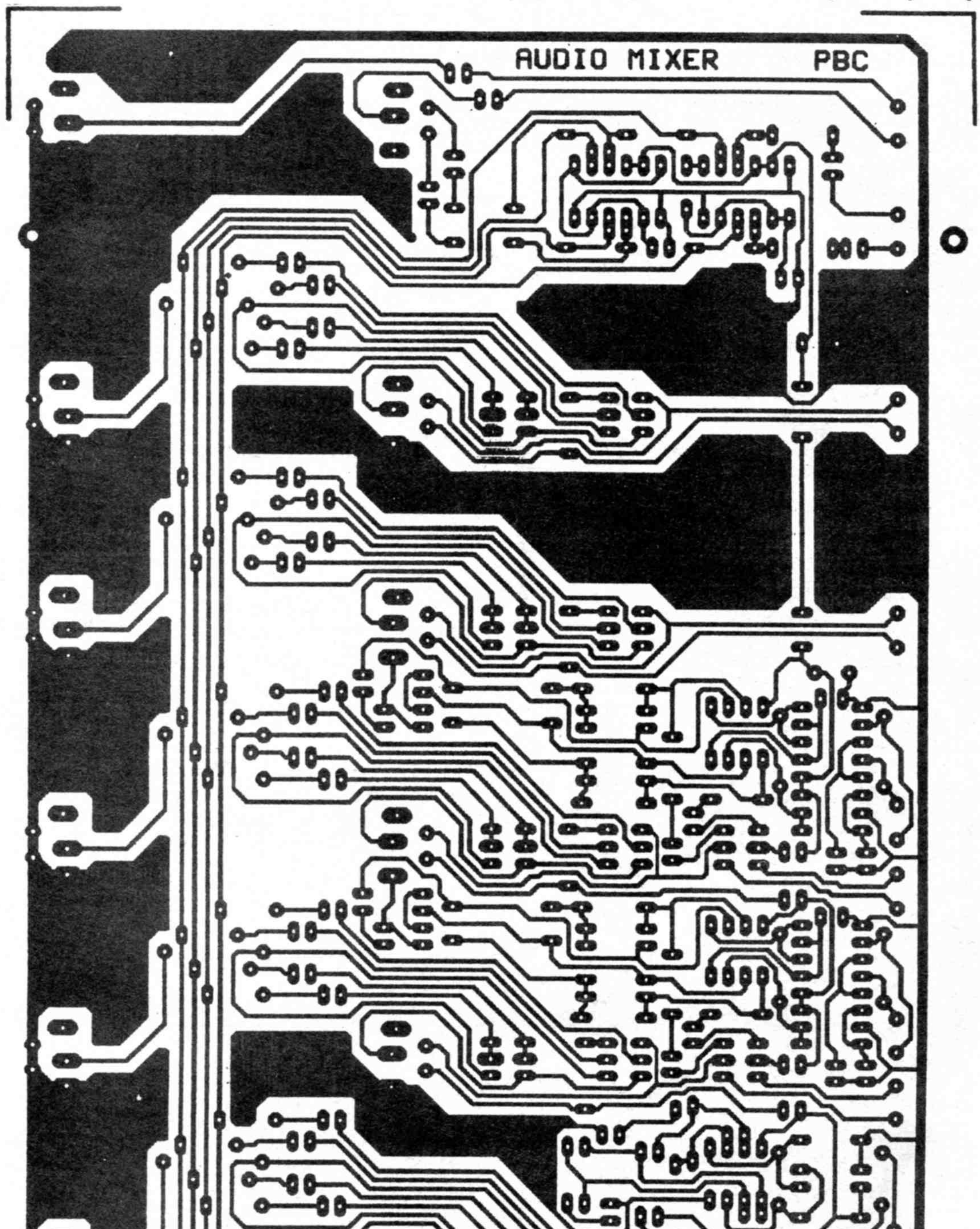
in Fig. 10. If the drilling is accurate, it will be very difficult to fit the pots in the wrong way round. Next fit the switches, ensuring a firm fit against the board since some strain will be placed on the p.c.b. tracks when the switches are operated.

It is important to note that the metal case of most of the slider potentiometers is used to link each *left-hand adjacent* circuit to 0V. If *any* sliders are omitted, it is essential to use wire links to join the unused pads labelled "G" to 0V

Connect the leads, using *screened* wire for the sensitive microphone and RIAA Pre-amp inputs and screened or ordinary wires for the line inputs. Note that the outer core of the screened cable is *not* connected to the p.c.b. since the "ground" connection is looped through all the input sockets from 0V on the power input socket. Ensure that all the leads are long enough, so that when connected to their sockets in the case, the p.c.b. can still be removed.

Finally, insert the i.c.s into their sockets ensuring they are aligned correctly.

Next month: Mixer final wiring, assembly and testing. Also separate pre-amp boards.



Full size printed circuit board (p.c.b.) copper foil master pattern for the Six-Channel Stereo Mixer (12-channels in all). This board is available from the EPE PCB Service, code 845. Details of separate Microphone and RIAA Pre-Amp p.c.b. modules will be given next month.

Innovations

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

Multimedia Centre

A VOLNET (Vocational Open Learning Network) Centre has been set up in Central London to provide educators and trainers with practical knowledge of multimedia systems.

The centre is equipped with state of the art hardware and software including Multimedia 486 PCs with Video Capture and Compression, Video for Windows and Apple Centris Multimedia System. There is also laser disc interactive Video and CDI.

The Centre offers initial training in Multimedia Free to *professional* trainers and educators. Workshops are held weekly. There will also be a number of special conferneces during Autumn 1993.

Learning Network

The Vocational Open Learning Network – VOLNET – is jointly managed by the British Association for Open Learning and the National Council for Educational Technology.

"All trainers and further education lecturers are invited to make an appointment and come in – free of charge. We would particularly like to see those who do not already have computer skills," said Michael Furminger, NCET director.

For further details contact: VOLNET UK, Dept EPE, 3 Devonshire Street, London W1N 2BA. Tel: 071 636 4186.

Safety First

A UNIQUE microprocessor based security system for a new car has been designed and manufacture by UK Electronics in conjunction with TVR Engineering.

The TVR Chimaera sports car, has a double dead locking system which, apart from giving special door locking facilities, also activates the electronic immobiliser to reduce further the chance of loss.

Normal external central locking is enhanced by having an internal locking control for use by an occupant. If an intruder breaks a window the doors will remain locked, denying easy access.

The locking/immobilising system suplied by UK Electronics of Oldham for fitting to the TVR cars has all the electronics fitted to one compact double-sided plated through hole printed circuit board.

NEW RANGE OF HIGH QUALITY KITS

GREENWELD have been appointed the sole importer in the UK for the range of excellent kits from DIY Electronics, currently selling extremely well in Australia. All kits are supplied with a full set of components, including sockets for all i.c.s; screen printed, solder masked, tinned fibreglass p.c.b.s and comprehensive instructions with chip data where relevant. Attractively packaged in Hong Kong using top grade components, they represent outstanding value for money.

There are 41 kits in the range at present covering all abilities and interests. They are especially recommended for the educational market, giving a detailed insight into the theory of electronics through practical experience. The projects range from a simple siren through to digital panel meters, logic probe, amplifiers, converters and a laser kit.

Prices start at under £5 including VAT, and a full list is available from Greenweld, 27D Park Road, Southampton SO1 3TB. Tel: 0703 236363, Fax: 0703 236307 – or use their *FaxOn-Demand* service – just dial 0703 236315 from any fax machine for instant information. Trade terms on all kits are available to bona fide dealers.

Electronic Fingerprinting

AN encapsulated 96-bit microprocessor, about the size of a grain of rice, is claimed to provide "electronic fingerprinting". Tiny enough to be hidden in a small circuit board or within any component or equipment, the IntaTag gives that item permanent identification which is virtually impossible to erase.

Each chip is programmed with its own recognition code as unique as an individual's fingerprint, the code being registered on a secure database. The 12-digit alpha numeric code is read by a hand-held scanner which excites the chip and reads back the code for identification purposes.

For further details contact DH Associates, Dept EPE, 7 The Lawn, St Leonards-on-Sea, East Sussex TN38 0HH. Tel: 0424 426187/720616. Fax: 0424 717971.

Showing Initiative

KINGTON in Herefordshire has been selected for a unique initiative as the "high tech" rural community of the future. The project named Connected Community *is the most innovative of its kind to be run in Europe and is supported by Apple Computer UK, BT, the Department of Trade and Industry and the Rural Development Commission.*

The project, to be hosted by Kington, will study the potential benefits that state-of-the-art technology can provide for the economic and social fabric of small towns and villages.

The effects of Kington's use of computer and communications equipment will be monitored over a 12 month period by The Henley Centre, Britain's leading social and economic research company.

Apple Computer, BT and secondary partners will provide over £¼ million of computer and communications equipment and support for Kington's winning bid specification.

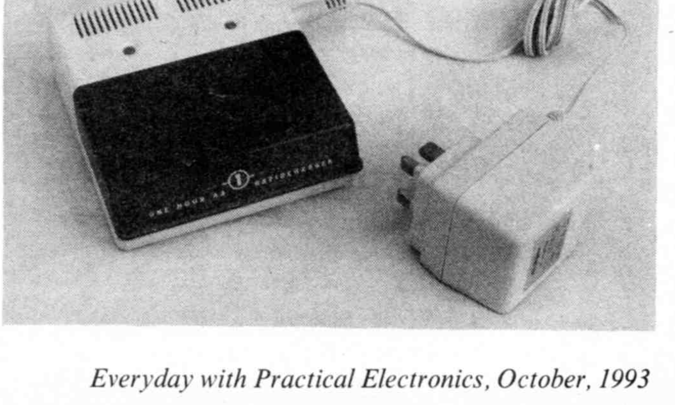
MILLENNIUM POWER SYSTEM

MILLENNIUM, one of the largest manufacturers of rechargeable power products in the world, has launched a new comprehensive range of Power Cells, Rapid Chargers and Power Packs in the UK.

These rechargeable products are said to offer a cost-effective, convenient and environmentally friendly alternative to throwaway batteries. They are ideal for products which use a lot of power, such as pocket TV's and electronic keyboards.

The cells come with a lifetime replacement guarantee and are all colour coded for easy identification. Available in five sizes – AA, AAA, C, D and 9V – they range in price from £4.95 for an AA cell 2-pack to £7.99 for a D cell 2-pack.

The charger pictured is priced at £16.99 and is claimed to be the fastest charger available in the UK – it can recharge four AA cells in just one hour. It is now available from electrical retailers.



New Technology Update

Ian Poole investigates display developments and new ideas for reducing on-chip component sizes.

LIQUID crystal display technology is heralded as the way forwards for future display technology. Many companies are looking to it for the next generation of displays for everything from computers to televisions. Although the l.c.d. is well established in the computer industry where it is widely used for portables, it has not yet been able to successfully enter the television market. The reason for this is twofold. In the first case it is more expensive than the traditional cathode ray tube. This is a very important feature in what is a very cost sensitive market. The other problem is that it is too slow to respond.

Currently large amounts of development work are being invested in overcoming these problems. Although some success is being experienced, estimates indicate that the earliest time that l.c.d.s could be available for widespread use in televisions is likely to be at the beginning of the next century.

However another new type of display which is being developed may be more suitable. Although the basic idea has been known for many years it has now been developed to a point where it can show many of its advantages. The display is known as an orientated colloidal particle flat panel display and it has been developed by a company in New York called Research Frontiers.

How It Works

The new display bears many similarities to an l.c.d. in its construction, but it works on a totally different principle. A simplified diagram is shown in Fig. 1.

A solution containing particles in a colloidal suspension is held between two glass plates. On the inside of the two plates patterned electrodes are deposited. However to prevent any current flowing between them through the colloidal solution a transparent insulating layer is placed over the electrodes as shown.

The key to the display is found in the particles in the solution. The long particles are normally orientated in a random fashion preventing light passing through as shown in Fig. 2a. However when a voltage is applied across the electrodes the particles align so light can pass across the display (Fig.2b).

Voltage

Unfortunately if a d.c. voltage is applied to the electrodes it is found that all the particles migrate to the same area giving depletion zones and destroying the display. To overcome this an a.c. voltage has to be used.

A large amount of work was undertaken to develop the correct solution. A number of different suspensions have been found to operate with varying degrees of success. The suspension which is used now is based upon Pyrazine compounds. This gives much better performance than any of the other solutions which have been tried in terms of life and operating temperature.

Current indications of the display are very encouraging. Not only is it expected to give an exceedingly good contrast ratio vastly better than that of an l.c.d., but it also gives a wide viewing angle in excess of 90 degrees. In addition to this it can operate down to temperatures of less than –30 degrees C. As a comparison l.c.d.s only work down to about 0 degrees C. Finally it has a reasonably fast response, slightly better than 100mS. This makes it just usable for video applications.

As the displays are likely to be cheaper than l.c.d.s this means that the next generation of displays for use in televisions may not be based around l.c.d. technology, but rather orientable colloidal particle displays.

New Ideas for Photolithography

Turning to a different topic, one subject which has cropped up a number of times in this column is the miniaturisation of components within integrated circuits. The smaller the individual components can be made, the greater functionality which can be placed on each chip.

Many ideas for reducing components sizes have been devised, some of which involve totally new processes. However there is still plenty of research being undertaken to improve existing techniques. Whilst this may not appear to be quite as exciting as some of the revolutionary new ideas it is every bit as important.

A wide variety of different technologies are used in the production of integrated circuits. One of these is called photolithography. This process is used to transfer the necessary patterns onto the silicon wafers so that operations like diffusion, epitaxial growth, and etching can be undertaken on the correct areas of the silicon.

Limiting Factor

Whilst the technique works very successfully, it is now becoming a limiting factor in the further reduction of i.c. component sizes. Currently the feature sizes are limited to about 0·6μm. However it is expected that a 16 megabit SRAM will be produced in the reasonably near future. It is calculated that if these chips are to become a reality then feature sizes of a little less than 0·4μm will be needed.

One method of achieving this is to use X-ray lithography. Unfortunately this is more expensive than normal photolithography and requires expensive re-tooling. If normal photolithography techniques can be used then the cost of these i.c.s could be kept to a minimum.

To achieve the required sizes two methods are being investigated. The first is called phase shifting. This entails depositing some optical material onto the mask. This phase shifts the light so that it is collimated onto the wafer.

Normally the mask is placed over the wafer and collimated light is passed through it to expose the photo-resist on the silicon. However the light will normally diverge slightly reducing the definition which can be obtained.

The second technique is the use of vertical cell capacitor structures. These are required so that sufficient cell capacitance is maintained to give reliable operation of the memory as cell sizes are reduced.

Progress on these developments has been very fast to date. The first trials of the techniques have already been undertaken. With them complete, minor modifications are being made before the trial production of a 4 megabit SRAM is made. This is expected to be completed by the end of 1993. If this is successful and it appears that it will be, then the project will be well on course for making a major contribution to the 16 megabit SRAM development. Apart from this it is likely that it will have a significant impact on other i.c. development programmes where size and cost are of great importance.

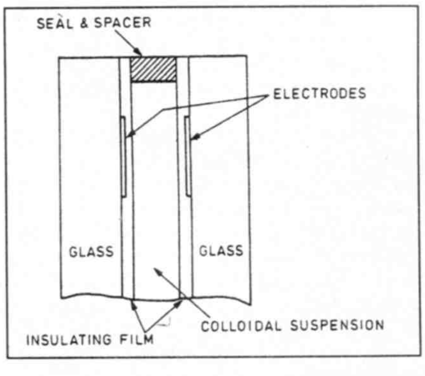


Fig. 1. Cross section through the display.

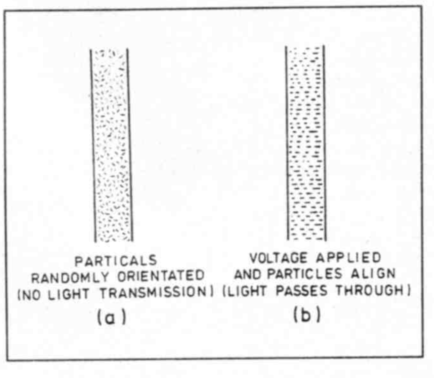


Fig. 2. Operation of the display.

MAGIC SOCKET

T. R. de VAUX-BALBIRNIE

Automatic switching of mains socket outlets.

THIS circuit is a convenient way of operating up to four 240V a.c. mains appliances at once without having to use individual switches. One possible use is for items of audio equipment where the amplifier, tuner, cassette and CD players or other possible devices such as a graphic equalizer need to be switched on together. The Magic Socket may also be found useful for switching on pieces of computing equipment such as the computer itself, disc drive, printer, monitor, modem, etc.

It is, of course, possible to provide a master switch to perform this function. However, if this is on view it is likely to look amateurish or out of place and, if situated out of sight, may be inconvenient to use. The Magic Socket therefore provides a neat solution.

MASTER AND SLAVES

The Magic Socket project appears as a standard four-socket trailing mains outlet (distribution board) with an additional box, which houses the electronic control circuit, mounted on the side. This box has a standard single mains socket - the master or *magic* socket - mounted on top (see photograph).

To use the device, a mains lamp is plugged into the "magic socket". When the light is switched on using its own on-off switch, the other four *slave* sockets will be activated automatically. The slave sockets may be used with any loads up to a total of 1000W on 240V mains (4A approximately).

It is important that the lamp, which is plugged into the master socket, be fitted with a standard *tungsten-filament* bulb with a rating of *60W*. Apart from that, any type will do such as an Anglepoise lamp, a decorative reading lamp or a strip light.

Whatever type of lamp is used it must, of course, be provided with its own on-off switch. Once set up with the appliances plugged into it, the whole device is placed out of sight and may be forgotten.

Note that there are some items which are not advised for use with the Magic Socket. These are appliances where a mains supply needs to be maintained to the circuit (even when apparently switched off) for memory-retention purposes (for storing a selection of radio station frequencies, for example).

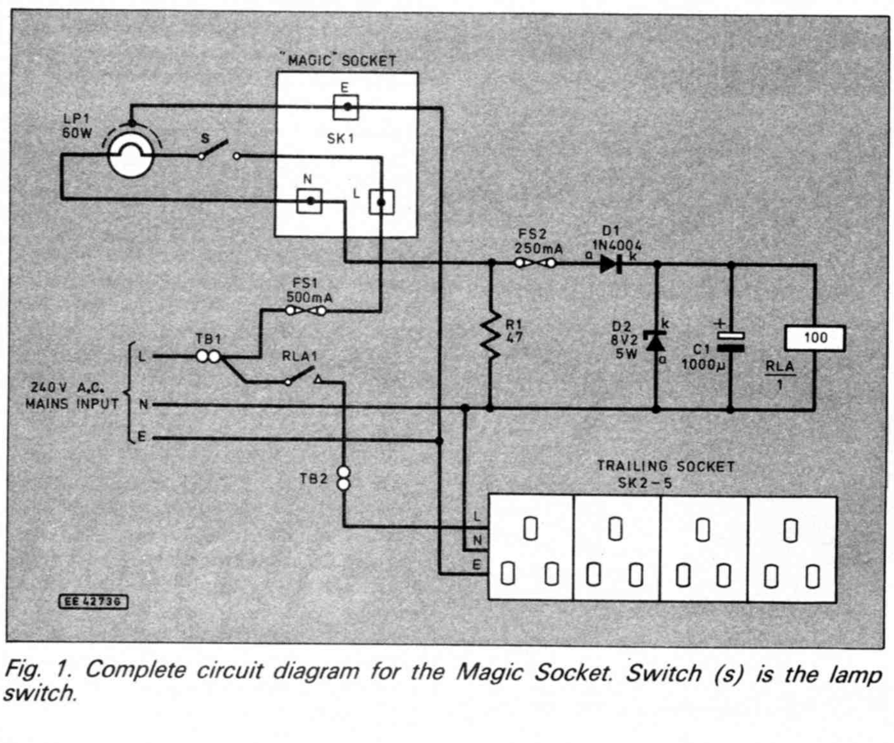


Fig. 1. Complete circuit diagram for the Magic Socket. Switch (s) is the lamp switch.

Some pieces of audio and TV equipment come into this category. Cutting off the mains supply completely to such devices may, over a period of hours, result in the loss of memory contents. It will be necessary to check this point in the instruction manual before using such appliances with the Magic Socket. Also, due to the inherent unreliability of filament lamps, the device should not be used where it is *essential* to maintain a supply since failure of the bulb will cause the slave sockets to switch off.

Constructing this circuit involves making mains connections. Any reader who is not certain of being able to make a safe job must therefore seek professional advice. Particular care must be taken over the quality of the soldered joints, to Earthing the case and to the values and type of fuses used. These latter points will be explained presently.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Magic Socket project is shown in Fig. 1. Note mains lamp, LP1, plugged in to the master – or *magic* – socket, SK1. When this is switched(S) on, current flows from the live supply wire, through fuse FS1, bulb LP1 filament and resistor, R1. From here it completes the circuit back to mains Neutral. With current flowing through R1, 9V approximately will be developed across its ends.

An explanation of how this figure comes about is given later but it is not essential to understand it to construct the circuit or to have a basic idea of how it works. The important point is that this low-voltage a.c. "supply" operates the rest of the circuit. *Note that although **low voltage**, it is still connected directly to the **mains** – it must therefore be regarded as potentially dangerous and treated with the same respect as the mains.*

The supply developed at R1 flows through fuse FS2, is half-wave rectified by diode, D1, and smoothed by electrolytic capacitor C1. The final result is a steady output of approximately 5V applied to the coil of relay RLA.

The specified relay having a nominal 6V coil is designed to operate at 4·5V approximately so this output voltage is sufficient to energize it. The normally-open contacts, RLA1, "make" and complete the circuit from the live wire (L) of the mains feed to the four slave sockets, SK2 to SK5 in the trailing socket. When LP1 is switched off, the supply is interrupted, the relay contacts part and operation of the slave sockets is cancelled.

The voltage developed across RLA coil is derived from a fairly complex interaction of circuit components which involves the resistance of the lamp filament and that of the relay coil. It is unnecessary to enter into details but the final outcome is that this voltage is less than that appearing across resistor R1.

Note that when the lamp is operating, the voltage across it will be some 9V less than the mains – that is, by the voltage "lost" across R1. The effect on its brightness is slight and, in fact, will extend its life significantly.

Zener diode D2 is connected in parallel with capacitor C1 and the relay coil as shown. Since in the absence of a fault there will be 5V approximately across its ends, it will have no effect. However, if the voltage were to rise for whatever reason, D2 would immediately conduct and the voltage "lock" at the Zener breakdown value of 8·2V. This happens briefly when the lamp is switched on.

COLD START

When the filament is cold (room temperature) its resistance (70 ohms approximately) is much less than when it is at full operating temperature (960 ohms). This has the effect of allowing a much higher current than normal to flow through resistor R1 (2A approximately) with a consequent high voltage appearing across it.

Although R1 is not designed to carry such a high current, it only happens briefly and it does not heat up appreciably in this time. Moreover, D2 locks the voltage across C1 and the relay coil to 8·2V for long enough to allow the filament to heat up and prevent damage. In a test on the prototype where the lamp was switched on and off repeatedly, all circuit components survived indefinitely.

It is important for fuses FS1 and FS2 to be of the correct type and have the correct rating as specified in the components list so that any rise in the operating current over a longer period of time than that due to a cold lamp filament will cut-off the supply as rapidly as possible. If this were not done, D2 would be destroyed and the high voltage developed across electrolytic capacitor, C1 would damage it. This would probably show its displeasure by exploding violently. It could also mean that diode D1 and the relay would be destroyed.

LARGE CURRENT

Should the relay coil itself fail and become open-circuit, the total current requirement for the lamp would flow through resistor R1. This would cause a higher voltage than normal to be developed across it – 12V approximately. The power dissipated by the resistor would therefore rise and it would become very hot but still remain within its power rating. With this type of fault, the slave sockets would, of course, fail to work.

Should the output circuit be overloaded – that is, if more than 4·5A were drawn so putting the contacts RLA/1 under strain, the plug fuse for the unit would blow or the fuse in the trailing outlet itself if it has one. Note, however, that this could still damage the relay contacts so overloading must be avoided in practice.

The prototype unit was tested under fault conditions of the type described and this confirmed that the circuit behaves safely as theory suggests.

CONSTRUCTION

Note that the circuit MUST be built in an* Earthed metal *box. A plastic box will not be strong enough for the purpose.

In view of the small component count, it is convenient to construct most of the Magic Socket circuit on a piece of tagboard and the relay on a subsidiary piece of 0·1in. matrix stripboard mounted on this. The tagboard component layout and positioning of the "relay board" is shown in Fig. 2.

Begin construction by cutting the tagboard to size (two rows of seventeen tags). Make the inter-tag links – sleeve the link wire between tags 28 and 33 to make certain it cannot touch any other tag.

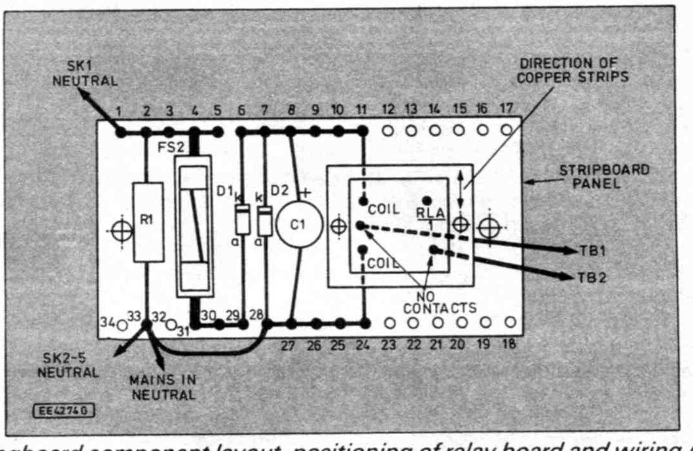


Fig. 2. Tagboard component layout, positioning of relay board and wiring (using 6A mains rated wire) to relay contacts directly.

COMPONENTS

See SHOP TALK Page

Resistor
- R1 47 3W

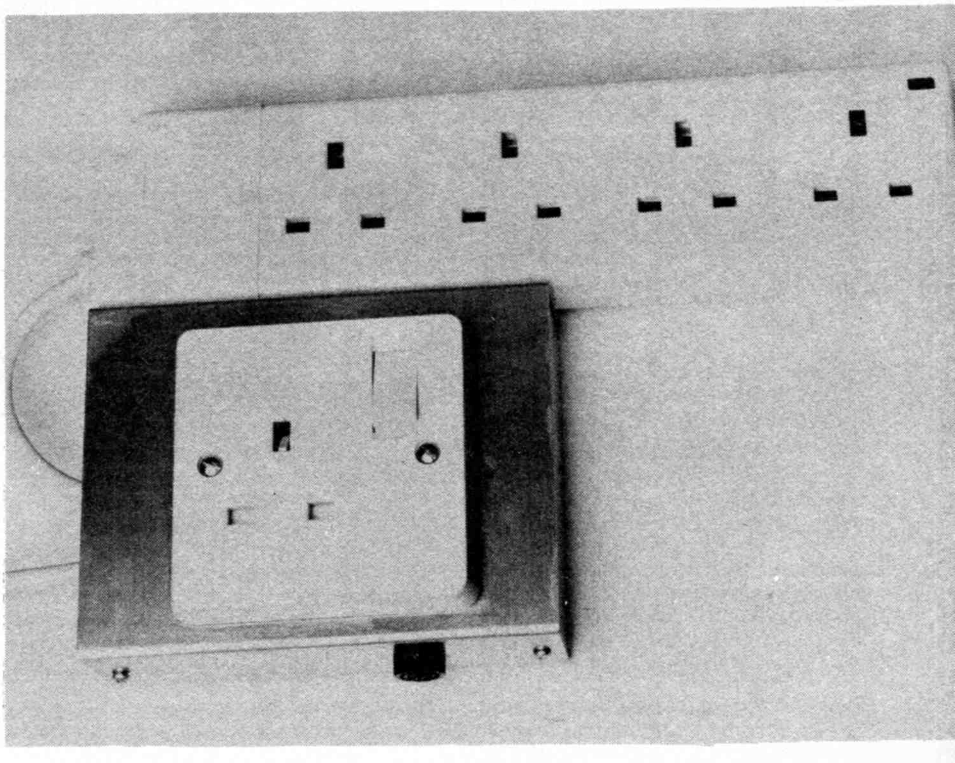
Capacitor
- C1 1000μ radial elect. 16V

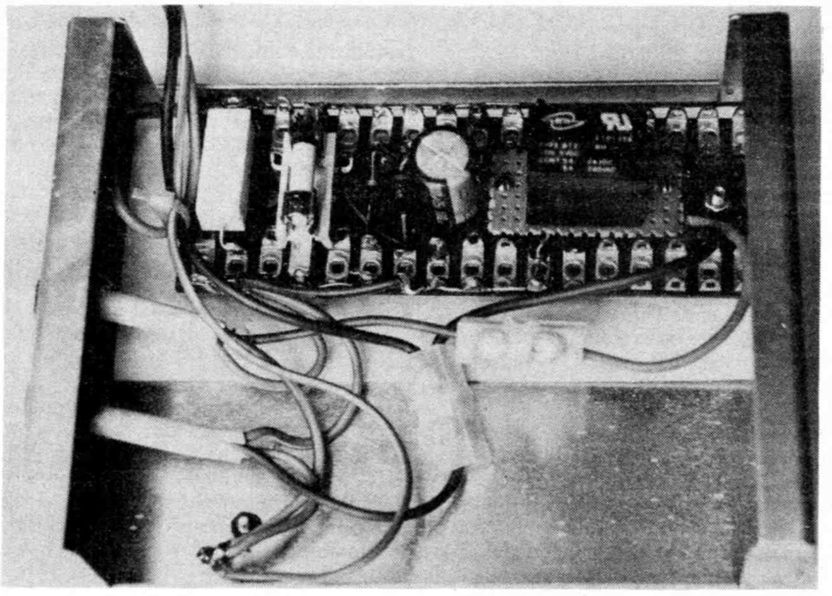
Semiconductors
- D1 1N4004 400V 1A rectifier diode
- D2 8·2V 5W Zener diode

Miscellaneous
- FS1 20mm panel fuse holder with 500mA high breaking capacity ceramic quick-blow fuse.
- FS2 20mm chassis fuse holder with 250mA high breaking capacity ceramic quick-blow fuse
- RLA Miniature relay with 6V 100 ohm coil, and 240V "make" or changeover contacts rated at 5A.

Tag board, 2 rows of 17 tags required; 0·1in. matrix stripboard, size 8 strips x 13 holes; 4-socket trailing outlet; single mains socket; 5A screw terminal block - 2 sections required; aluminium box, size 133mm x 102mm x 38mm approx; strain relief grommets (2 off); solder tag; 5A mains fuse for trailing socket (if required); 5A fuse for mains input plug; 1A (or 2A) plug fuse for lamp. 6A mains rated wire; stranded connecting wire; M3·5 nuts (2 off) (see text); small fixings; stand-off insulators (4 off); solder, etc.

Approx cost guidance only **£11**





Layout of components inside the METAL box. The relay board is mounted above the mains board using plastic spacers. Note the use of two screw-terminal strips.

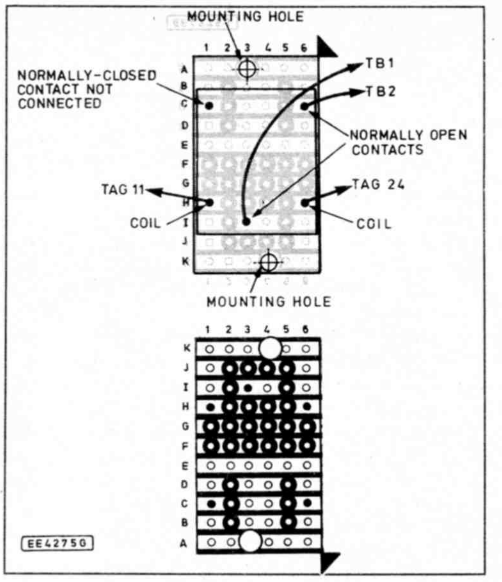


Fig. 3. Using a piece of stripboard to mount the relay. The breaks in the copper must be made as shown.

Follow by soldering the on-board components into position. It may be necessary to flatten some of the tags for resistor R1 and fuse FS2 to fit properly. R1 should stand about 3mm clear of the panel to allow a free flow of air around it – this is because it becomes warm in operation and can become hot under fault conditions. Some ventilation is therefore necessary.

Make certain that all soldered joints, *particularly those at R1*, are sound and cannot dislodge in service. Take care to observe the polarity of capacitor C1. This is because it is an electrolytic and may rupture if connected the wrong way round. Take care also to connect correctly the other polarity-sensitive components, diodes D1 and D2.

RELAY BOARD

Refering to Fig. 3, cut a piece of 0·1in. matrix stripboard to size 8 strips x 13 holes. Drill the two mounting holes in the positions shown and, referring to Fig. 2, make holes in the tagboard panel to correspond with these.

Solder the relay on the stripboard as indicated. Note that the pins on the specified relay do not match the 0·1in matrix perfectly. However, by bending the pins slightly and using a little *gentle* persuasion it can be made to fit. If necessary, drill the holes in the stripboard to a slightly larger diameter.

Solder 10cm pieces of *mains-rated* wire of 6A rating minimum *direct* to the "make" contacts – i.e. not via the copper strips. Make certain these connections are secure and cannot break free in use. Connect short pieces of light-duty wire to the relay coil tags.

Attach the stripboard to the tagboard panel using two small fixings through the holes drilled for the purpose (see photograph). Place 3mm plastic stand-off insulators on the bolt shanks to allow sufficient clearance for the relay wiring to pass between the stripboard and tagboard panel. Solder the coil connections to tags 11 and 24 as shown (see Fig. 2).

BOXING CLEVER

Hold the completed circuit panel assembly in position on the base of the box and mark the positions of the fixing holes. Drill holes in the box to correspond with these.

Make the large hole in the top section of the box to accommodate the single mains socket, SK1. To do this, first make a paper template of the shape of the rear of the socket. Hold this in position and draw round the outline in pencil. Drill a series of closely-spaced holes around this then cut out the shape using a small hacksaw blade. Finish by filing the edges smooth, drilling the two mounting holes and attaching the socket.

The size of the fixing bolts provided with the socket are size M3·5 so if using these you will need a pair of matching nuts. Since these are not available from all suppliers, it may be easier to use more readily-obtainable nuts and bolts perhaps of a slightly different diameter.

Drill holes for fuseholder FS1 mounting, for entry of the mains input lead and for the wire passing through to the trailing socket – make these latter holes large enough to accommodate the strain relief grommets which will be used to secure them later. Drill a small hole in the base section of the box for the "Earthing" solder tag and attach all remaining components.

When mounting the circuit panel, include short stand-off insulators on the bolt shanks to keep it 3mm minimum clear of the base of the case. Use a piece of thick cardboard wider than the tag board underneath to provide insulation as an additional precaution.

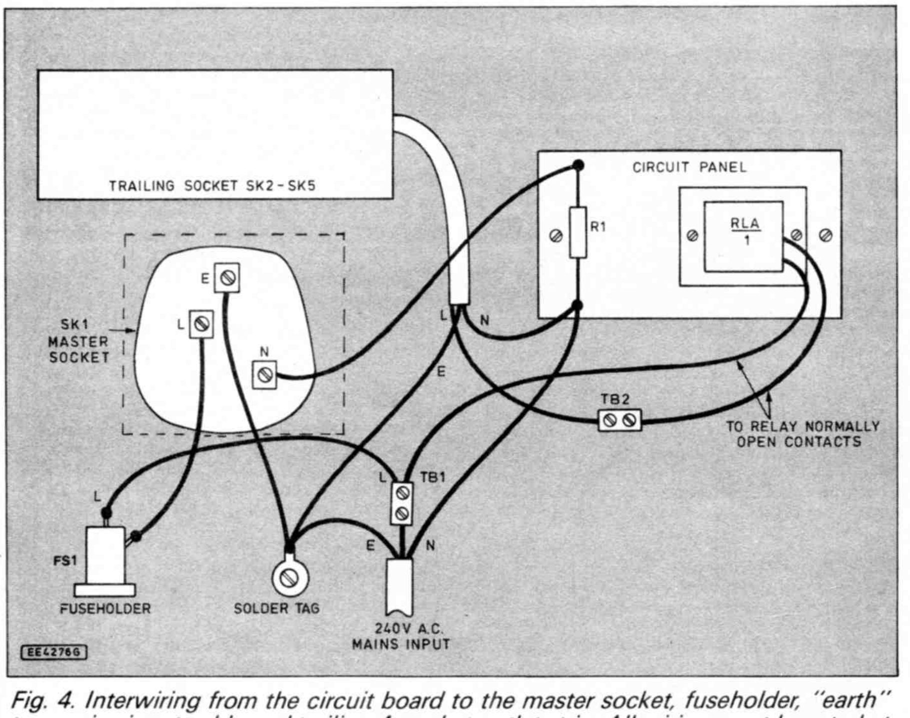


Fig. 4. Interwiring from the circuit board to the master socket, fuseholder, "earth" tag, mains input cable and trailing 4-socket outlet strip. All wiring must be rated at 6A minimum.

RELIEVE THE STRAIN

Remove the top of the trailing multi-socket and check where holes may be drilled in the side to attach the new section. The site of these will depend on the exact type of trailing socket used.

Mark the positions in both sections

and drill the holes. Secure the two sections together using small fixings. Note that the fixing bolts must remain clear of any obstructions and must under no circumstances cause short-circuits inside the trailing socket housing.

Cut off a piece of 3-core mains wire of 6A rating minimum about 20cm long and connect this to the trailing socket. Feed it through the hole in the box and secure it with a strain relief bush. Re-assemble the trailing socket.

Cut off another piece of similar mains wire to use as the input lead. Strip 5cm of the outer sheath from the end, feed it through the hole made in the box and fit a strain relief bush to hold it securely. Refer to Fig. 4 and complete the internal wiring shortening any wires as necessary. Note that all wiring *must* be made with *mains-type* wire of 6A rating minimum.

Note also the method of using the pieces of screw terminal block, TB1 and TB2 – do not use taped joints or other makeshift methods. Check that the Earth (E) wiring to the solder tag is secure and cannot break free. Fit a plug to the free end of the input wire and insert a 5A fuse.

