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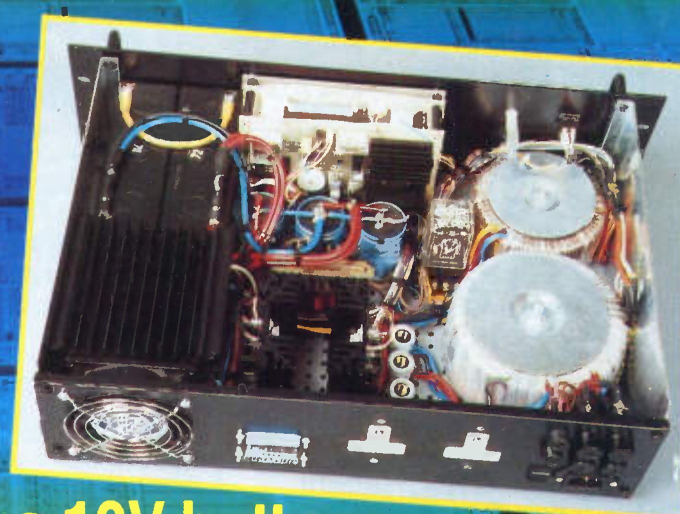
BULL ELECTRICAL 1994 CATALOGUE



250W/600W INVERTER & UNINTERRUPTABLE POWER SUPPLY

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Enhance your Christmas display and prolong bulb life

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Staying alive with electrical equipment – Part 1.

AUTO ALARM

Protect your car from theft

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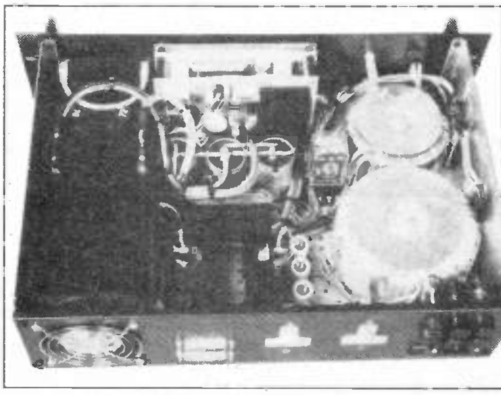
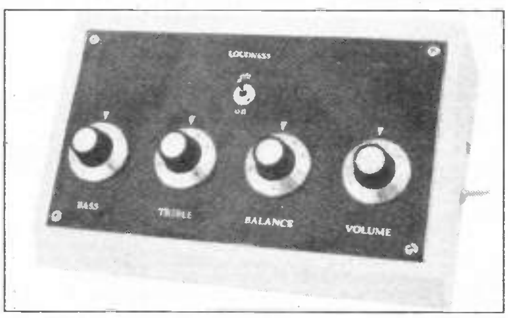
EVERYDAY WITH PRACTICAL
ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY

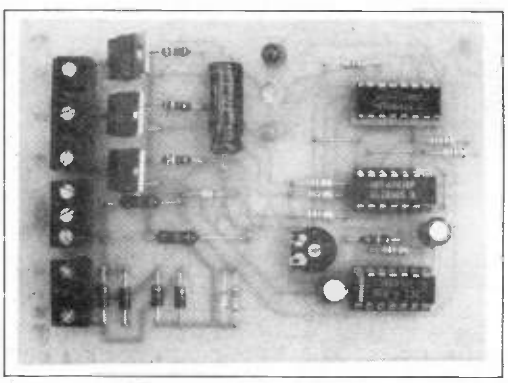
VOL. 22 No. 12 DECEMBER 1993

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

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







Our January '94 Issue will be published on Friday, 3 December 1993. See page 875 for details.

Projects

THREE-WAY CHRISTMAS TREE LIGHTS FLASHER by Mike Argent **888**
Highlight your tree decorations and prolong bulb life

AUTO ALARM by M. G. Argent **896**
Pulsed car alarm with overiding anti-mugger "panic button"

250W/600W INVERTER & UNINTERRUPTABLE POWER SUPPLY – 1 by Mark Daniels **909**
Beat any power cuts with this powerful emergency back-up supply – will run the central heating or protect computer data

MULTI-PURPOSE AUDIO SYSTEM – 3 by Max Horsey **925**
Tone Control module and 1W Stereo Amplifier

WATERPROOF DELAY SWITCH by T. R. de Vaux-Balbirnie **934**
Will control any exterior lighting up to 750W. Ideal for outdoor security lights

Series

SAFETY FIRST – 1 by T. R. de Vaux Balbirnie **900**
Electrical safety in the home – some do's and don'ts!

CIRCUIT SURGERY by Alan Winstanley **906**
Your problems solved and circuit ideas

INTERFACE by Robert Penfold **922**
The page for computer enthusiasts

AMATEUR RADIO by Tony Smith G4FAI **944**
Less UK Amateurs; Global Overview; Country Changes; Novice Licence in Sweden

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Improved Hard Disk; 3D LCDs

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A new software service for teaching electronics

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A wide range of technical books available by mail order – Order for Christmas Now!

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PCBs for EPE projects – some at sale prices!

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FREE BULL ELECTRICAL CATALOGUE
between pages 912 and 913

Readers Services • Editorial and Advertisement Departments 887

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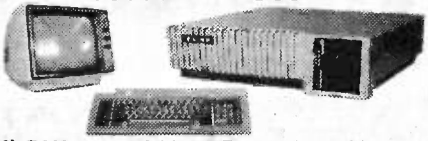

- 256k RAM - expandable to 640k
- 4.7 Mhz speed
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- 2 serial & 1 parallel ports
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Optional FITTED extras: 640K RAM £39. 12" CGA colour monitor with card £39. 2nd 5-1/4" 360K floppy £29.95. 20 mbyte MFM hard drive £99.

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286 AT - PC286

- 640k RAM expandable with standard SIMMS
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BRAND NEW AND BOXED!

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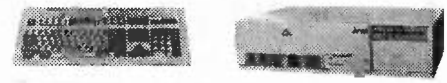
The Philips 9CM073 is suggested for the PC286 and the CM8873 for the PC386. Either may use the SVGA MTS-9600 if a suitable card is installed. We can fit this at a cost of £49.00 for the PC286 and £39.00 for the PC386.

386 AT - PC386



- 2 meg RAM expanded by slots
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- 1.2 meg 5-1/4" floppy
- VGA card installed
- 2 serial & 1 parallel ports
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- Co-processor socket
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Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported).