While thinking about fuses, fit the reading lamp plug with a 1A fuse (if this is unavailable use a 2A fuse) and the fuseholder on the trailing socket (if one exists) with a 5A fuse. Insert fuses FS1 (500mA) and FS2 (250mA) – note that these must be 20mm types described as *mains* fuses and having *high breaking capacity ceramic* construction. Not all suppliers stock these – see *Shop Talk*. Glass fuses are unsuitable here since, under certain fault conditions, they could blow very violently and shatter. For the correct degree of protection, It is essential for all fuses to have the values specified (see components list).

Replace the lid of the box and secure it with the self-tapping screws provided. It may be necessary to drill new fixing holes in the side to which the trailing socket is attached. *Note that the case must be assembled before the unit is plugged in to the mains.*

As the two sections of the case are brought together, check carefully for possible trapped wires and obstructions. Check also that resistor R1 does not touch anything since it becomes hot in operation.

TESTING

It is convenient to test the Magic Socket project by using two reading lamps – one for the magic socket and the other plugged into one of the trailing socket outlets. Remember, the one in the master socket must have a ***60W*** bulb fitted.

Plug the unit into the mains and switch on. Switch on the lamp plugged into the master socket – the other lamp should operate. Switch the magic socket lamp off and the slave sockets should switch off too.

If all is well, the Magic Socket may be put into permanent service. If the unit is to be placed on a surface where scratching must be avoided, it will be necessary to fit self-adhesive plastic feet to the base. Note that it is normal for the unit to become warm after a prolonged period of use.

If the lid of the box needs to be removed for any reason, *it is essential first to unplug the unit from the mains*. This is because of the danger of possible touching of the exposed mains connections inside.

NINE VOLTS

Some readers will wish to know why 9V exists across resistor R1 while the circuit is operating. The current for the lamp flows partly through R1 and partly through the relay coil RLA, via diode D1. The current through the lamp filament is nominally 250mA because it is a 60W bulb and the current is given by the Power Formula:

$$I = P/V = 60/240 = 0{\cdot}25A \text{ or } 250mA$$

In fact, the current is slightly less than this because R1 reduces it. The current through the relay coil is found by using Ohm's Law. Since the resistance of the coil is 100 ohm for the specified relay and there is 5V approximately across it:

$$I = V/R = 5/100 = 50mA$$

The current through R1 is therefore the total current minus the current through the relay coil – i.e. 200mA approximately. Since the value of R1 is 47 ohm, Ohm's Law may be used to find the voltage across it:

$$V = I \times R = 0{\cdot}2 \times 47 = 9{\cdot}4V$$

Whatever the application, let the Magic Socket take control! □

SHOP-TALK

with David Barrington

Teach-In '93

Most parts used in this month's *Teach-In* are similar to those used for the *Mini Lab* series. The thermistor could be any small bead or disk type with a resistance of 4·7 kilohm at 25°C, i.e. Maplin FX21X. The Darlington transistor type TIP112 is also available from the same source.

The logic level f.e.t. is a little more difficult to find. We understand that Farnell Electronic Components have a good selection – the cheapest is the STP17N05L. If you have some suitable *n*-channel MOSFETs (<1A at 50V) give them a try, but some types will not be fully turned on by the logic level output voltages from the VIA.

The stepper motor could be any small device – perhaps from a printer or plotter. **Magenta Electronics (☎ *0283 65435*)** supplies both 6V and 24V units that move in 7½ degree steps. The 24V device has an impedance of 50 ohms and will operate from 5V to 12V without consuming large amounts of current, and still produces adequate torque for the demonstrations. Many other advertisers have small steppers available, but avoid types that have a low impedance as the *Mini Lab* will not be able to supply enough current.

Linear Power Supply

The components and double-sided p.c.b. for the *Linear Power Supply* were chosen and designed to fit into a steel (it must be metal) instrument case. The one depicted in the article is the **Maplin** XJ27E. Most of our advertisers will be able to offer something similar, but it must be metal so that it can be safely "earthed".

The toriod mains transformer was custom-made and available from **Lyon Forge (☎ *0702 610607*)**. Formerly Lord Transformers, the device carries the code 30/LT/14-10. The transient suppressor should be the 250V a.c. type.

The multi-way audio locking connectors/sockets may prove difficult to find locally, the ones on the model were obtained from Maplin. Similar connectors are stocked by audio specialists **Henry's Audio Electronics (☎ *071 723 1008*)**. The heatsink is the Maplin "high power type 2E" (code HQ70M). This is claimed to be rated as having a temperature rise, at the centre of the 'sink, of 2·4°C/W.

The double-sided printed circuit board is available from the *EPE PCB Service*, code 844.

Magic Socket

Mains-rated wire of 6A *minimum* must be used in the *Magic Socket* project to make connections directly to the relay "make" contacts. Likewise, similar rated wire must be used for all interwiring connections.

Extreme care must be taken at all times when constructing this project as mains voltages are present on the circuit board. It is important that the correct type and rating fuses are used so that the supply will cut-off rapidly in the event of any fault condition.

It is most important that all fuses, including the 1A/2A "reading lamp" fuse, have the values specified. The circuit fuses FS1 and FS2 should be the 20mm *ceramic* types and should be stocked by most of our component advertisers. If not, then a visit to the local electrical shop should provide the correct types.

The 6V miniature relay used in the prototype model was purchased from **Maplin** (code JM17T) and has contacts rated 5A at 240V a.c. The pins of the relay will have to be bent slightly to fit it on the board. Other relays can, of course, be used provided the coil rating is the same, the contacts can handle the load and it will work down to 4·5V

Remember that the lamp, plugged into the "master socket" must be fitted with a 60W *tungsten filament* bulb.

L.E.D. Sandglass

Looking through the requirements for the *L.E.D. Sandglass* project, all devices seem to be readily available items and should be stocked by most of our component advertisers. The header plug and socket are now standard lines with most suppliers.

In some instances, you may have to settle for a "metal film" resistor when ordering the 5·6 meghom resistor. Not all advertisers stock the complete range of "carbon film" types, but the difference in price is very small.

Regarding the l.e.d.s, it might be worthwhile approaching one of our advertisers, such as **Greenweld**, to see if they are prepared to give a small discount on a "10-plus" basis. The "bargain lists", issued at this time of year, usually carry some opto-devices at reduced prices.

The two printed circuit boards for the Sandglass are available as a pair from the *EPE PCB Service*, codes 841/842 (see page 795).

Multi-Purpose Audio System 1-Six Channel Stereo Mixer

The only items that need careful consideration when buying parts for the *Six-Channel Stereo Mixer* are the case, centre-off switches and slider potentiometers.

The dual 9stereo) slider "pots" for which the large p.c.b. is designed were purchased from **Maplin** (code JM87U) and must have metal bodies and be p.c.b. mounting types. Most advertisers only seem to stock "mono" types. The centre-off switches came from the same source and are type F from their sub-Min range.

Suitable plastic console cases, with sloping aluminium front panels, are stocked by advertisers, but prices do vary quite considerably and it might be worth "shopping" around. The large p.c.b. and "optional" pre-amp boards are obtainable from the *EPE PCB Service*, see list on page 795.

Kettle Alert

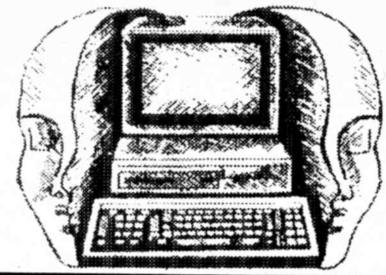
Before looking at component buying for the *Kettle Alert*, we must endorse the warning that, "as this unit carries up to 12A at 240V a.c. it should not be constructed by anyone without experience of working on mains voltages."

The polyester capacitor rated at 400V d.c./250V a.c. may be difficult to locate locally. However, metalised polypropylene types specially manufactured for continuous connections across the mains, are fairly common and should be readily available – you must specify the rating above when ordering.

We have been searching far and wide for a plug box with a *metal* earth pin. Nearly all advertisers stock these boxes but they have a plastic earth pin. The only source we have found is from **Harrogate Electronic Services (☎ *0423 564353*)**. Supplies are limited and are on a "first come first served" basis.

The printed circuit board is available from the *EPE PCB Service*, code 843.

INTERFACE



Robert Penfold

ANYONE who has followed developments in the world of computers could not have failed to notice that software prices have come down quite dramatically over the past few years. In "real terms", something like a top word processor program is much less than half the cost of its equivalent program five years ago.

The modern equivalent is certain to be far more advanced than its predecessor. With competitive upgrades and other special offers, some popular "mega" software can be had at such low prices that it is tending to squeeze budget software out of the market.

Freebies

This is probably one reason that so much "free" software of good quality is currently available. Most of the major new offerings from shareware libraries seem to be ex-commercial software which has simply been placed into the public domain, or is being sold at very low cost as shareware.

There is also quite a lot of "free" software which is either old versions of well known programs, or basic versions of normal commercial software. This software has been given the name "freeware". In most cases anyone can use the software without having to pay any registration charges. This might seem to be unduly generous, but the software companies are clearly hoping that a reasonable percentage of users will like the programs, and will buy the full-priced "real thing".

Specialist software for use in electronics is now starting to get the freeware treatment. Several examples have been mentioned in previous *Interface* articles. The latest example is a freeware printed circuit design program called "Easytrax". This is actually the most basic of the programs in the range sold by Protel Technology Ltd.

This is not a "crippled" version of the program, and it is supplied with a useful range of screen, printer, and plotter drivers. A large library of component outlines is provided, and the program seems to be able to handle very large and complex boards.

Although it is freeware, there are "strings attached". The main one is that only "non-commercial" use is permitted. Professional users who wish to continue using the program after a trial period are expected to purchase the commercial version. However, private and educational users can use this software for as long as they like, free of charge.

Making Tracks

Although this is the most basic of Protel's printed circuit design programs, it is still a fairly advanced piece of software. It can be run on a basic PC having twin floppy drives, but it is much better using a machine that has a hard disk, VGA or super VGA display, and a 80286 (or better) microprocessor. The optional mouse should be regarded as essential. Installation is reasonably straightforward as an installation program is included.

The program has a modern user interface. Status information, etc. is provided at the bottom of the screen via two lines of text. The rest of the screen is normally given over to the drawing area. Pressing the left hand mouse button brings up the main menu in the top left hand corner of the screen. Selecting a menu option brings up a sub-menu, which might in turn give access to a further sub-menu or a dialogue box.

The menu structure is very logical and I found it quite easy to control the program. There are keyboard shortcuts to some functions, such as preset zooming and changing layers.

The basic method of using the program is to first place the various components. The connections are then added, one by one, working from a list of interconnections (a netlist). Double-sided tracking can be accommodated, as can multi-layer tracking with up to four mid-layers. There is a simple but reasonably effective auto-router which operates on a one track at a time basis. Like most simple auto-routers, it cannot handle single-sided boards.

The program can then generate a netlist from the interconnections in the drawing, and this list is checked against the original netlist. If preferred, you can ignore netlists and simply work direct from a circuit diagram. This is a less reliable method because it is more difficult to locate any errors or missing tracks, but it has the advantage of being very quick and simple. It is the method that is most appropriate to relatively simple boards, but it is often a bit awkward to use this system with the more sophisticated printed circuit design programs.

Output Drivers

Completed designs are printed or plotted via a separate program. This has drivers for a range of dot-matrix printers, laser printers, pen plotters, and photo plotters. It provides full control over X and Y scaling, layers to be plotted, plot quality, etc. Provided the output device is up to the task, the hard copy is of a high standard (see Fig.1).

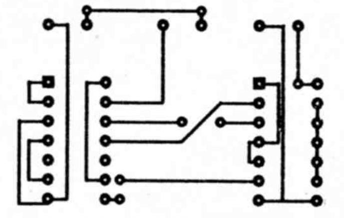


Fig. 1. A small sample printout from Easytrax. This was produced using a 300d.p.i. laser printer.

Although the program is relatively simple, it has quite a good range of features, including excellent pan and zoom facilities, an undelete function, independent snap and visual grid settings, connection highlighting, etc. The graphics are superb, and the screen redraws at a very impressive rate.

Many of the more simple printed circuit design programs are let down by poor editing facilities, but Easytrax has a full range of editing commands. Moving tracks and components, for example, is very straightforward. The program showed no signs of instability, and it seems to be free from traps which make it hard to get out of an option chosen by mistake.

Documentation

There is about 60k of on-disk documentation. This consists mainly of installation notes, a tutorial dealing with the basics of drawing up a board, and a further tutorial on plotting a board. The final section provides a brief description of every command.

The documentation does not provide a detailed description of every facility, but unlike much software of this type, everything seems to work in a logical and sensible manner. Once a few basics have been mastered there is little difficulty in finding and using the more advanced facilities.

The manual claims that this program is so easy to use that you could be using it to design your own printed circuit boards within an hour of installation. While this is probably a slight exaggeration, it is no more than that. I found this program to be much easier to use than most of the other printed circuit software I have tried. It is simple enough to be easy to learn and use, but is sophisticated enough to comfortably handle complex boards.

Easytrax is well suited to the needs of electronic hobbyists. Occasional users should not find themselves having to continually relearn how to use the program. Of the various shareware, freeware, and public domain programs of this type, Easytrax is not the most sophisticated, but for electronics hobbyists it is probably a good choice. It is one of the best thought out programs I have encountered, and is certainly a piece of software I can wholeheartedly recommend.

Easytrax 2.06 is available on a single high density disk from The PDSL, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL (Tel. 0892 663298, Fax 0892 667473). It is on disk H251. It might be available from other shareware sources, but it will be under a different catalogue number.

Memory Loss

Erasable programmable read only memories (EPROMs) are extremely useful devices, which are not restricted to ROM software applications. They are to be found in many pieces of equipment, some of which are not even microprocessor based.

As an example, some time ago I experimented with a MIDI pedal unit which sent various MIDI messages to a synthesiser when the pedal was operated. This was easily achieved using a UART, an EPROM, and some simple logic hardware. The EPROM was programmed with the bytes of data that had to be transmitted.

The alternative would have been to have numerous octal tri-state buffers with their inputs hard wired with the appropriate binary patterns. This would not be very practical, and would make it difficult to implement changes to the transmitted data. By contrast, an EPROM is easily erased and reprogrammed with totally different data.

The obvious problem with EPROMs is that they are only a practical proposition if you have some means of programming and erasing them. Erasing is achieved using what is basically just a box containing an ultra-violet tube. The latter emits short wavelength ultra-violet radiation.

EPROMs have a window in the top of the encapsulation which permits the ultra-violet to reach the silicon chip. Here the ultra- violet causes electrical charges to be leaked away, and after about 20 minutes or so the EPROM has total amnesia.

Note that an ultra-violet light box of the type used for producing printed circuit boards is unsuitable for erasing EPROMs. These light boxes produce light at the long wavelength end of the ultra-violet spectrum. This has no significant effect on EPROMs.

EPROM erasers are not exactly cheap, but they are not that expensive either. The same is not true of EPROM programmers. Stand-alone units mostly cost several hundred pounds, and even the lower cost add-on units for computers now seem to cost well over £100. Simple home constructed add-on programmers can be produced for very much less than this.

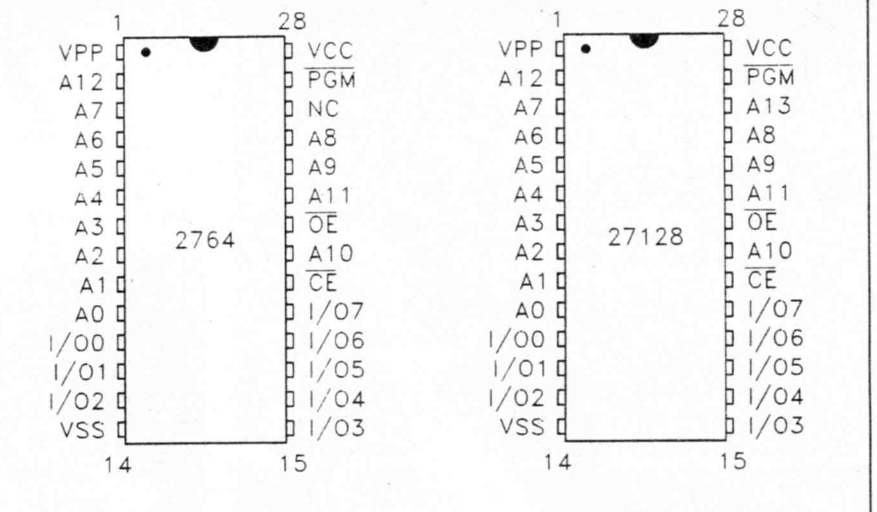


Fig. 2. Printout details for the 2764 and 27128 EPROMs. The pinouts are the same apart from the function of pin 26.

27 Series

The 27 series of EPROMs (2732, 2764, etc.) have been popular for many years now, and are a good choice for use in do-it-yourself projects. They are reasonably inexpensive, readily available, and uncomplicated to use. Fig.2 gives pinout details for the 2764 and 27128 EPROMs. Apart from the window, these have a standard 28 pin d.i.l. plastic encapsulation.

The 2764 is a 64k chip, but this is 64k bits not bytes. It is internally organised to store 8192 by 8 bits of data, or some 8k in normal computer terminology. The 27128 has 128k bits of storage which are organised as 16384 by 8 bits of data. In other words it is a 16k memory chip.

Addressing 8192 memory locations requires 13 address lines, and these are A0 to A12 on the 2764. Addressing 16384 memory locations requires 14 address lines, and these are A0 to A13 on the 27128.

The only difference in the pinouts of these two chips is that pin 26 of the 2764 has no internal connection, whereas it is the A13 input of the 27128. This makes it easy to produce a programmer that can handle both devices. The address lines are used when programming the device and when reading back data.

The eight bit data bus (I/O0 to I/O7) is a bidirectional type, and is used for both programming data into the EPROM and reading it back again. Pin 20 and pin 22 are ordinary chip enable and output enable inputs, both of which are negative active.

Programming

Programming is achieved by first placing the appropriate binary pattern for the first address onto the data bus, and setting all the address inputs low. A potential of 12·5 volts must be applied to pin 1. This is the only input that operates at this level. All the others operate at normal 5 volt logic levels, and are fully TTL compatible.

Older 2764s required 21 volts, but these are now obsolete. Modern 12.5 volt chips are normally marked with the programming voltage, so there is no excuse for "zapping" them using a 21 volt programmer.

Pin 27 (PGM) is pulsed low in order to "blow" the data into the EPROM. The binary value on the address bus is then incremented by one, and the data byte for the next address is placed on the data bus. Pin 27 is then pulsed low again. This process is repeated until all the memory cells have been programmed.

Next month: We will look at some circuits for EPROM programming.

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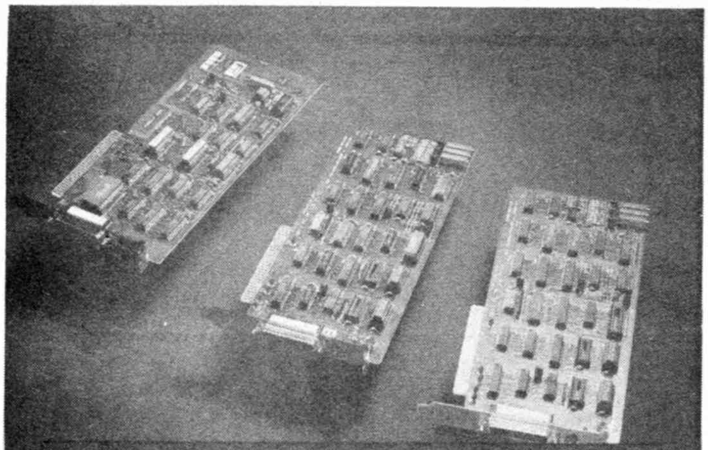

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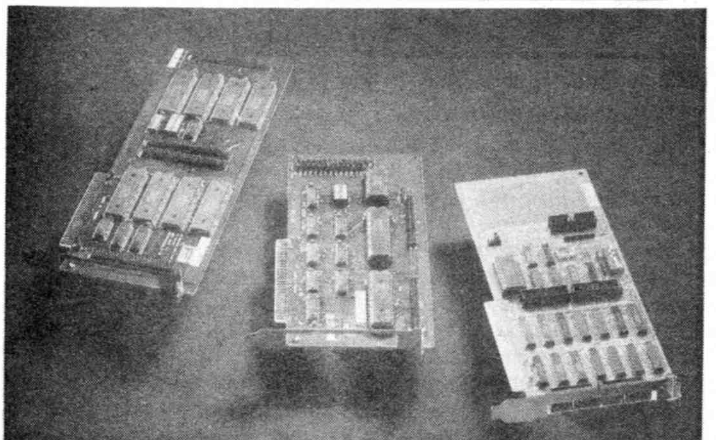

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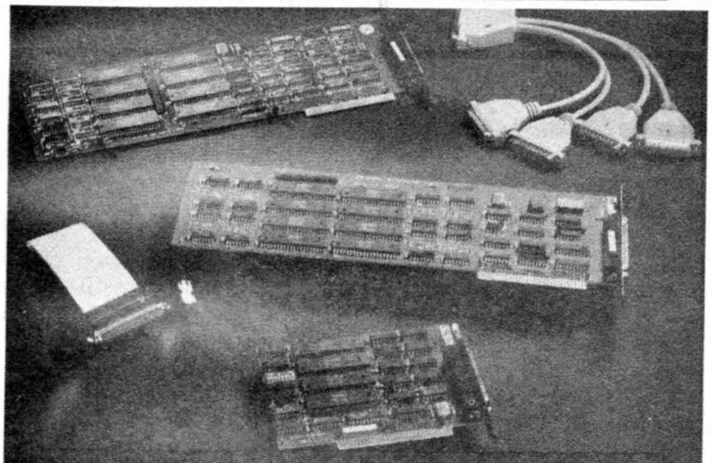

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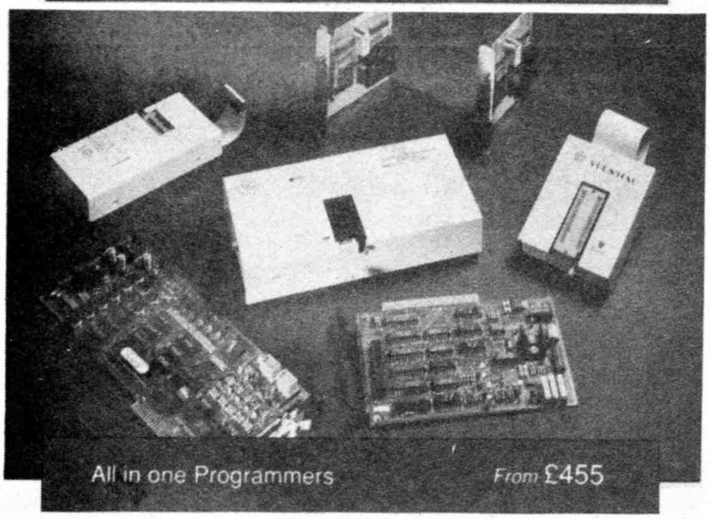

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Special Feature

Audio Amplifier Design, Engineering or Alchemy?

JOHN LINSLEY HOOD

PART 3

The effects of transistor types on sound quality.

IN THE previous part of this short series, I took a brief look at the differences between bipolar and MOSFET transistors as power amplifier output devices, and concluded that MOSFETs were to be preferred in this position because they didn't suffer from "hole storage" and "minority carrier" effects. This could, among other things, lead to a sluggish "switch off" response if the transistor was driven hard on – a phenomenon which had exactly the same effect, in producing a signal blanking paralysis of the amplifier, under turn-off conditions, as Transient Intermodulation Distortion, (TID), has under turn-on conditions, and is just as audibly unpleasant.

BIPOLARS vs MOSFETS

However, the fact that MOSFETs are much faster in action – have a much higher f_T – also means that the "h.f. compensation", the "slugging" of the h.f. gain characteristics of the system normally required to achieve loop stability in an amplifier using negative feedback, need not come into operation at as low a frequency, or to such a great extent. This usually allows the negative feedback loop to remain effective, both in reducing noise and distortion, and in cleaning up the transient response of the amplifier, up to much higher frequencies.

The effect of this is usually to give a MOSFET based audio amplifier a somewhat "cleaner" sound quality in the upper mid and high end of the audio frequency range. MOSFETs are also known to have a much more "linear" relationship between their input voltage and output current than any bipolar junction transistors, and this makes it easier to design a low distortion amplifier with MOSFETs than with bipolars, and reduces the amount of negative feedback (NFB) needed for a given performance. This generally helps the designer achieve good stability under awkward loudspeaker load conditions.

While most of the differences proclaimed by the "subjective sound" fraternity are, in reality, pretty tiny I am convinced that there are generally some small but noticeable differences in tonal quality between MOSFET and junction transistor based power amplifiers and that designs based on MOSFETs usually sound better. (I say "usually" because there are some grotty MOSFET designs around, so their use gives no automatic guarantee of excellence).

INFLUENCE OF CIRCUIT DESIGN

There are three main tasks which the would-be audio amp. circuit designer must accomplish, apart from the need to achieve some target level of harmonic and intermodulation distortion and output power over the required frequency range and into some specified load, usually a high power eight ohm resistor. These are: the need to ensure that the circuit will still deliver the required output signal into a real-life output load, such as a loudspeaker, which isn't just a pure resistor; that it will do so without sporadic instability; and that it will also amplify transient signals, having steep rise or fall rates, without significant waveform deformation.

It is the effectiveness of the design in avoiding these three snags, ones that I think of as the "Cinderella" problems – because they are so often neglected – which is, I believe, the main source of the differences, usually fairly subtle, in sound quality between one design and another. Yes, I will accept the engineers point that a design which exhibits these problems is not "competently engineered" – but, since these faults are always present to some extent, the question is then "how much is too much?". There is certainly no agreed specification on these things.

OPTIONS

In achieving these objectives, the skilled engineer will have a number of design options at his disposal. Each of these has advantages and drawbacks. For example, at the input of an amplifier, one could use a single transistor in what is called a "single-ended" layout, shown in Fig. 1a. Where the signal input is connected to its base(b), its emitter(e) is taken to some reference voltage line, and the output is taken from its collector(c), and negative feedback, (NFB), if any, is also taken to its emitter.

The advantage of this layout is that it is simple, but there will always be a large amount of distortion in this stage, except on very small input signals. This layout is awkward to use in "Direct Coupled" amplifiers where the output d.c. level is required to be the same as that of the input.

A simple improvement on the single-ended layout is shown in Fig. 1b, where two transistors are used, connected as a "long tailed pair". This gives much less distortion than the single-ended arrangement, for the same input signal level, but has only half the stage gain, and the "tail" resistor, R3, which is connected, in this case, to the positive supply line, offers a route for the intrusion of unwanted, and probably distorted signals from this line.

From the point of view of the purist, there is also the snag that if the distortion reducing negative feedback signal is taken to the base of TR2, it doesn't do anything to correct for any errors in the path between the input (TR1 base) and TR2 base. Some "ultra-Fi" designs therefore take their NFB line directly to TR1 base, as I have shown in Fig. 1c, though this leads to an awkwardly low input impedance. Using a very high impedance "constant current source", (CC_1), as the tail load, both helps to keep out supply line rubbish,

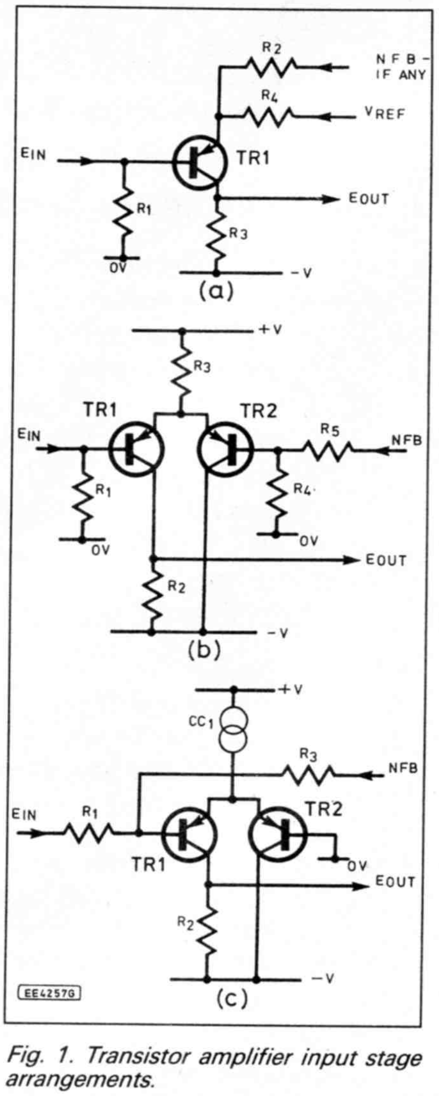

Fig. 1. Transistor amplifier input stage arrangements.

and also improve the TR1 to TR2 coupling.

I have shown *pnp* transistors in the circuit diagrams of Fig. 1, because they have a somewhat lower input noise level, but, in most applications, there is no significant difference. Now, do these circuit configurations sound the same?

I have never made a direct comparison between all three circuits. However, for the sake of simplicity, I used the input layout of Fig. 1a, in a "Simple 10W Class A Amplifier", back in 1968. I later tried out an "improved" version, using an input long-tailed pair, as in Fig. 1b.

This had a lower measured harmonic distortion figure, but I still preferred the sound of the original circuit. To be fair, there were several reasons why this could have been, possibly including the observation that simpler systems often sound better – regardless of their measured performance.

FEEDBACK ON DISTORTION

Negative feedback (NFB) is widely used as a means of improving the performance of amplifier designs. It is good practice to try to make the circuit as distortion free as possible before applying NFB, and then to use the correct amount. (Too little may actually worsen the performance, by introducing higher order, and more dissonant, harmonic components not originally present. Too much may simply worsen the stability of the amplifier). The use of an input long-tailed pair circuit shown in Fig. 1b and Fig. 1c is helpful, as is the "cascode" layout shown in Fig. 2.

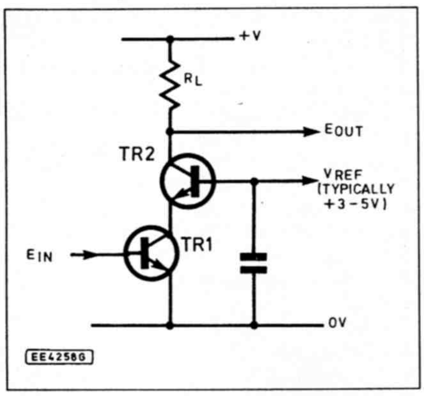

Fig. 2. The "cascode" type of layout.

The advantage of this last arrangement, Fig. 2, is that the input transistor, TR1, operates under a nearly constant collector voltage, to convert an input (base) current, into a larger collector current – a process which is normally quite linear. The "cascode" transistor, TR2, simply takes the output current from TR1, and delivers it to the output load, R_L, as from a very high impedance source. This usually gives a somewhat greater stage gain than the simple layout of Fig. 1a, as well as a much flatter frequency response, and a lower phase shift and distortion factor.

These benefits greatly appeal to circuit designers, and in some published layouts every gain stage is cascode connected. I have done no comparative tests on the sound quality of simple vs. cascode stages, but I would be surprised if there are no differences.

Another commonly used technique in circuit design is to make the circuitry as nearly fully symmetrical as possible. One approach is that in which the standard long-tailed pair layout of Fig. 1b is elaborated into the

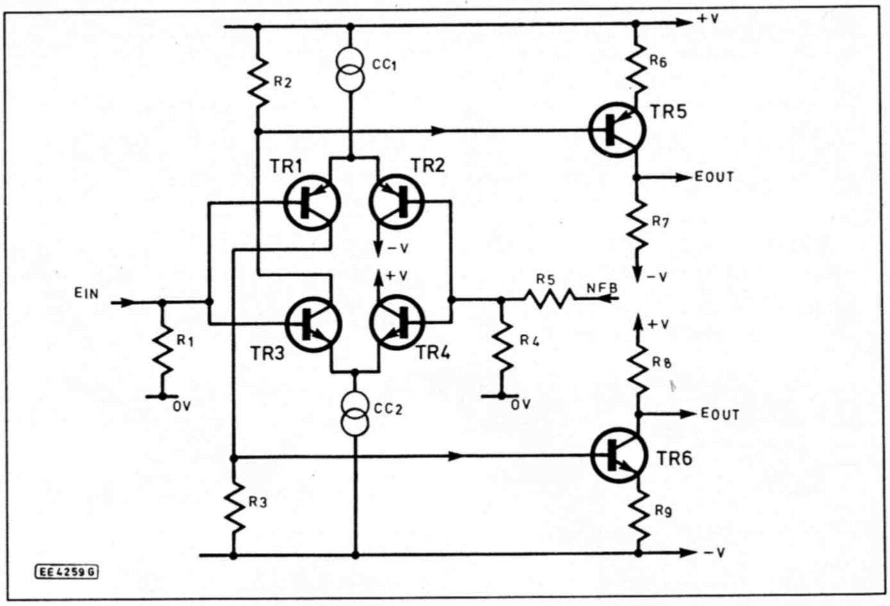

Fig. 3. Elaboration of input long-tailed pair into fully symmetrical layout.

circuit of Fig. 3, and so on throughout the amplifier. The idea of this approach is that positive going signal voltage excursions will be handled identically to negative going ones.

In my experience, there is an audible difference between symmetrical and non-symmetrical designs, with the symmetrical design sounding somewhat "brighter", in spite of an apparently identical frequency response within the audio pass-band. I do not know why this should be, but one can theorise. Certainly there are user preferences in this area.

Two other major sources of sound quality differences in commercial amplifier systems lie in the variations in the circuitry of, and the frequency response inaccuracies resulting from, the preamplifier "RIAA" gramophone input circuitry, and the nature of the power amplifier loop stability h.f. compensation techniques used. In this case, layouts which give the amplifier the kind of "open loop", i.e. prior to the application of negative feedback, frequency response shown in Fig. 4a, are preferable to me to those which give the kind of frequency response shown in Fig. 4b, though both may be arranged to give a similar stability margin.

OXYGEN-FREE HYPE

Hi-Fi product promotion, these days, seems to consist of an ounce of reality, flattened under a ton of advertisers "hype". A convenient recent example is the widely claimed "oxygen-free single crystal copper".

Frankly, I regard this as a myth, along with the hippogryphs and sea-monsters that old-time map makers used to fill in blank bits on their charts. Certainly, copper can, and will, be made oxygen-free – for a time – though it rapidly re-absorbs oxygen if it is heated above about 180°C: and remember that a typical soldering iron bit, in use, will sit at some 220°C to 250°C.

Care is necessary when making and refining copper, and the best electrical grade material is electrolytically formed, with the electrolytic slabs being melted into bars in an oxygen free environment. The practical reason for this is that copper is annealed, after rolling into sheets or drawing into wires, in an atmosphere of hydrogen, at 250°C to 325°C, and the hydrogen, which diffuses into the copper, will react with any dissolved oxygen to release steam, which disrupts the structure, and impairs its electrical conductivity. This is called "embrittlement" in the trade.

"Single crystal"? That's another matter. Most things which can be melted, and which can exist in crystalline form, can be made into single crystals by the "Czochralski" technique, in which a small seed crystal is very slowly withdrawn, during a day or two, from the surface of the melt.

This is hardly a practical large scale

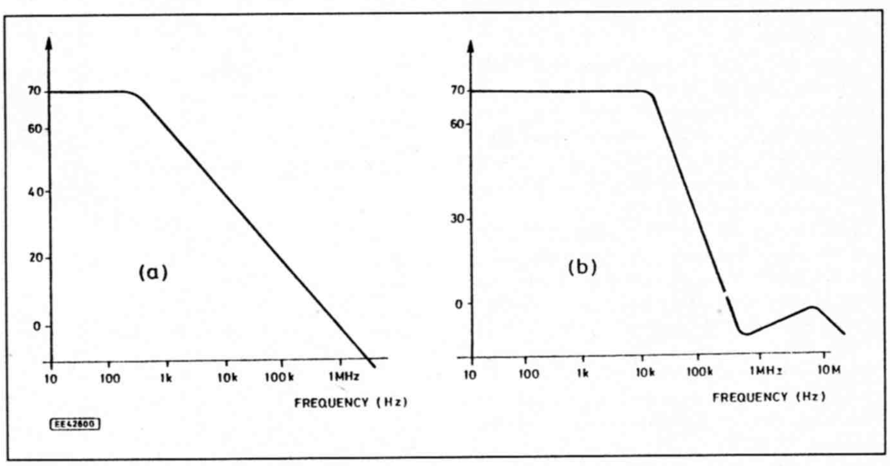

Fig. 4. Alternative h.f. "closed loop" compensation characteristics.

production process. Moreover, even if it was mono-crystalline in the first place, any subsequent extrusion, rolling or drawing will cause it to recrystallise, as would heating above about 180°C to 190°C, due, perhaps, to soldering.

The reason for the "hype"? Because someone observed that the conductivity of copper could be worsened, by one or two percent, by the presence of crystal interfaces, known to the metallurgist as "grain boundaries", because these serve to concentrate the inevitable impurities which then scatter the moving electrons which comprise the current flow.

CONCLUSIONS

I do believe that there are small differences between the results given by different circuit designs and component constructions, and that even quite small defects in operation can often be heard. They can usually also be measured, if one looks in the right place; an exercise which is often more difficult than I would wish. However, when the engineering is done well, different approaches can lead to remarkably similar results – or otherwise there would be a vast difference in sound quality between say a *Quad 405*, and a *Pioneer M-90*, and there isn't.

Much of what is claimed by the "golden eared" fraternity, does exist – but is much, much smaller than they think – and when it exists, and it sometimes doesn't, there are good reasons why. □

FOX REPORT

by Barry Fox

PIRATE SPACE

The launch of Virgin's rock radio station, 1215 AM, has sparked a lot of interest in why there are so many new radio stations and how many more there can be. Much of what is happening can best be summed up by the old adage, where there is a will, there is a way.

Just as the pirate radio ships of the 60s forced the British government into starting Radio One, so the pirate stations of the 80s made it impossible for the government to keep on saying that there were no spare frequencies. People could hear for themselves that the pirates were operating in spare frequencies. But they were also causing interference, largely because they were using cheap equipment.

They used cheap kit because they knew it was at risk of confiscation by the DTI's inspectors. Also the pirates were using as much power as they could muster.

Nature is cruel. Although it needs a strong radio signal to provide clear hiss free stereo, it takes only a very weak interference signal to spoil reception of a stereo station with fluttering sounds, "birdy" chirping noises and occasional snatches of distorted music or speech. Licensing stations, on carefully defined frequencies at restricted power, was an obvious way out. The government also stood to earn some money from the licences, too.

Essentially, the Government did a deal with the BBC. It could retain its four national f.m. networks, but had to end the wasteful luxury of simulcasting the same programme on two different wavebands. The BBC had to agree to give up the two m.w. frequencies this released.