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5.25" **EXTRA SPECIAL BRAND NEW Mitsubishi MF501B** 360K. Absolutely standard fits most computers £22.95(B)
* **Data cable included in price.**
Shugart 800/801 SS refurbished & tested £175.00(E)
Shugart 851 double sided refurbished & tested £275.00(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW £250.00(E)

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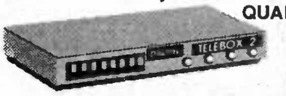
End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only........................£299(E)

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

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

Telebox ST	for composite video input monitors	£32.95
Telebox STL	as ST but with integral speaker	£36.50
Telebox MB	as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification.	£69.95
Telebox RGB	for analogue RGB monitors (15khz)	£69.95

Shipping code on all Teleboxes is (B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals...........MUK.....£249 (F) MUD.....£525 (G)

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims 13" x 5" x 2.5". Fully guaranteed RFE. £85.00 (B)

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Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New £22.95(B)

Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms. £24.95(C)

Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New. £49.95(C)

Boshert 13090.Switch mode.Ideal for drives & system. +5v @ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a. £29.95(B)

Farnell G6/40A. Switch mode. 5v @ 40a.Encased £95.00(C)

Farnell G24/5S. As above but 24v @ 5a. £65.00(C)

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

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

Only £29.95 or 2 for £53 (B)

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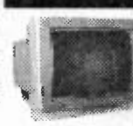
Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Pillar 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
Nikon PL-2 Projection lens meter/scope	£750
Sekonic SD 150H 18 channel Hybrid recorder	£2000
HP 7580A A1 8 pen high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

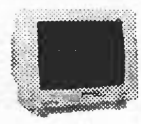
BRAND NEW PRINTERS

Microline 183. NLQ 17x17 dot matrix. Full width.	£139 (D)
Hyundai HDP-920. NLQ 24x18 dot matrix full width.	£149 (D)
Qume LetterPro 20 daisy. Qume QS-3 interface.	£39.95 (D)
Centronics 152-2 9 x 7 dot matrix. Full width.	£149 (D)
Centronics 159-4 9 x 7 dot matrix.Serial. 9-1/2" width	£ 99 (D)

MONITORS



14" Forefront Model MTS-9600 SVGA multisync with resolution of 1024 x 768. 0.28 pitch. "Text" switch for word processing etc. Overscan switch included. Ideal for the PC-386 or PC-286 with SVGA card added. Also compatibe with BBC, Amiga, Atari (including the monochrome high resolution mode), Archimedes etc. In good used condition (possible minor screen burns). 90 day guarantee. 15" x 14" x 12". Only............£159(E)



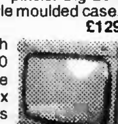
14" Philips Model CM8873 VGA multisync with 640 x 480 resolution. CGA, EGA or VGA, digital/analog, switch selectable. Sound with volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with IBM PC's, Amiga, Atari (excluding the monochrome high resolution mode), BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only ....£139(E)

Philips 9CM073 similar (not identical) to above for **EGA/CGA** PC and compats. 640 x 350 resolution. With Text switch with amber or green screen selection. 14" x 12" x 13-1/2"........£99(E)

KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality Tv with our RGB Telebox. Good used condition. 90 day guarantee. Only..£125 (E)

KME as above for PC EGA standard......................£145 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case.Full 90 day guarantee. Only .... £129 (E)



NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual reasons. Only.........**£69** (E)

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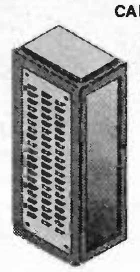
Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools,Shops,Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

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

CALL FOR PRICING ON NTSC VERSIONS!

Superb Quality 6 foot 40u

19" Rack Cabinets



Massive Reductions

Virtually New, Ultra Smart!

Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels.......£275.00 (G)
Rack 2 Less side panels ....£145.00 (G)

1992 Winter Issue of *Display News* now available - send large SAE - PACKED with bargains!

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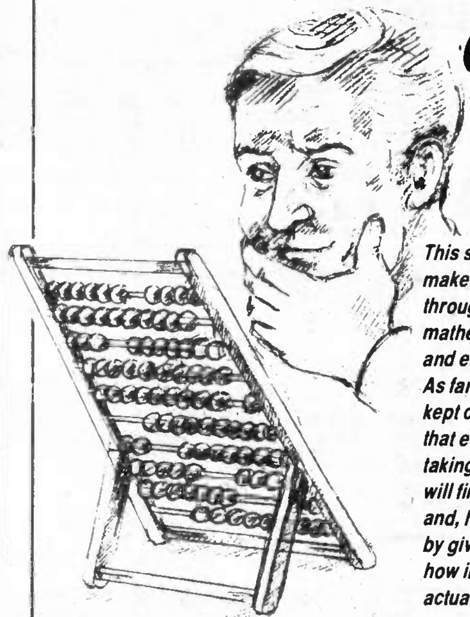
NEXT MONTH

CALCULATION CORNER



This series is designed to help you make your way, at your own pace, through the often imagined fears of mathematics, as applied to electronic and electrical engineering matters. As far as possible, everything will be kept on a quite elementary level so that even those readers who are not taking examinations in this subject will find something of interest to them and, hopefully, overcome their fears by giving them an opportunity to see how illusionary many of these fears actually are.

AUTOMATIC NIGHT LIGHT

Light switches can be difficult to locate in the dark, especially by the young and by those who are not as agile as they used to be. This system avoids switches and operates a light without conscious effort on the part of the user. By making sure that a light comes on when a person gets out of bed, accidents are avoided.

Although this circuit was designed as an automatic night-light it could be the basis for numerous automatic control systems in and around the home.

TIMER AND NiCAD CAPACITY CHECKER

NiCad cells do not last for ever. Occasionally they develop internal short circuits due to metal whisker growth, but more often their capacity simply fades away due to the well-known "memory" effect, or plain old age. Camcorder batteries in particular often fail prematurely due to the use of relatively high charge and discharge rates. With the ever-increasing popularity of NiCads, a means of checking remaining storage capacity is highly desirable, this project provides the necessary tests.

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JANUARY '94 ISSUE ON SALE FRIDAY, DECEMBER 3rd 1993

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NEW (MADE BY SOUND LAB)

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TIE CLIP MICROPHONE SYSTEM

A portable diversity receiver with tone squelch and noise reduction circuitry. The antenna A-B indicators indicate the switch in channels as the performer moves about. The Belt-clip transmitter has an intermediate mute position on the on/off switch to eliminate switch-on pop. Output from the receiver is via a 6.35mm unbalanced socket. Note: the receiver is 12V AC powered. Recommended power supply P007D.

***Receiver:** Frequency: 174.1, 174.5, 174.8MHz, Frequency response 30Hz to 18KHz, S/N ratio, 100dB, RF sensitivity 15dB at S/N 60dB, De-emphasis: 50μ sec, Power: 12V DC.*
***Transmitter:** Frequency response: 30Hz to 18KHz, RF power: 2mW, Modulation: FM 15KHz, Spurious emissions: 45dB, Power: 9V DC battery (not supplied).*

ORDER CODE: G205A
ONLY £245.00

EXTRA SPECIAL CHRISTMAS OFFER!

12 BAND RECEIVER

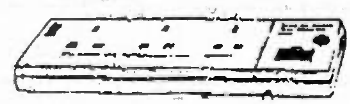
Price
£17.50
NORMALLY £21.50
WHILE STOCKS LAST.
OFFER CLOSES DEC. 25.

A compact 12 Band Receiver covering FM, MW, LW and 9 Short Wave bands. A built-in bar antenna receives the MW and LW transmissions and the telescopic rod antenna receives FM and SW transmissions. An additional 20ft. wire antenna is provided to improve SW reception. The tuning LED lights when a strong signal is present. Wave band selection, tone and volume is by slider control.

Frequency coverage: FM: 88 to 108MHz, MW: 530 to 1620kHz, LW: 150 to 270kHz, SW1: 5.85 to 6.23MHz, SW2: 6.95 to 7.42MHz, SW3: 9.45 to 9.95MHz, SW4: 11.45 to 12.23MHz, SW5: 13.40 to 14.15MHz, SW6: SW7: 17.35 to 18.35MHz, SW8: 20.80 to 22.15MHz, SW9: 24.95 to 26.95MHz. Power: 6V DC (4 x AA batteries). Dimensions: 196 x 35 x 123MHz.

Order Code B118D

13A Fused 4-Way Extension Lead 3 metres.
Order Code: ELEC/MS/4LP
Price 1 + £5.99. 10 + £5.00



SPECIAL OFFER £3.99
13A 4-Way Socket with Neon Indicator, Fused to BS 1363/A
Order Code: ELEC/MS/4F

NI-CAD BATTERIES

A range of Nickel Cadmium batteries that will replace dry cell batteries. Capable of being recharged some 1000 times they are very economical in all applications.
**When possible Hitachi brand will be supplied.*
(We offer a suitable charger for these Ni-Cads at the end of this section).

Type	Volt	Ah	Order Code	Price 1+	10+	100+
AAA	1.2V	180mAh	BAT/AAA	£1.60	£1.40	£1.15
AA	1.2V	500mAh	BAT/AA	£1.00	90p	70p
AA	1.2V	650mAh	BAT/A650	£1.60	£1.40	£1.15
C	1.2V	1.2Ah	BAT/C	£1.99	£1.79	£1.40
C	1.2V	2.0Ah	BAT/C1	£2.65	£2.40	£1.99
D	1.2V	1.2Ah	BAT/D	£2.15	£1,90	£1.50
D	1.2V	4.0Ah	BAT/D1	£5.95	£5.30	£4.25
PP3	9V	110mAh	BATPP3	£4.75	£4.25	£3.89

METAL DETECTOR – Y090A

Easy to use lightweight, well balanced metal detector. Detects gold, silver or copper coins and other metal objects through earth, sand or rocky soil.

Features:
- On/Off Volume control
- Tuning control for sensitivity adjustment
- VU meter
- Headphone socket
- Telescopic non-corrosive shaft
- 8" waterproof and shock resistor search coil

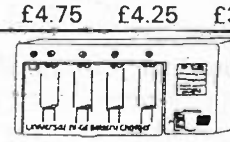
Length closed: 630mm, Length extended: 940mm, Power supply: 9V DC (PP3), Weight: 1.2kg.

NEW ORDER CODE: Y090A
ONLY £69.99

METAL DETECTOR – Y090

Lightweight, compact metal Detector with 6in. diameter search coil for locating coins, artefacts, jewellery and metal objects. Double moulded plastic handle houses finger tip controls for sensor tuning and dynamic loudspeaker sounds on detection..
Length closed: 550mm, Length extended: 880mm, Power supply: 9V DC (PP3), Weight: 0.75kg.

NEW ORDER CODE: Y090
ONLY £22.99



NI-CAD BATTERY CHARGER
Capable of charging 4 x AAA, AA, C or D sizes, 2 x PP3. White in colour, free-standing unit with LED 'Charging' indicators. A built-in tester is provided for 1.5V batteries.
Power 240V AC. Dimensions: 180 x 85 x 50mm.
Order Code: BAT/CHARGE/UNI/B
Price 1 + £4.99 10 + £4.75

SOLDER 18 & 22SWG 500gm REEL

	1+	10+
18SWG 500G	£4.95	£4.70
22SWG 500G	£4.99	£4.75

Remember: Our prices INCLUDE VAT!

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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

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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

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VOLTAGE REGULATORS
1 amp 7805/7812/7815 all 33p each. 7905/7912/7915 all 39p each
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100mA 78L05/78412/78L15 all 26p each. 79L05/79L12/79L15 all 29p each
Adjustable LM317T 47p each. LM723 29p each, L200 £1.28 each
Transistors TIP2955 70p each, TIP 3055 70p each
2N3053 29p each, 2N3055 70p each, 2N4403 28p each, 2N3819 40p each
MICRO IC'S –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

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

OPTO DEVICES – LEDS – ETC

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

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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

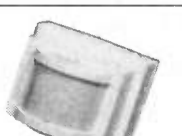
10 or 20 minute bell cut off +ve or −ve trigger* timed relay contacts. £4.96

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

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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

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Standard on/off £1.00 each
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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

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£1.00 BARGAIN PACKS

SUB-MINIATURE TOGGLE SWITCHES

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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
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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
BO40 **25 x ASSORTED ELECTROLYTIC CAPACITORS** PCB mounting useful values
BO41 **25 ASSORTED PRE-SET RESISTORS**
BO42 **6 x 3·5mm LINE JACK SOCKETS** (mono)
BO43 **6 x 3·5mm JACK PLUG** (mono)
BO44 **8 x 3·5mm CHASSIS SOCKET** (mono)
BO45 **2 x TRIACS** 800 volt 8 amp
BO46 **12 x BC213L** Transistor
BO47 **12 x MIN SLIDE SWITCH** dpdt
BO48 **15 x MIN CERMET TRIMMER POTS** (good range of values)
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BO50 **1 x 12V DC RELAY** 4-pole c/o with plug in base
BO51 **4 x LM324** quad op-amps
BO52 **4 x 555** Timer
BO53 **5 x 741** op-amp
BO54 **25 x IN4001** diode
BO55 **20 x IN4007** diode
BO56 **1 x SLOTTED OPTO**
BO57 **1 x DAC08** Digital to analogue convertor with data
BO58 **4 x OPTO ISOLATOR**
BO60 **3 x C106D** Thyristor
BO61 **5 x 78M05 VOLTAGE REGULATORS** positive 5 volt 500mA