Also, although a large number of public and emergency services used to operate in the v.h.f. "entertainment" band, for everyone to hear, they have been moving out to get some privacy.

The Radio Authority is granting three licences for national commerical networks. Two have already been given, one to Classic FM, the national v.h.f. station, and the other to Virgin's m.w. rock station. Virgin is using the m.w. frequency which Radio 3 gave up in February 1992. Radio One quits the m.w. at the end of next year, and its slot goes to INR3, the third national network.

PRIZES

The real prizes are the v.h.f. frequencies because f.m. provides hifi stereo and better resistance to interference. Hence Richard Branson's current game plan. Having applied for and won m.w. 1215 for Virgin's music station, he is now lobbying for something quite different, on the v.h.f. band. This is greedy and cheeky, like satellite broadcaster BSB's whine that it was saddled with the MAC TV system, when that was the franchise it had applied for.

The v.h.f. band is neatly bundled into packages, all spoken for by the BBC and Radio Authority. There is nothing for Branson.

The BBC has 88-90.2MHz for Radio 2, 90.2-92.4 for Radio 3 and 92.4-94.6 for Radio 4. Radio 2 and Radio 3 currently have around 170 transmitters. Radio 4 has around 130, which accounts for the complaints of patchy coverage. But Radio 4 coverage should eventually match Radio 2 and 3. Unlike the commercial stations, the BBC is obliged to go on investing in the many new transmitters needed to reach the last few percent of listeners, even though it is not cost-effective.

Local BBC stations use 94.6-96.1 and local commercial stations use the band 96.1-97.6. Radio One has 97.6-99.8 and the national commercial radio stations, such as Classic FM, have 99.8-102. Independent local radio stations also has 102-103.5 and BBC local has 103.5-105.

The top slot in the f.m. band, 105-108 MHz, is still used in Britain by public utilities such as the gas, electricity and water authorities. The police, ambulance and fire brigade emergency services have alrady moved out of the lower slots in the bands which they occupied. The 105-108MHz slot should be clear by 1995, a year earlier than planned.

The Radio Authority will license this band, probably for use by low power local radio stations because there is a real risk of high power stations at these frequencies interfering with the radio location beacons used by aircraft in the band just above. These beacons put out overlapping fan beams and the aircraft lines up to fly down a null path in the middle, where the beams cross. Any interference will make the null line wobble.

This, incidentally, is why airports now ban cars from parking on roads in the flight path. Their electronics, and radios, can leak enough signal to wobble the null. (The glide path transmitters which give the aircraft height information are in the u.h.f. band).

Most of Radio 4 is currently duplicated on f.m. and l.w., but the BBC has long been planning a split, putting a news and current affairs station on l.w. and theatre speech output on f.m.. This has angered those who find difficulty in receiving Radio 4 on f.m. either because they live in areas of poor reception or abroad.

Robbing the BBC of its Radio 4 f.m. frequency would kill the plan for a news and current affairs station and mean that people who currently enjoy good reception of Radio 4 on f.m. would in future have to make do with narrow bandwidth mono on the long wave. Many hifi receivers will not tune to the long wave. So this argument will run and run.

DIGITAL AUDIO

There will be even more contention in the mid-90s, if the DTI and broadcasters are successful in their plan to start a completely new digital audio broadcasting service on a slice of frequencies in the v.h.f. band once used by the old 405 line TV system. This DAB service would provide digital quality reception all over the UK without the fluttering interference on f.m. caused by multi path reception, especially in cars. There would be room for around twenty new programmes.

But who will run these programmes, and pay for them? Should they be split evenly between the BBC and independent commercial broadcasters? These are the questions which will very soon start burning and it is where Branson should be conentrating his energies.

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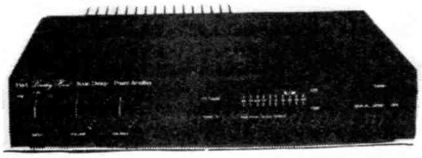

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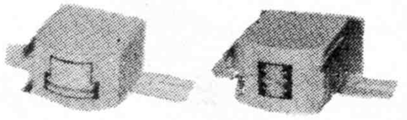

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Teach-In '93

with Alan Winstanley
Keith Dye B.Eng(Tech)AMIEE and
Geoff MacDonald B.Sc(Hons) AMIEE

Part 12

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

WELCOME to the last part of *Teach-In*. In this part we will look at further ways of interfacing peripherals to computers using the *Micro Lab*, and give examples of software to control the devices. The final batch of experiments that have been built into the *Micro Lab* are revealed to allow closed loop control of external loads, voltage to frequency conversion, and playing tunes from internal lookup tables. We conclude with a look at a reaction timer that will allow you to test both yourself and your new software skills.

CONTROLLING EXTERNAL PERIPHERALS

Controlling external devices with the *Micro Lab* is achieved through the 65C22 *Versatile Interface Adapter* (VIA). The circuit diagram for the 65C22 and 34-way output connector are shown in Fig. 12.1. The VIA may be used to simply turn devices on and off or to automatically perform more complex tasks such as counting input pulses and serial to parallel and parallel to serial conversion.

When interfacing a computer to external devices, you should always use a suitable interface circuit. This is because most computer outputs cannot supply enough current to power devices like lamps, l.e.d.s, relays and motors so you will need to use a transistor of some sort to do the actual switching of the device. Also, if anything goes wrong with the device, then an interface circuit will (hopefully!) protect the more expensive computer circuitry from damage.

The data sheet for the 65C22 shows that port A (pins 2 to 9) and port B (pins 10 to 17) outputs have different drive capabilities. Port A and its two associated control lines CA1 and CA2 can drive two standard TTL loads and present two TTL loads to an input source. In current terms these pins can typically source 1·5mA (minimum

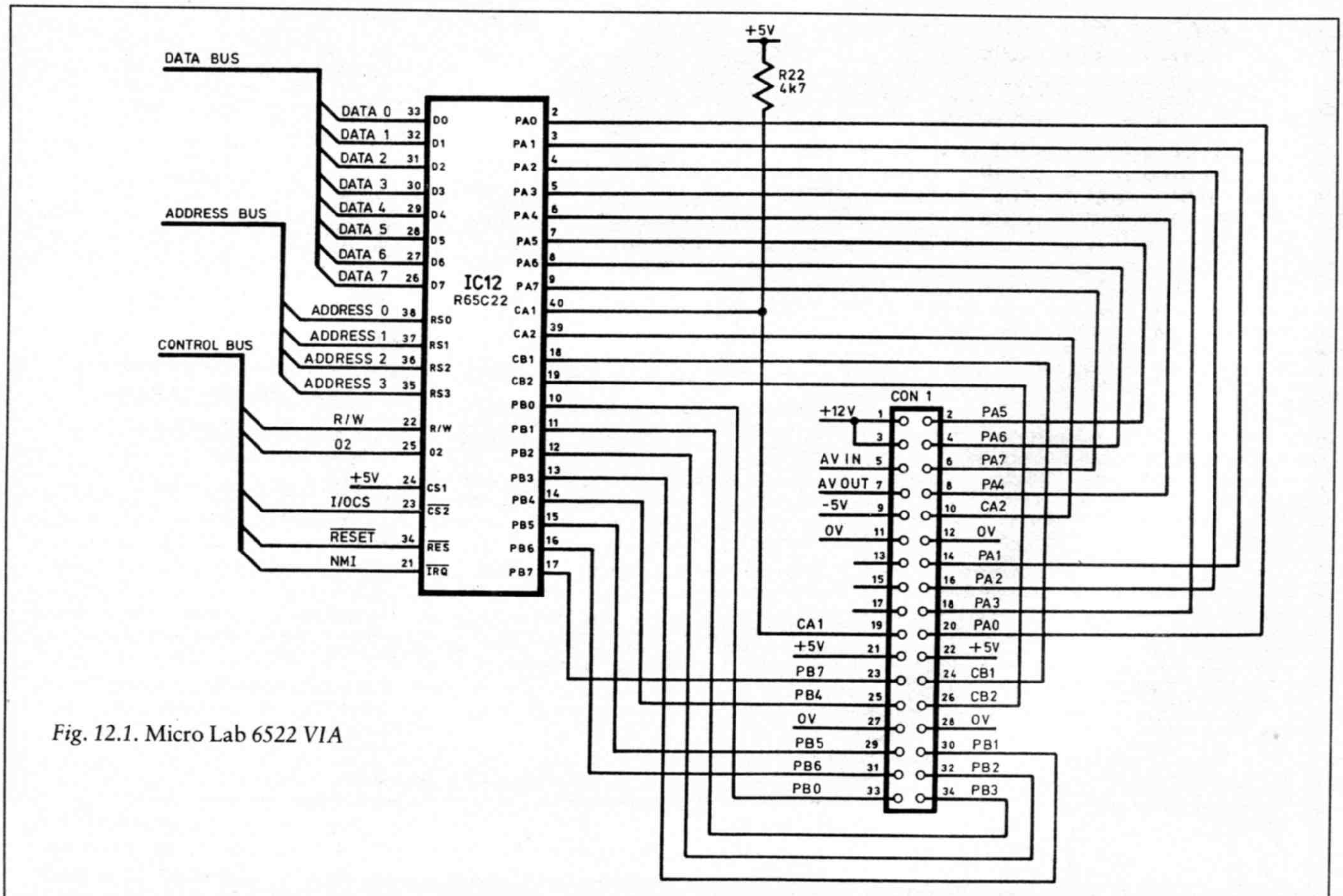


Fig. 12.1. Micro Lab 6522 VIA

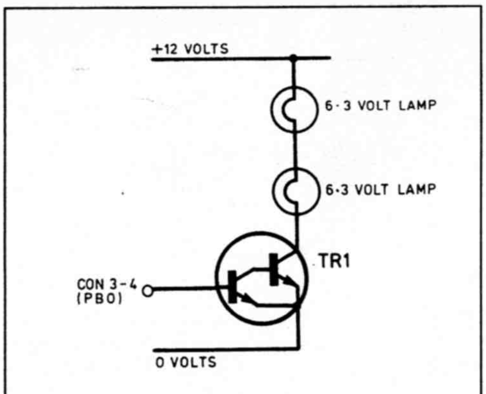


Fig. 12.2(a). Control of lamps with Darlington transistors

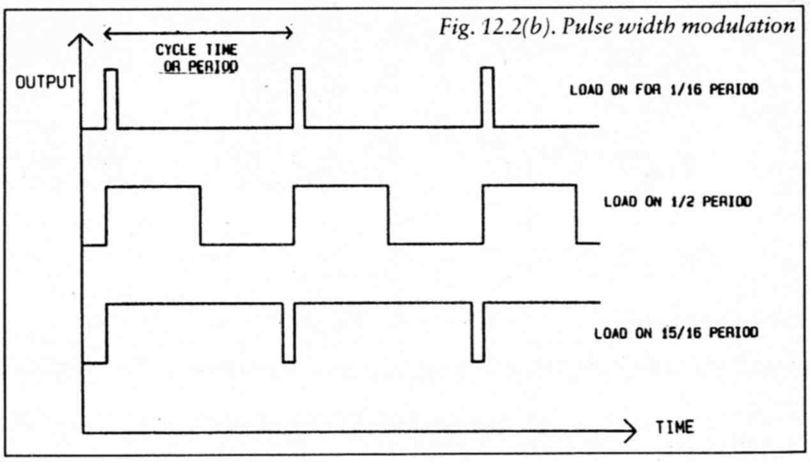


Fig. 12.2(b). Pulse width modulation

0·2mA), and sink a minimum of 3·2mA. Port B and its control pins CB1 and CB2 can sink the same minimum current of 3·2mA while being able to source (or drive) typically 6mA (minimum 3·2mA at 1·5 volts). This makes port B ideal for driving Darlington transistors and other loads requiring higher drive currents.

We will use the 65C22 ports for driving external loads, and producing variable frequency square waves. The 65C22 is a highly complex i.c. capable of many other functions and readers are advised to obtain a full data sheet on the device to use it to its full potential. Some details are included in the separate box item on the 65C22.

CONTROLLING A FILAMENT LAMP

A circuit which may be used to control a filament lamp is shown in Fig. 12.2(a), although you could replace the lamp by any device which requires no more than the maximum rated current of the Darlington transistor (2A for the TIP112) or the current available from the power supply (up to 1 amp on the *Mini Lab*). To control the lamp, we must first turn the port connected to the base of the Darlington transistor into an output:

```
0200    A9 01     LDA  #$01    ;Set PB0 to output
0202    8D 42 80  STA  $8042
```

Now, we can turn on the lamp by writing a "1" to the output register of the 65C22 corresponding to pin PB0 (i.e. bit 0 of ORB/IRB):

```
0205    A9 01     LDA  #$01    ;Turn lamp on
0207    8D 40 80  STA  $8040
```

To turn the lamp off, we would write a "0" to ORB/IRB. Before we do this, we will make the program pause for one second:

```
020A    A9 64     LDA  #$64    ;Delay for one second
020C    20 18 00  JSR  $0018
020F    A9 00     LDA  #$00    ;Turn lamp off
0211    8D 40 80  STA  $8040
0214    00        BRK          ;End program
```

When you run this program, the lamp will turn on for one second then turn off (you may find that the lamp turns on when the *Micro Lab* is reset, so you will need to run the program twice to see it work correctly).

We can change the program to flash the lamp by adding the following code:

```
0214    A9 64     LDA  #$64    ;Delay for one second
0216    20 18 00  JSR  $0018
0219    4C 05 02  JMP  $0205   ;Repeat
```

We can make the lamp flash faster by reducing the values at addresses 020B and 0215 – this shortens the delay time. If we make the delays short enough, the lamp will become continuously on because it takes time for the filament to heat up and cool down, however it will appear to be dimmed because it is unable to reach full brightness before being turned off again.

The brightness of the lamp depends on the average power being delivered to it. So, if the value at address 020B is greater than the value at address 0215, the lamp will be powered longer than it is turned off and, so, will glow brighter. The cycle time is constant due to the software program looping round, and the brightness (or average power) is proportional to the *mark to space ratio* of the on/off times.

The following program uses this fact to vary the brightness of the lamp under control of the user. It works by having a byte in memory (at 90h) which sets the lamp brightness. The lamp is first turned on then the program counts down to zero from this value. Next, the lamp is turned off and the program counts down to zero from 127 – "lamp brightness". Finally, the program checks to see if the user has pressed either the "0" or the "1" key and subtracts or adds 4 to the lamp brightness as required.

```
0200    A901     LDA  #$01    ;Set PB0 as an output
0202    8D4280   STA  $8042
0205    A900     LDA  #$00    ;Set the initial
                              brightness of the lamp
0207    8590     STA  $90
0209    A901     LDA  #$01    ;Switch the lamp on
020B    8D4080   STA  $8040
020E    A690     LDX  $90     ;Count up to the
                              "lamp brightness"
0210    CA       DEX
0211    10FD     BPL  $0210
0213    A97F     LDA  #$7F    ;Calculate 127 –
                              "lamp brightness"
0215    38       SEC
0216    E590     SBC  $90
0218    AA       TAX
0219    A900     LDA  #$00    ;Switch the lamp off
021B    8D4080   STA  $8040
021E    CA       DEX          ;Count to 127-"lamp
                              brightness"
021F    10FD     BPL  $021E
0221    201E00   JSR  $001E   ;Key pressed?
0224    AA       TAX          ;Store key value in IX
0225    A590     LDA  $90     ;Store "lamp
                              rightness" in Acc
0227    E030     CPX #$30     ;Key="0"?
0229    D006     BNE  $0231
022B    38       SEC          ;Yes – Subtract 4 from
                              brightness
022C    E904     SBC #$04
022E    4C3802   JMP  $0238
0231    E031     CPX #$31     ;Key="1"?
0233    D003     BNE  $0238
0235    18       CLC          ;Yes – Add 4 to lamp
                              brightness
0236    6904     ADC #$04
0238    297F     AND #$7F     ;Make brightness
                              between 0 and 127
023A    8590     STA  $90
023C    4C0902   JMP  $0209   ;Start again . . .
```

This type of power control is called *Pulse Width Modulation* or *PWM*. Fig. 12.2(b) shows three output waveforms for 1/16, 1/2, and 15/16 lamp brightness. Note that the cycle time remains constant whilst the on/off times are varied as a proportion of the cycle. A common use of PWM is to control d.c. motor speeds, particularly in models. Switching the load on and off to control the average power is a very efficient method of using transistors. By only operating in one of two states – either hard on (e.g. saturation) or hard off, they never operate in their linear region. This means that the internal resistance of the transistor is either very low (on) or very high (off), and the transistor can switch high currents without dissipating great amounts of heat.

SOUND OUTPUT

The 65C22 contains two sixteen bit timer/counters which may be used for many operations. To generate sound output, we can make Timer 1 continuously count down from a specified value and invert the PB7 output when it goes below zero. This generates a square wave with a controllable period on this pin. When connected to an

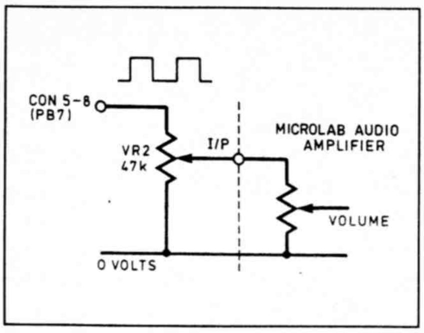
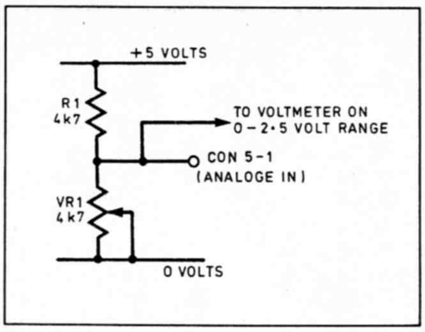


Fig. 12.3 (left). Frequency output to amplifier.

Fig. 12.5 (right). Varying the input voltage for Demonstration Program 6.

Fig. 12.4 (below). Demonstration Program 6.




```
81F8              ;***********************************************************************
81F8              ;***                                                                 ***
81F8              ;*** Everyday Electronics Micro-Lab                                  ***
81F8              ;***                                                                 ***
81F8              ;***    Name:           Demonstration 6                              ***
81F8              ;***    Version:        1.0                                          ***
81F8              ;***    Author:         Geoff MacDonald                              ***
81F8              ;***    Date:           13/01/1993                                   ***
81F8              ;***    Last Update:                                                 ***
81F8              ;***                                                                 ***
81F8              ;***********************************************************************
81F8
81F8                              ;Read the analogue input and use the result to set the
81F8                              ;frequency of pulses output by the 65C22.
81F8
81F8  A901      D_DEMO6:          LDA     #1            ;Initialise the 65C22 for sound
81FA  201500                      JSR     SOUND
81FD  8DFFFF    DEMO6A:           STA     $FFFF         ;Initiate A/D conversion
8200  A00A                        LDY     #10           ;Delay
8202  88        DEMO6B:           DEY
8203  D0FD                        BNE     DEMO6B
8205  AD2080                      LDA     AIN           ;Read analogue input
8208  A8                          TAY                   ;Set sound output frequency
8209  A201                        LDX     #1
820B  A900                        LDA     #0
820D  201500                      JSR     SOUND
8210  A90A                        LDA     #10
8212  201800                      JSR     DELAY
8215  A55D                        LDA     KBSIZE        ;Key pressed?
8217  F0E4                        BEQ     DEMO6A        ;No - repeat
8219  202100                      JSR     KBCLR         ;Clear keyboard buffer
821C  A900                        LDA     #0            ;Sound off
821E  AA                          TAX
821F  A8                          TAY
8220  201500                      JSR     SOUND
8223  00                          BRK                   ;Terminate
```

amplifier (such as the one on the *Mini Lab*) a sound is produced. Fig. 12.3 shows a method of connecting port PB7 to the amplifier. The variable resistor VR2 is used to attenuate the typically four volt signal before the amplifier input volume control.

To set the frequency of the sound, we load the Timer 1 latches with the desired count. This value is automatically loaded into the timer whenever it goes below zero. The timer decrements at the system clock rate. So, the sound output frequency is given by:

$$f_s = \frac{f_c}{2t}$$

Where: f_c = system clock frequency,
f_s = sound output frequency,
t = Timer 1 latch value (T1L)

To initialise this mode of operation, we write a C0h to the Auxiliary Control Register (ACR) of the 65C22. This sets Timer 1 into continuous run mode with output on PB7. To set the output frequency, we firstly write the high byte of T1L into T1L-H, then write the low byte into T1L-L then we write the high byte into T1C-H. This last operation sets the counter running. There is a subroutine within the *Micro Lab* monitor program which does all of this for you. Calling the routine with *Acc= 1* will initialise the 65C22 to output sound. Calling it with *Acc=0, IX=High byte* and *IY=Low byte* will output a sound. If IX=0 and IY=0 then sound output is disabled.

SIGNAL CONVERSION

As we have seen before, it is often necessary to convert one type of signal into another (the modern telephone is a good example of this – sound signals are converted into analogue voltages by the microphone in the telephone, this is then converted into a digital data stream at the exchange which is then converted into pulses of light and sent down fibre optic cable to the next exchange. At the final destination exchange the signals are converted back to analogue signals for transmission to the receiving telephone). This type of conversion may be performed using the *Micro Lab*. Demonstration Program 6 (see Fig. 12.4) converts an analogue voltage into variable frequency pulses by continuously reading the analogue input port then calling the SOUND routine with the value read. The circuit in Fig. 12.5 allows you to vary the input voltage using a potentiometer. The frequency output from PB7 is coupled to the amplifier using the circuit shown in Fig. in 12.3. Thus allowing you to hear the output frequency through the *Micro Lab* speaker.

We found that we could also leave the analogue input to the *Micro Lab* open. The floating input to the A/D converter can be controlled by placing your finger across the analogue in and analogue out terminals on the *Micro Lab*. Weird "music" can be created this way!

DIGITAL MUSIC

Last month, we looked at sound sampling. One of the drawbacks of sound sampling is the large amount of memory required to store the samples. It is possible to get a computer to play music without the need to have massive amounts of memory using the method described above. For the musically minded, each note in the scale is at a particular frequency, and as you go up an octave, the frequency doubles. So, a note A is at a frequency of 440Hz, the note A an octave higher is at a frequency of 880Hz and the A an octave lower is at a frequency of 220Hz. If we number the notes Rest=0, C=1, C#=2, D=3, Eb=4, E=5, etc. and have a table in memory which converts a note number into a value which can be loaded into the Timer 1 latches, we can play simple tunes.

Fig. 12.6. Demonstration Program 7.

```
8224                  ;***************************************************************************
8224                  ;***                                                                     ***
8224                  ;*** Everyday Electronics Micro-Lab                                      ***
8224                  ;***                                                                     ***
8224                  ;***     Name:          Demonstration 7                                  ***
8224                  ;***     Version:       1.0                                              ***
8224                  ;***     Author:        Geoff MacDonald                                  ***
8224                  ;***     Date:          18/01/1993                                       ***
8224                  ;***     Last Update:                                                    ***
8224                  ;***                                                                     ***
8224                  ;***************************************************************************
8224
8224                              ;Reads data from memory and uses it to play a
8224                              ;tune using the 65C22 VIA.  The data is of the
8224                              ;form:
8224                              ;      NOTE, LENGTH, NOTE, LENGTH, NOTE, LENGTH...
8224                              ;Where NOTE   =(0;Rest | 1:A1 | 2:Bb1 | 3:B1 | 4:C2..)
8224                              ;And   LENGTH =(1:0.16S | 2:0.32S | ... | 7:1.12S)
8224                              ;A NOTE of value $FF terminates the tune.
8224                              ;The start address of the tune data should be stored
8224                              ;in locations $90 (low) and $91 (high)
8224
8224  FFFF070606+    FREQTABH: DFB     $FF,$07,$06,$06,$06,$05,$05,$05,$04
822D  04040403+                DFB     $04,$04,$04,$03,$03,$03,$03,$03
8235  02020202+                DFB     $02,$02,$02,$02,$02,$02,$02,$01,$01
823E  FFFF6DFFFAFF89+FREQTABL: DFB     $FF,$6D,$FA,$89,$3B,$E3,$88,$31,$E4
8247  FFAD6929FFEC+            DFB     $AD,$69,$29,$EC,$B1,$7A,$4C,$1B
824F  FFF5FFC3FF997B+          DFB     $F5,$C3,$99,$7B,$53,$33,$14,$F3,$DB
8258
8258  A590       D_DEMO7:      LDA     $90              ;Save tune start on stack
825A  48                       PHA
825B  A591                     LDA     $91
825D  48                       PHA
825E  A901                     LDA     #$01             ;Initialise 65C22 for sound
8260  201500                   JSR     SOUND
8263  A000       DEMO7A:       LDY     #$00
8265  B190                     LDA     ($90),Y          ;Get note value
8267  C9FF                     CMP     #$FF             ;End of tune?
8269  F036                     BEQ     DEMO7B
826B  AA                       TAX
826C  BD3E82                   LDA     FREQTABL,X       ;Convert to 65C22 count value
826F  A8                       TAY
8270  BD2482                   LDA     FREQTABH,X
8273  AA                       TAX
8274  A900                     LDA     #$00
8276  201500                   JSR     SOUND            ;Play sound
8279  A001                     LDY     #$01             ;Get note length
827B  B190                     LDA     ($90),Y
827D  0A                       ASL     A                ;Convert to delay time
827E  0A                       ASL     A
827F  0A                       ASL     A
8280  201800                   JSR     DELAY            ;Delay
8283  A2FF                     LDX     #$FF             ;Staccato pause
8285  A0FF                     LDY     #$FF
8287  A900                     LDA     #$00
8289  201500                   JSR     SOUND
828C  A901                     LDA     #$1
828E  201800                   JSR     DELAY
8291  18                       CLC                      ;Point to next note
8292  A590                     LDA     $90
8294  6902                     ADC     #$02
8296  8590                     STA     $90
8298  A591                     LDA     $91
829A  6900                     ADC     #$00
829C  8591                     STA     $91
829E  4C6382                   JMP     DEMO7A
82A1  A200       DEMO7B:       LDX     #$00             ;Turn sound off
82A3  A000                     LDY     #$00
82A5  A900                     LDA     #$00
82A7  201500                   JSR     SOUND
82AA  68                       PLA                      ;Restore tune start address
82AB  8591                     STA     $91
82AD  68                       PLA
82AE  8590                     STA     $90
82B0  00                       BRK
```

Scale of C

```
$01,$04   ;C
$03,$04   ;D
$05,$04   ;E
$06,$04   ;F
$08,$04   ;G
$0A,$04   ;A
$0C,$04   ;B
$0D,$04   ;C
$0D,$04   ;C
$0C,$04   ;B
$0A,$04   ;A
$08,$04   ;G
$06,404   ;F
$05,304   ;E
$03,$04   ;D
$01,$04   ;C
$FF,$FF   ;End
```

Twinkle Twinkle Little Star

```
$01,$04 $08,$04
$01,$04 $06,$04
$08,$04 $06,$04
$08,$04 $05,$04
$0A,$04 $05,$04
$0A,$04 $03,$08
$08,$08 $01,$04
$06,$04 $01,$04
$06,$04 $08,$04
$05,$04 $08,$04
$05,$04 $0A,$04
$03,$04 $0A,$04
$03,$04 $08,$08
$01,$08 $06,$04
$08,$04 $06,$04
$08,$04 $05,$04
$06,$04 $05,$04
$06,$04 $03,$04
$05,$04 $03,$04
$05,$04 $01,$08
$03,$08 $FF,$FF
$08,$04
```

Fig. 12.7. Micro Lab *stored tunes*

Demonstration 7 (see Fig. 12.6) uses such a table to play tunes stored in memory. A tune is stored in memory in the following way:

Note, Length, Note, Length, Note, Length . . .

To tell the program to stop, we put a note value of FFh. So, to play a scale of C, the table would be:

0200	**01 04**	**;C**
0202	**03 04**	**;D**
0204	**05 04**	**;E**
0206	**06 04**	**;F**
0208	**08 04**	**;G**
020A	**0A 04**	**;A**
020C	**0C 04**	**;B**
020E	**FF FF**	**;End of tune**

Next, you need to tell the program where in memory the tune table is stored. The low byte of the start address is stored at 90h and the high byte of the start address is stored at 91h:

0090	**00 02**	**;Tune start address**

If you now run Demonstration 7, you should hear a scale of C.

There are two tunes stored in the *Micro Lab* EPROM. The first, a scale of C which goes up then down, is stored at B000h. The second is *Twinkle, Twinkle Little Star* and is stored at address B100h. To play these, simply store the start address of the tune you want to listen to in 90h and 91h as:

0090	**00 B0**	**;Tune start address – Scale of C**

then run Demonstration Program 7. The data for these tunes is shown in Fig. 12.7.

FEEDBACK CONTROL

When a computer system is used to control a device or process, it will often need to know the state of the thing which it is controlling. For example, an active suspension system on a car will be continuously monitoring the forces on each wheel in order to set the suspension hardness. The computer will estimate and set the required hardness and will continue to monitor the wheel forces in order to refine and correct the setting. This type of control is called *Feedback Control*, as the output from the system is fed back into the input.

The simplest form of feedback control is to simply switch a device on or off depending on the input value. Demonstration Program 4, see Fig. 12.8, is a simple temperature control system using this technique. The program reads an input voltage level on the analogue I/P and compares it to a stored value. An output is switched on if the input is below the stored value, and off if the output is above. For our experiment we will use the same Darlington driver circuit used in Fig. 12.2(a). The lamps become the measured heat source, and we will control the average temperature of one of the lamps.

Connect up the circuit in Fig. 12.9, placing the thermistor R1 against one of the lamps. Hold it in place with some insulating tape to enable it to measure the heat emitted from the lamp glass. The output from the circuit is connected to the *Mini Lab* voltmeter on the 0 to 2·5 volt scale, and to the *Micro Lab* input via CON5.1. Adjust VR1 to set the thermistor output using the voltmeter to see the analogue output range. Remember that the analogue input of the *Micro Lab* is exactly the same as the voltmeter on 0 to 2·5 volt range. This makes it easy to "see" the voltage being applied to the *Micro Lab* analogue input. The lamp drive circuit from the *Micro Lab* is the same circuit we used in Fig. 12.2.

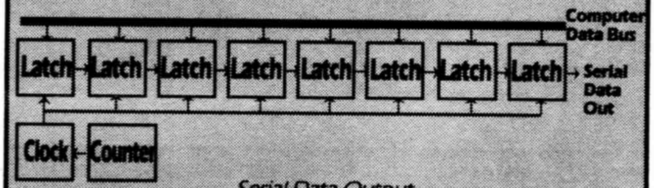
Run the Demonstration Program 4. The bottom line of the l.c.d. shows a bar which represents the temperature, and the top line shows the desired temperature. This may be changed using the "0" and "1" keys. When the input temperature is below this point, the lamp is turned on, when it is above the line, the lamp is turned off. The end result is that when the temperature is approximately correct, the lamp will flash on and off, attempting to keep the temperature constant.

This type of on/off control is how a central heating system normally works – although the on/off times are measured in minutes and not microseconds as in this last experiment. Figure 12.10 shows the temperature of a room in which a typical mechanical thermostat switches on when the temperature falls below the set point, and off when above. These mechanical thermostats have some hysteresis in their operating points of about two degrees C.

Serial Input/Output

There are two common ways in which computers communicate with complex external peripherals (such as disk drives, printers, other computers, etc.). One is *parallel I/O*, which sends data bits in parallel down several wires at once (similar to the way devices communicate on the computer data bus). The other way is to use *serial I/O*, which sends the data one bit at a time using a pair of wires – normally one for a reference voltage the other for the actual signal. Bi-directional communication may be achieved by adding a third wire. Using this method is obviously slower then sending the data in parallel, but it is often used for long distance connections as the wiring is cheaper.

To send data serially, a *shift register* is used. This comprises a series of latches, each with two inputs. One input is connected to the output of the previous latch and the other input connected to the computer data bus to allow the computer to load the register with a value to send:



Serial Data Output

The clock generates a square wave which makes the data shift into the next latch. The counter ensures that the clock stops when all of the data has been shifted out. A similar circuit is used to read serial data in.

Before sending a byte of data, it is normal to send a *start bit*. This is a single bit which informs the receiving shift register that data is to follow, so it should reset its counter and start its clock running. The receiver usually samples the incoming data roughly at the mid-point of each bit to improve reliability. As long as both clocks are running at approximately the same speed the data will be received correctly, as they are re-synchronised each time a start bit is received. The 65C22 VIA contains serial to parallel and parallel to serial circuits.

A standard for serial communications called RS232 evolved many years ago. This standard uses +12V for a "0" and –12V for a "1". This relatively large voltage difference makes it possible to transmit data over quite large distances. Additionally, a *parity bit* is transmitted at the end of each byte of data. This bit is used to check that the data has been received correctly. It is either set or cleared to make the total number of 1's in the byte either even or odd (depending on the protocol used – this must be agreed upon by the sending and receiving equipment). If the receiver is expecting, say, an even number of bits and it receives an odd number, then it knows that the data is incorrect.

Fig. 12.8. Demonstration Program 4.

```
8129                 ;*********************************************************************
8129                 ;***                                                               ***
8129                 ;*** Everyday Electronics Micro-Lab                                ***
8129                 ;***                                                               ***
8129                 ;***     Name:          Demonstration 4                            ***
8129                 ;***     Version:       1.0                                        ***
8129                 ;***     Author:        Geoff MacDonald                            ***
8129                 ;***     Date:   .      13/01/1993                                 ***
8129                 ;***     Last Update:                                              ***
8129                 ;***                                                               ***
8129                 ;*********************************************************************
8129
8129                                 ;Read a temperature via the analogue input and switch on
8129                                 ;a lamp if the temperature falls below an adjustable level.
8129
8129  200C00         D_DEMO4:        JSR      CLEAR           ;Clear display
812C  A990                           LDA      #$90            ;Set initial required temp. set-point
812E  8590                           STA      $90
8130  A9FF                           LDA      #$FF            ;Initialise 65C22
8132  8D4280                         STA      VIA+2
8135  A590           DEMO4A:         LDA      $90             ;Show required temp. set-point
8137  4A                             LSR      A
8138  4A                             LSR      A
8139  4A                             LSR      A
813A  4A                             LSR      A
813B  AA                             TAX
813C  A000                           LDY      #0
813E  A97C                           LDA      #$7C
8140  201200                         JSR      POSCHAR
8143  A200                           LDX      #0              ;Write set point in Hex.
8145  A000                           LDY      #0
8147  A900                           LDA      #0
8149  200900                         JSR      CURSOR
814C  A590                           LDA      $90
814E  202400                         JSR      HEXOUT
8151  A200           DEMO4I:         LDX      #0              ;Position cursor at left side
8153  A001                           LDY      #1              ;of bottom row of screen
8155  A900                           LDA      #0              ;with cursor switched off
8157  200900                         JSR      CURSOR
815A  8DFFFF                         STA      $FFFF           ;Initiate A/D conversion
815D  A00A                           LDY      #10
815F  88             DEMO4B:         DEY
8160  D0FD                           BNE      DEMO4B
8162  AD2080                         LDA      AIN             ;Display current temp. as a bargraph...
8165  48                             PHA                      ;Save temperature
8166  4A                             LSR      A               ;Get bargraph length...
8167  4A                             LSR      A
8168  4A                             LSR      A
8169  4A                             LSR      A
816A  AA                             TAX                      ;...in IX
816B  A010                           LDY      #$10            ;Get display line length in IY
816D  A9FF           DEMO4C:         LDA      #$FF            ;Display a solid block...
816F  200600                         JSR      OPCHAR
8172  88                             DEY
8173  CA                             DEX
8174  10F7                           BPL      DEMO4C          ;...the required number of times
8176  A920           DEMO4H:         LDA      #$20            ;Clear the rest of the line
8178  200600                         JSR      OPCHAR          ;   by writing space characters
817B  88                             DEY
817C  D0F8                           BNE      DEMO4H
817E  68                             PLA                      ;Restore temperature reading
817F  C590                           CMP      $90             ;Compare it with the set-point
8181  9004                           BCC      DEMO4D
8183  A200                           LDX      #$00            ;Too hot - turn lamp off
8185  F002                           BEQ      DEMO4E
8187  A201           DEMO4D:         LDX      #$01            ;Too cold - turn lamp on
8189  8E4080         DEMO4E:         STX      VIA
818C  A55D                           LDA      KBSIZE          ;Key in buffer?
818E  F0C1                           BEQ      DEMO4           ;No - get next temp. reading
8190  A590                           LDA      $90             ;Clear temperature set-point char.
8192  4A                             LSR      A
8193  4A                             LSR      A
8194  4A                             LSR      A
8195  4A                             LSR      A
8196  AA                             TAX
8197  A000                           LDY      #0
8199  A920                           LDA      #$20
819B  201200                         JSR      POSCHAR
819E  201E00                         JSR      KBLAST          ;Get ASCI  value of key
81A1  C930                           CMP      #$30            ;Key = "0"?
81A3  D009                           BNE      DEMO4F
81A5  A690                           LDX      $90             ;Yes - set-point > 0?
81A7  F011                           BEQ      DEMO4J
81A9  C690                           DEC      $90             ;Yes - decrement set-point
81AB  4CBA81                         JMP      DEMO4J
81AE  C931           DEMO4F:         CMP      #$31            ;Key = "1"?
81B0  D00B                           BNE      DEMO4G
81B2  A690                           LDX      $90             ;Yes - setpoint < 255?
81B4  E0FF                           CPX      #$FF
81B6  F002                           BEQ      DEMO4J
81B8  E690                           INC      $90             ;Yes - increment set-point
81BA  4C3581         DEMO4J:         JMP      DEMO4A
81BD  C91B           DEMO4G:         CMP      #$1B            ;Key = "ESC"?
81BF  D0F9                           BNE      DEMO4J
81C1  00                             BRK                      ;Yes - terminate
```

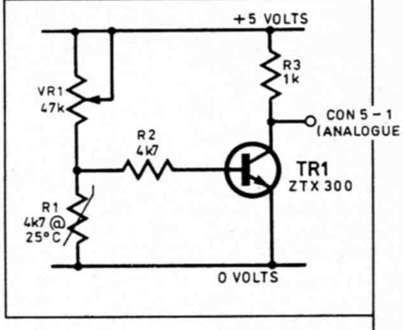


Fig. 12.9. Temperature measuring circuit.