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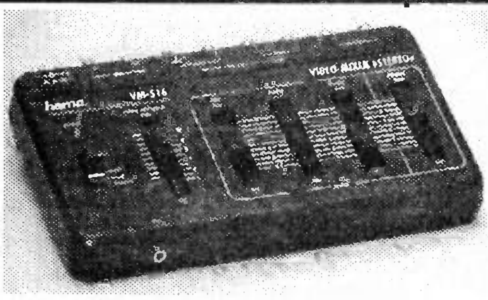
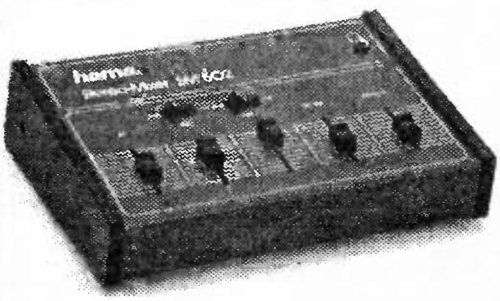


VM516 Stereo Video Mixer

Desk type video sound mixer with enhancer. Allows seperate smooth adjustment and mixing of original video sound with 3 external sources (mic, cassette etc). Master output control. Also continuously adjustable slider corrects video signal when copying. Supplied with 12V mains adaptor

Our Special Low Price: £39.95



SM502 Stereo Mixer

4 Channel audio mixer with inputs for mic, mag/cer phono and tape/tuner. Outputs for headphones and to amplifier. Freq Res 20-20000Hz, S/N ratio >55dB. Supplied with 9V mains adaptor

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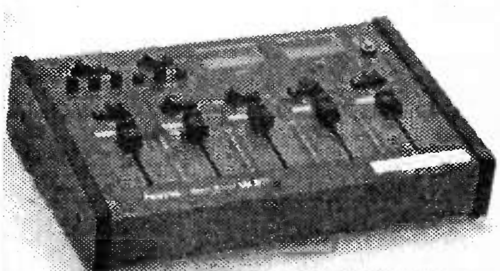

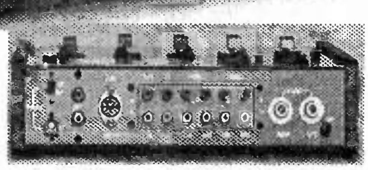

SM507 Stereo Mixer

Big brother of SM502 - this one has all the facilities of the above mixer + twin VU meters and an additional record/replay DIN socket. As can be seen from the inset pic, the socketry on the rear is excellent.

Our Special Low Price: £69.95

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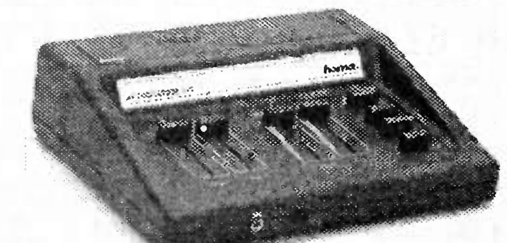

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AV140 Audio/Video Processor

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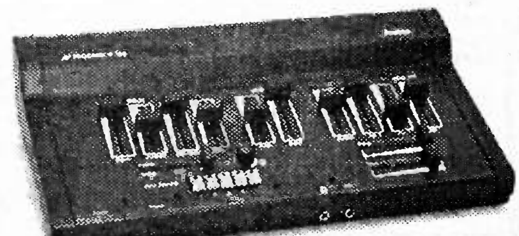

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The ultimate processor - excellent spec, will handle S-VHS & Hi-8. Fitted with a variety of sockets. 5 video, 3 audio inputs; 5 mixed outputs + headphone monitoring. Contrast, Colour sat, Contour controls, 7.7Mhz video bandwidth, resolution >430 lines; 30-25,000Hz audio freq res. Auto noise suppression. 12V PSU supplied.

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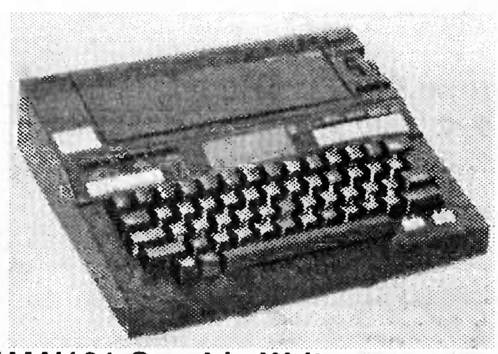

HAN101 Graphic Writer

Produces tables, bar & linear graphs, pie charts - 18 fonts in 9 type sizes (8-75 char. per line). Prints on paper or clear film. Ideal for producing OHP transparencies in up to 4 colours! Compact - 320x260x60mm. Uses 4xD cells, or mains adaptor (supplied) FREE OHP set - 10 sheets + 2 x 4 colour pen sets

List Price £299

Our Special Low Price: £99

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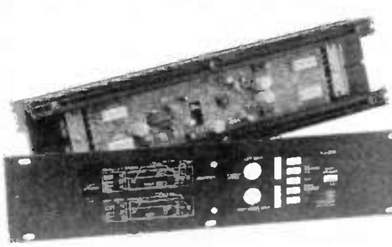
£109.50 K3507(12V)

£109.50 K3509(24V)

400W MONO/STEREO AMPLIFIER

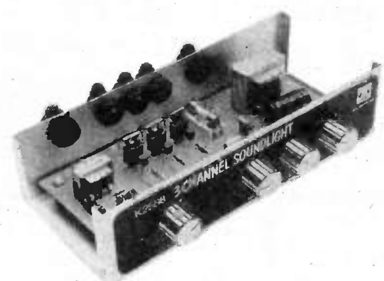


- ❑ UNIVERSAL, SOLID AND COMPACT
- ❑ OVERLOAD AND SHORT CIRCUIT PROTECTED
- ❑ IDEAL FOR USE IN THE CAR WITH THE IN-CAR AMPLIFIER POWER SUPPLY (K3508)

A universal, solid and compact 400w Mono/Stereo amplifier offering stereo amplification of 2 x 100W into 4 ohms, 2 x 75W into 8 ohms and 200W into 8 ohms Bridged-Mono. The ampllifier is overload and short-circuit protected with thermal and speaker pop switch On/Off suppression. It may be used as a built-in module or free-standing in an enclosure. Complete with heatsink housing, self-adhesive printed panel, components, PCB and full instructions.

£59.80 K4005

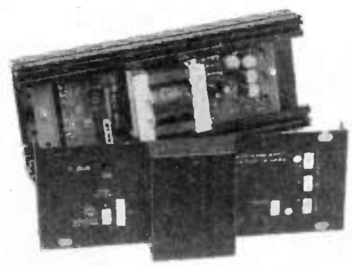
3 CHANNEL SOUND TO LIGHT



A complete three channel sound to light unit to enable entertaining colours to be added to your music. Three outputs, high, middle and low tones have separate sensitivity adjustment making the unit compatible with either amplifiers or tape/cassette decks etc. Complete with housing, components, PCBs, knobs and transformers. NB not suitable for halogen lights.

£34.98 K2588

IN CAR AMPLIFIER POWER SUPPLY



A power supply that allows conventional amplifiers or amplfication modules to be used in the car, such as the K4005 400W mono/stereo amplifier. The advantage of a separate supply module is that the high current connecting wires to the battery can be kept short, thus reducing power loss and the amplifier can be placed close to the loudspeakers to maintain optimum damping for excellent bass-frequencies. To avoid interference the 0V output has been separated from the cars chassis. The PSU is supplied with casing.

£65.90 K3508

Prices included VAT (at 17.5%). Postage and packing £1.40 per order.

The 224 page Cirkit Electronic Constructors Catalogue has complete details of all the above kits plus many more, together with components, books and test equipment. Send for your copy today! £1.90 (+30p p&p)

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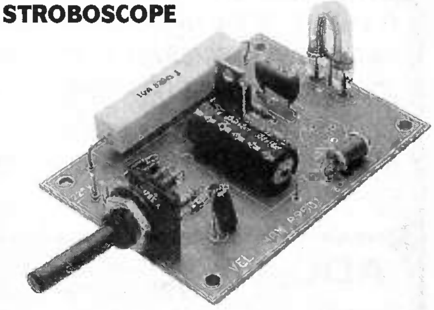
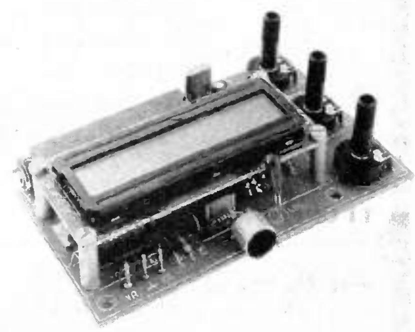


- ❑ SUITABLE FOR DISCO LIGHTING, FILM EFFECTS AND EXPERIMENTS

Stroboscope flashing light effect. Suitable for many applications, for example disco lighting, photography, lightning effects for films, making moving objects appear to be stationary. Supplied with a high quality PCB, all components and full instructions.

£13.25 K2601

MORSE DECODER WITH LC-DISPLAY



Everybody who owns a shortwave receiver may already have tried to decode those mysterious morse messages. Unfortunately, intensive training is required to follow experienced signallers or automatic stations. This decoder easily keeps up with the quickest of signallers, and neatly notes everything on the LCD.

£58.75 K2659

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VOL. 22 No. 12 DECEMBER '93

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WE TOLD YOU SO!

The Innovations dry cell charger launched a few months ago is on target to sell more than one million units before Christmas. This charger was developed by Coltronics Systems Ltd. Following the publication of our *Dry Cell Charger* project in the September 1991 issue of EE we were in touch with Coltronics to discuss the general marketing problems created by the battery companies. We carried a news item on their charger in the July 1992 issue.

After decades of battery companies claiming it can't be done and of the popular press announcing new inventions to do it every few years – they do seem to forget what has already happened very quickly – it's good to see a system in popular use. Now perhaps the battery companies will get behind the idea, market their own chargers and dedicated dry cells then everyone will benefit, not least the environment.

The basic techniques employed were certainly known and used in the second world war, if not before, and various designs have been published since – one large battery company even marketed a charger in the USA about 20 years ago. At last an innovative electronics company has managed to get a large marketing organisation to back the product and it looks like dry cell recharging will now be common practice.

It's good to see a small UK company like Coltronics achieving such a breakthrough, particularly against the might of the large battery manufacturers, some of which have taken deliberate steps to squash sales of dry cell chargers for obvious financial reasons. Well done Coltronics.

TEACH-IN SIX

Over the past few years we have reprinted various Teach-In series in book form. This year we will reprint Mike Tooley's *Design Your Own Circuits* series as *Teach-In No. 6*. The series has been highly acclaimed, particularly by those in education; the book is A4 size, contains about 140 pages and is packed full of design information, module designs and layouts and a range of complete projects.

Teach-In No. 6 will cost £3.45 and will be available from your newsagent on 12th November. **Place an order now to make sure of your copy.**

READERS' ENQUIRIES

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

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

COMPONENT SUPPLIES

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

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

We regret that **we cannot provide data or answer queries on projects that are more than five years old.**

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Although the proprietors and staff of EVERYDAY with PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or are in the form of inserts.

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

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Annual subscriptions for delivery direct to any address in the UK: £22. Overseas: £28 (£45.50 airmail). Cheques or bank drafts (**in £ sterling only**) payable to Everyday with Practical Electronics and sent to EPE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. Tel: 0202 881749. **Subscriptions start with the next available issue.** We accept Access (MasterCard) or Visa payments, minimum credit card order £5.

BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.20 (£3 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.**

BINDERS

New style binders to hold one volume (12 issues) are now available from the above address for £4.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery.*

Payment in £ sterling only please.
Visa and Access (MasterCard) accepted, minimum credit card order £5. Send card number and card expiry date with your name and address etc.

THREE-WAY CHRISTMAS TREE LIGHT FLASHER

MIKE ARGENT

A festive three set lights flasher that will add sparkle to your tree decorations. Will prolong bulb life.

CHRISTMAS tree lights are notorious for ceasing to work the moment they are switched on, especially after having been carefully placed decoratively – or otherwise – over the newly acquired tree, complete with sticky pine needles.

The reason for their failure is often because of the sudden inrush of current from the mains during switch on. If you add to this a basic flashing light circuit, the chances of premature failure is increased many times.

This Christmas tree light flasher not only switches three sets of lights on in a pleasing order i.e. not simply one set after the other, but also uses "zero switching" for longer bulb life.

CIRCUIT DESCRIPTION

The circuit diagram for the Three-Way Christmas Tree Light Flasher is shown in Fig. 1. The mains into the unit is rectified by the diode bridge D1 to D4. This provides a full wave d.c. supply at mains voltage and is used fundamentally to power the three lamp-driving thyristors CSR1 to CSR3.

The power for the integrated circuits IC1, IC2 and IC3 is derived from this high d.c. voltage via voltage dropping resistor R1 and the 10V Zener diode D5 with it's smoothing capacitor C1. The value of resistor R1 can be one of two values depending on whether the optional light emitting diodes (l.e.d.s) D7 to D9 are fitted.

Without the l.e.d.s the value of resistor R1 is 100k and consumes little power from the supply. If the l.e.d.s are desired, then R1 needs to be changed to 22k 3W.