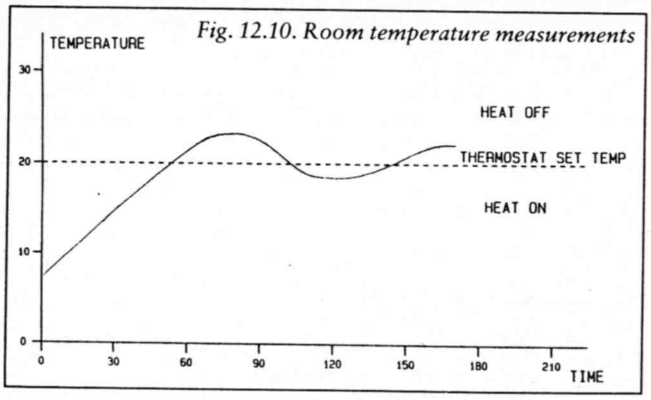


Fig. 12.10. Room temperature measurements

Because most systems use hot water in radiators the room carries on heating after the system has been turned off. Similarly, as the boiler has to heat the water when the system turns back on there is a delay in putting more heat back into the room. This allows the room temperature to fall further before once again rising and overshooting the desired setpoint. Greater accuracy could be obtained if the mechanical controller was replaced by a computer that measured the temperature and controlled the heat source more intelligently.

PROPORTIONAL FEEDBACK

A slightly more complex type of control would determine the *difference* between the actual temperature and the desired temperature and set the lamp brightness to a multiple of this difference. This is called *proportional* feedback control, because the control signal is proportional to the difference between the actual and desired signals. Using this type of control would result in less oscillation of the temperature. In fact, if the multiplier is small enough, the system is unlikely to oscillate at all, but will respond very slowly to changes in temperature.

More complex systems would determine the *rate* at which the temperature varies and sets the control signal accordingly. This allows the system to predict what is going to happen and reduce oscillation even further whilst still maintaining a fast response to changes in temperature. This is called *derivative* control – the control signal is determined by differentiating (calculus) the input signal with respect to time.

The most complex systems use an accurate computerised *model* of the system being controlled, allowing the computer to predict the effect a change will have. The model will be modified by the program to allow for changes in the system over a period of time. This is the way in which car *engine management systems* work. They allow the characteristics of the car to be changed as required – one minute you could be using the economy setting which uses one gallon of petrol every 50 miles and the next you could be accelerating to 70 m.p.h. in a few seconds with the sports setting!

The more complex control systems measure the combustion efficiency of the exhaust gases. The computer will continuously use this information to change the model of the car as the car itself changes with use, automatically compensating for wear and tear.

STEPPER MOTORS

Stepper motors are used in many control devices such as printers and plotters, robots, computer disk drives, etc. This is because they allow the computer to accurately position the motor without the need for complicated and expensive feedback mechanisms such as

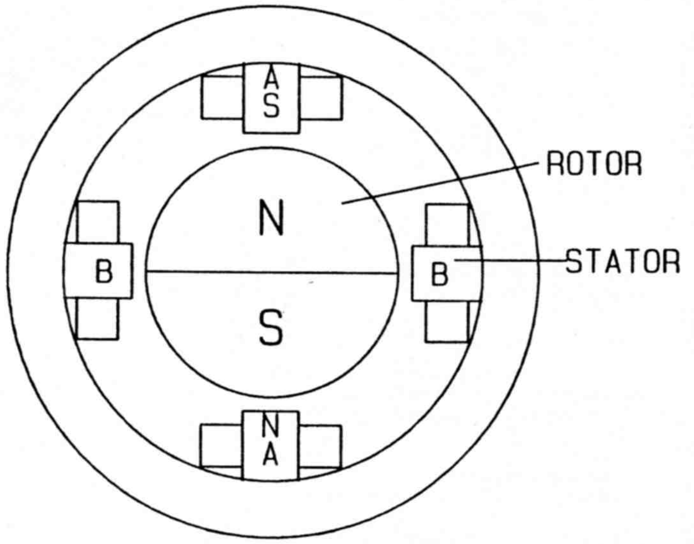


Fig. 12.11. Permanent magnet stepper motor.

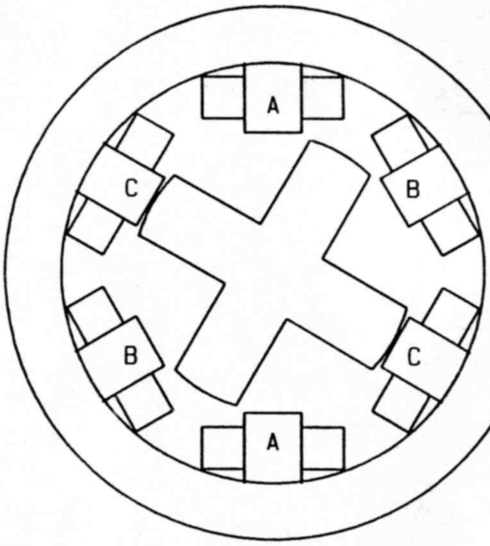
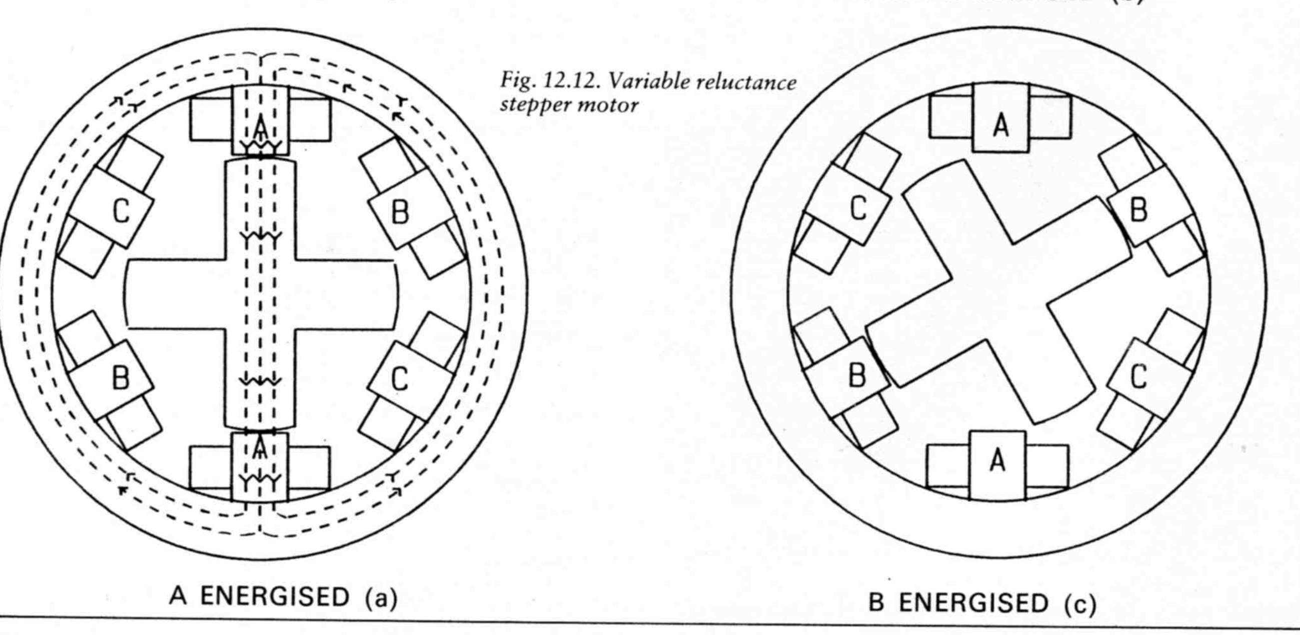



Fig. 12.12. Variable reluctance stepper motor

rotary shaft encoders. The shaft encoder is a device that gives an output proportional to its rotational position. The output is used by the controlling computer to ensure that the motor has turned the shaft to the desired angle.

When using a stepper motor, once the program knows the start position of the motor – which can be determined using a simple switch – it can keep count of the number of steps which have been sent to it, adding one for a step in one direction and subtracting one for a step in the other direction. It therefore knows the exact angle of the motor shaft at all times. The only problem occurs if the load on the motor is sufficient to stop it from rotating. To allow for this, programs occasionally return the motor to the start position to verify that all is well.

A simple permanent magnet stepper motor is shown in Fig. 12.11. Coils A are wound such that when a d.c. voltage is applied the top pole generates a south pole, and the bottom pole generates a north pole. The rotor is a permanent magnet with half polarised as a north and half a south pole. The rotor will turn to allow the magnetic poles to align with their equal and opposite electromagnetic poles. When coil A is turned off and coil B energised the rotor will turn 90 degrees to align with the new electromagnetic poles.

The direction of rotation can be controlled by the direction of current flow in the coils. When this type of motor is de-energised the permanent magnet will still hold the rotor in alignment with the stator poles. This is a useful feature as it would allow a control system to remain in its current state in the event of a power failure.

Another type of stepper motor is the variable reluctance type shown in Fig. 12.12(a). The winding pairs produce large magnetic fields when energised by a d.c. current. This flux will flow through the rotor teeth. The rotor will turn to allow a pair (or set) of teeth to align with the poles of the energised electro magnets and present a minimum reluctance to the main flux path.

When A is turned off and B energised the rotor will turn to align with the pole faces. In this motor this would be a 60 degree step. Turning off B and turning on C would produce a further 60 degree step. If the energising sequence ABC is repeated the motor will rotate in these 60 degree steps. Fig. 12.12(b) shows a variation of this sequence where coils A and B are energised at the same time. This will produce a half step as the rotor attempts to align itself halfway between the two poles. Now a sequence A, AB, B, BC, C, CA, A, will rotate the motor in 30 degree steps.

The variable reluctance motor has no torque when the power is removed from the coils, and can easily be turned. Most small stepper motors are of a hybrid construction where the variable reluctance rotor contains some magnetic properties. These motors have a small torque when the power is removed that can stop them from moving.

MOTOR DEMONSTRATION

Stepper motors are readily available, and we can demonstrate their operation with the *Micro Lab*. The stepper motor we used for our experiments was designed for use in a printer mechanism and is an example of the hybrid type. Turning the motor by hand the magnetic indentations can be felt as the internal teeth align. To avoid consuming too much current from the *Mini Lab* the 24 volt stepper motor was run from 12 volts. (It will even run from 5 volts with reduced torque!). This motor has four coils or *phases*. The motor is more complex than our simple diagram as the motor has split each coil into smaller sections, and the rotor has more teeth to provide a smaller step size of 7½ degrees, or 48 steps per revolution.

A circuit for connecting the stepper motor to the *Micro Lab* is shown in Fig. 12.13. The four Darlington transistors are TIP112 with a minimum h_{fe} of 1,000. This will allow the port B drive to fully turn on the devices. The diodes D1 to D4 are needed to suppress back e.m.f. induced in the coils when the Darlingtons are turned off. This is similar to the protection diode placed across the relay coil in the *Mini Lab*. The colour code will only apply to the type of stepper motor that we used for our experiments.

Check your own motors to ascertain the coil sequence. If you do not have any data use a resistance meter to establish the coil connections. Apply voltage to each coil and observe the step direction. When you have the right sequence the motor will increment a step each time power is applied to a coil.

An alternative driving circuit is shown in Fig. 12.14. This uses a special class of f.e.t. designed to interface with logic level voltages. The f.e.t.s are particularly efficient, and have a very low on resistance. This allows quite small devices to handle 10s of amps without overheating. The input impedance of the gates is high and can easily be driven

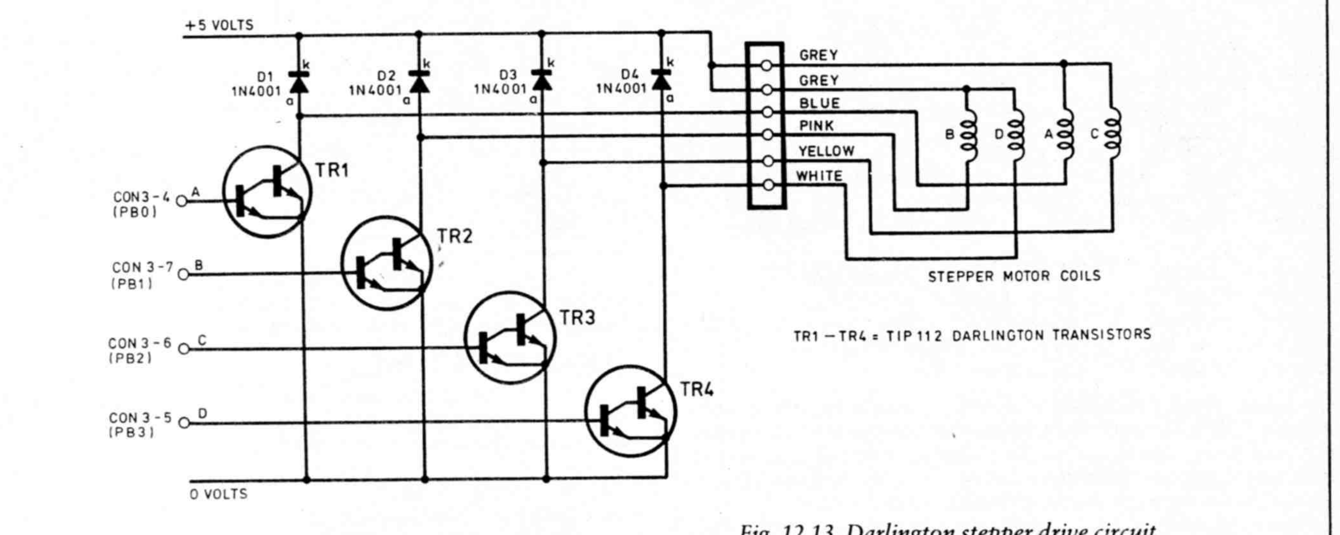


Fig. 12.13. Darlington stepper drive circuit

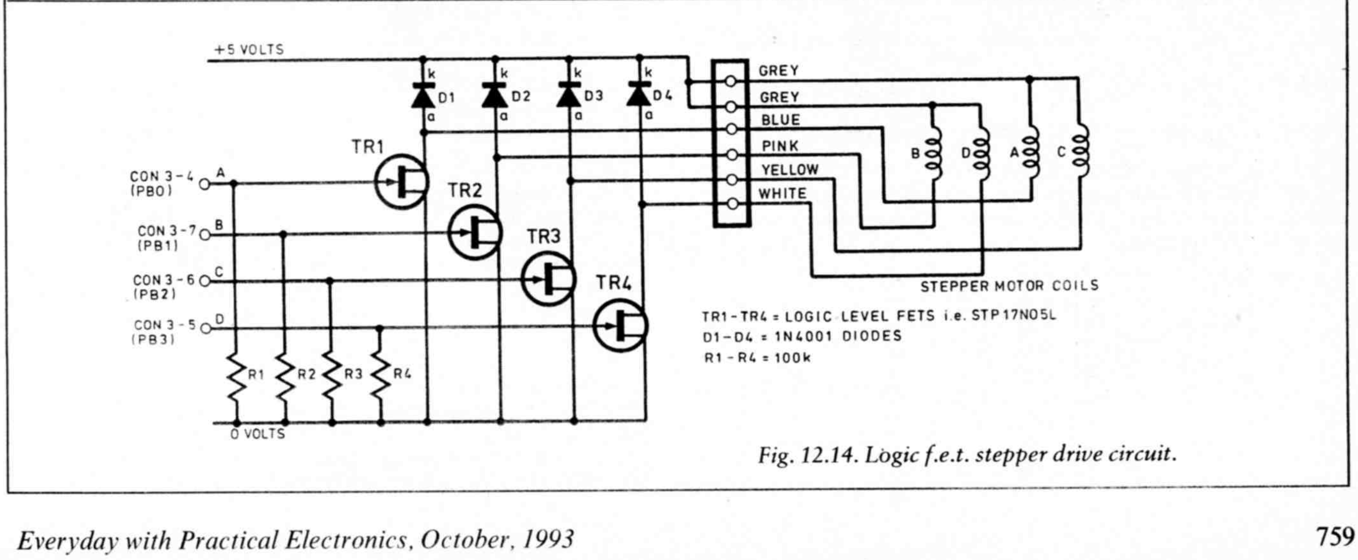


Fig. 12.14. Logic f.e.t. stepper drive circuit.

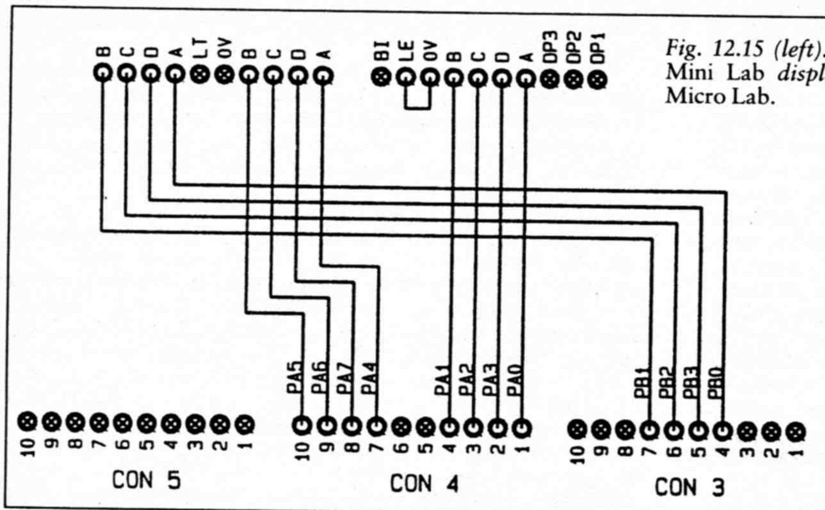


Fig. 12.15 (left). Driving the Mini Lab *display from the* Micro Lab.

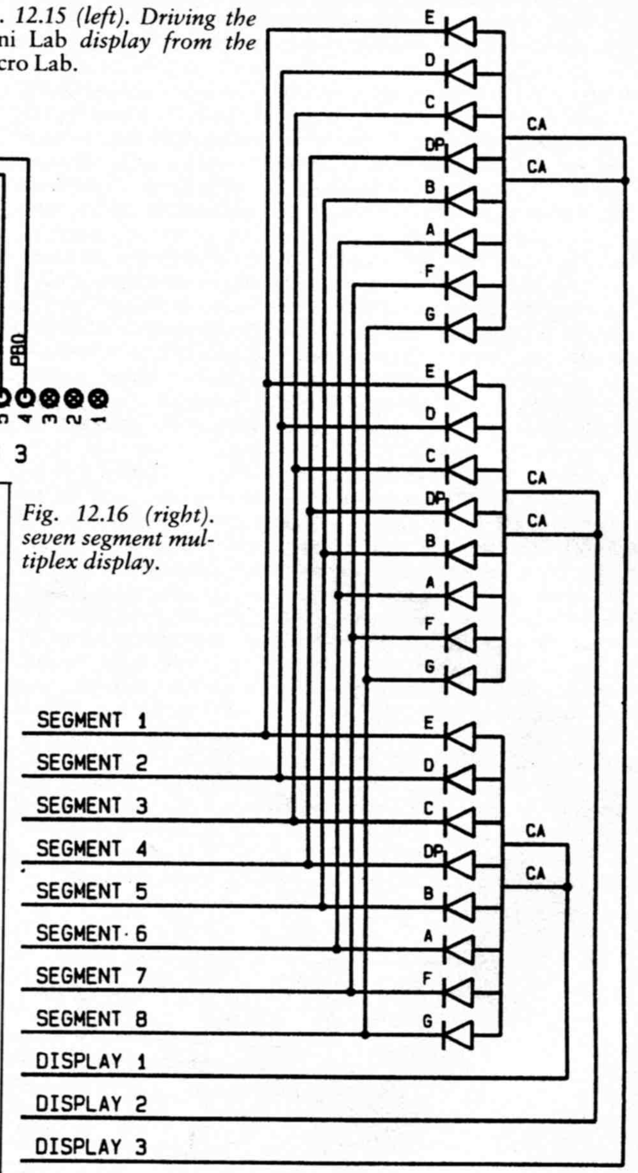


Fig. 12.16 (right). seven segment multiplex display.

from port A of the 65C22 VIA. The high impedance can lead to false triggering by radiated electrical noise into the gate connections as they act as aerials. To avoid this resistors R1 to R4, each 100 kilohms, are placed between the gate and ground.

MOTOR CONTROL PROGRAM

A simple stepper motor control program is given below. This program uses a look up table to read the value which is to be sent to the port connected to the stepper. Fig. 12.13 or 12.14 can be used to drive the stepper motor. The look up table drives each coil in turn:

Step Number	Coil: D	C	B	A
1	0	0	0	1
2	0	0	1	0
3	0	1	0	0
4	1	0	0	0

```
0200   A9 FF      LDA  #$FF       ;Set port B to all
                                   outputs
0202   8D 43 80   STA  $8042
0205   A2 00      LDX  #$00       ;Initialise the table
                                   pointer
0207   BD 19 02   LDA  $0219,X    ;Get value to send to
                                   stepper
020A   8D 41 80   STA  $8040      ;Send it to stepper
020D   A9 08      LDA  #$08       ;Delay for 0.08
                                   seconds
020F   20 1E 00   JSR  $001E
0212   E8         INX             ;Point to next table
                                   entry
0213   E0 04      CPX  #$04       ;End of table?
0215   D0 F0      BNE  $0207      ;No – start again
0217   F0 EC      BEQ  $0205      ;Yes – reload IX with 0
0219   01 02      DFB  $01, $02   ;Data table
021B   04 08      DFB  $04, $08
```

You can change the speed of the motor by altering the value at address 020Eh. However, the faster the motor is turning the weaker it is. Also, if you attempt to turn the motor too fast, the shaft will not have time to align itself with the next coil before the next step occurs. This will make the shaft oscillate rather than rotate.

Making the shaft rotate in the opposite direction can be performed in two ways: 1. Change the data table to read 08h, 04h, 02h, 01h. 2. Change the following lines of code:

```
0205   A2 03      LDX  #$03       ;Initialise the table
                                   pointer
0212   E8         DEX             ;Point to next table
                                   entry
0213   E0 04      CPX  #$FF       ;End of table?
```

This type of stepper control is called *wave drive*. On our motor this produced 48 steps per revolution. You can use the following table to generate *half-steps*. This increases the step resolution but halves the rotation speed.

Step Number	Coil: D	C	B	A
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	0	1	0	0
6	1	1	0	0
7	1	0	0	0
8	1	0	0	1

Modify the above program to use this table. You will need to convert the binary values into hexadecimal in order to enter it and also modify the program to allow for a larger table.

REACTION TIMER

To round things off, we will build a reaction timer game, similar to one of the *Mini Lab* projects, using several different input/output peripherals. The game operates in the following way:

1. **User starts the game**
2. **Switch off "start" light**
3. **Wait for a random period of time**
4. **Light "start" light**
5. **Set a counter to 999**
6. **Display count value**
7. **Subtract one from count value**
8. **If count = 000, then go to step 10**
9. **If "stop" key not pressed, go to step 6**
10. **Stop program**

Now, we should decide what we are going to use for input and output devices. The eight l.e.d.s on the *Micro Lab* are suitable for the "start" light, and the keypad is suitable for the "stop" key, but the l.c.d. is a bit small for the counter – 7-segment l.e.d.s would be much more effective, but there is only one on board the *Micro Lab*. So, before we write the program, we should connect up three 7-segment displays on the *Mini Lab* as shown in Fig. 12.15. The circuit uses three i.c.s which convert a four bit binary number into a display code (similar to the exercise given in *Teach-In* part 7).

Without these BCD to 7-segment display i.c.s, we would either need to use seven (or eight if we needed the decimal point) output pins for each display or we would need to *multiplex* the displays. Multiplexing is used to reduce the number of pins and i.c.s required when driving several displays. Each similar segment on all of the displays is connected together (all of the top segments would be connected together, etc.). The eight lines are then connected to eight output ports via suitable drive transistors and resistors. Next, the common pin on each digit is connected to an output port via a suitable drive transistor, see Fig. 12.16.

We can now switch each display on one at a time by switching the common pin and set up the digit to be displayed on the eight segment lines. If this is performed quickly enough, there will be no flicker. However, each digit is only on for a fraction of the time, and with longer displays this on time is reduced. This will make the display appear dim in the same way as the lamp was made to dim in the PWM experiment.

Right, back to the reaction timer. We now have suitable input and output devices set up, so we can get on with the program. The first part is easy, it should turn off the "start" indicator:

```
0200    A9FF      LDA  #$FF    ;Switch LEDs off
0202    8D0080    STA  $8000
```

Next, we need to delay for a random period of time. To make sure that the period is not too short, we should put in a fixed delay of a

The 65C22 VIA

The 65C22 Versatile Interface Adapter (VIA) is a flexible input/output (I/O) control device. It contains 16 bi-directional (either input or output) ports, four handshaking lines used for controlling the data into and out from the ports, two 16 bit counter/timers, a serial to parallel/parallel to serial shift register and it can latch data on the input ports. Because of the large number of facilities offered by the 65C22, a complete description of its operation and use is beyond the scope of this article, however a description of some of the more common aspects of the device is given here. The diagram below shows the internal logic blocks in the 65C22.

Operation of the 65C22 is controlled by sixteen registers. In the *Micro Lab*, these are at addresses 8040h to 804Fh. The registers are described below.

Address	Designation	Description
8040h	ORB/IRB	Input/Output Register (port) B.
8041h	ORA/IRA	Input/Output Register (port) A.
8042h	DDRB	Data Direction Register B.
8043h	DDRA	Data Direction Register A.
8044h	T1C-L	Timer 1: Latches/Counter–Low byte.
8045h	T1C-H	Timer 1: Counter – High byte.
8046h	T1L-L	Timer 1: Latches – Low byte.
8047h	T1L-H	Timer 1: Counter – High byte.
8048h	T2C-L	Timer 2: Latches/Counter–Low byte.
8049h	T2C-H	Timer 2: Counter – High byte.
804Ah	SR	Shift Register.
804Bh	ACR	Auxiliary Control Register.
804Ch	PCR	Peripheral Control Register.
804Dh	IFR	Interrupt Flag Register.
804Eh	IER	Interrupt Enable Register.
804Fh	ORA/IRA	Input/Output Register A (as 8041h).

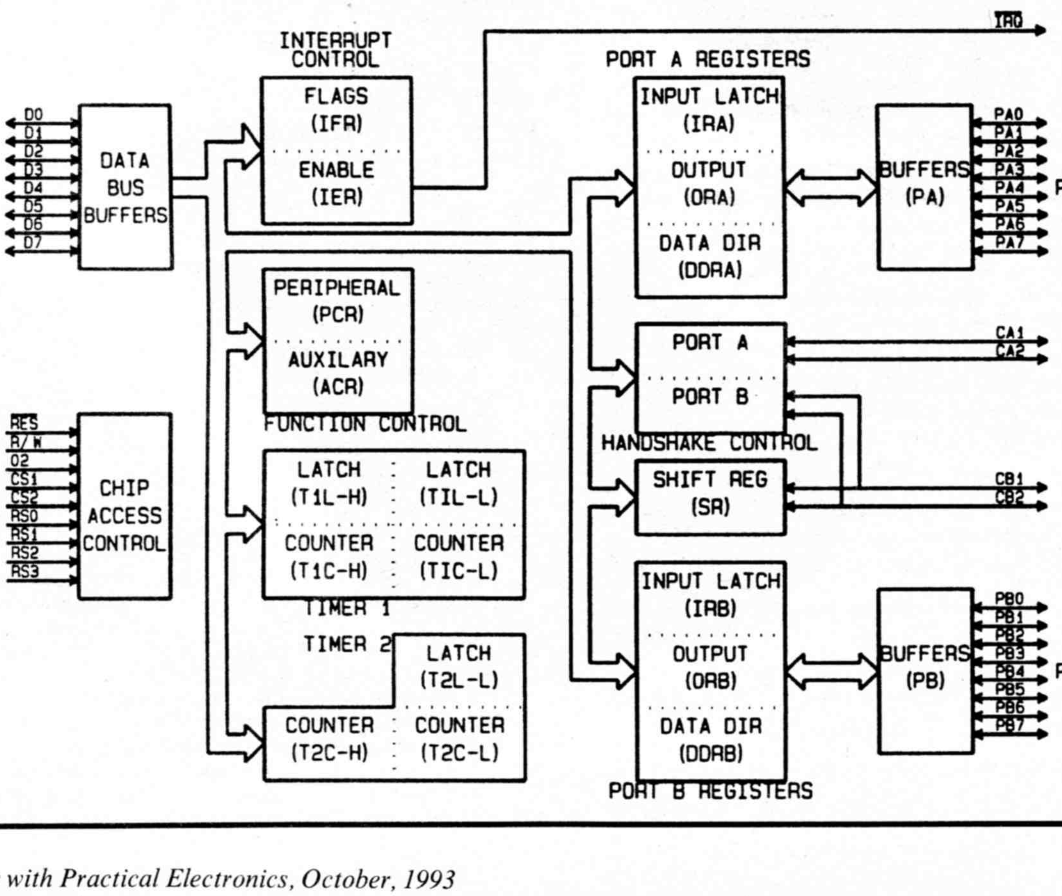
Operation of the 16 I/O ports is controlled by the four registers ORA/IRA, DDRA, ORB/IRB and DDRB. The DDR registers are used to set whether individual pins are inputs or outputs. A "0" in a bit of the DDR causes the corresponding pin to be an input, a "1" causes is to be an output. So, to set bits 0, 1, 6 and 7 or port A as outputs and bits 2, 3, 4 and 5 of port A as inputs, you would use a program like this:

```
0200 A9 C3      LDA #$C3      ;Set up DDRA
0202 8D 43 80   STA $8043
0205 00         BRK
```

To set all eight bits of the port as outputs, you would load the accumulator with FFh, and to set the whole port as input you would use 00h. Reading from ORA/IRA (8041h) or ORB/IRB (8040h) will return the logic level at the port (bit 0 if 8041h returns the level at PA0, etc.) in much the same way as the switch inputs on the *Micro Lab*. When a pin is programmed as an output, the voltage on a pin is controlled by the corresponding bit of ORA/IRA or ORB/IRB. A "1" causes the output to go high (<2·4V), a "0" causes the output to go low (>0·8V). Data may be written to bits corresponding to inputs, but the output signal is unaffected. This is similar to writing to the l.e.d.s on the *Micro Lab*.

As example, to set all eight bits of port B to outputs and have PB0, PB2, PB4 and PB6 at >2·4V and PB1, PB3, PB5 and PB7 at <0·8V, we would use:

```
0200 A9 FF      LDA #$FF      ;Port B all outputs
0202 8D 42 80   STA $8042
0205 A9 55      LDA #$55      ;Bits 0, 2, 4 & 6=5V
0207 8D 40 80   STA $8040     ;Bits 1, 3, 5 & 7=0V
020A 00         BRK
```



couple of seconds before doing the random delay. This delay is actually for 2.55 seconds, as we are not changing the accumulator value after switching off the l.e.d.s. The random delay is performed by reading the value of T1C-L (the low byte of timer 1 counter) which continually counts down when the 65C22 has been reset. This value is loaded into the accumulator before calling the DELAY subroutine. We do this twice to increase the total possible time.

```
0205   201800   JSR  $0018   ;Delay for 2.55 Sec
0208   A002     LDY  #$02    ;Random delay from
                             0 to 6.1 Sec
020A   AD4480   LDA  $8044
020D   201800   JSR  $0018
0210   88       DEY
0211   D0F7     BNE  $020A
```

Now, we need to switch on the "start" indicator (l.e.d.s), set the start value of the counter to "999", initialise the 65C22 so that we can use the three 7 segment displays to display the count on and, finally, empty the keyboard buffer so that no one can cheat!

```
0213   A900     LDA  #$00    ;Switch on LEDs
0215   8D0080   STA  $8000
0218   A909     LDA  #$09    ;Set counter to 999
021A   8590     STA  $90
021C   A999     LDA  #$99
021E   8591     STA  $91
0220   A9FF     LDA  #$FF    ;Set ports A&B to
                             output
0222   8D4280   STA  $8042
0225   8D4380   STA  $8043
0228   202100   JSR  $0021   ;Empty keyboard
                             buffer
```

OK, the system is now initialised, so we can display the count on the 7 segment displays.

```
022B   A590     LDA  $90     ;Display count
022D   8D4080   STA  $8040
0230   A591     LDA  $91
0232   8D4180   STA  $8041
```

Now, we can subtract one from the counter. As we are counting in decimal, the easiest way to do this is to use the 6502's decimal mode (by setting the decimal flag in the PSW), then subtract 1 using the SBC instruction:

```
0235   F8       SED          ;Set decimal mode
0236   A591     LDA  $91     ;Subtract 1 from low
                             byte of counter
0238   38       SEC
0239   E901     SBC  #$01
023B   8591     STA  $91
023D   A590     LDA  $90     ;Subtract borrow from
                             high byte
023F   E900     SBC  #$00
0241   8590     STA  $90
0243   D8       CLD          ;Set normal binary
                             mode
```

If the counter has gone below zero, then the high byte will equal 99. We can check for this to see if the player was too slow.

```
0244   C999     CMP  #$99    ;Counter
                             under flow?
0246   F00D     BEQ  $0255   ;Yes – stop
                             program
```

We should now have a short delay, otherwise only another computer would be able to play! The delay routine in the monitor is a bit long for this application, so we will use our own.

```
0248   A040     LDY  #$40    ;Short delay
024A   88       DEY
024B   D0FD     BNE  $024A
```

Finally, we should check to see if the "stop" button has been pressed. If it has not, then the program should jump back. If it has, then the program should stop.

```
024D   201E00   JSR  $001E   ;Key pressed?
0250   D003     BNE  $0255   ;Yes – Stop
0252   4C2B02   JMP  $022B   ;No – jump back
0255   00       BRK
```

Once you have entered the program, run it with the GO command. You can adjust the value in the delay (at address 0249h) to either speed it up or slow it down, as necessary.

Feel free to modify the program. Some suggestions are:

- Add some sound effects – a ticking "clock" noise before the "start" lamp comes on, or "well done" and "hard luck" noises.
- The "start" l.e.d.s could be made to display a pattern before they all come on.
- Rating messages could be displayed on the l.c.d. depending upon the final count value.
- A high score could be kept and displayed on the l.c.d.

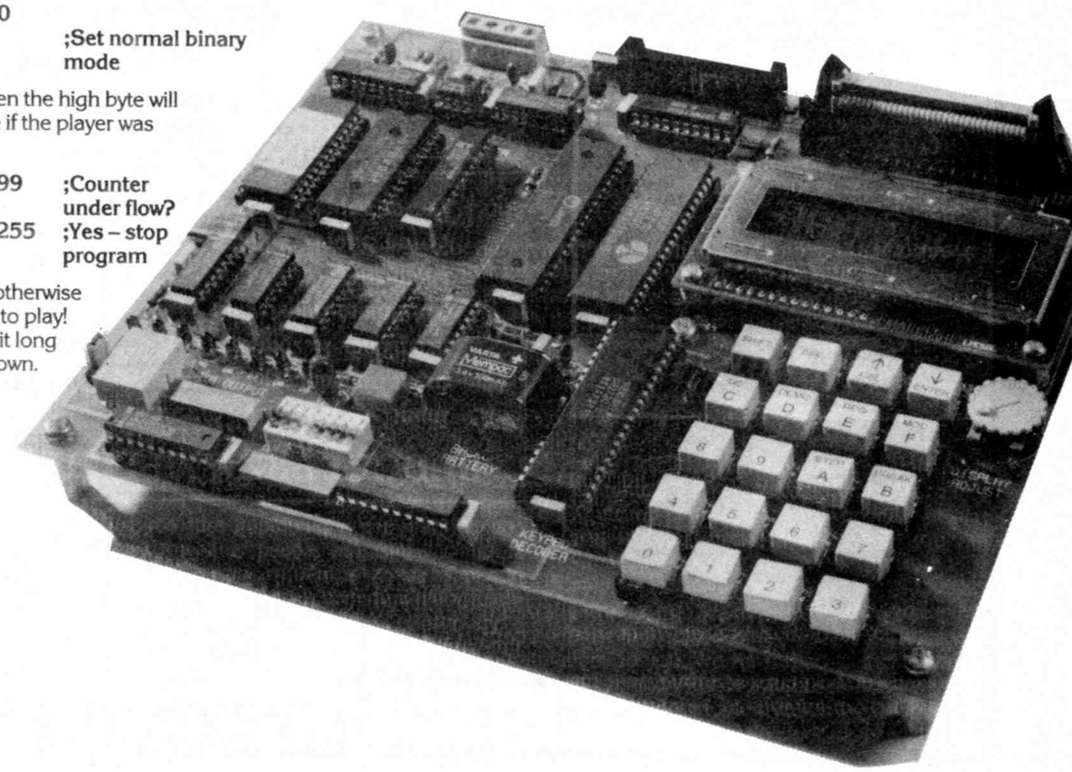
CONCLUSION

We have come to the end of the *Teach In* series. We hope that readers who joined up in the first episodes have managed to survive the course. Congratulations to you. We have tried to include most topics covered by the GCSE and A level syllabuses, but inevitably space has seen the exclusion of some topics. Check the syllabus with your tutors to see where additional study is needed.

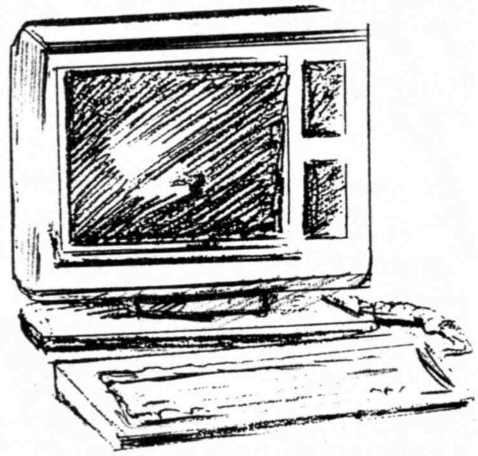
ON GOING

The *Micro Lab* does not end here and will become the basis for a number of new projects. The first will be the addition of the printer port to allow hard copy of your developed programs. A relay board will be designed to allow interfacing to larger loads, and a *Micro Lab* power supply will allow the unit to survive on its own without the *Mini Lab*. Following on from these will be a robot buggy called *Robo-Spot*. This will allow *Micro Lab* to grow up and move under its own intelligence!