The light switching order is determined by the counter IC3. It is connected as a binary counter and it's outputs switch in the sequence – A, B, A + B, C, C + A, C + B, C + B + A – recurring. On the last count, Q4 (pin 2) enables the JAM inputs (pins 3, 4, 12, 13) and resets the counter to count 1, ready for recycling, ad infinitum.

This provides a pleasing effect which is further modified by clocking the counter irregularly, using two separate oscillators IC1d and IC1c coupled to an AND gate IC2b which clocks the counter IC3 only when both oscillators have high outputs simultaneously.

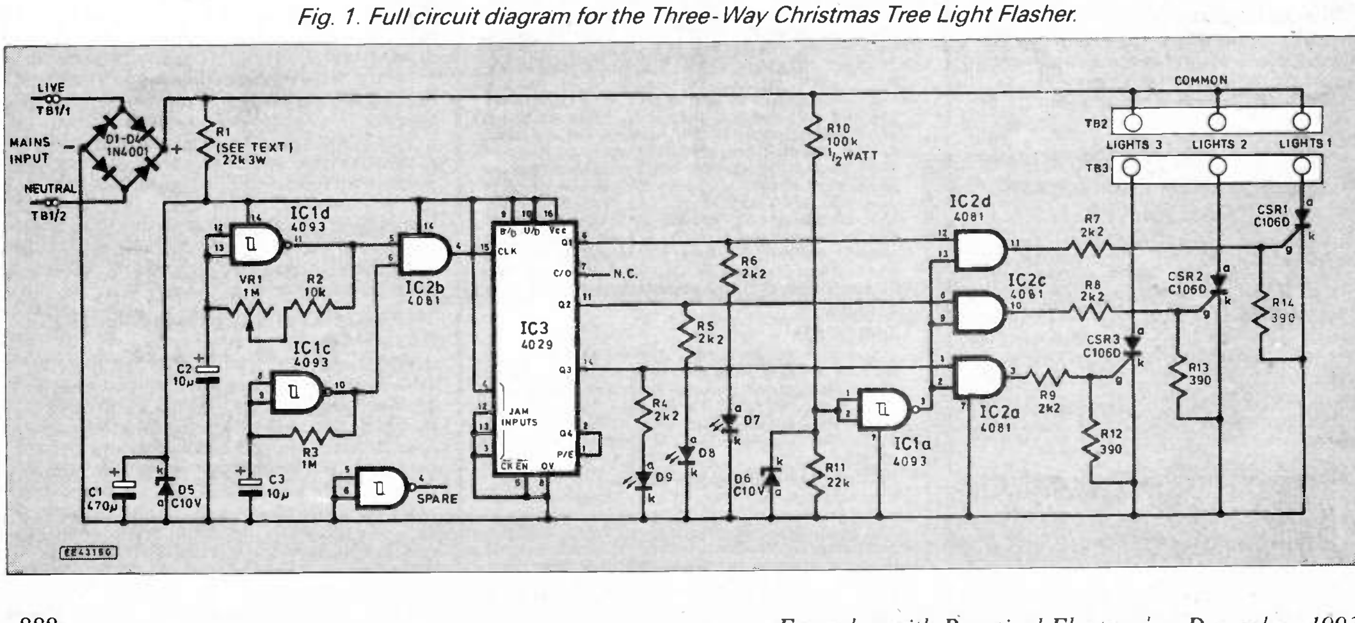
ZERO SWITCHING

To provide zero switching, the pulsating high d.c. voltage from the bridge rectifier is divided by resistors R10 and R11 and the junction fed to a Schmitt NAND gate IC1a. The output of this gate will be high while it's inputs are at near zero volts.

As the mains goes through it's full cycle, the Schmitt gate IC1a detects the voltage rise and switches it's output low. The AND gates IC2a, IC2c and IC2d are then prevented from passing changes from the counter outputs to the lamp drivers CSR1 to CSR3, therefore ensuring that the lights are "zero-switched" avoiding surge currents and also minimising electrical interference to other equipment. The Zener diode D6 clamps any spurious voltages preventing damage to IC1.

If desired, l.e.d.s (D7 to D9) can be fitted on the counter outputs and if this is done, resistor R1 needs to be lowered in value to about 22k and *MUST* be a 3W rating to provide the extra current drive. The printed circuit board layout is designed to accommodate the larger size resistor. The l.e.d.s also require series resistors, R4, R5 and R6 respectively, to be fitted.

Fig. 1. Full circuit diagram for the Three-Way Christmas Tree Light Flasher.



CONSTRUCTION

Constructing this unit involves making mains connections. Any reader who is not certain of being able to build it safely is strongly advised to seek professional advice and help.

Bearing in mind that the whole unit is at mains potential, and to ensure safety, the use of the ready made printed circuit board (p.c.b.) is recommended. This board is available from the *EPE PCB Service*, code 853.

The completed p.c.b. MUST be put in a tamper proof plastic case, particularly if it is to be sited in a room where children may be left unattended. The prototype was housed in a double 13A "back" box with a blank front cover.

The printed circuit board component layout and full size copper foil master pattern is shown in Fig. 2. Commence

COMPONENTS

Resistors

R1	100k ½W or 22k 3W (see text)
R2	10k
R3	1M
R4 to R9	2k2 (3 or 6 off – see text)
R10	100k ½W
R11	22k
R12 to R14	390 (3 off)

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

See SHOP TALK Page

Potentiometer

VR1	1M miniature carbon preset, lin.

Capacitors

C1	470µ axial elect. 16V
C2, C3	10µ radial elect 16V (2 off)

Semiconductors

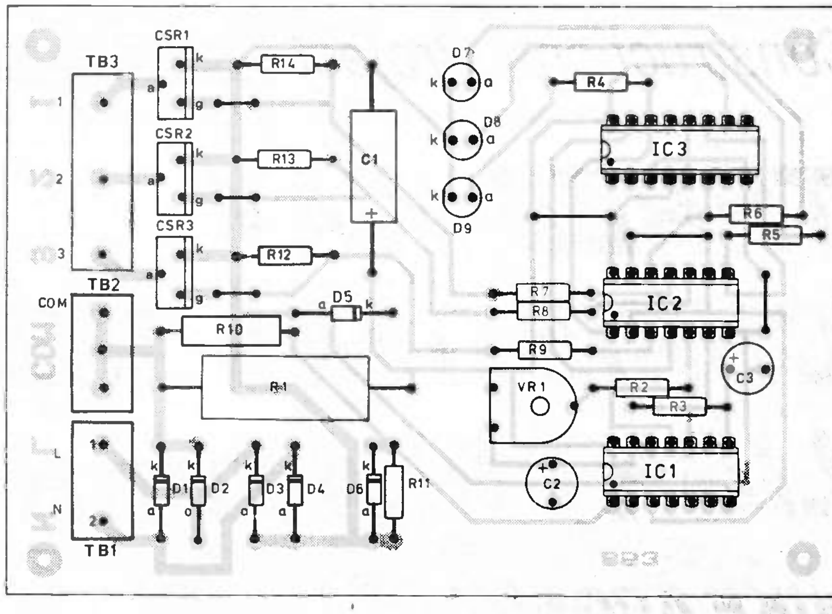
D1 to D4	1N4004 1A 400V rec. diode (4 off)
D5, D6	10V 400mW Zener diode (2 off)
D7 to D9	5mm l.e.d. (3 off)
CSR1 to CSR3	C106D thyristor (3 off)
IC1	4093 quad 2-input NAND Schmitt trigger
IC2	4081 quad 2-input AND gate
IC3	4029 pre-settable up/down counter

Miscellaneous

TB1	2-way p.c.b. mounting (double spacing) screw terminal block
TB2	3-way p.c.b. mounting (single spacing) screw terminal block
TB3	3-way p.c.b. mounting (double spacing) screw terminal block

Electrical 13A back box (for surface mounting double mains socket), with front blanking panel; printed circuit board, available from *EPE PCB Service*, code 853; 14-pin i.c. socket (2 off); 16-pin i.c. socket; self-adhesive p.c.b. stand-off feet (4 off); mains cable and 3-pin 13A plug, with 1A fuse; single-core tinned wire for inter-links; solder etc.

Approx cost guidance only **£17**



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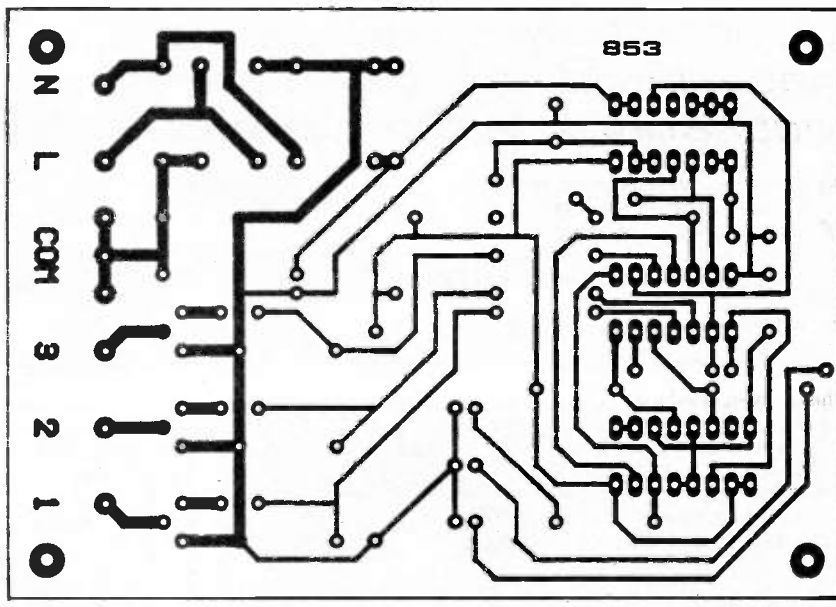
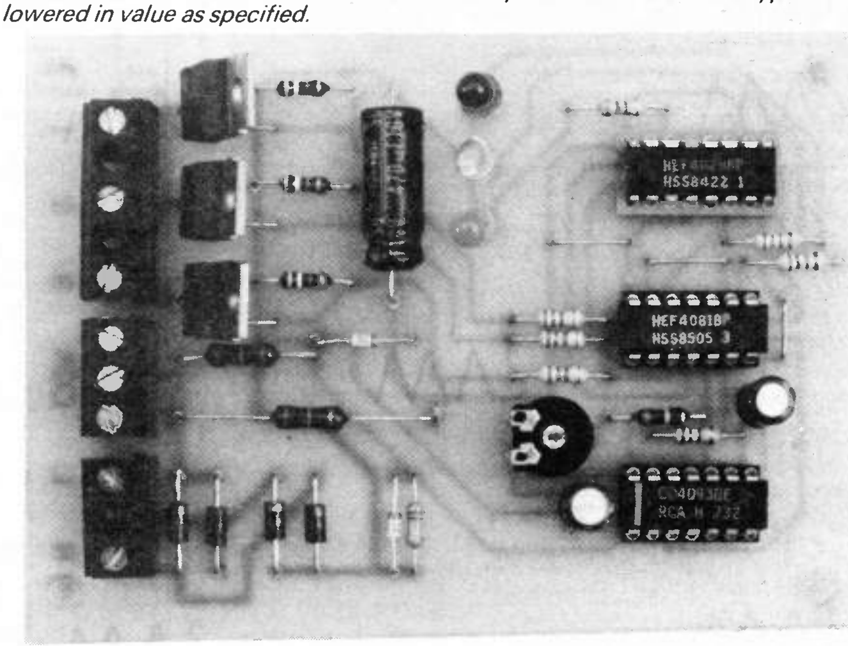


Fig. 2. Printed circuit board components layout and full size underside copper foil master pattern.

Layout of components on the completed board. Note that if the l.e.d.s are to be included in the circuit resistor R1 must be replaced with a 3 watt type and be lowered in value as specified.



board construction with the smallest components working up to the largest. Pay special attention to solder joints, ensuring that there are no solder "bridges" or splashes across tracks and that the thyristors are not leaning over precariously and likely to short together.

Make sure that the polarised components i.e. electrolytic capacitors and semiconductors are fitted the right way round. Also, fit sockets for the i.c.s. to enable initial voltage checks.

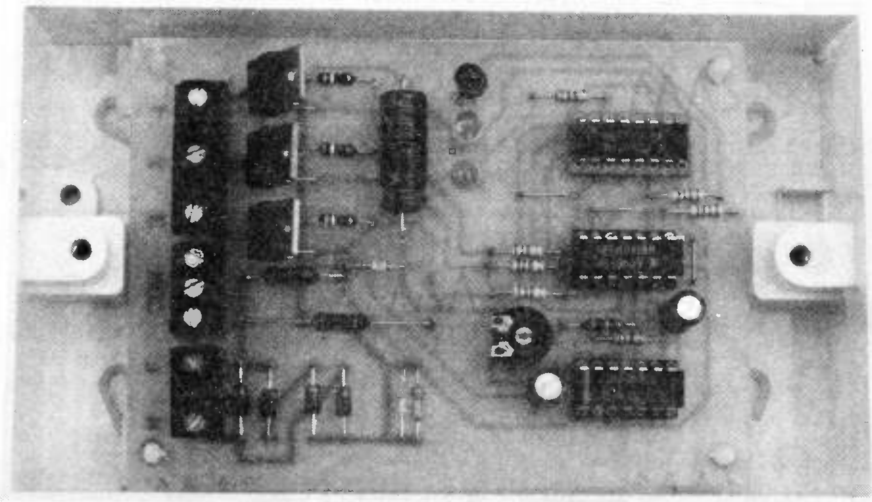
If l.e.d.s are not to be fitted, resistors R4, R5 and R6 can be omitted as well. The p.c.b. is held in place using self-adhesive stand-offs at each corner of the board.