After that it's up to you. Write and let us know your ideas for any useful applications utilising the power of the *Micro Lab* at the heart of a command and control centre. We will investigate any worthwhile suggestions with a view to sharing them with other *Micro Lab* users. Meanwhile Robo Spot is wagging its tail expectantly in the workshop waiting to be let out to play! □



LINEAR POWER SUPPLY



AMSTRAD PCW 8-CHANNEL A/D CONVERTER

JASON SHARPE

PART THREE

A "stand-alone", high quality p.s.u. for the serious experimenter. Outputs: +5V(1·5A); +12V(1A); −12V(0·5A) −5V(0·5A)

ALTHOUGH designed specifically for the Amstrad PCW A/D Converter, and written for the ADC project, the range of voltages covered by this unit make it an ideal general purpose power supply for the workbench. It will find a particular niche for those experimenters working on i.c. based circuits or where a "split" (plus and minus) supply is needed.

Back to the ADC, for the unity gain buffers to give an output voltage swing of 0V to 5V they require a supply voltage of at least ±1V either side of this. The PCW has a 12V output, a voltage inverter could have been used to give −12V. This approach, however, was not used as the resulting voltage would have been rather noisy.

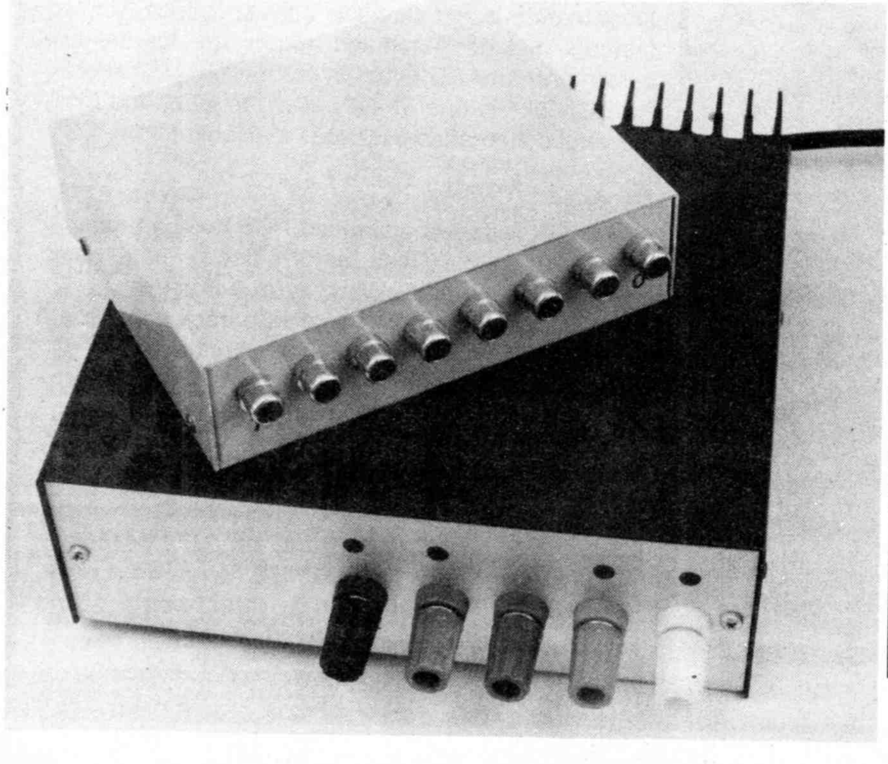
Instead, it was decided to run the whole ADC unit from an external supply. The Linear Power Supply Unit was designed for general purpose use, to give most of the voltages normally associated with computers. It can also be used to power a second (external) disc drive.

TRANSFORMER

A custom wound toriod transformer (see *Shoptalk*) was used for this circuit. A custom transformer was chosen, rather than an "off the shelf" type for several reasons.

For the range of output voltages / currents required it would have been necessary to use two transformers, this would have meant more wiring, and also a larger case.

Completed Linear Power Supply with the Amstrad A/D converter (August '93).



With the custom transformer the voltages have been chosen to be quite close to the output voltage (plus voltage drops), so that regulators only have to dissipate small amounts of power. Toriodal transformers also have the advantages of being compact, efficient and have low external magnetic fields.

Although the custom transformer is slightly more expensive than using two standard transformers the extra cost is recuperated because a smaller case can be used.

CIRCUIT DESCRIPTION

The full circuit diagram for the Linear Power Supply is shown in Fig. 1. The circuit is quite simple and just consists of standard regulator i.c.s.

The outputs of the secondary windings of transformer T1 are rectified by REC1 and REC2. The d.c. output from REC1 is smoothed by capacitor C1. IC1 is a variable regulator which is used to regulate the voltage to ≃5V (see Testing).

Capacitor C4 improves the circuits ripple rejection and diode D2 provides a discharge path. D1, D3 to D6 are included to protect the regulators.

The mains input is switched and fused with a 500mA anti-surge fuse as toriod transformers draw a large current at switch-on. Also included is a transient suppressor which absorbs any high voltage spikes that may appear on the mains supply.

POWER SUPPLY FORMULAE

When designing this power supply it was discovered that there was very little in-

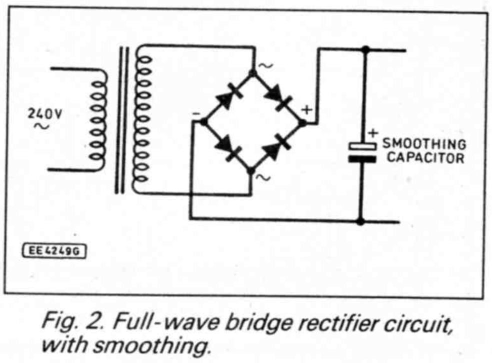


Fig. 2. Full-wave bridge rectifier circuit, with smoothing.

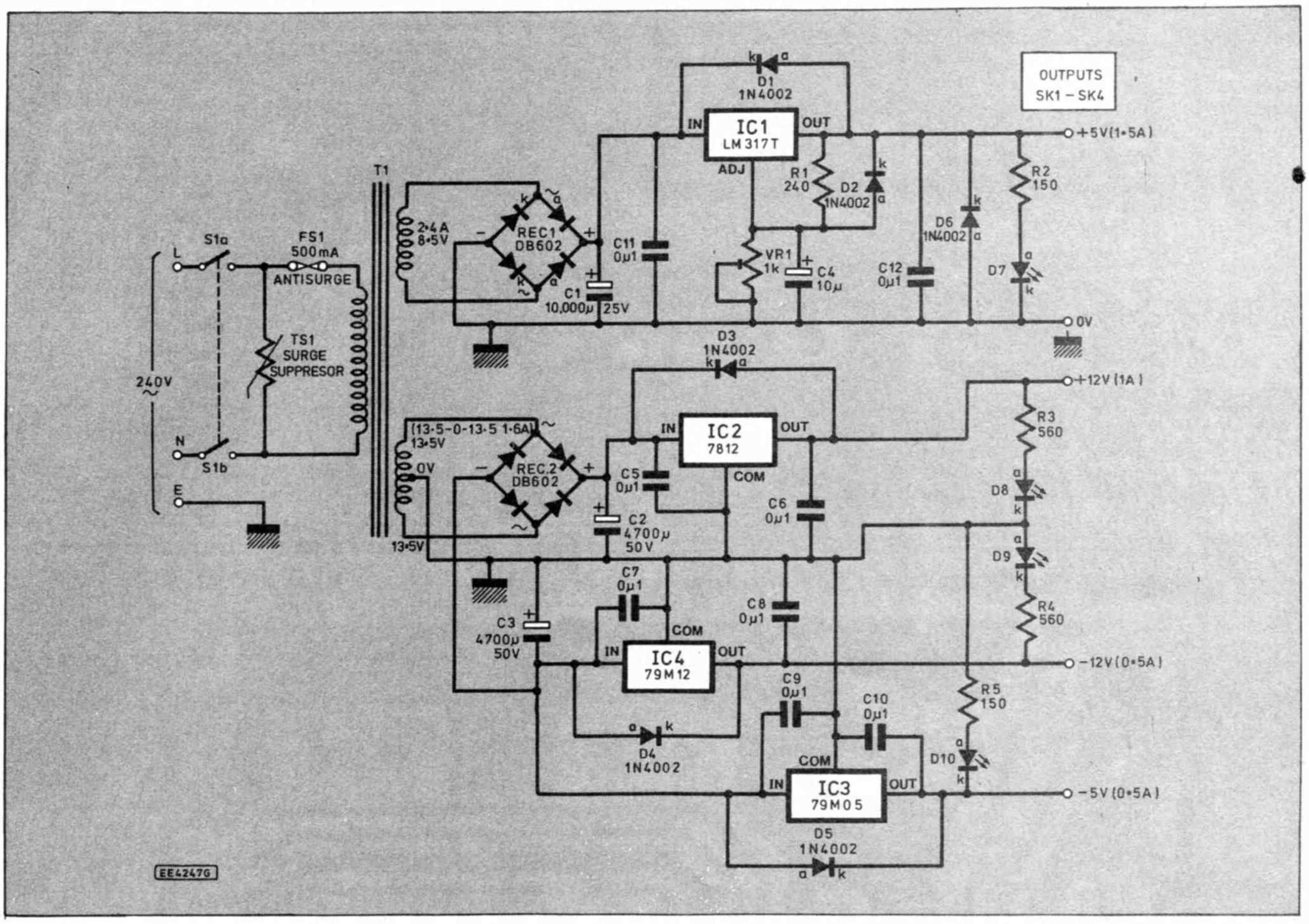


Fig. 1. Complete circuit diagram for the Linear Power Supply.

formation about power supply design in my reference material. Below is some useful information for choosing power supply components.

The information is basically all you need to build power supplies using the 78/79 series regulators, with output currents of a couple of amperes. With larger currents other items need to be taken into consideration.

Transformer Rating

For full-wave "bridge" rectification refer to Fig. 2. The output voltage of a transformer *decreases* as the load *increases*. The output voltage normally quoted for transformers is the *Full Load* voltage.

The output voltage with no load will be:

$$\simeq (1 + (\text{Regulation\%} \div 100)) \times (\text{Full load Voltage})$$

Transformer current should be:

$$\simeq 1{\cdot}6 \times [\text{Max. d.c. current required}]$$

Transformer Voltage

$$\simeq 0{\cdot}707 \times [\text{Rectified (d.c.) voltage}]$$

Smoothing Capacitor

The voltage rating of the smoothing capacitor should be at least 5V higher than the transformers [NO LOAD voltage] × 1·5.

The value of capacitor required depends on the amount of ripple that is acceptable (see Fig. 3), normally the full load voltage ripple is kept below two volts.

$$[\text{Full load Ripple (V)}] \simeq \frac{0{\cdot}01 \times [\text{Full load d.c. current}]}{[\text{Capacitor size (Farads)}]}$$

Note 1: Large electrolytics typically have tolerances of ±20 per cent, this means a capacitor marked 10,000µF may in the worst case only have a capacitance of 8000µF so this should be taken into account, especially if you intend to make more than one power supply.

Note 2: You should avoid using excessively large capacitors as this will increase transformer heating, and ultimately stress the rectifiers.

Rectifiers

A general rule of thumb is to use rectifiers with a current rating twice the maximum d.c. current required.

UNREGULATED D.C. VOLTAGE

To work out the *minimum* required transformer output voltage, all voltage drops (worst case) should be taken into account. How to work out the minimum required transformer voltage for the 78 series regulators is shown below:

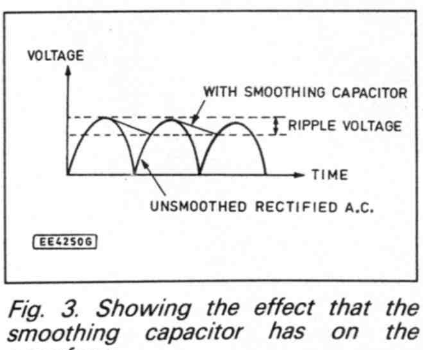
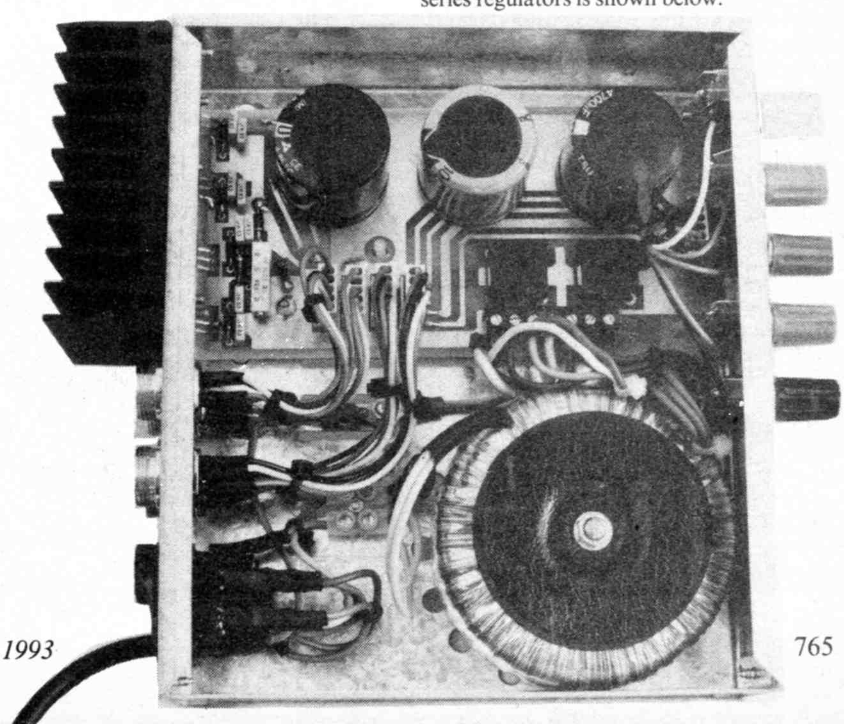
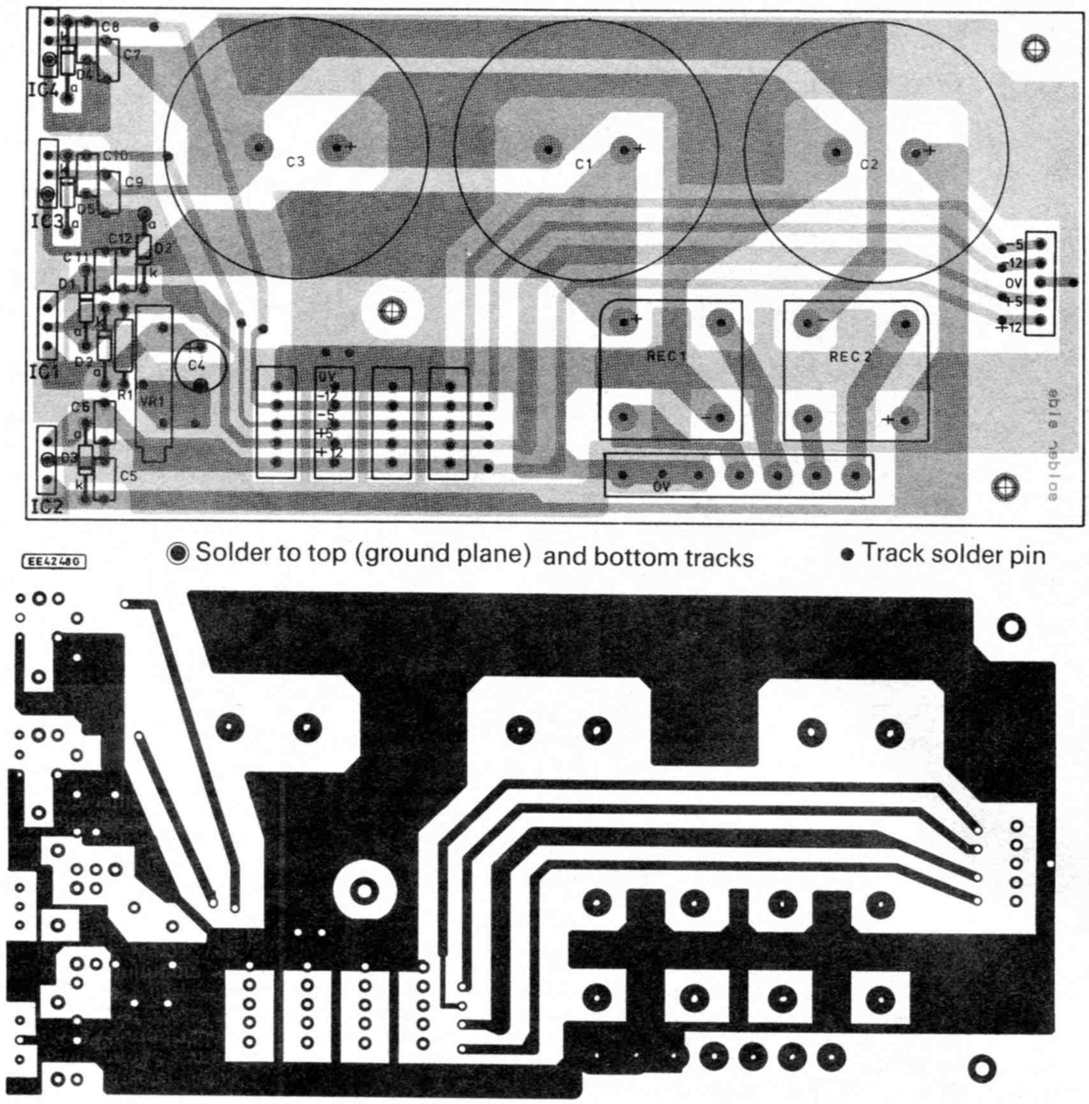


Fig. 3. Showing the effect that the smoothing capacitor has on the waveform.





[Transformer Full load voltage] × 1·41
≃Vreg (regulator output voltage)
+ 2·5V (Regulator voltage drop)
+ Vrip (Full Load ripple voltage)
+ 1·2V (Diode voltage drop)

CONSTRUCTION

The Linear Power Supply is built on a double-sided printed circuit board (p.c.b.), which is housed in a *Metal* instrument case. The circuit board topside component layout and details of the copper foil master patterns are shown in Fig. 4. This p.c.b. is available from the *EPE PCB Service*, code 844.

When assembling the p.c.b., first insert the track-pins into the VIAs (VIAs are used to connect tracks on one side of the p.c.b. to tracks on the other side, marked • on the component overlay). Push them in from the top side of the board and solder the track-pins on both sides of the p.c.b. and check the connections with a multimeter (set to Ohms or "tone").

You will probably find it easiest to solder in the components in ascending size e.g. resistors, diodes, p.c.b. plugs, up to the regulators, do not insert the three large electrolytics yet. The regulators should be mounted approximately 9mm above the p.c.b. (Fig. 5a). Finally, check the p.c.b. for shorts caused by solder splashes etc.

The leads marked with a ◉ on the component overlay should be soldered to the top layer of the p.c.b. as well as the bottom. The interwiring details from the p.c.b. to the off-board components is shown in Fig. 8.

CASE

The power supply components and p.c.b. were designed to fit into a metal (steel) instrument case measuring 175mm × 155mm × 58mm (see *Shoptalk*). All drilling and mounting details below and in Fig. 5 refer to this size case.

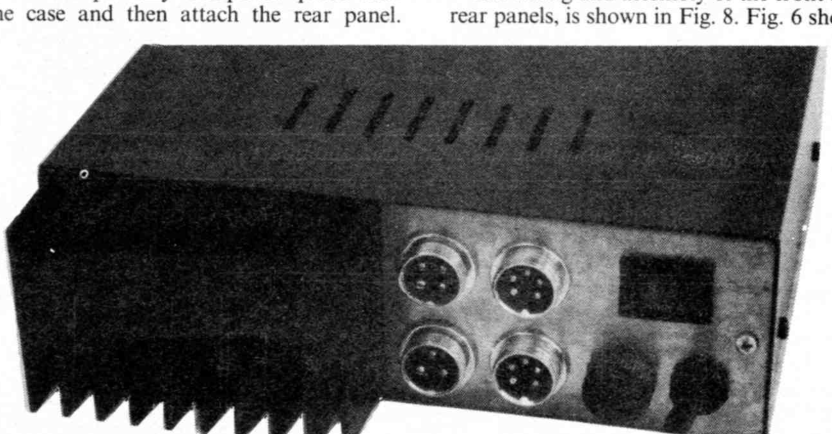
Drill the rear panel and heatsink as shown in Fig. 5b and remove all burrs especially on the heatsink. Also drill the base of the case. File the heads off four small bolts so they will fit into the slots at the ends of the heatsink and then mount it on the rear panel.

Fix the partially completed p.c.b. into the case and then attach the rear panel. Mark the location of the mounting holes required for the regulators. Then disassemble the unit, drill the heatsink and solder the remaining components into the p.c.b.

When fixing the heatsink to the rear panel for the last time smear some heatsink compound around the edges of the heatsink which touch the metal box. Fix the completed p.c.b. into the case.

The regulators should now be bolted to the heatsink (on the assembled rear panel) using bushes and silicon rubber washers, these require no heatsink paste. When this is completed use a multimeter to check that none of the regulator metal tabs are *electrically* connected to the case or heatsink.

The wiring and assembly of the front and rear panels, is shown in Fig. 8. Fig. 6 shows



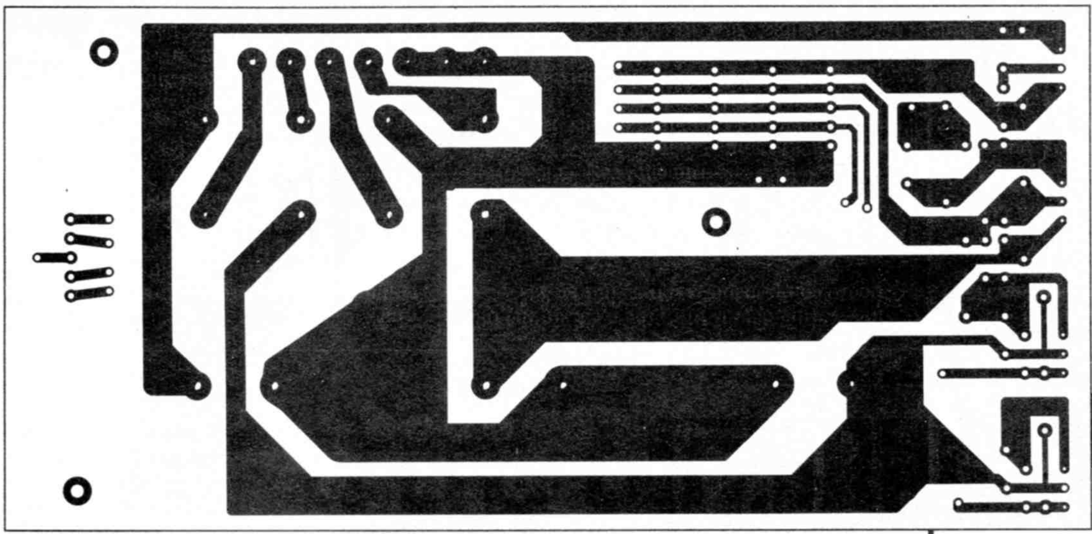


Fig. 4 (opposite page). Printed circuit board component layout and topside copper foil master pattern. The underside foil master is shown left.

See SHOP TALK Page

COMPONENTS

Resistors

R1	240
R2, R5	150 (2 off)
R3, R4	560 (2 off)

All 0·25W 5% carbon film

Potentiometer

VR1 1k multi-turn cermet preset

Capacitors

C1 10,000 radial elect. 25V
C2, C3 4700µ radial elect. 50V (2 off)
C4 10µ tantalum bead 25V
C5 to C12 0µ1 polyester 63V (8 off)

Semiconductors

REC1, REC2 DB602 6A 200V bridge rectifier (2 off)
D1 to D6 1N4002 1A 100V rec. diode (6 off)
D7 to D10 Green cylindrical l.e.d. (4 off)
IC1 LM317T adjustable voltage regulator (+1·2V to 37V) 1·5A
IC2 7812 +12V 1A voltage regulator
IC3 79M12 –12V 0·5A voltage regulator
IC4 79M05 –5V 0·5A voltage regulator

Miscellaneous

T1 Toroid mains transformer; 240V primary: 13·5V-0V-13·5V at 1·6; and 8·5V at 2·4A secondaries (30/LT/14-10)
S1 D.P.S.T. illuminated rocker switch
FS1 500mA anti-surge fuse and chassis mounting fuseholder
TS1 Mains (250V a.c.) transient suppressor
SK1 4-pin chassis plug/line socket (audio locking connectors)
SK2 3-pin chassis plug/line socket (audio locking connectors)
SK3, SK4 5-pin chassis plug/line socket (audio locking connectors)

Metal (steel) case, size 175mm x 155mm x 58mm; printed circuit board, available from *EPE PCB Service*, code 844; screw terminal post, one black, blue, green, red and yellow; 7-way p.c.b. mounting screw terminal block; 2-way screw terminal block; 5-way Minicon connectors (5 off); heatsink (2·4°C/W); insulated crimp eyelet terminals; heatshrink sleeving; multi-coloured stranded connecting wire; plastic cable ties; insulating mounting kit for voltage regulator (4 off); heatsink compound; solder etc.

Approx cost guidance only **£64**

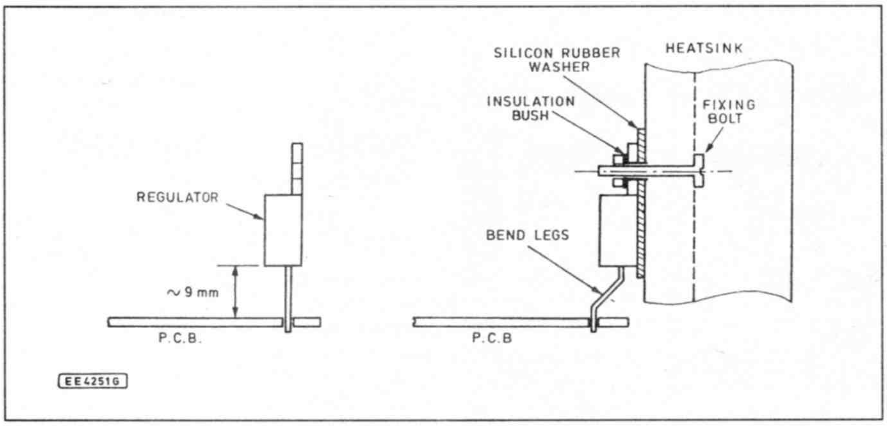


Fig. 5a. Method of mounting the regulators and heatsink on the rear panel.

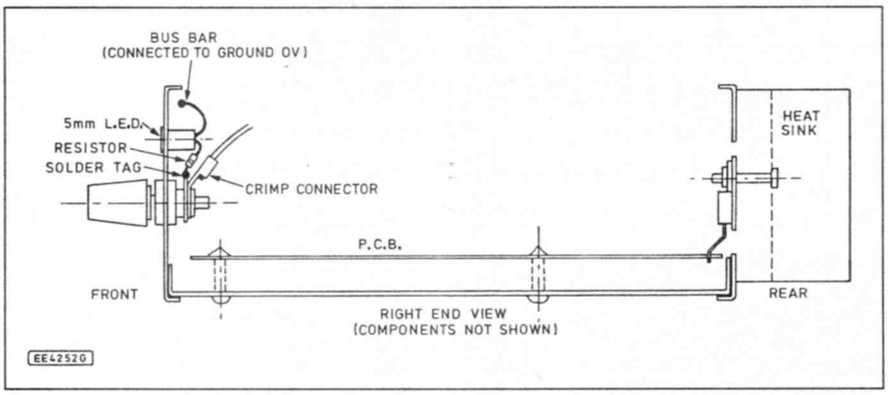
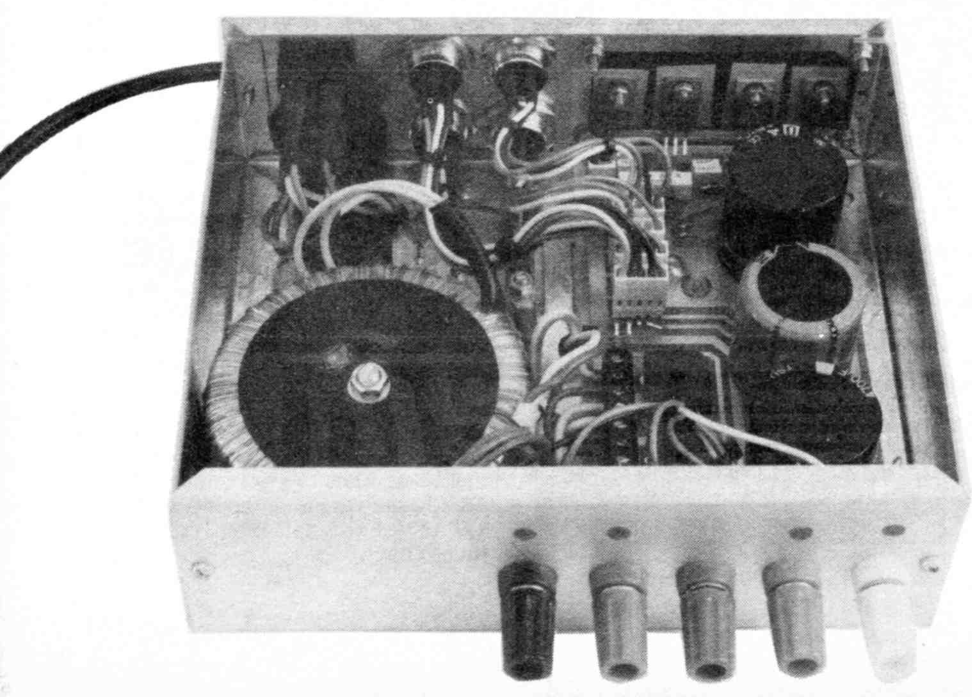


Fig. 5b. Output terminal mounting (and wiring). See Fig. 8. for bus bar wiring.



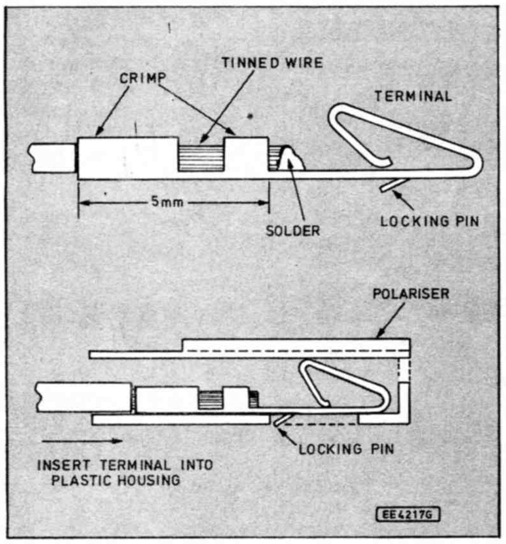


Fig. 6 (left) Assembly of the "Minicon" connector.

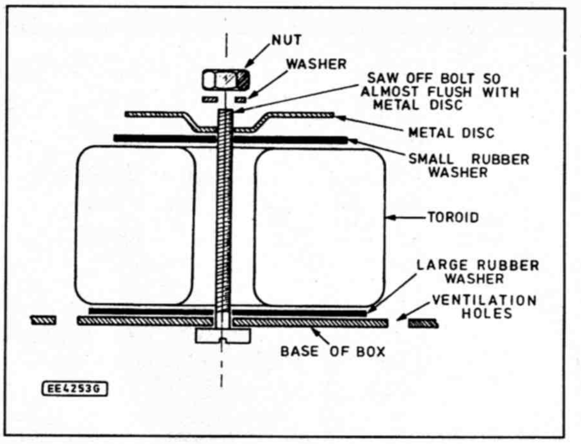


Fig. 7. (right). Method of mounting the toroidal transformer on the base of the metal case.

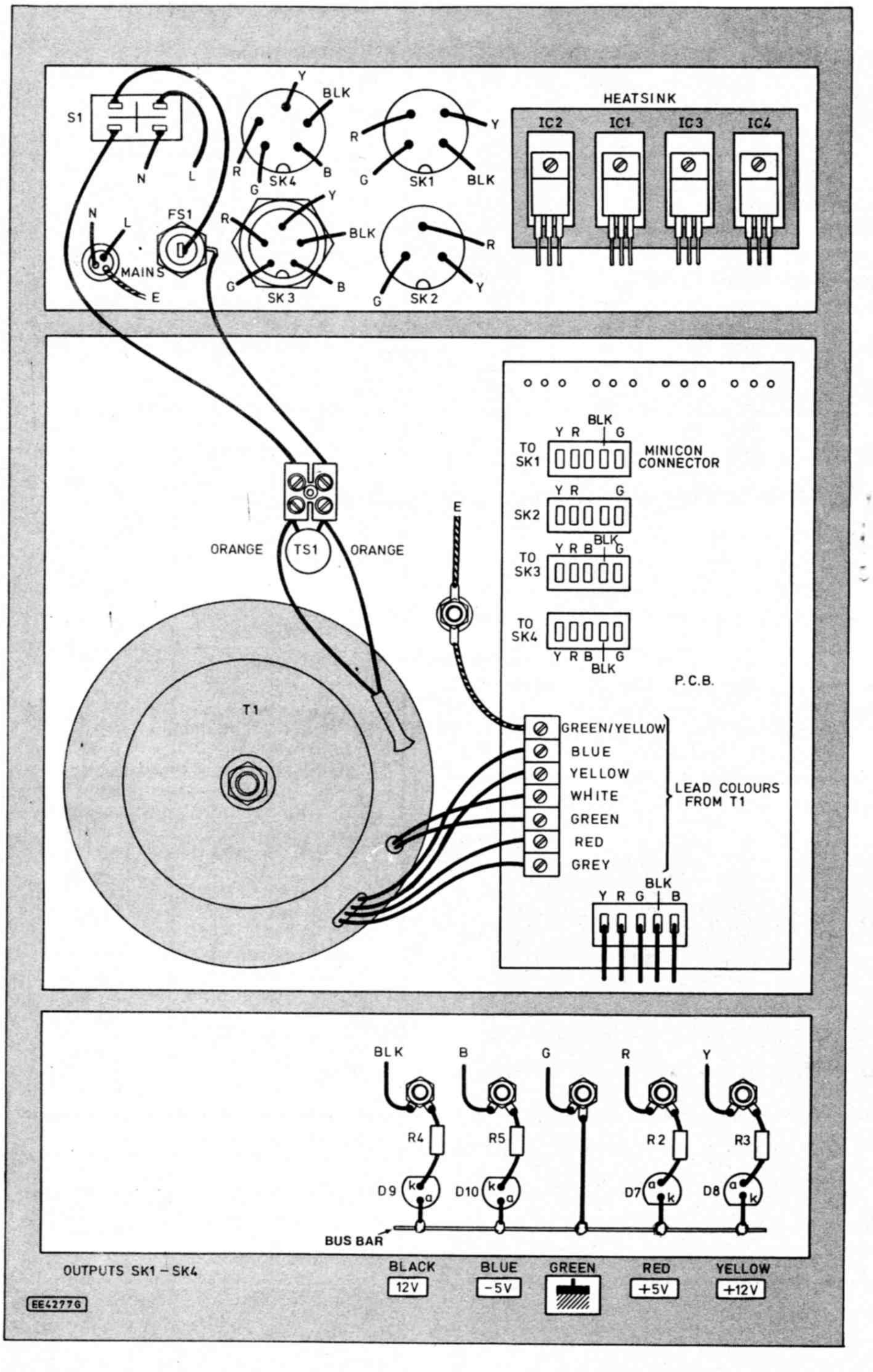


Fig. 8 (below left). Interwiring from the front and rear panels to the circuit board and transformer.

how to assemble the Minicon connectors. The use of the p.c.b. connectors is recommended as this makes assembly and disassembly far easier than it would be if the wires were soldered directly to pins.

All the solder connections on the rear panel should be insulated (heatshrink sleeving was used on the prototype). When wiring up the fuseholder, connect the incoming "live" wire to the *BACK* of the holder.

TRANSFORMER MOUNTING

The method of mounting the toriodal transformer on the base of the case is shown in Fig. 7. Once the position of the mounting bolt hole has been established and drilled, and before the transformer is fixed to the case base, a series of ventilation holes need to be drilled in the base around the transformer. You can use the large rubber washer as a "rough" guide for marking out the holes, but leave plenty of room for the coils which overhang the washer.

Important note: Make sure that both ends of the toriod fixing bolt does not simultaneously come into contact with the case, as this will create a "shorted turn" and cause damage to the transformer winding.

TESTING

Before connecting the power check the connections at the plug with a multimeter. make sure the earth (E) is connected to the case and live (L) and neutral (N) are not!

Commence testing by connecting the unit to the mains and testing the output voltages. All of the indicator lights should light up.

Measure the voltage between pins 3 and 5 of the PCW expansion connector (the voltage should be around 5V). Then adjust the output voltage of the power supply with preset VR1 to the same voltage, within 0·1V, as that on the expansion connector. Also check that the other outputs are at the required voltage.

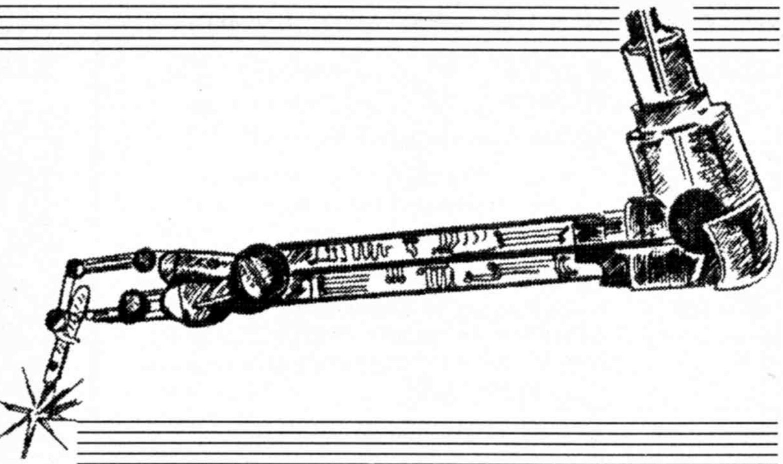
IN USE

In normal use the power supply runs well, producing very little heat. It will run with full current load on all channels, but if you intend to do this for *long* periods of time you are recommended to fit heatsinks to the rectifiers. Also the LM317 regulator becomes very hot if left in this state, so additional heat sinking may be required.

In full load condition the regulator (and hence the heatsink) can become very warm to the touch, so you should be careful of this, and ensure adequate ventilation. The unit should not "overheat" as the regulators shut down when they get to hot (at about 120°C!), but the life of the semiconductors will be reduced if they are run in high temperatures. □

Regular Clinic

CIRCUIT SURGERY



MIKE TOOLEY B.A.

Welcome once again to* Circuit Surgery*, our regular clinic devoted to readers' problems. This month we provide information on component substitution together with a list of "preferred" semiconductor devices. This will be particularly useful for those of you who may from time to time have experienced difficulty obtaining the parts specified in* EPE *articles. We also describe a "Budget Pre-Amplifier" which can be used with the Power Amplifier described last month:

Optical fibre

Anton Sutton writes from Cyprus with two questions:

"I wonder if you could show a simple design of an alarm system using possibly the CD4001 CMOS i.c., with exit and entry delay. Could you also tell me how much fibre optic costs in England because I can't buy it in Cyprus."

Well Anton, I will be describing a simple "Room Alarm" in next month's *Surgery*. In the meantime, you can obtain optical fibre from Maplin Electronic Components (Maplin order code: XR56L).

The fibre is 0·1 inch in diameter and is sold in multiples of one metre up to a maximum length of 100m in one single length. The fibre costs 98p per metre (postage and packing is extra), but you should note that the cable is supplied "rough cut" and you will have to very carefully trim each end cleanly with a razor blade (or a *very* sharp knife) before use.

Maplin can also supply you with some low-cost fibre optic couplers (MFOE71 and MFOE76 emitters and FD12N detectors). Details for using these are found in their latest catalogue. If you haven't got one of these it is available at very reasonable cost and is well worth sending for!

Table 1: Recommended "industry standard" transistors which will replace the majority of other devices in the same class

Small signal general purpose:	BC108, BC548 (*npn*) BC178, BC558 (*pnp*)
Low noise audio amplifier:	BC109, BC549 (*npn*) BC179, BC559 (*pnp*)
Low power switching:	BSX20, 2N706, 2N2369 (*npn*)
High voltage switching:	BU326A, 2N6545 (*npn*)
VHF RF amplifier stages:	BF173, BF180 (*npn*)
MF/HF RF amplifier stages:	BF115, BF494 (*npn*)
Low power audio output:	BD131 (*npn*) BD132 (*pnp*)
Medium power audio output:	TIP41A (*npn*) TIP42A (*pnp*)
High power audio output:	TIP3055, 2N3055 (*npn*) TIP2955, MJ2955 (*pnp*)
Medium power Darlington:	TIP121 (*npn*) TIP122 (*pnp*)
High power Darlington:	MJ3001 (*npn*) MJ2501 (*pnp*)

Notes: 1. Check pinouts before fitting replacements.
2. Check tab/case connections of power transistors fitted on heatsinks (in some cases insulating washers and bushes may be required)
3. If possible, check data sheets for absolute maximum ratings.

Component Substitution

I am often asked to suggest component substitutes for the designs that appear in *EPE*. Sometimes readers are attempting to build circuits that appeared many years ago (in which case some components may have become "obsolete" and therefore unavailable from the usual suppliers). In other cases the devices in question may no longer appear in suppliers' catalogues.

In difficult cases it is, however, nearly always possible to substitute an alternative component. However, before you attempt to replace that high-voltage diode or giant power transistor you ***must*** ensure that the replacement component is up to the job!

The considerations will vary with the type of component but the following should provide you with a basic guide:

Capacitors

When dealing with capacitors, make sure that the substitute component has an equal or higher working voltage than the component you are replacing. A 25V electrolytic makes a suitable replacement for a 16V device but not for a capacitor rated at 35V.

It is generally unwise to replace a non-electrolytic component with a polarised (electrolytic) one. There are usually good reasons for *not* using electrolytics!

It is also worth noting that capacitors vary greatly in size and performance depending upon the type of dielectric and construction. In general, you can use a component having a similar or better quality dielectric than the unit you are replacing *provided* the *working* voltage is greater than that of the original component.

Finally, it is worth mentioning that electrolytic (and some other types of capacitor) exhibit a rather wide tolerance. If the exact value is important (as in the case of timing and oscillator circuits) it is wise to check the value of the component before use. In many cases (e.g., in coupling and decoupling applications) this will not be necessary.

Resistors

Make sure that the substitute resistor has an equal or higher power rating than the component you are replacing. A 0·5W resistor makes a suitable replacement for one rated at 0·25W but not for a component rated at 1W.

It is also worth checking that the replacement component is of similar type and construction to the one you are replacing. For various reasons, carbon resistors do not usually make sensible replacements for wirewound components, and vice versa.

As with capacitors, it is wise not to deviate too far from specified resistor values in the case of oscillator and timing circuits. Most designers will, however, allow for some variation in tolerance. Note, however, that if the author has specified a close tolerance (e.g., plus or minus one per cent) component, there is usually a very good reason!

Diodes

When considering diodes, the replacement component must have an equal or higher working voltage (expressed either in terms of "peak inverse voltage" or "reverse maximum voltage") and an equal or greater forward current rating than the original.

Note that certain types of diode are unsuitable for operation in high speed switching applications, or where leakage is important, or when the forward voltage drop may be important. For the last reason, silicon diodes do not normally make sensible replacements for germanium components, and vice versa.

Transistors

For transistors, the maximum working voltage (collector-emitter and collector-base) is important as is maximum collector current. The maximum *reverse* collector-base and emitter-base voltages can also be critical when the stage is used in large-signal or switching applications. It is also wise to consider maximum power dissipation, upper frequency limit, noise figure, etc, depending upon the application.

As with diodes, silicon transistors should not normally be used to replace germanium components, and vice versa. Finally, it should go without saying that you should only replace an *npn* transistor with another *npn* component, and similarly for *pnp* devices!

Table 1 shows a list of "industry standard" transistors which will cope with the vast majority of replacement and substitution problems. Note that you *must* carefully check the pinouts in relation to the device that is being replaced – failure to do this can result in the instant destruction of the transistor and possibly some of the other components too!

Budget Pre-Amplifier

Lastly this month I have included the circuit details of a simple pre-amplifier to complement our Budget Power Amplifier. The complete circuit diagram of the Budget Pre-Amplifier is shown in Fig. 1.

The circuit is based on a low-cost dual operational amplifier, the first stage of which operates as a straightforward inverting amplifier whilst the second stage forms a conventional active Baxandall tone control stage with individual Treble and Bass controls. This approach is cost effective and uses the minimum of components.

The circuit provides 12dB of boost and cut at about 100Hz (bass) and 10kHz (treble). A single Volume control is provided but you can easily add "mixer" controls for each of the inputs (simply connect each input to the top end of a 47k log. carbon potentiometer and take each slider to its respective positive connection on capacitors C1, C2 or C3).

Note that Input 1 is designed for a five kilohm source (such as a microphone or guitar pick-up); Input 2 is available for general purpose ("auxiliary") use (50 kilohm) whilst Input 3 is ideal for use with a radio tuner (500 kilohm). When used with the Budget Power Amplifier, full output can be obtained for signals of less than 10mV at the "auxiliary" input.

Construction is not at all critical but it is essential to use screened input and output leads to avoid unwanted hum and feedback. If desired, the components associated with the tone controls (VR1 and VR2) may be wired directly to the two potentiometers.

Next month: We describe a simple "Room Alarm" with exit and entry delay. In the meantime, if you have any comments or suggestions for inclusion in *Circuit Surgery*, please drop me a line at: Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT. Please note that I *cannot* undertake to reply to individual queries from readers however I will do my best to answer all questions from readers through the medium of this column.

BUDGET PRE-AMPLIFIER SPECIFICATIONS

Input Signal (for full output):	less than 10mV pk-pk at 1kHz
Input Impedance:	5k, 50k and 500k (nominal)
Frequency Response:	10Hz to 30kHz at -3dB (flat)
Maximum Boost/Cut:	± 12dB (typical)
Distortion:	less than 0·005% at 1V output
Power Supply Voltage:	+15V and –15V d.c. (max.)
Power Supply Current:	less than 15mA

COMPONENTS

Budget Pre-Amplifier

Resistors

R1, R4	4k7 (2 off)
R2	47k
R3, R5	470k (2 off)
R6, R7	10k (2 off)
R8, R9	22k (2 off)

All 0·25W 5% carbon film

Potentiometers

VR1, VR2	100k rotary carbon, lin (2 off)
VR3	47k rotary carbon, log

Capacitors

C1, C2, C3	1μ axial elect. 35V (3 off)
C4	10μ axial elect. 25V
C5, C6, C7, C8	10n ceramic (4 off)
C9, C10	47μ radial elect. 25V 2 off)

Semiconductor

IC1	TL082 Dual J-f.e.t. op. amp

Miscellaneous

Matrix board (approx. 60mm x 100mm); terminal pins (9 off); 8-pin low-profile d.i.l. socket; knobs (3 off); screened lead; connecting wire; case, to choice; solder etc.

Approx cost guidance only **£8.50**

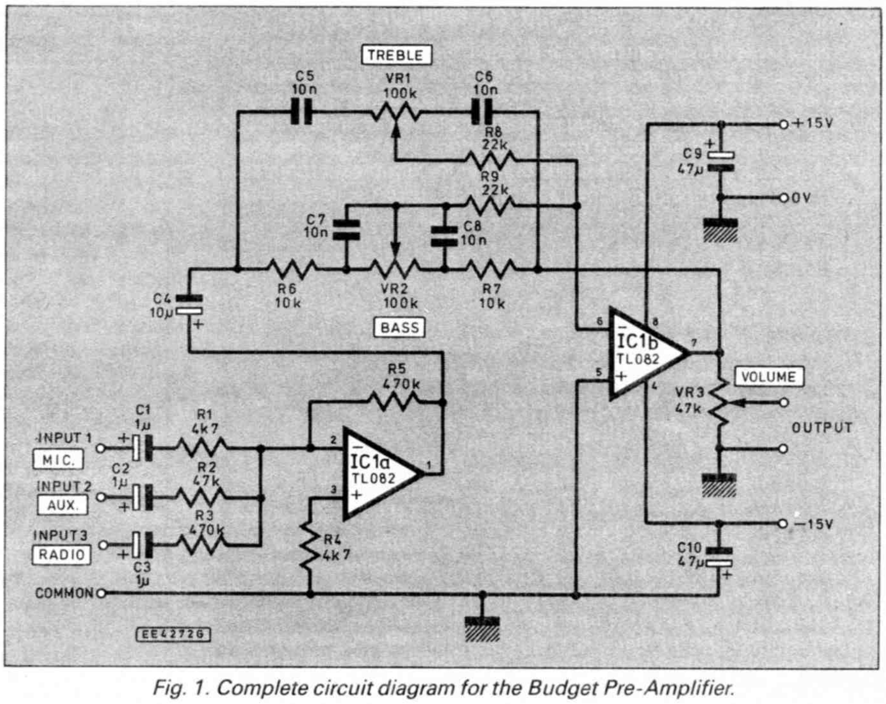


Fig. 1. Complete circuit diagram for the Budget Pre-Amplifier.

BECOMING A RADIO AMATEUR

IAN POOLE

Becoming a licenced amateur is quite easy. Virtually anyone can get "on the air" with a little effort.

AMATEUR RADIO is a hobby which has captivated the interest of many millions of people since the very dawn of the wireless era. It can be a relaxing, interesting, creative or in fact whatever you want it to be.

Some people enjoy chatting to friends on the other side of town, or possibly the other side of the world. Other people enjoy constructional projects or experimenting with new techniques and finding out how they work. Some enjoy the challenge of contacting stations from as many different countries around the world as possible. In fact it is surprising how many countries there are, and where amateur radio operation has taken place.

PIONEERS

The hobby does not only benefit its members. Down the years radio amateurs have made large contributions to science. If it was not for the pioneering spirit of many of the early amateurs the short wave bands would not have been opened up as quickly as they were.

In the early 1920s radio amateurs were relegated to the short waves because they were thought to be of little use for long distance communications. Not deterred by this amateurs continued to experiment. As a result they made the first transatlantic contact in November 1923, and then almost a year later a contact was made with the other side of the globe.

Today amateurs still display this pioneering spirit. They are still playing a vital role in pushing back the frontiers of technology. The large number of active stations means that propagation studies can be carried out relatively easily. Not only this, but new systems like packet radio have been tried out to a large degree by amateurs pursuing their hobby.

Apart from helping in new discoveries the hobby can benefit others when amateurs use their equipment to help the emergency services. This can be of particular use when large scale disasters occur. Fortunately these occasions do not happen very often but when they do amateur radio has a vast fund of equipment and expertise which can be volunteered.

With such a wide variety of aspects to the hobby, amateur radio can be tailored to suit the needs of every individual. Some will like operating whilst other like constructing and experimenting. There will be those who like to have a mixture of both. In fact whatever one's interest there is plenty in the hobby. Even if one's interests change there are still plenty of new aspects to investigate.

FIRST STEPS

Anybody can listen to the amateur bands, see Table 1, without a licence. It can be very interesting and quite instructive as well. In fact it is probably one of the best ways of starting in the hobby. Many people start with one of the "World Band" types of radio to get a flavour of the bands. A number of them are available. The large manufacturers like Sony, Panasonic and Grundig make a very good selection, and prices start at around £130.

However when it comes to more serious listening, especially on the h.f. bands a proper communications receiver is needed. The various dealers offer a wide selection of receivers with prices from about £300 upwards. Unfortunately these receivers are not cheap but the cost can be brought within more reasonable limits if second hand equipment can be considered. There can be a bit more risk in buying a receiver this way, but if it is bought from a reputable dealer the risk can be minimised. Alternatively an experienced amateur could look at the receiver and give a second opinion.

BUILD IT YOURSELF

Apart from listening, it can be very useful to try a bit of construction. There are plenty of designs in the amateur radio literature for useful pieces of equipment. (A *20 Metre Receiver* design will be published in *EPE* next month – Ed.) Another idea which is probably more appropriate for anyone building up something for the first time is to use a kit. This approach makes it a lot easier to build a circuit because a lot of the difficult p.c.b.s and metalwork will be completed. It also gives a much more professional appearance as it is often possible to buy a ready made case for the item.

Once most people have listened on the bands for a while they will want to transmit. However before this can be done it is necessary to have a licence. Fortunately they are not difficult to obtain, although a degree of commitment is needed.

TYPES OF LICENCE

In the UK there are now four types of licence to cater for the needs of a wide variety of people. There are two standard licences: the class A and the class B licences and in addition to this there are class A and B Novice licences. However before any of them can be obtained some tests or courses have to be completed.

The standard class A licence gives access to all modes and to all of the amateur bands. However to be issued with one of these

Table 1: UK Amateur Bands

Frequency Limits (MHz)		Approximate Wavelength
1·81	2·00	160 metres (Top Band)
3·50	3·80	80 metres
7·00	7·10	40 metres
10·10	10·15	30 metres
14·00	14·35	20 metres
18·068	18·168	17 metres
21·00	21·45	15 metres
24·89	24·99	12 metres
28·00	29·70	10 metres
50·00	52·00	6 metres
70·00	70·50	4 metres
144·00	146·00	2 metres
430·00	440·00	70 cms
1240·00	1325·00	23 cms
2310·00	2450·00	13 cms
3400·00	3475·00	9 cms
5650·00	5680·00	6 cms
5755·00	5765·00	6 cms
5820·00	5850·00	6 cms
10000	10500	3 cms
24000	24250	
47000	47200	
75500	76000	
142000	144000	
248000	250000	

Table 2: UK Novice Licence Bands

Frequency Band (MHz)		Types of Transmission Permitted
1·950	2·000	Morse, Telephony, RTTY, Data
3·565	3·585	Morse
10·130	10·140	Morse
21·100	21·149	Morse
28·100	28·190	Morse, RTTY, Data
28·300	28·500	Morse, Telephony
50·620	50·760	Data
51·250	51·750	Morse, Telephony, Data
433·000	435·000	Morse, Telephony, Data
1240·000	1325·000	Morse, Telephony, RTTY, Data Facsimile, SSTV, FSTV
10000·000	10500·000	Morse, Telephony, RTTY, Data Facsimile, SSTV, FSTV

Maximum power 3 watts r.f. output or 5 watts d.c. input.

RTTY – Radioteletype
SSTV – Slow-scan television
FSTV – Fast-scan television

licences it is necessary to have passed a theory examination called the Radio Amateurs Examination (RAE) as well as a Morse test.

For people who do not want to learn Morse the class B licence giving access to the bands above 30MHz may be the answer. This only requires a pass in the RAE and it gives sufficient facilities for many people.

Novice licences have been introduced quite recently. They are intended to give a route to help newcomers into the hobby, particularly those who are younger, although anyone can apply to hold a novice licence. As a result the tests required for these licences are less stringent than the standard ones.

As might be expected the novice licences do not give the same facilities as the standard ones. The bands are summarised in Table 2. From this it can be seen that access is allowed to a wide variety of bands and modes of transmission. This is ideal because it gives a good introduction to all aspects of amateur radio from the more recognised forms of communication like speech and Morse to the new data modes which are fast gaining popularity all around the world.

NOVICE POWER

It will be noticed that the power limits for the novice licence are fairly low. However, it is still quite sufficient to make some very good contacts. On the h.f. bands, broadly speaking those below 30MHz, it is possible to make contacts over many thousands of miles even with a comparatively modest aerial. The use of a better aerial will obviously bring better results and make long haul contacts easier.

On the v.h.f. and u.h.f. bands the power restrictions will probably be less noticeable. Indeed many people with even the standard licence use powers below the maximum permitted by the novice licence. They must obtain satisfactory results otherwise they would change to higher power equipment.

In order to obtain a novice licence you have to attend a specially designed course. It gives a basic understanding about radio and there is a large element of practical work. In fact the emphasis is on learning by doing. There are a number of these courses around the country which are run under the auspices of the RSGB (Radio Society of Great Britain) who will be able to supply details.

Having successfully completed the course it is necessary to sit an examination based on the work covered in the course. This Novice Radio Amateurs Examination is fairly straightforward and is conducted by the City and Guilds. The actual examinations are held in a number of centres around the country. The City and Guilds Institute are able to supply details of the examination centres, although the course tutor will no doubt know where the nearest one is.

With both the course and the examination successfully completed it is possible to apply for a class B novice licence. This gives access to all the novice frequencies above 30MHz. To have access to the novice frequencies below 30MHz it is necessary to pass a Morse test at five words per minute. This test is conducted by the RSGB.

FULL LICENCES

The novice licences have been very successful since they were first introduced in 1991. Through them a large number of people have entered the hobby. However many people will find that they want to progress to either the class A or class B licences. Alternatively some may want to apply for this licence straight away.

Holders of these licences have access to far more frequencies as shown by Table 1. Those holding the class B licence have access only to the bands above 30MHz whilst class A licensees can use any of the bands. Power levels are much higher than for the novice licence. On many bands powers up to 400 watts can be used. This means that far greater distances can be reached with ease.

To be able to apply for these licences different examinations have to be passed. For the class B licence the Radio Amateurs Examination has to be taken. Then in addition to this a Morse test is required for the class A licence.

THE RAE

The RAE examination is more advanced than the examination for the novice licence but even so there is no reason why most people should not be able to pass it.

Like the novice licence examination the RAE is set by the City and Guilds. It is held twice a year: in May and December, and it consists of two multiple choice papers. The first lasts for 75 minutes and covers the licensing conditions, transmitter interference, and EMC (Electromagnetic Compatibility). The second paper lasts for only 30 minutes but it covers operating procedures, simple electrical theory, solid state devices, receivers, transmitters, propagation, aerials and measurements.

As the RAE may seem like a very large hurdle there are a number of steps which can be taken to make it easier. The first one is to try to find a local evening course. There are a number of them which are run around the country at schools and also radio clubs. To find out where they are being held a visit to the local radio club (the RSGB will tell you where the nearest one is) could help. Alternatively contact the local education authority or the RSGB.

If it is not possible to find a course all is not lost. Many people have studied by themselves and have successfully passed the exam - including myself. It must be admitted that it is a little harder to do it this way, but if one is determined to pass the exam this can easily make up for missing out on a course.

There are a number of good books to help prepare for the examination. The first is called the *RAE Manual* and it is published by the RSGB. Another book from the RSGB is called *How to Pass The RAE* and this is also very useful. In addition some general background reading about the hobby always helps. Magazines like *Everyday With Practical Electronics* are ideal because they give a lot of general information about electronics and radio.

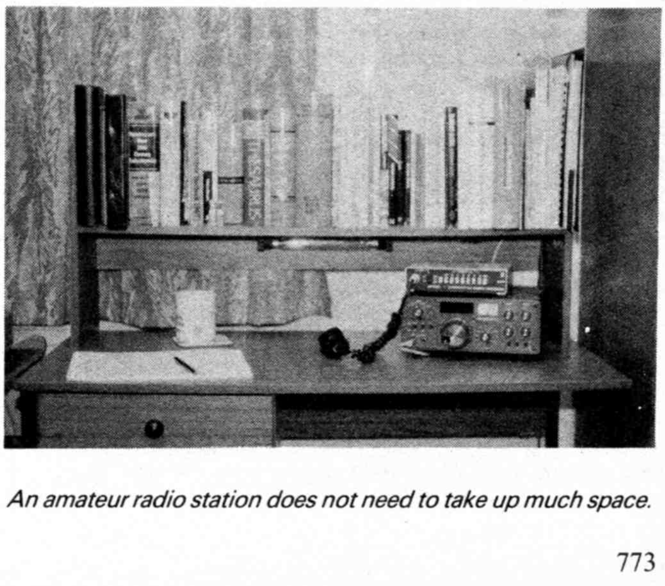
Finally it can be a great help to listen on the bands. This gives first hand experience of the operating procedures which are used. It can also be quite instructive as many people talk about their equipment, how it works and the problems they have encountered.

THE MORSE TEST

With the RAE under your belt the next step is the Morse. Many people will not need to take it because the class B licence will offer all they need, but for anyone wanting to transmit on the h.f. bands it is necessary to take it.

Unfortunately, a number of people find the thought of learning Morse quite daunting and as a result there are a lot of stories around about the difficulties involved and how people have struggled with it. Whilst this is true in some instances by no means everybody has problems with it and you should not be put off by it. Be determined, settle down to learning it with real determination and that is the major battle overcome.

There are many ways of learning the code. Often one person will find one way better than another so it is as well to remember to be



An amateur radio station does not need to take up much space.

flexible and if the first method does not work try another. Keep plugging away at it and you will succeed.

Often radio clubs will run classes for their members. If there is a club locally then it is worth investigating to see whether it runs anything. Even if there are not any formal classes it is still possible to obtain a lot of encouragement and assistance from people who have been through the same learning process themselves.

In addition to courses and clubs there are a number of other approaches which can be adopted. One is to buy a pre-recorded tape, or alternatively a local ham could be enlisted to help make one. All it may need is some characters recorded.

Another approach is to use a Morse "tutor". These items are electronic units which generate random sets of characters. The speed can be adjusted to suit and as such they make an ideal aid to learning. In fact a specialized tutor does not necessarily have to be bought because there is plenty of software around to do this sort of thing on a wide variety of different computers.

It is often helpful to learn Morse with a friend. In this way the impetus can be kept up more easily. On your own it can be very easy to let things slip and not practice as regularly. With a friend there can be a bit more pressure to keep things going.

FIRST STEPS

When starting out the different characters must be learnt first of all. The best way to do this is to listen to each character several times, possibly on a pre-recorded tape. By doing this the actual rhythm of each character is learnt and this is all important. It is no good learning each character by looking at its dots and dashes.

Once the basic characters have been learnt practice in reading Morse is needed. This can be achieved with tutors, tapes, and even listening on the air. The bottom ends of the eighty and forty metre bands have a fair amount of reasonably slow Morse, especially at the weekends. Look between frequencies of 3·500 to 3·600MHz and also 7·00MHz to 7·04MHz. There is even some activity on two metres around 144·050MHz, although not nearly as much.

Sending Morse should be left until it is possible to read at least 10 words a minute. If you start to send too soon then bad sending habits can be created which are difficult to "unlearn" later.

Eventually it will be possible to read at the required speed. Before applying it is best to be able to read a little faster than the basic speed because exam nerves will undoubtedly slow you down. However when you are in the test remember that the examiner is there to enable you to pass and he will help you as much as he can.

ON THE AIR

The day will eventually come when the licence arrives. The rig can be "fired up" and the first contacts made. To most people there is a mixture of excitement and nervousness. Because of this it is best to try for a few easy contacts with local stations. Don't try to contact some fantastically rare station which has a great pile up on top of his signal.

It is also worth bearing in mind for those that have taken the trouble to learn the Morse code that it can be very useful on the air. It is a great pity if all the effort put into learning it is wasted and it is not used at all. Many people find that they can make contacts using Morse when they would have no chance any other way. It can also be a very enjoyable mode to use anyway.

The main thing to bear in mind is to enjoy the hobby. Investigate new areas and try new bands or modes. All of this keeps a lively interest in amateur radio and adds to the enjoyment of the hobby.

Addresses: Radio Society of Great Britain (RSGB),
Lambda House, Cranborne Road, Potters Bar,
Herts EN6 3JE. Tel 0707 695015

Further Reading:

An Introduction To Amateur Radio I D Poole
ISBN 0 85934 202 6 **Order code BP257** **Price £3.50**
Pub Bernard Babani (Publishing) Ltd

An Introduction To VHF/UHF For Radio Amateurs I D Poole
ISBN 0 85934 226 3 **Order code BP281** **Price £3.50**
Pub Bernard Babani (Publishing) Ltd

Setting Up An Amateur Radio Station I D Poole
ISBN 0 85934 245 X **Order code BP300** **Price £3.95**
Pub Bernard Babani (Publishing) Ltd

All the above, and a further selection of amateur radio books, are available from the *EPE Direct Book Service* – see the book pages towards the end of this issue for information and ordering details.

Techniques

ACTUALLY DOING IT!

by Robert Penfold

SOME time ago I commented on the fact that do-it-yourself project cases were much less popular now than they were about 20 years ago. In fact I suggested that do-it-yourself case construction was probably of little interest to anyone these days. Inevitably perhaps, this brought in some readers letters asking for more information in the magazine about this aspect of project building. Therefore, by popular demand, this month's *Techniques* is devoted to the subject of home constructing simple project cases.

BEG, BORROW, OR BUY

It is only fair to point out that unless you are careful, it is quite possible to spend more money producing a home constructed case than if you simply went out and bought a ready-made equivalent. In days gone-by there were plenty of small do-it-yourself shops which had lots of off-cuts of plywood, chipboard, aluminium, and other materials at very low prices. Although these were offcuts, in many cases they were actually quite large. The aluminium offcuts in particular, were often larger than the sheets sold by most of the component retailers.

If you are lucky you might still be able to find a local source of cheap materials. If there are no do-it-yourself outlets that sell cheap offcuts, there may be a local manufacturing company which is willing to supply some suitable materials. Larger do-it-yourself stores sometimes sell off damaged or substandard goods at low prices. These will often be perfectly adequate for case building.

If you are going to produce your own cases, you must learn to be a hoarder who throws nothing away. I have used a lot of chipboard and hardboard in home made cases, and much of this material came from the packaging around self-assembly furniture.

FULL PRICE

If all else fails, materials have to be purchased at full price from component retailers, do-it-yourself superstores, or whatever. It is well worthwhile shopping around though, as prices seem to differ significantly from one supplier to another.

I would strongly advise potential case builders to work out the costs involved before starting to buy the materials. Twenty years ago there were relatively few ready- made cases available, and those that were on offer had very high price-tags by today's standards. You are unlikely to obtain the same financial advantage in project case construction these days, and could end up paying more by doing it yourself.

I would not take the view that it is definitely not worthwhile building a case if it will cost about the same as a ready-made unit, or even if it costs slightly more. If you enjoy case building, any marginally higher costs are not of any real importance. If you do not particularly enjoy this aspect of project building, and are only interested in making cost savings, it is something that may no longer be worthwhile.

In general, the larger the case, the greater your chances of being able to undercut the ready-made variety. This is simply because large ready-made cases seem to cost disproportionately more than the smaller types.

A point worth making is that building your own case means that you can produce a case of precisely the right size and style for any given project. When using ready-made cases it is normally necessary to compromise to some degree. There are dozens of small cases to choose from, and it is usually possible to find something that will accurately match your requirements. There are relatively few medium and large cases available though, and with large cases in particular, quite a high degree of compromise is often called for.

DRESSING UP

Before considering the construction of cases from scratch, it would be a good idea to take a look at a few simple methods of turning a very basic chassis or case into a much more presentable case. An ordinary aluminium chassis actually makes quite a good instrument case if it is used up-side down, so that the removable base panel becomes the lid. With a few minor additions a chassis can be turned into quite a good cabinet for hi-fi projects, or other projects that must look reasonably good in order to blend into the decor.

The easiest way of doing this is to produce a "book- ends" type case. These seem to be less fashionable than they once were, but a case of this type can still look very smart, and it is very easy to convert a chassis into one of these. Basically, it is just a matter of drilling a couple of holes in each side panel of the case so that a wooden end cheek can be mounted at each end of the case.

Each end cheek should be about 10mm bigger than the case on each of its larger dimensions. This gives the end cheeks an all-round overhang of about 5mm

The thickness of the end cheeks is not too important, and anything from about 10mm to 25mm should give attractive results. Ideally the end pieces would be made from pieces of good quality timber (mahogany, teak, etc.), varnished to give a good natural finish.

The more usual alternative is to use a low-grade timber or scraps of particle board. In either case, covering the ends with a wood grain effect self-adhesive plastic will give a very acceptable finish. This material is available from Woolworths, etc., in a range of patterns. There is usually at least one wood grain finish material which is suitable for our present purposes. A teak effect material is probably the best choice.

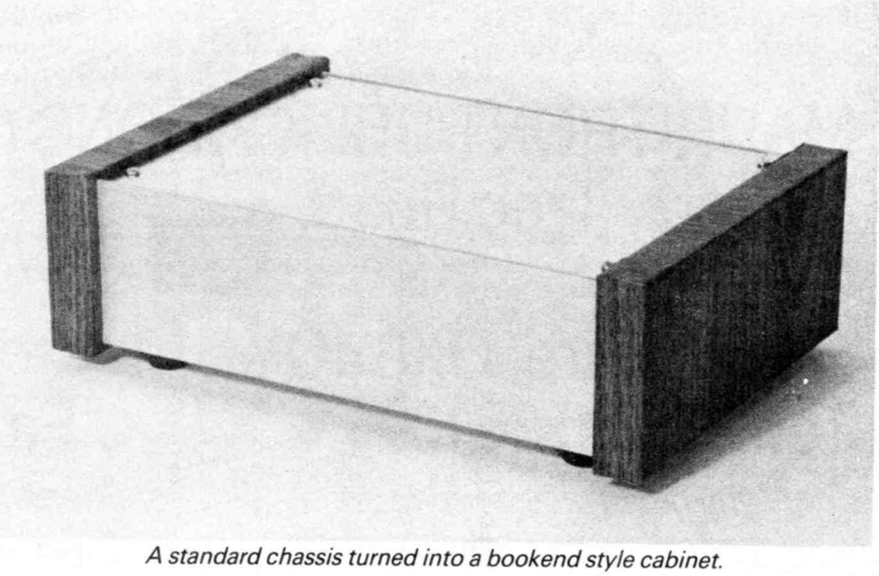
The pieces of wood or particle board must be clean and dust-free if the plastic veneer is to adhere properly. In order to obtain neat results the material needs to be stretched quite tightly around corners. It is easily trimmed to a neat finish using either a sharp modelling knife or a good pair of small scissors.

Sometimes this material can be a bit reluctant to stick down properly at the edges. This is easily cured by augmenting the existing adhesive with a minute amount of any general purpose adhesive.

QUALITY

Although in the past these self-adhesive materials had a deserved reputation for being rather short-lived, modern soft plastics seem to be much longer lasting. I have some cases which were covered with self-adhesive plastic veneers over ten years ago, and they show no signs of the hardening and cracking which often plague these materials in the past.

The photograph below shows a 202mm by 153mm by 65mm chassis which has been given the book-ends treatment. It has also been fitted with four cabinet feet, and some left-over brushed aluminium effect veneer has been added to the front



A standard chassis turned into a bookend style cabinet.

panel. This veneer seems to be genuine plastic, but it gives quite a convincing finish. It is very much thicker than normal self-adhesive plastic veneers, and is semi-rigid. The plastic is tough, but it can be cut to size using a modelling knife fitted with a new blade. It is available from Maplin Electronics in two sizes.

With a bit of ingenuity it is possible to make practically any aluminium chassis or simple folded aluminium case look quite elegant. This method almost certainly represents the cheapest way of producing smart looking cases.

FROM SCRATCH

It is possible to build some very simple but effective cases using a combination of aluminium sheet and either wood or particle board. Fig.1 shows a case that is about the most simple form of do-it-yourself case that is reasonably neat and practical. This type of case has the advantage of not requiring any metal bending, which is something that can be difficult to carry out successfully unless you have access to the correct equipment.

This case is based on two pieces of timber or particle board, and four sheets of aluminium. The wooden end pieces are about 20 mm to 25 mm thick. If particle board is used, it should obviously be covered with a self adhesive plastic veneer to give a neat finish. Again, a teak effect wood grain finish is probably the most appropriate.

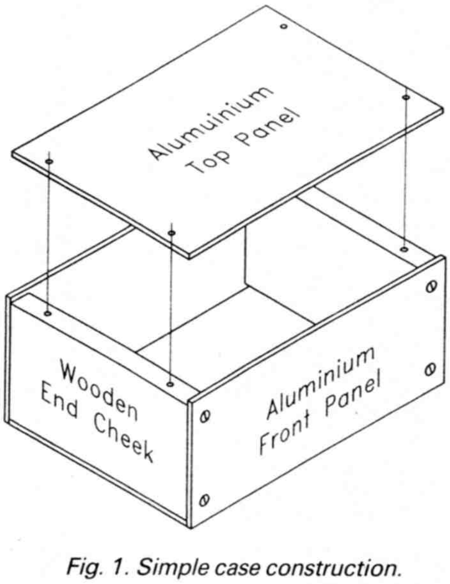


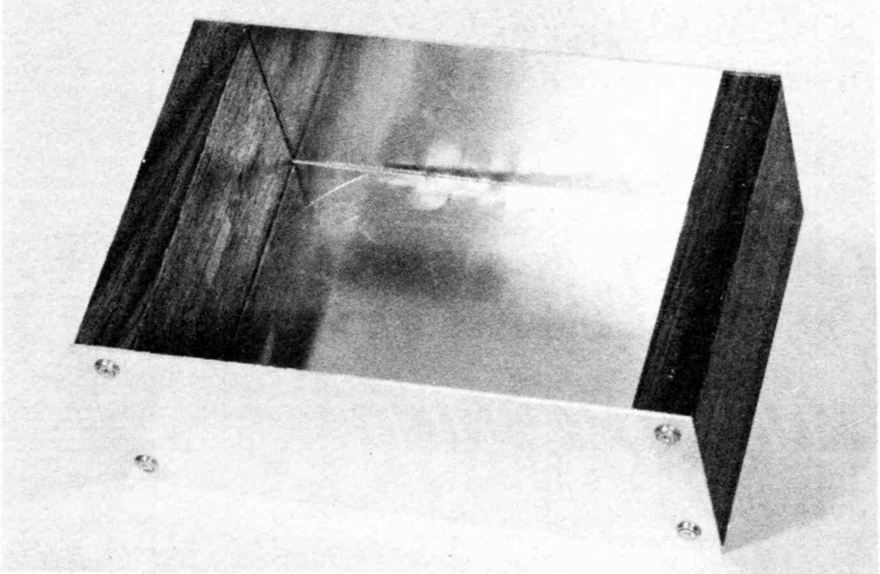
Fig. 1. Simple case construction.

The four aluminium panels are made from 16 or 18 s.w.g. material. These seem to be the only gauges of aluminium that are readily available these days. 16 s.w.g. aluminium is the thicker gauge, and as such it is significantly more expensive than the 18 s.w.g. variety.

For very large cases it might be worthwhile using 16 s.w.g. material, but 18 s.w.g. aluminium is usually more than adequate for home constructed cases. In fact 20 s.w.g. aluminium is adequate for most small and medium size cases, but it seems to be difficult to obtain at present.

CUTTING

In order to produce neat results it is essential that the aluminium panels are accurately cut to the right sizes, with good straight cuts. A hacksaw will cut through aluminium quite well, but making long cuts with a hacksaw is awkward. It is also very difficult to make long straight cuts using this tool.



Simple case with wooden end panels.

I find that the best way to cut aluminium is to make a deep score line using a sharp modelling knife. A steel rule (or a plastic one having a metal insert) is used to guide the blade along the correct line.

If the aluminium is then repeatedly bent backwards and forwards along this line, it will soon fatigue and break along the score line. Unless the aluminium is very deeply scored, it is advisable to clamp it between two pieces of wood so that the score line is just slightly clear of the wood pieces. Otherwise there is a tendency for the aluminium to become curved close to the cut. If this is allowed happen, it will be very difficult to flatten the two pieces of aluminium out again.

This method should produce a reasonably clean cut with no significant wastage. The cut edge will probably be slightly rough, but it can be quickly and easily smoothed off using a small flat file.

PRIZE SIZE

Remember that the front and rear panels are slightly taller than the end pieces, so that the top and rear panels will fit flush with them. The extra height is obviously equal to double the thickness of the aluminium, but in practice it is probably better to play safe and allow fractionally more than this. The front and rear panels should therefore be about four millimetres higher than the end pieces when using 18 s.w.g. aluminium panels. An extra five to six millimetres is about right when using 16 s.w.g. panels.

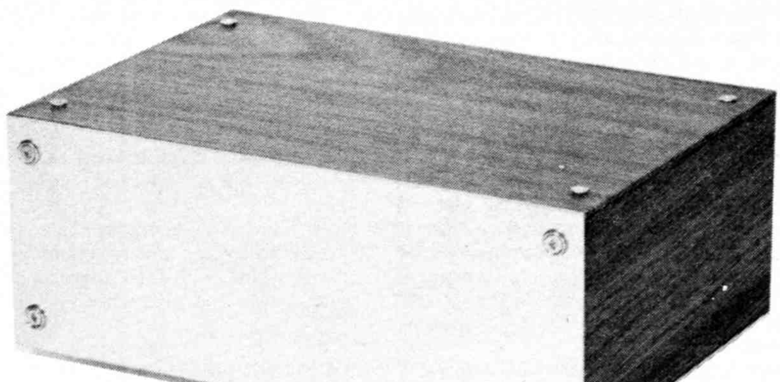
The top, bottom, front, and rear panels are all fixed to the end pieces using woodscrews. For most cases four woodscrews per panel will suffice, but for larger cases it might be necessary to use six screws per panel. The panels themselves can be used as templates when marking the positions of the screw-holes. A bradawl is then used to make start- holes for the screws.

Decorative cup washers can be used over the screws to give a better appearance, and I would certainly recommend the use of these on the screws which hold the front panel in place. If the end pieces are covered with a veneer, the case will probably look smarter if the top panel is covered with the same material. To complete the case four cabinet feet are added.

VARIATIONS

Numerous variations on this basic type of case are possible. For instance, smaller end pieces can be added inside the main end cheeks. The four aluminium panels are then fixed to these smaller end pieces, so that a book-ends style case is produced. With a little ingenuity it is possible to modify the basic design to produce a case that will suit practically any project.

Next month we will continue on the subject of home-made cases, but will consider some designs that involve metal bending.



The finished home-made project case.

Constructional Project

FAKE CAR ALARM

MUNGO HENNING

No false triggering, just three components will, it is hoped, persuade any would-be intruder to "drive-on".

TAKE a moment to consider your car. What's the insurance premium like? Got an excess on the policy? Assuming that you do not already have a car alarm, consider the penalties that you will pay for an attempted break-in, never mind a full break-in, or even the car being stolen altogether.

Just such an incident happened to the author last year. Parked beside lots of other cars, someone ripped off the horizontal weather-seal strip between the driver's window and the driver's door, then proceeded to bow-out the thin metal at the middle-top of the door to gain access to the lock mechanism.

Probably more by luck than anything else we assume that the culprits were disturbed, because nothing was stolen from the car. After involving the police, the next day I had all the hassle of telephoning my insurance company and arranging for a claim form to be sent out.

This was followed by a visit to my local car repair firm (the state of the car meant that it would be trivial for anyone else to gain entry, what with the lock mechanics in full view), to assess damage and repair cost. Luckily the repair was swift and cheap, but it made me anxious to avoid a repetition now that I know how vulnerable the car is.

To digress, it is most important to always inform the police about any such incidents. A police relative recalls going to an incident only to be told by the complainant that "this was the sixth time it had happened".

When asked about the other five occurrences the complainant said that they had not informed the police. Fair dues: if the police are not informed of incidents how can they take any action?

FALSE ALARM

The obvious first thought I had about the attempted break-in was to fit a car alarm. I always get annoyed when I hear car alarms falsely going off (usually accompanied by the quizzical looks from the culprit/owner as they embarrassingly fumble for the suitable off switch), which seems to be a growing occurrence.

Since car alarms can also be expensive, I decided against this course of action. The next best thing would be a fake car alarm, in the form of a flashing l.e.d.

Appropriately mounted, it could act as a warning to any would-be intruder. Many real car alarms have such flashing l.e.d.s fitted, to warn the user as well as the owner that the alarm is operating.

I am also quite lazy about things, so a FIFI design (Fit It and Forget It) would be ideal. The tiny circuit diagram shown in Fig. 1 meets these requirements. There is not much to the circuit, but the lack of components should not detract from its effectiveness.

The l.e.d. is of the special "flashing" variety in that a flash unit is integral to the l.e.d. itself. The one used did not require a limiting resistor if fed from five volts. Since a car battery is nominally 12V it seemed prudent to add such a resistor.

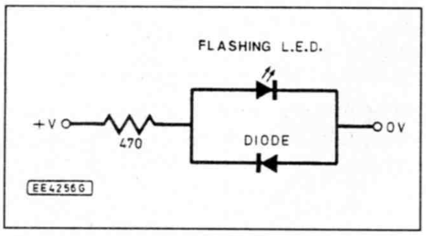


Fig. 1. Circuit daigram for the Fake Car Alarm. The cathode (k) connection of the flashing l.e.d. is indicated by a chamfer on its body and the shorter lead. The lead nearest to a "band" on the body of a diode indicates the cathode (k). A typical value for the resistor would be 470 ohms.

The third component is a simple diode wired across the l.e.d. but with its anode (a) connected to the l.e.d.s cathode (k). This is to protect the l.e.d. should a large negative voltage appear across its anode to cathode terminals.

The current consumption of the unit is minimal, so there would be no problem with powering it all the time from the battery. However, the unit is meant to attract people's attention and this could include the driver *whilst driving*, so it would be nice to only power the unit when the ignition if OFF.

The solution chosen here is to power the unit *across* the ignition switch (that which is operated by the ignition key). This may seem daft at first, but in this way, the unit is truly FIFI since the driver need do nothing to switch it off.

This of course relies on a tiny bleed current path available when the ignition is off, but in my experience such a path is available.

CONSTRUCTION

IMPORTANT: The vehicle battery MUST be disconnected when carrying out any wiring and/or soldering to the car electrics. An in-line fuse is recommended for this unit.

Not being a top-of-the-range model, my car had an unused switch socket covered by a plastic blanking plate. This proved ideal as the location for the l.e.d. and the components are simply soldered directly onto the l.e.d. leads once the appropriate hole is drilled and the l.e.d. fitted to the blanking plate (a dab of superglue works wonders).

Connect two leads to power the unit using *thin* wire of length to reach through the steering column cover and up to the ignition switch. Access to the ignition switch will be different for each model of car, but in mine all it took was removing a couple of awkwardly-placed screws and the switch points were exposed.

Without re-soldering the whole ignition switch it was quite straight-forward to briefly melt the top layer of the solder at the connection and "weld-on" the new wire. A bit of experimentation is probably in order to determine which points you should connect to!

TAKE NOTE

A couple of final points. Should you decide to fit an in-line fuse to the unit, fit it near to the ignition switch and if possible make sure that this is concealed. Either way, use thin connecting wire to power the unit. Note that a short across these power wires is the equivalent of by-passing the ignition-key switch, perhaps termed "hot-wiring" the ignition.

Of course, the aim of this circuit is to deter potential criminal activity involving your car (when the car next to it has no such signs of an alarm). However, this deterrent is a bluff and gives no real protection. Determined criminals will go to great lengths if a particular car (or its contents) are desired, so you probably won't stop them, even with a real alarm system.

But for a few quid (or a rummage through your component box), and an hour or so of your time the FIFI benefits are, in my opinion, well worth it.

You can always boast to your neighbours that your car has a true "silent alarm" (groan). □

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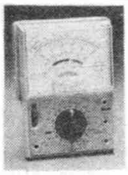

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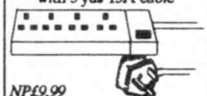

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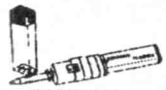

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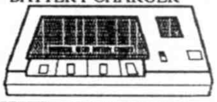

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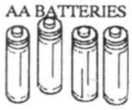

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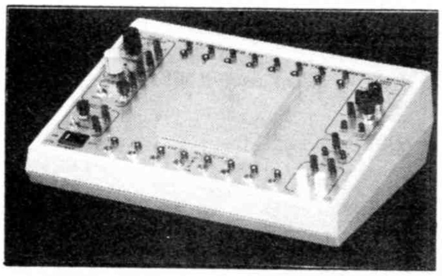

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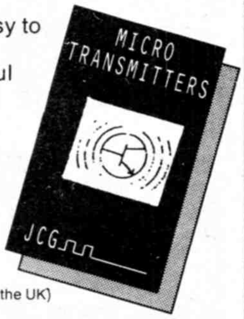

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KETTLE ALERT

BART S. TREPAK

A bleeping reminder that the kettle has boiled – can be used with all automatic electric kettles.

THE OLD adage that a watched kettle never boils is obviously not true unless of course there is something wrong with it. The fact remains that they do appear to take a long time to boil with the result that when you want a cup of tea, you put the kettle on and go off to do something else.

After what seems like an appropriate time you return to find that the kettle has indeed boiled and switched off but you are then left wondering how long ago this was and if the water has since cooled down. Just to make sure, you switch the kettle on again to bring it to the boil and stand over it to watch which can sometimes take another 20 or 30 seconds, which can seem like an hour.

We are, of course, bad at estimating the passage of time even when we are not engrossed in some other task. In the past this was not a problem as the kettle itself would inform the user when it had boiled by utilising the steam produced to blow a whistle.

With the advent of electric kettles, manufacturers seem to have concerned themselves more with experimenting with different shapes and materials and making sure that the kettle switches itself off when it has boiled, but seem to have forgotten to add a buzzer to alert the user that it has done so. Often it only produces a "click" which can be missed when you are in the kitchen and is certainly inaudible when you are elsewhere. The idea for this project was born when we took out our old (non electric) whistling kettle for a camping holiday and realised what we had been missing.

SELF-SERVICE

The initial concept was to mimic the action of the conventional kettle, by using a thermistor to sense the production of steam and activate a sounder of some description, but further thought revealed some problems. The thermistor, for instance, would of course need to be mounted on or near the spout which was quite difficult in itself. This would tend to interfere with the normal use of the kettle and would probably need to be removed to pour out the water.

From a safety point of view, the device would also have to be battery powered so a box would be needed to house the battery and electronics and the whole lot mounted on the kettle, adding the further requirement that the box would also have to be at least splash-proof and preferably waterproof. This would not be too difficult at the manufacturing stage as the kettle itself could be designed to accommodate the extra circuit, but to fit a box to an existing kettle without it looking like a box stuck on a kettle would be virtually impossible.

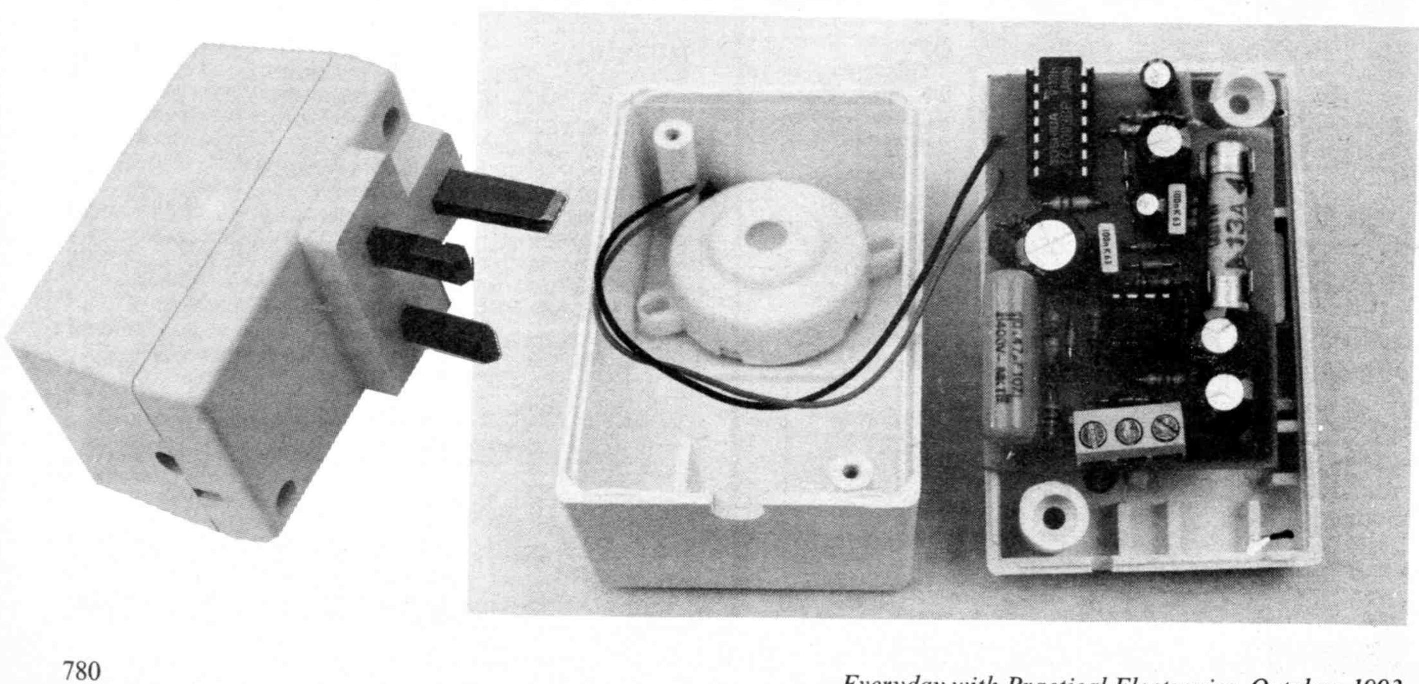
Then a better solution presented itself. The kettle itself must already have a sensor which operates when the water has boiled as this is used to switch off – so why fit another? All we then need to do is to switch on a sounder when the kettle switches *off*. This can, of course, be done anywhere, such as at the plug and neatly side steps the problem of mounting a box on the kettle.

The other requirements are also relaxed as the unit no longer needs to be particularly waterproof and the mains supply can be used to power the unit saving the inconvenience of housing the batteries and changing them at regular intervals once the unit is in use. On the debit side, the unit will only work with a kettle which switches itself off when it has boiled, but these tend to be the most common types nowadays so this should not really present a problem.

This unit carries up to 12A at 240V a.c. and it should not be constructed by anyone without some experience of project building and of working with mains voltages.

VOLTAGE DROP

The obvious way to determine when the kettle has switched off would be to monitor the voltage across the element. Unfor-



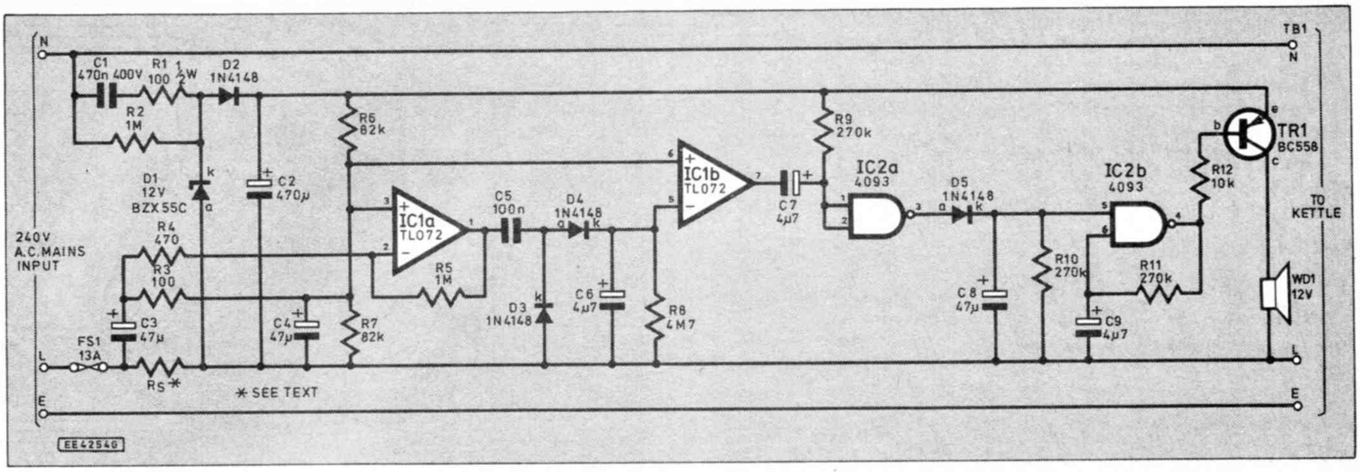


Fig. 1. Complete circuit diagram of the Kettle Alert.

tunately, the element is in series with the switch inside the kettle and its connections are not available externally so this method cannot be used.

This leaves only the current drawn by the kettle which will range from a few amperes when the kettle is on to zero when it has switched off. This current can be passed through a resistor and the resulting voltage drop monitored.

Most kettles seem to have a power rating of between 1·5W and 3kW which at 240V represents a current of between 6A and 12A and to obtain a usable voltage drop of say 1V, a resistor of about 0·2 ohm would be required. With a 1·5kW kettle the power dissipation in this resistor would be 7·2W (I^2R) rising to 28·8W for a 3kW kettle. This is obviously too high a dissipation to accommodate in a small box so a smaller value resistor must be used and the resulting voltage amplified to a suitable level.

A glance through a few component catalogues revealed that wirewound resistors appear to be available with a minimum resistance value of either 0·1 ohm or 0·5 ohm which, as we have said, is too high if the dissipation is to be kept to reasonable proportions, so it was decided to make one. Resistance wire was considered but this is difficult to solder to, so a piece of p.c.b. track was tried.

Using 2oz copper clad board with a piece of track 3mm wide (which should be capable of carrying up to 18A) and 24mm long, it was found that a voltage drop of about 1·7mV was obtained from a 100W light bulb (which is a current of about 400mA). A 6A to 12A current would produce a voltage drop of 25mV to 50mV which, with only a modest amount of amplification, would produce a usable signal.

CIRCUIT DETAILS

The complete circuit diagram for the Kettle Alert is shown in Fig. 1. This consists of resistor Rs (etched on the printed circuit board) and an amplifier based on IC1 together with the alarm circuit based on IC2.

The a.c. voltage across Rs is amplified by the op.amp IC1a which has a gain set by resistors R4/R5 with capacitors C3 and C4 coupling the signals to the input. The amplified voltage is rectified by diodes D3 and D4 producing a voltage across capacitor C6. IC1b compares this voltage to that appearing across resistor R7 and its output goes high when the kettle is switched on, and falls when the kettle switches off as the charge on capacitor C6 leaks away, via resistor R8.

The negative transition is passed to IC2a by capacitor C7, causing a positive pulse at its output (pin 3) which charges capacitor C8 via diode D5. IC2b forms a gated oscillator which now oscillates at a frequency determined by capacitor C9 and resistor R11 (about 1Hz with the component values specified), causing transistor TR1 to turn on and off pulsing the buzzer WD1. If required, the value of C9 could be changed to produce an audio frequency and the buzzer replaced by a piezo element to provide a continuous tone, however a pulsed tone is much better in attracting attention.

Capacitor C8 now discharges via resistor R10 causing the buzzer to switch off after about 10 seconds. Again the time for which the buzzer sounds can be varied to suit individual requirements by changing the values of either C8 or R10.

The power for the circuit is supplied by a low loss voltage dropper capacitor C1 ***(this capacitor must be rated for use at 240V a.c.)***, and clamped by the Zener diode D1. This is then rectified and smoothed by diode D2 and capacitor C2 to give a 12V d.c. supply.

CONSTRUCTION

Because of the way that the resistor Rs is implemented, it is advisable to build the circuit on a printed circuit board (p.c.b.). It may be possible to use stripboard but this has not been tried, especially as the current carrying capacity of many types of board is not specified.

COMPONENTS

See SHOP TALK Page

Resistors

R1	100 ½W
R2	1M
R3	100
R4	470
R5	1M
R6, R7	82k (2 off)
R8	4M7
R9 to R11	270k (3 off)
R12	10k
Rs	see text

All 0·25W 5% carbon film, except R1 and Rs

Capacitors

C1	470n polyester, 400V d.c./250V a.c.
C2	470µ radial elect. 16V
C3, C4, C8	47µ min. radial elect. 50V (3 off)
C5	100n
C6, C7, C9	4µ7 min. radial elect. 63V (3 off)

Semiconductors

D1	BZX55C12V Zener diode
D2 to D5	1N4148 silicon diode (4 off)
TR1	BC558 *pnp* transistor
IC1	TL072 op.amp
IC2	4093 CMOS quad 2-input NAND Schmitt trigger

Miscellaneous

FS1	13A mains fuse
WD1	12V buzzer

Printed circuit board available from the *EPE PCB Service,* code 843; plug box with *metal* Earth pin; 3-way p.c.b. mounted terminal block; 8-pin i.c. socket; 14-pin i.c. socket; two p.c.b. fuse clips; connecting wire; double-sided adhesive tape; solder etc.

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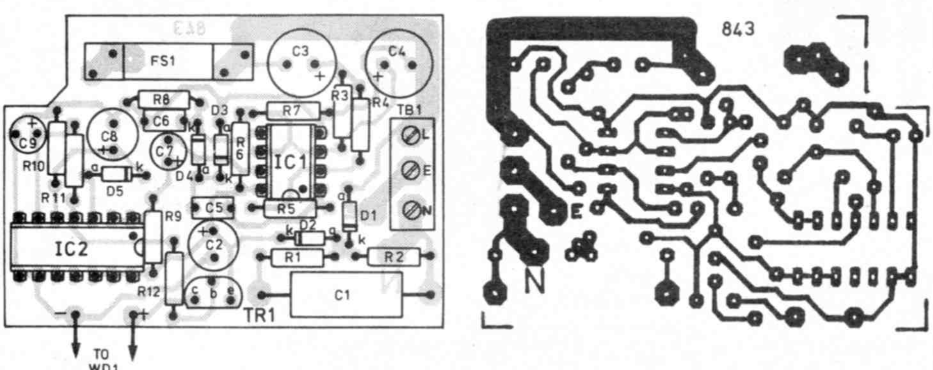
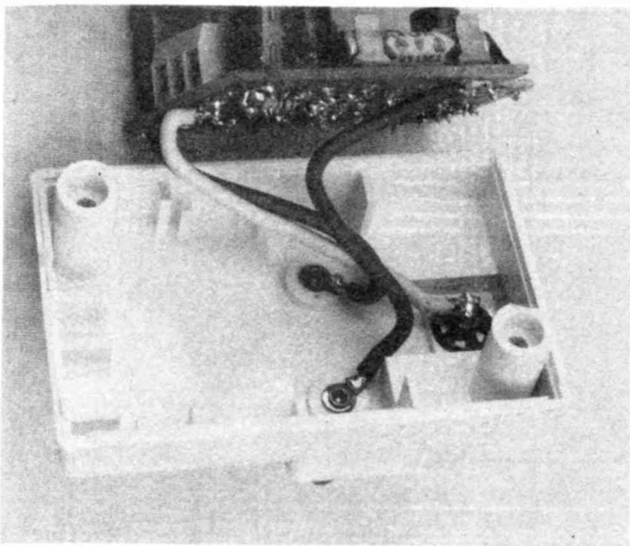
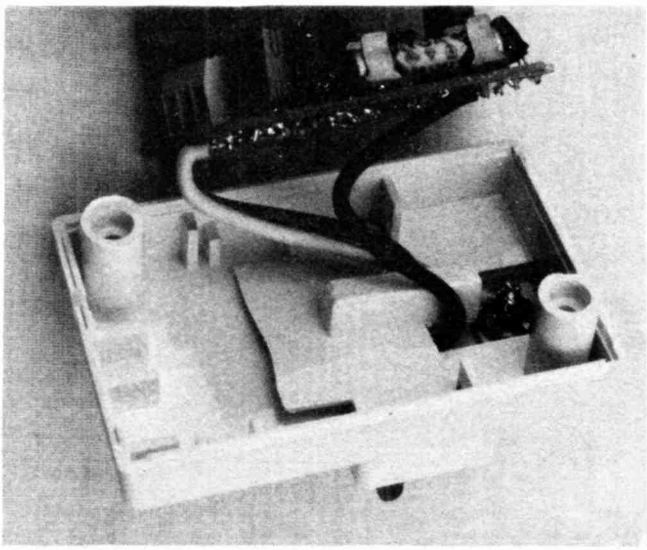


Fig. 2. P.C.B. layout and wiring for the Kettle Alert.





The connections to the mains pins . . . . must be protected with an off-cut of plastic

The printed circuit board topside component layout and underside copper foil master is shown in Fig. 2. This p.c.b. is available from the *EPE PCB Service*, code 843.

Construction of the circuit is fairly straight-forward and should not pose any problems as long as care is taken to ensure that diodes, electrolytic capacitors and i.c.s are soldered into the circuit the right way around. Sockets are recommended for the i.c.s, especially IC2 which is a CMOS device and static sensitive and should therefore be handled carefully.

The circuit is quite tolerant of component changes and many may be varied to tailor the circuit to individual requirements. make sure however that capacitor C1 has a rating ***of at least 250V a.c. or 400V d.c. and is suitable for use at mains voltages***, as failure of this component could cause severe damage to the rest of the circuit.

When assembly has been completed, double-check the wiring again to make sure that there are no bridged tracks. In a circuit of this type, an incorrect connection or a bridged track could easily result in the full 240V a.c. mains voltage being applied to a component rated at only 20V or 30V d.c. and it doesn't take much imagination to visualise the result!

Do not attempt to test the unit without mounting it in a fully enclosed plastic case. Mains voltages are present on the p.c.b. and the finished unit should be carefully checked before plugging it in.

PLUGGED-IN

The circuit has been designed to fit into a plug box of the type used for small d.c. mains adaptors and since it is designed to replace the plug itself, provision for fitting a mains fuse has also been made. These boxes are readily available but most do not have a metal Earth pin. In this application it is ***essential*** that a box with a ***metal earth pin*** is purchased as even in a plastic kettle, the element itself must be "earthed".

The three pins in the box should be connected to the appropriate points on the printed circuit board with suitably rated wire. Remember that the current flowing in these wires could be as high as 12A depending on your kettle. Note that the earth (E) and neutral (N) wires go straight to the output terminal block TB1.

Finally, connect the buzzer to the printed circuit board at the points shown, making sure that it is connected the right way around (red lead to the hole nearest to the transistor). The buzzer may be secured to the lid of the box with a piece of double-sided adhesive tape.

In practice, it was found that the sound from the buzzer was quite adequate from within the box. However, if you are in the habit of putting the kettle on and then going to the potting shed at the bottom of the garden, then the buzzer may be mounted behind a hole drilled in the lid of the box to enable a louder sound to be generated.

Remember to make a hole for the kettle lead. As there is no provision on the box for anchoring the cable, another method of doing so must be found such as a cable strain relief bush or grommet to prevent direct stress on the p.c.b. and terminal block if the cable should be pulled.

FULL STEAM AHEAD

The unit is now ready to test. Connect a kettle lead to the terminals with the brown wire (L) to the right hand terminal, the blue wire (N) to the left hand terminal and the green/yellow or earth wire (E) to the centre. Insert an off-cut of plastic over the back of the pin connections – see photos above – to make sure that nothing can short with them, then close up the box and switch on.

After a few seconds, switch the kettle off manually whereupon a series of "beeps" should be produced and after some 10 to 15 seconds these should stop. You may find that sometimes the circuit produces its series of beeps when it is first powered up but this is of no consequence.

If all is well, fill the kettle with water and switch on. When you hear the "beeps" you will know that its time to relax with a well earned cup of tea. □

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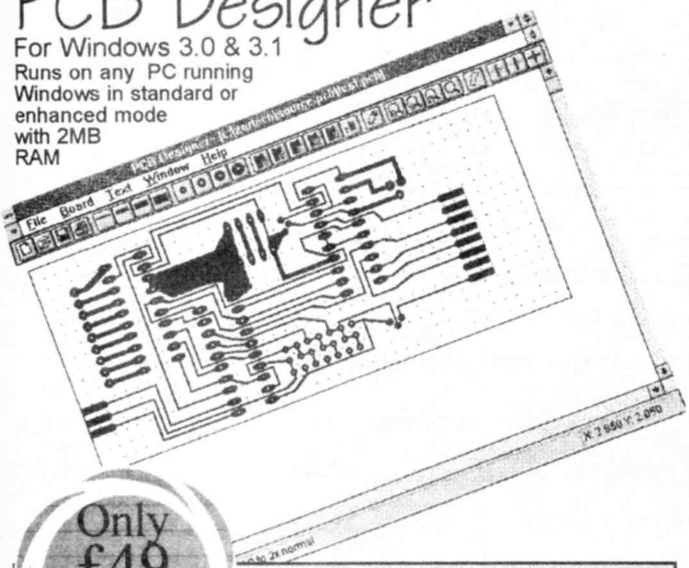

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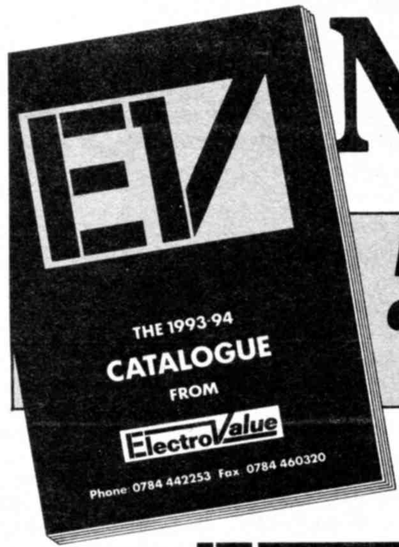

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Constructional Project

L.E.D. SANDGLASS

MARK DANIELS

An l.e.d. novelty that mimics the "sands of time".

THE boiling of an egg has for centuries, been timed using a sandglass. There have been many recent attempts to update the egg-timer using modern electronics, many of which have enjoyed a reasonable degree of success.

However, most, if not all of these attempts have deviated quite considerably from the original concept of sand in glass, usually opting for some form of visual or audible indication that the timing period has ended. This often removes the need for continual monitoring of the timer, which can be an advantage.

The egg-timer described here is intended only to mimic the sand in glass device it replaces without providing (sometimes annoying?) audible evidence of its presence. It merely attempts to bring the traditional egg-timer up to date without greatly altering the original concept. The display medium in this timer is an array of twenty light emitting diodes (l.e.d.s), rather than the slightly more traditional sand.

DISPLAY

The display consists of twenty 5mm diameter l.e.d.s arranged as two isosceles triangles placed point to point, thus forming the figure 8 shape of a sandglass as in Fig. 1.

The illustration also shows the order in which the l.e.d.s "fall". As the sand falls the red l.e.d.s of the upper inverted triangle turn off and their corresponding partners in the lower triangle illuminate green to represent the sand which has fallen. The operation continues until all of the red l.e.d.s have switched off, and all of the green ones are glowing, at which point the timing ceases and, with luck, if the timer is set correctly the egg should be done to perfection!

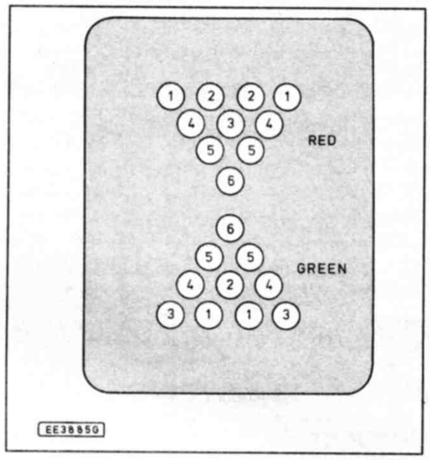


Fig. 1. Display layout and operating sequence.

CIRCUIT DESCRIPTION

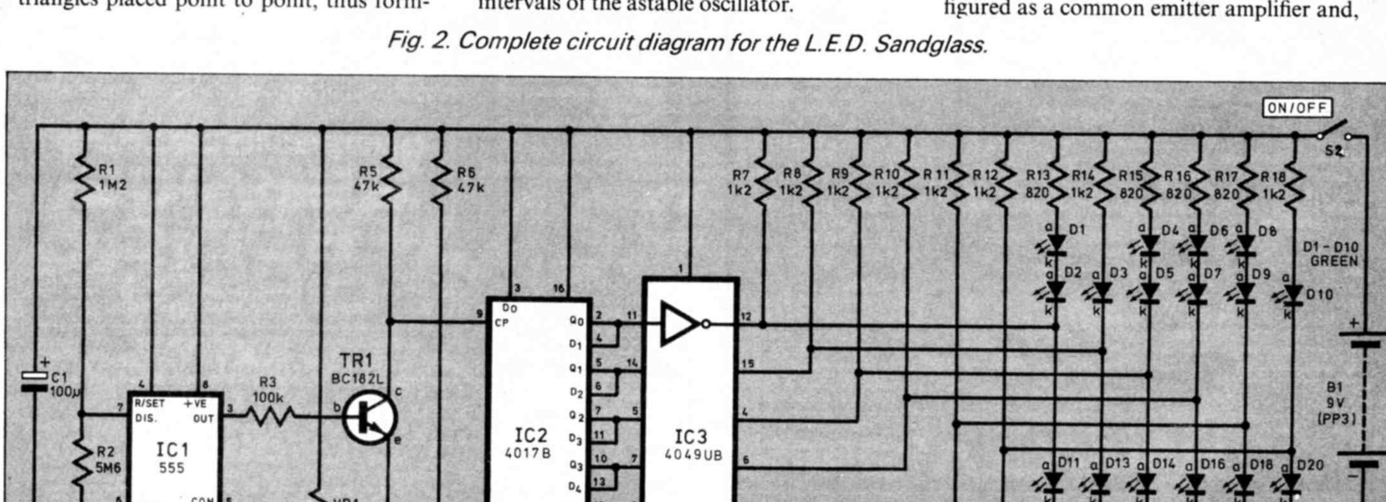
The complete circuit diagram for the L.E.D. Sandglass is shown in Fig. 2. Power for the circuit is drawn from a PP3 9V battery, B1 via switch, S2, the on/off switch, a miniature slide type.

The 555 timer, IC1 is employed in its astable mode to generate a low frequency rectilinear waveform of unequal mark-space ratio, which is determined by resistors R1 and R2. These two resistors, along with capacitor C2 also set the basic timing intervals of the astable oscillator.

A control voltage applied to pin 5 of IC1 allows adjustment of the operating frequency without altering the mark-space ratio of the timer. The necessary control voltage is derived from the 9 volt supply using a potential divider network, consisting of a preset potentiometer, VR1 and fixed resistor, R4, the control voltage appearing at pin 5 of IC1.

The output of IC1 at pin 3 is applied to the base of transistor TR1, via current limiting resistor R3. The transistor is configured as a common emitter amplifier and,

Fig. 2. Complete circuit diagram for the L.E.D. Sandglass.



as such, the waveform at its collector is inverted compared to the output of IC1. Resistor, R5 is included to pull the input pin of IC2 high when TR1 is turned off, since CMOS inputs must not be left floating.

The inversion performed by TR1 and R5 is necessary since the clock input of IC2 (pin 9) is positive edge triggered and would be clocked immediately at switch on or after reset, as the first half cycle of IC1 is positive.

The CMOS integrated circuit, IC2 is a Hex D-type flip-flop. Each of the six flip-flops contained in the device have a single input and output. All are internally linked to the clock input.

In this circuit the input terminal of the first gate, pin 3, is connected to the positive supply rail and when a clock pulse arrives on pin 9 the data on pin 3 is transferred to its output, pin 2 which goes high.

The input of the next flip-flop in the chain (pin 4) is connected to the output of the first (pin 2) and on the second clock pulse its output also goes high. The first, and all the remaining flip-flops in the chain are unaffected by this change, since their inputs and outputs were both low before the clock pulse. The third flip-flop now has a high on its input, but its output cannot change state until the next clock pulse arrives.

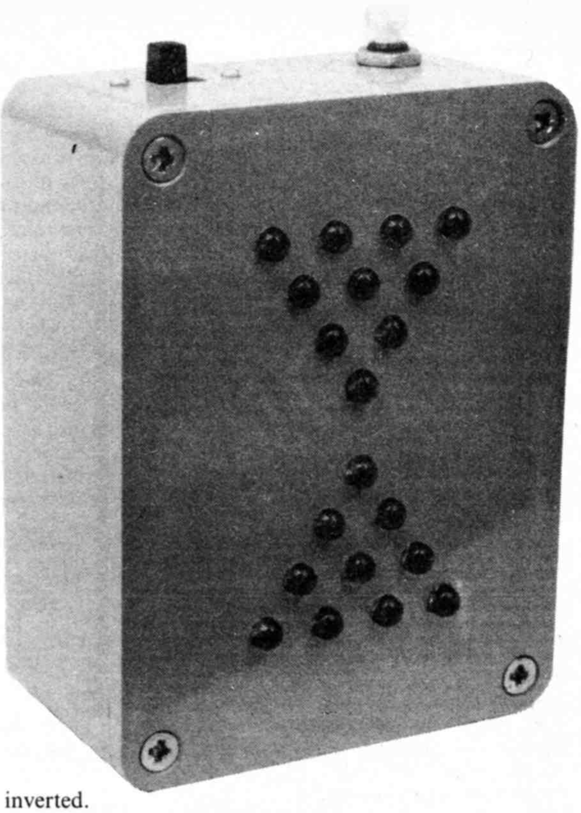
The data is thus transferred through the divider chain one bit at a time, until all outputs are high. When the last output goes high the process does not stop, although it appears to do so, as all the data moving down the chain is now identical and all the outputs thus remain high until a reset pulse is applied to pin one of IC2 by depressing switch, S1 momentarily.

DISPLAY DRIVER

The outputs of IC2 are only standard low current CMOS outputs which are not capable of supplying the current required to drive the l.e.d.s and a buffer stage is necessary. A 4049UB Hex inverting buffer, IC3, which has high current outputs, was used in the prototype to drive the display.

A 4050UB could be used equally well in this application, being pin compatible with the 4049UB with the exception that its outputs are not inverted. This causes no electrical problems here, as the display can simply be inverted to compensate for the inverted display which results from the use of this alternative component.

The outputs of IC3 are connected to the positive supply rail via pull-up resistors, R7 to R12. This provides the buffers with balanced current driving capabilities, since the i.c. is capable of sinking considerably larger currents than it can source. Without the resistors the buffers would not be able drive sufficient current through the l.e.d.s, D11 to D20 which may, as a result, only glow dimly, or worse IC3 may be damaged by the excess current.



Diodes D1 to D10 are the green l.e.d.s and have their current limited by resistors R13 to R18. Where the l.e.d.s light up in pairs they are series connected to keep the current through IC3 to a minimum, whilst maintaining brightness. The remaining l.e.d.s D11 to D20, with their respective current limiting resistors, form the red half of the display.

The electrolytic capacitor C1, included for the purposes of supply decoupling, absorbs the spikes produced by IC1 as it "crowbars" the supply once per cycle. Without this decoupling IC2 may be triggered falsely by the spikes, thus producing inaccurate timing.

COMPONENTS

Resistors

R1	1M2
R2	5M6
R3	100k
R4	22k
R5, R6	47k (2 off)
R7 to R12, R14, R18, R20, R24	1k2 (10 off)
R13, R15 to R17, R19, R21 to R23	820 (8 off)

All 0·25W 5% carbon film

Potentiometer

VR1 47k sub-min. horizontal preset, lin.

See SHOP TALK Page

Capacitors

C1	100μ radial elect., 25V
C2	4μ7 tantalum

Semiconductors

D1 to D10	5mm green l.e.d.s (10 off)
D11 to D20	5mm red l.e.d.s (10 off)
TR1	BC182L *npn* silicon transistor
IC1	555 timer
IC2	40174B or 74C174 Hex D-type flip-flop
IC3	4049B Hex buffer inverter

Miscellaneous

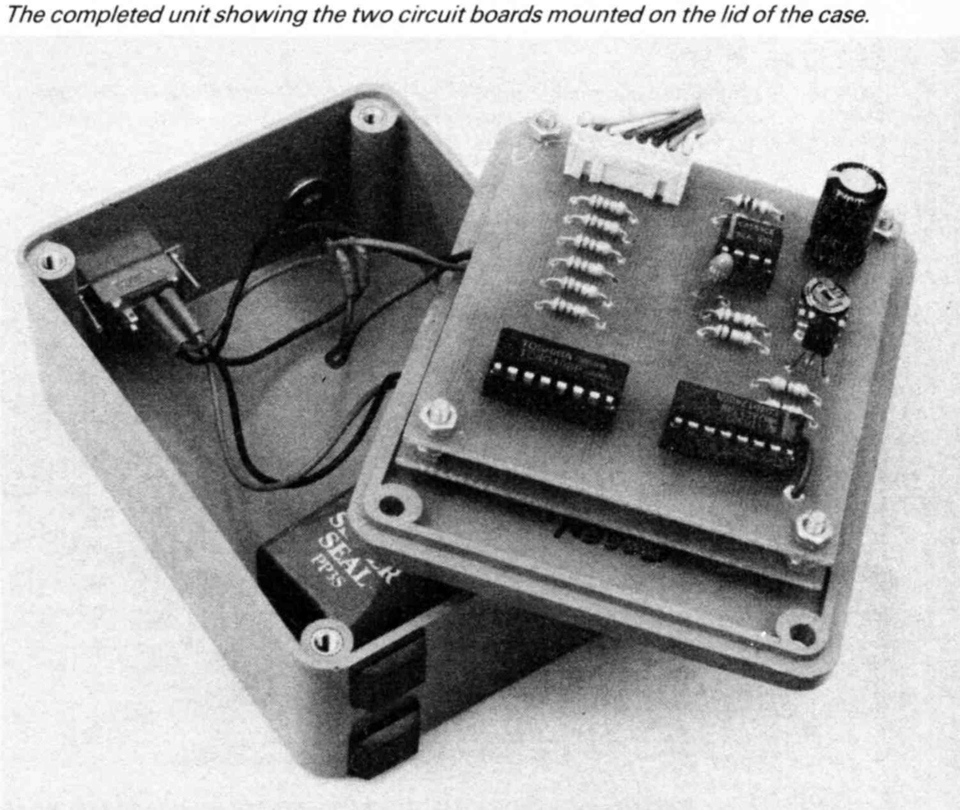
B1	PP3 9V battery, with connector
S1	Push-to-make switch
S2	d.p.d.t. miniature slide switch

Plastics case, size 100m x 76mm x 41mm; 8-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); 8-way p.c.b. header plug and socket; connecting wire, self-adhesive rubber feet (4 off); solder etc.

Printed circuit boards available from the *EPE PCB Service*, codes 841 and 842.

Approx cost guidance only **£14**

The completed unit showing the two circuit boards mounted on the lid of the case.



CONSTRUCTION - MAIN BOARD

The three i.c.s and their support components are mounted on a single-sided glass-fibre printed circuit board, the full size copper foil pattern and component layout for which are shown in Fig. 3. This board is obtainable from the *EPE PCB Service*, code 841.

The order of assembly of this board is relatively unimportant if sockets are used for the three i.c.s. Transistor TR1 should be the last component to be soldered into place.

An 8 way p.c.b. header set, comprising a 0·1in. pitch plug, which is soldered to the board and a socket which is fitted to flying leads is recommended for the main external connections to this board. The header socket uses crimp terminals, which are fitted to the wires by crimping with a special tool and then inserting them into the plastic plug body.

It is not envisaged that a great many readers will have access to the correct tool for the crimping the terminals and the following method may be adopted. Bare approximately 3mm of conductor and insert it into the crimp, close the crimp over the conductor using narrow nosed pliers and carefully solder the wire to the terminal.

Finally close the insulation crimp over the insulation of the wire. The terminal may then be inserted into the header socket, when it should engage with a positive click.

The final connection to this board is made by threading a lead through the hole in the p.c.b. adjacent to its pad, from the underside and then inserting it into its correct hole from the top before soldering it into place.

The three i.c.s may now be inserted into their respective sockets, observing normal handling precautions for the CMOS devices, IC2 and IC3.

DISPLAY BOARD

All twenty l.e.d.s and their current limiting resistors are mounted on a separate printed circuit board. The foil pattern and respective component overlay are shown in Fig. 4. This board (842) is also available from the *EPE PCB Service* and forms a pair with the main board.

It is recommended that the resistors are assembled on the board first as the l.e d.s are sensitive to excess heat. All of the l.e.d.s of each colour should ideally come from the same manufacturing batch to ensure accurate colour and intensity matching, although in practice the differences in separate batches of the same l.e.d.s are normally minimal.

If there is any uncertainty a simple comparison test using a 9 volt battery and an 820 ohm resistor in series with each l.e.d. in turn should avoid any problems at a later stage of construction.

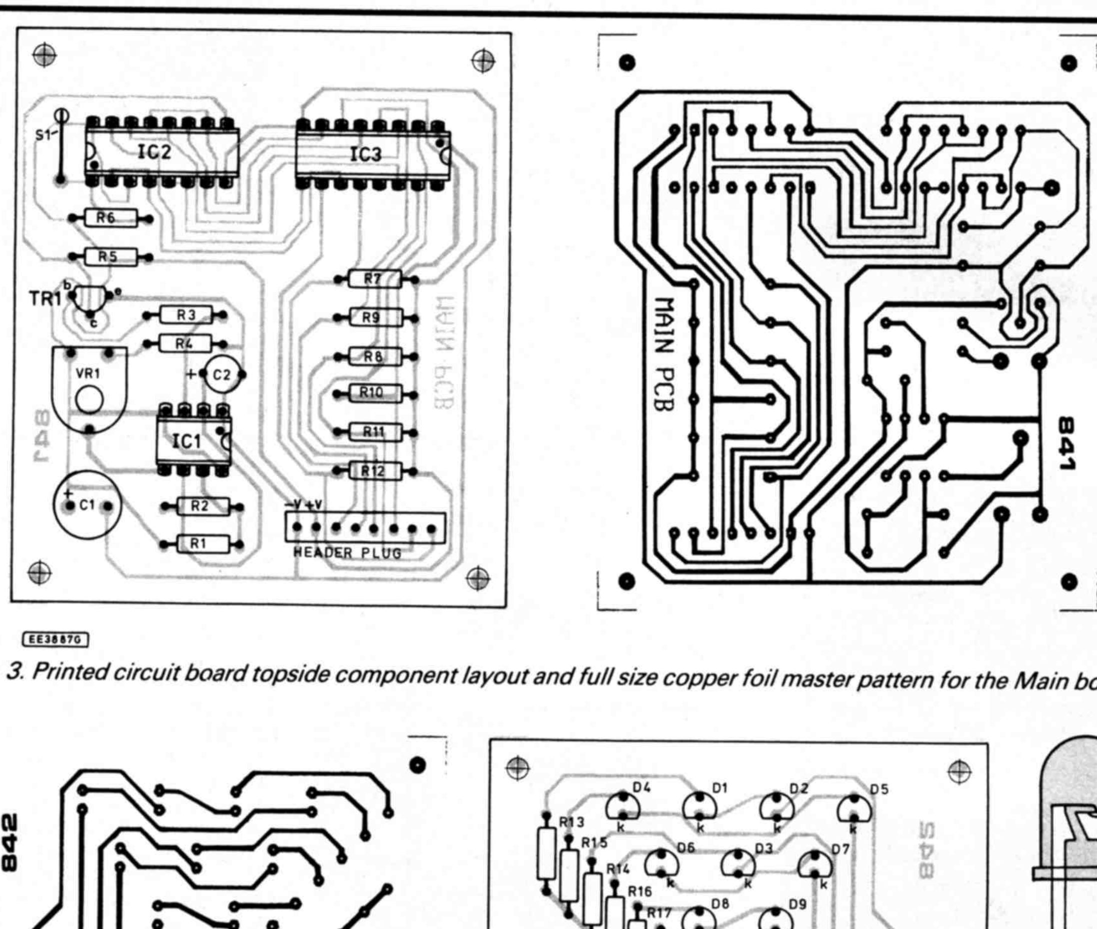


Fig. 3. Printed circuit board topside component layout and full size copper foil master pattern for the Main board.

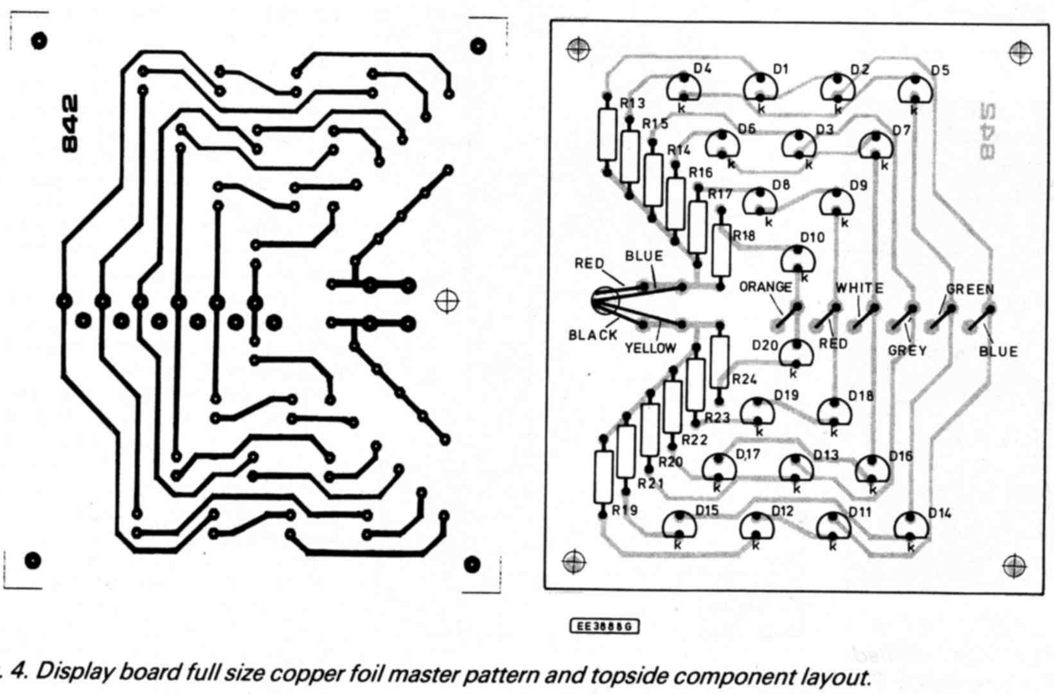


Fig. 4. Display board full size copper foil master pattern and topside component layout.

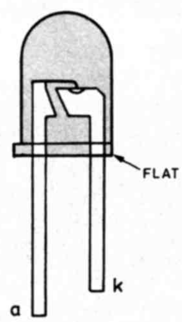
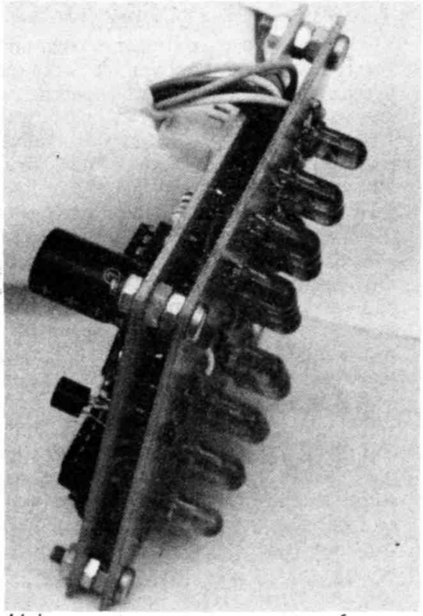
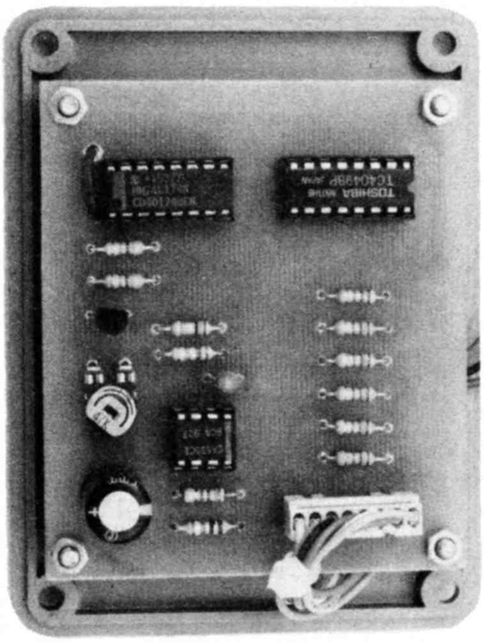


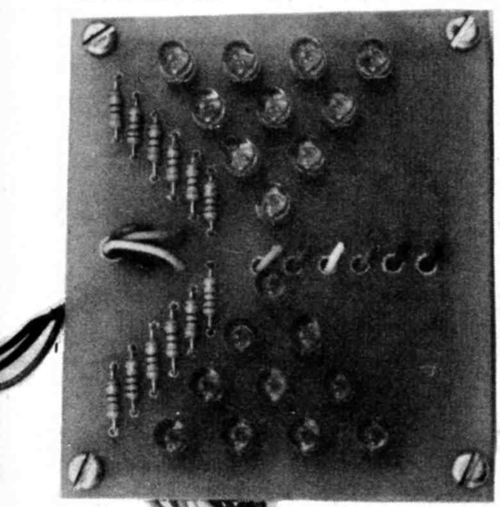
Fig. 5. Identifying the leadout wires of the l.e.d. The cathode lead is usually adjacent to a flat on the body and shorter. The internal connection is the larger of the two.



Using nuts as spacers to form a "sandwich" of the two boards.



The completed timer board mounted on the case lid.



The finished display board is mounted face-down below the main board, the l.e.d.s protruding through the case lid.

Assembling the l.e.d.s on the board requires a little care, since they must *all* end up at the same height above the p.c.b. Stops are provided on the pins of most l.e.d.s and when they are inserted into 0·8mm holes they set them above the surface of the board by a fixed amount, thus setting them all at the correct height.

Ensure that when they are fitted the l.e.d.s stand square to the board and in line with the others in the same row. It is also important to ensure that all l.e.d.s are inserted the correct way round as they are polarity conscious – see Fig. 5..

INTERWIRING AND CASE

All interconnecting details between the two boards and the external components are shown in Fig. 6. Ensure that the leads used between the header plug/socket and the display board are sufficiently long to enable the boards to be mounted back to back when assembled.

The main board and display board have been designed so that when mounted in the manner described the connections between the two are in line and in the correct order without crossing any leads over. The wires are threaded through the holes next to their respective pads, as shown and are then inserted into the holes in the pads before being soldered in the normal manner.

If the recommended size of box is used the positions of the holes for the two switches will be as shown in Fig. 7. The switches should be mounted close to the back of the case, in order to clear the main p.c.b. when it is fitted.

Allow sufficient length of connecting lead to permit the box lid to be laid flat on the bench next to the main box, when removed. Both battery connections are made to switch, S2, a double-pole changeover slide switch, which in this application is only used as a double pole on/off switch.

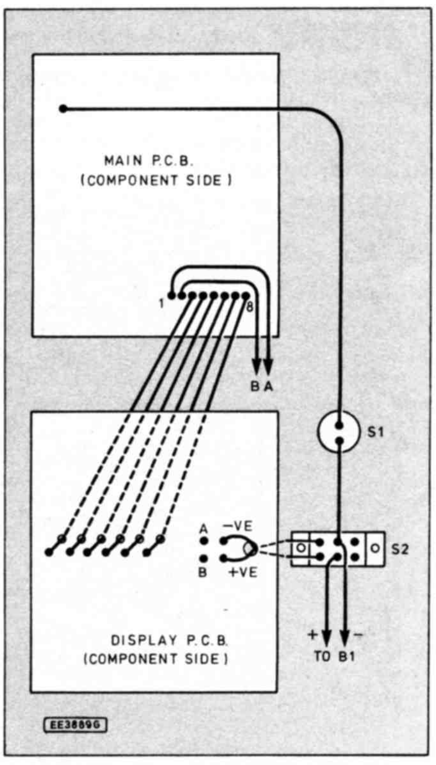


Fig. 6. Interwiring between the two p.c.b.s and switches.

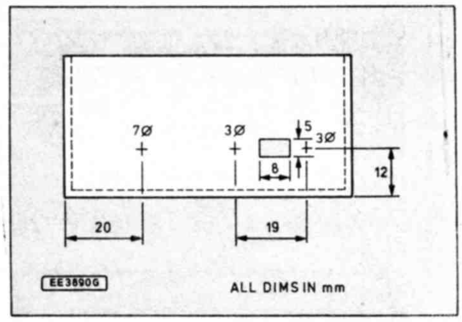
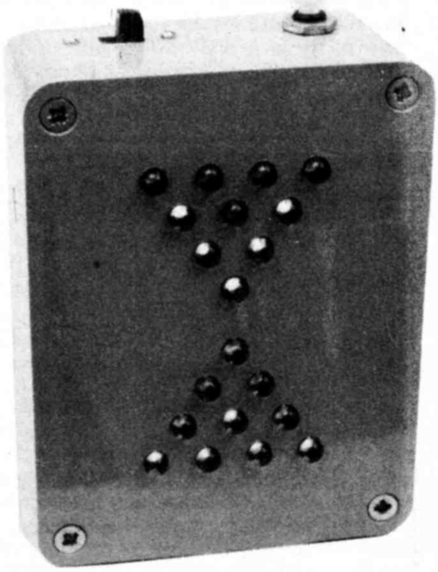


Fig. 7. Drilling and dimensions for mounting the switches in the case. The display l.e.d. layout can be seen below.



SETTING UP AND TESTING

Connect a 9V battery to the battery connector and switch on. Ten l.e.d.s should be illuminated. Pressing the Reset button, S1 should reset the display to all red l.e.d.s lit and all green ones off. If the display already shows this then a reset operation will do nothing.

If the above can be obtained leave the unit running and check the display for correct operation against Fig. 1. Any discrepancies may be corrected by checking and altering the wiring between the two boards, although mistakes here are unlikely.

If one or two of the l.e.d.s do not illuminate at any time it is most likely due to incorrect connections being made to them, and simple de-soldering and re-insertion the correct way round will cure this. The polarity of an l.e.d. may be ascertained by comparing it with Fig. 5 where it will be seen that the internal cathode (k) connection is the larger of the two. This applies in the vast majority of cases, but one notable exception is Ultra and Hyper-bright types where the opposite normally applies.

Preset potentiometer, VR1 should be adjusted once the unit is functioning correctly, to give the desired time for your eggs. If it is not possible to obtain the required time further adjustment may be made by changing the value of resistor, R2 or capacitor C2. Making either of these larger in value lengthens the delay.

Resistor R2 should ideally be kept in the range 1M to 10M, while C2 may be varied between 1μF and 22μF. Values outside of this range may be used but will give times vastly different from those required for the aforementioned purposes. □

Home Base

Jottings of an electronics hobbyist – Terry Pinnell

Deaf Alarm

Chatting to a friend in the office, we got onto the topic of early rising, and he mentioned that he had to wake his deaf teenage daughter each morning. She had to leave very early for work but because of her handicap could not use normal alarms like a clock or radio. I could feel my problem-solving muscles flexing as he spoke, and the following weekend found me engrossed in exploring the electronic possibilities.

There were really two distinct design decisions to be made: what device should do the actual waking, and how to trigger it at the chosen time. Ruling out sound, the options I considered for the waking device were:

Light

How pleasant it would be to make a virtue out of a necessity and wake her by simulating the sun beaming down onto her face. A bright spotlamp perhaps, or an infra-red lamp of the sort sometimes fitted in expensive bathrooms. The latter was quickly dismissed as I didn't know enough about IR to be sure of its complete safety in the case of prolonged exposure.

However I did try a few experiments with a normal domestic 100W spotlamp, but came rapidly to the conclusion that even flashing a couple of feet away it couldn't be reliably expected to wake someone up, even if they happened to be facing directly towards it.

Breeze

So how about a pleasant stream of refreshing air from a bedside fan? The only type I could immediately put my hands on was a little novelty affair with self-extending vanes about 50mm across, driven by a 1·5V battery. Predictably, that proved virtually useless.

When holding it even as close as a couple of inches from one ear, I could just about convince myself that it might wake me up, rather than just prompt me to pull the duvet around my head. But it was clearly impossible to devise a reliable way of ensuring the fan *stayed* in position relative to the sleeper – short of strapping it to her head!

This miniscule device was clearly not doing justice to the basic idea though, so I next rigged up a much larger fan, using a mains driven motor and a set of blades I dug out of my junk box. Finding a way to mount it was not easy. With the fan inside a large aluminium coffee tin for example, I could only just detect the breeze a couple of feet away. The impracticality of this idea was by then becoming glaringly obvious, so I abandoned it.

Electric Shock.

I have to confess that I did fleetingly toy with the idea of a (battery operated!) wrist strap of some sort. The contacts would deliver a modest voltage of 40V or 50V. But it really was fleeting!

Good Vibrations

I suppose you would not be surprised if I told you that I went on to consider water dripped over the unfortunate sleeeper, or perhaps a rope around her ankle connected to a heavy-duty winch ... but even I have my limits. No, the idea finally implemented was very simple, but proved extremely effective.

The method selected was to improvise something which would vibrate sufficiently if placed under the pillow. After experimentation I eventually chose a small d.c motor with a lead weight (courtesy of my fishing tackle box) secured off-centre to its spindle. This was all enclosed snugly in a sturdy plastic pill container.

I tried various d.c voltages using my home-built bench supply and experimented with several different motors. The one I finally settled on was a powerful specimen, which produced a strong vibration when using 3V to 4·5V. It had a hungry peak current consumption of about 1 to 2 amps though, so I was certainly going to need HP2 (D-type) batteries.

I suppose if I'd been making it for use within my own family then I would probably have considered NiCads, as they could have been smaller and still delivered the high current and I would have been able to recharge them easily.

Trigger

Having selected the "output" medium, the other main design decision was how to trigger it at the set time. I dismissed the absurdly expensive (although potentially reliable) method of extracting a signal from a clock/radio. Also discarded were ideas dependent on a long duration timer circuit. Conventional analogue versions using a large capacitor and resistor would be inexact and would be quite impractical in use.

Digital types would either be too expensive, or, if made out of the simple TTL or CMOS i.c.s which I had to hand, they would probably require starting the device at precisely 2-to-the-power-N seconds before wake up. For anyone other than full time members of the Masochists' Society that was not exactly what you'd call a user friendly arrangement, nor a welcome chore before falling into bed after a late night party, even if she had a Ph.D in Maths, which she didn't.

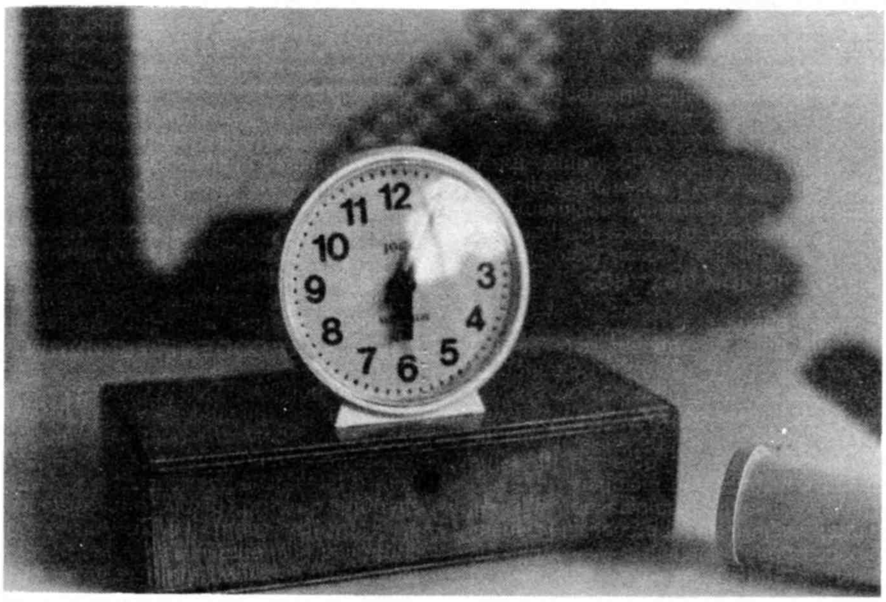
No, my choice was right at the other end of the technology scale: an old, cheap mechanical alarm clock – which I just happened to have in my loft. Almost as far removed from a digital alarm as an abacus is from an Intel 486 chip. The astonishing thought occurs that there may conceivably be young EPE readers who have never encountered one of these archaic items of bedroom equipment. If so, they will no doubt want to study the photograph with appropriate awe.

But how could this old alarm clock trigger power to the motor-vibrator? Unfortunately I jumped to what I now realise was the silly conclusion that some form of sound detector was the answer. I spent several days cheerfully experimenting with a plethora of such designs. My loose-leaf circuits binder is six pages thicker as a result of this digression. If it's sound-detection you want, I'm your man.

Waste of Time?

But for reasons which I won't attempt to fathom, sometimes the further back I can push the finishing point of a project, and the more options I can explore en-route, the more satisfaction I get out of it. So what might sound a real waste of time was actually fun. Who can confidently define "a waste of time" anyway?

Sanity eventually prevailed and I abandoned the sound detecting approach as gross over-kill. The finally chosen method will be revealed when I conclude the saga next month; hope the suspense doesn't keep you awake nights.



The final alarm using a mechanical clock.

REPORTING AMATEUR RADIO

Tony Smith G4FAI

ISWL AWARDS

As the winter nights draw in radio hobbyists spend more time tuning round the bands, often working for operating awards which record their achievements and decorate their shack walls at the same time! Apart from providing a demonstrable record, working for an award adds a pleasurable extra dimension and purpose to both amateur radio operating and shortwave listening

Chris Carrington, Publicity Officer of the *International Short Wave League*, has drawn my attention to the fact that the ISWL has nine awards available to both members and non-members of the League. Eight are open to both licensed amateurs and SWLs; several are open to broadcast band listeners as well, while the ninth is exclusively for broadcast listeners. They are free to members and a small charge is made to non-members.

Full details can be obtained from the ISWL Awards and Contests Manager, *Herbert Yeldham G6XOU, Deal Hall Farm, Burnham Marshes, Burnham-on-Crouch, Essex CM0 8NQ.* There's no mention of postage, but I'm sure an s.a.e. or IRC would be appreciated.

R.F. RADIATION HAZARDS

In the USA, the Federal Communications Commission proposes to update its guidelines for evaluating environmental radio frequency (r.f.) radiation from FCC regulated transmitters, including those used by amateur radio operators.

The existing (1982) guidelines use a term called "specific absorption rate" (SAR). This is basically the time frame in which r.f. is absorbed into the human body.

The formulae are complex, but the guidelines generally indicate that low power transmitters with seven watts or less r.f input power are safe. They recommend frequency-dependent exposure limits as studies have shown that the human body absorbs r.f. energy at some frequencies better than others, with the most restrictive limits being in the 30MHz to 300MHz range.

The even more stringent 1992 standards proposed, and already adopted by the American National Standards Institute and the Institute of Electrical and Electronic Engineers, are based on recent data on biological effects, and look at r.f. exposure under both "controlled" and "uncontrolled" conditions.

A controlled environment is one "... under the control of an aware user." Again complex formulae apply when determining safe levels for both environments. There are also new restrictions on r.f. fields induced in the human body at frequencies below 100MHz.

EXCLUSIONS

In certain situations, however, there are exclusions from the formula. For example, in a controlled environment, low power transmitters radiating seven watts or less are deemed safe at 450MHz or below when the antenna is more than 2·5cm from the body (but note that a "rubber duck" antenna on a handheld transceiver is frequently closer to the head than that).

The safe level is reduced as the frequency rises. For example, 2·5 watts is the maximum safe level for low power devices at 1240MHz in a controlled environment.

While transmitter users are considered to be in a controlled environment, others in the immediate vicinity are deemed to be in an uncontrolled environment, where the guidelines are stricter.

The safe level of a low power transmitter operating below 450MHz in an uncontrolled environment is 1·4 watts, and at 1240MHz about half a watt. Field strengths drop off sharply as the distance from a radiator increases, and a 2-metre transmitter running 500 watts e.r.p. (effective radiated power) would meet the required limits if the antenna was 11 metres above ground level. *(W5YI Report).*

FRENCH NO-CODE REFERENDUM

Anticipating that the IARU Region 1 Conference in Belgium, in September, would be discussing the question of a Morse-free licence, the French national radio society, REF, conducted a referendum last April.

Members were asked: "Do you want radio amateurs to have access to 28 MHz (observing the IARU bandplan) without having to pass a Morse code examination? 'Yes' or 'No'?"

The result of this referendum was a majority of 71 per cent saying "Yes", and I understand that REF then decided to submit a proposal to the IARU Conference based on that result, suggesting code-free operation for amateurs in the 10-metre band.

The conference, is one of three regional conferences under the aegis of the *International Amateur Radio Union*, and does not, itself, have the power to change the international regulations. The rules are formulated by the *International Telecommunications Union*, and it may be some years yet before formal proposals for change, supported by all three IARU regions are placed before the ITU; especially as the influential American Radio Relay League (ARRL) decided earlier this year to continue to support the retention of the code as an examination requirement for amateur operation below 30MHz.

FREE MORSE PROGRAMS

In the meantime, anyone wishing to be a radio amateur operating on the h.f. bands will still need to pass a Morse test. Learning the code is not all that difficult once you are committed to the idea and a popular way to do it nowadays is by computer.

In this connection, *Morsum Magnificat* (the Morse magazine) is offering free copies of a number of Morse learning programs developed by Dr. Gary Bold ZL1AN, who writes the "Morseman" column in *Break-In*, the journal of New Zealand's national radio society. These provide a complete learning package ranging from the needs of complete beginners to those wishing to achieve high operating speeds.

TEACH, is a "start from scratch" code teacher which teaches all Morse characters from their sound. New symbols are introduced one at a time, with the longest, most uncommon, symbols first. This program is adaptive inasmuch as it uses feedback from the student's performance to modify the teaching process, deciding which characters need to be sent most often and when new characters should be introduced.

RNDM generates random code groups at any speed, at any audio frequency, from any subset of characters, printing each group on the screen after it has been sent.

FSEND sends any ASCII file as Morse.

KBD is a Morse keyboard simulator with anything typed on the keyboard sent as audio Morse.

RWD is a random word sender. It reads any ASCII file, pulls out individual words and sends them in random order. This provides practice in reading "real words" without the possibility of anticipating what follows.

MREAD reads Morse after connecting a key across two pins of the RS232 port. It decodes what is sent and prints it on the screen. This can be of great assistance in learning to send readable Morse or improving existing keying ability.

All sent codes in these programs use Farnsworth (ie, extended) spacing up to 14wpm but any other Farnsworth speed can be set while programs are running if this is desired.

The original (IBM compatible) programs require GWBASIC or QBASIC to run them. However, compiled versions are also included in the UK distribution for those preferring to run them without BASIC. A long README ASCII text file explains everything, and detailed instructions are provided in TXT files for each program.

Some of the advice given is based on the New Zealand plain language amateur Morse test but learners aiming for the UK test, which involves sending and receiving amateur abbreviations, etc., can still master the code using TEACH. They can then generate suitable material in ASCII text files, which can be used with FSEND or RWD, to help them prepare for the UK test.

The complete set of programs, is available free of charge by sending a formatted 3·5 inch disk (DD or HD), together with a *stamped addressed envelope* for its return, to me at 1 Tash Place, New Southgate, London N11 1PA.

DIRECT BOOK SERVICE

The books listed have been selected by Everyday with Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue.

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It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic recipe book with numerous examples showing how theory can be put into practice using a range of commonly available "industry standard" components and devices.
A must for everyone involved in electronics!
256 pages Order code DATA £8.95

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Owen Bishop
Another EE value for money publication aimed at students of electronics. The course is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. The book does not contain masses of theory or formulae but straightforward explanations and circuits to build and experiment with.
Exploring Electronics contains more than 25 useful projects, assumes no previous knowledge of electronics and is split into 28 easily digestible sections.
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Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.
Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.
The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.
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Contents: Features – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Project Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; Actually Doing It – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.
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Computers and Computing

HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM
D. Weale
This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs and how to actually make your choice as well as sections on the law, ergonomics and a glossary of common terms.
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This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PC's. It covers both floppy disc-based systems and hard disc-based systems.
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The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
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The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

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COMPUTERS AND MUSIC – AN INTRODUCTION
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This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

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This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can even be confusing.

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GUIDE TO BUILDING ELECTRONIC PROJECTS
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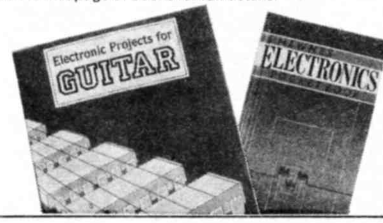

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ELECTRONIC POWER SUPPLY HANDBOOK
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This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.
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E. A. Parr
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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
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A. Pickford
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There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
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NEW NEW NEW

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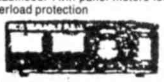

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Resistor pack 2500 resistors 1/8-2W 50 different values £8.95

Resistor jumbo pack 25000, 1/4 and 1/2W resistors our choice of values and size, will be mainly in boxes or rolls of 1000, 2000 and 5000 of one type £25.00
Qwerty keyboard, 58 key good quality switches, new £5.00
Qwerty keyboard with serial output, no data (used) £6.00
Polyester capacitors, box type, 22.5mm lead pitch 1µf 250V dc **20p** each, **15p** 100 +, **10p** 1000 + 2.2µf 250V dc **30p** each, **20p** 100 +, **15p** 1000 + 3.3µf 100V dc **30p** each, **20p** 100 +, **15p** 1000 +
1µf 50V bipolar electrolytic axial leads, **15p** each, **7.5p** 1000 +
0.22µ**f 250v** polyester axial leads, **15p** each, 100 + **7.5p** each
Philips 123 series solid aluminium axial leads, 33µf 10V & 2.2µf 40V **40p** each, **25p** 100 +
Multilayer AVX cerami capacitors, all 5mm pitch, 100V 100pf, 150pf, 220pf, 10,000pf (10n) **10p** each, **5p** 100 +, **3.5p** 1000 +
Welwyn W23 9W 120 ohm **35p** each, **20p** 100 +
680 ohm 2W metal film resistor, **4p** 100 +, **2p** 1000 +
Solid carbon resistors, very low inductance, ideal for RF circuits, 27ohm 2W, 68ohm 2W **25p** each, **15p** each 100 +, we have a range of 0.25W, 0.5w, 1w and 2w solid carbon resistors – please send SAE for list
Intelegent 4 digit alphanumeric (5x7 dot 0.145") red LED display, 12 pin 0.6 inch wide package, Siemens type DLR1414 **£2.50** each, **£2.00** 30 +, data sheets **£1.00**
AMD 27256-3 Eproms **£2.00** each, **£1.25** 100 +
DIP switch 3PCO 12 pin (ERG SDC-3-023) **60p** each, **40p** 100 +
Disk Drive Boxes for a 5.25 disk drive with room for a power supply light, grey plastic 67mm x 268mm x 247mm .... **£7.95** or **£49.50** for 10
Hand Held Ultrasonic remote control £3.95
Computer grade 58000µf 60V capacitors with screw terminals £4.95
CV2486 gas relay 30mm x 10mm dia with 3 wire terminals, will also work as a neon light .... **20p** each, **£7.50** per 100
A23 12V car alarm remote control and lighter battery .... **75p** each, **£50.00** 100 +
40µf 370V a.c. motor start capacitor (dielectrol type containing no PCBs) .... **£5.95** each, **£49.50** for 10

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Wide range of CMOS TTL 74HC 74F Linear Transistors kits, rechargeable batteries, capacitors, tools etc. always in stock

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POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E., 60p STAMPED FOR CATALOGUE ★

OMP MOS-FET POWER AMPLIFIERS
HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS

THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

PRICES:-MXF200 £175.00 MXF400 £233.85 MXF600 £329.00 MXF900 £449.15

SPECIALIST CARRIER DEL. £12.50 EACH

OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE

★ ECHO & SOUND EFFECTS★

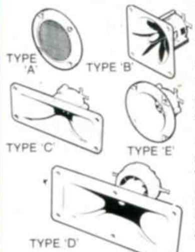
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.**

Price £144.99 + £5.00 P&P

SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

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



TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi apeakers. **Price £4.90 + 50p P&P.**

TYPE 'B' (KSN1005A) 3½" super horn for general purpose speakers, disco and P.A. systems etc. **Price £5.99 + 50p P&P.**

TYPE 'C' (KSN1016A) 2"x5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. **Price £6.99 + 50p P&P.**

TYPE 'D' (KSN1025A) 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. **Price £9.99 + 50p P&P.**

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. **Price £5.99 + 50p P&P.**

LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. **Price £4.10 + 50p P&P.**

ibl FLIGHT CASED LOUDSPEAKERS

A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12" cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

***ibl* FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR**
***ibl* FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR**

SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00
Delivery £6.00 per pair

IN-CAR STEREO BOOSTER AMPS

THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS

150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono

ALL POWERS INTO 4 OHMS

Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

PRICES: 150W £49.99 250W £99.99 400W £109.95 P&P £2.00 EACH

OMP MOS-FET POWER AMPLIFIER MODULES

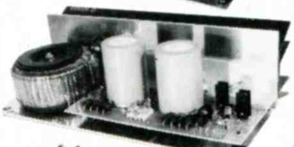
SUPPLIED READY BUILT AND TESTED.

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8" 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. **PRICE £32.71 + £2.00 P&P**

10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. **PRICE £33.74 + £2.50 P&P**

10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. **PRICE £43.47 + £2.50 P&P**

12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. **PRICE £35.64 + £3.50 P&P**

12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. **PRICE £36.67 + £3.50 P&P**

12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**

12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. **PRICE £70.19 + £3.50 P&P**

15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. **PRICE £50.72 + £4.00 P&P**

15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. **PRICE £73.34 + £4.00 P&P**

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. **PRICE £8.90 + £2.00 P&P**

10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. **PRICE £13.65 + £2.50 P&P**

10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. **PRICE £30.39 + £3.50 P&P**

12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. **PRICE £42.12 + £3.50 P&P**

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. **PRICE £9.99 + £1.50 P&P**

6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. **PRICE £10.99 + 1.50 P&P**

8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. **PRICE £12.99 + £1.50 P&P**

10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. **PRICE £16.49 + £2.00 P&P**

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PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
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PRICE £8.80 + £1.00 P&P

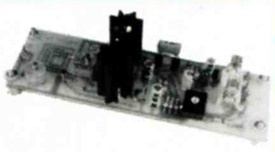

PHOTO: 3W FM TRANSMITTER

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