TESTING

CARE MUST BE TAKEN BECAUSE THE UNIT IS AT MAINS POTENTIAL.

Check thoroughly that the p.c.b. is assembled correctly. Connect one lead of each of the three Christmas tree light sets to the terminal block TB2 marked COM (common), and the other lead of each light set to 1, 2 and 3 respectively of terminal block TB3. The box case mentioned earlier ***MUST*** be drilled and fitted with proper strain relief bushes to take all mains and light connecting wires. ***DO NOT USE THE*** break-away cut-outs for external wires.

The mains plug ***MUST be fused at 1A*** because there is no fuse on the p.c.b. Connect the Live (brown) and Neutral (blue) leads of the mains cable to the terminal block TB1 at positions L and N, see Fig. 2.



The finished circuit board mounted in the electrical (double) 13A back box.

If possible, before fitting the i.c.s in their holders, connect a d.c. voltmeter across capacitor C1. Switch the mains supply on and there should be an approximate reading of 10V.

Switch off the mains and connect the meter across either Zener diode D6 or resistor R11. Switch the mains back on and check that this gives a similar reading. Note that these readings are only approximate and will vary according to the load that the meter represents.

Fit the i.c.s and repeat the above. The lights should now flash at a speed which will vary when preset VR1 is adjusted. If l.e.d.s are fitted these will flash at the same rate as the lights. □

Innovations

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

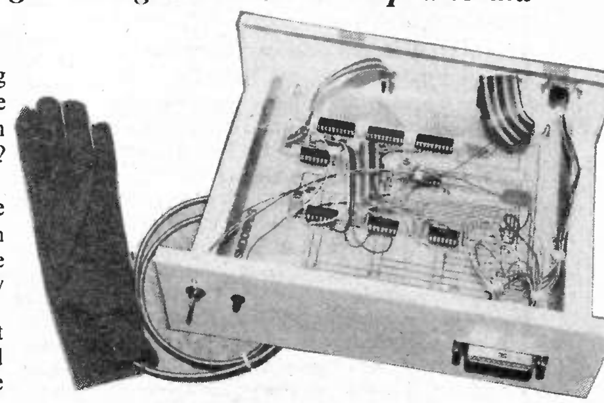
SPEAK TO ME

An exhibition that highlights just some of the problems faced by people with communications difficulties has just opened at the Science Museum, London and will run until 30 January 1994. The exhibition looks at some of the latest technologies being used and developed to aid communications problems.

A GREATER proportion of our lives today seems to be taken up with receiving and passing on messages in many different ways and forms. However, have you stopped to think what it would be like to be the only person who cannot join in the conversation? Or how would you feel if nobody else spoke your language? For some people with disabilities this can be an everyday experience.

How technology can and might help solve this problem in the future is the theme of the *"Speak to Me"* exhibition now running at the Science Museum. One in a series of *Science Box* exhibitions, these small shows are an important part of the Museum's public awareness inititives to make contemporary science and technology accessible to everyone.

The exhibition looks at four methods of communication used by different disabled communities: synthesized speech; Braille; Deafblind Alphabet and British Sign Language. Visitors will have the chance to try out for themselves the different methods.



Speech Synthesiser

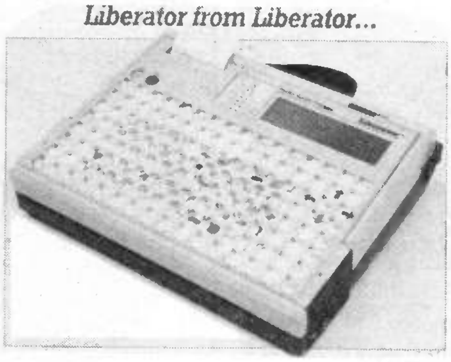
With the development of advanced electronics and computers it is now possible to turn words into artificial speech by using a speech synthesiser computer.

With the early machines it was the thankless task of typing individual letters to spell out words that made them frustrating and unpopular with the user. Then, thanks to pioneering research in America by linguist Bruce Baker, a way was developed in which phrases and sentences could be built up quickly using a keyboard, with pictures rather than letters, and a special software package called Minspeak.

By using symbols and pictures in different combinations instead of typewriter keys, the software "predicts" whole sentences from a few key words. Using this method is claimed to be twice as fast as a letter based keyboard.

One example on display using the Minspeak software is the Liberator portable speech synthesis system. Using the symbol based keyboard it is claimed that many thousands of individual words can be "spoken".

Liberator from Liberator...



Speaking Hand

People who are both deaf and blind can communicate using the Deafblind Alphabet, which was devised by Edward Evans earlier this century. Using this "sign language", each word is spelled out one letter at a time by touching the palm and fingers of the left hand.

Another exhibit on display is an experimental "talking glove" designed by University College London student Robert Kline. Called the Speaking Hand it recognises the Deafblind Alphabet and turns it into artificial speech or text.

By watching the action of the "speaker", Robert identified 18 touch points on the listener's left hand that would enable the 26 letters of the alphabet to be reproduced. Special pressure sensors were then sewn to the fingers and palm of a glove at these touch points and the sensors used to feed signals back to a microcomputer. The computer then translates these signals into either text on a monitor or synthesised speech.

Electronic News

Braille is a form of writing specially designed for people who are blind. Each letter is represented by a pattern of raised dots which you read by touch. Braille was developed by Louis Braille in 1824, while he was studying at the National Institute for the Blind in Paris.

Although Braille is an effective form of communication for people who are blind, there is still very few publications printed in Braille. This means that they have limited access to everyday newspapers and often rely on others to read aloud or listen to audio tapes.

A new system being demonstrated is the Electronic Newspaper. Developed by the RNIB in conjunction with several companies, it is designed to give greater independence and access to information. The process is already being used to broadcast an electronic version of the *Guardian* newspaper. It takes about twenty minutes to transmit one issue, which can then be stored in the computer's memory.

Each night the computer-generated pages of the next day's newspaper are stripped of their graphics and then broadcast by ITV transmitters in the unused bands of their UHF television frequencies. The signal can be picked up by a normal television aerial and a receiver stores the data on the hard disk of a modified personal computer. The transmission is in code to prevent unauthorised access, so a decoder is also needed (as for satellite TV).

The data can then be converted into magnified text on a monitor or into synthesized speech. Alternatively, the data can be turned into Braille using a Soft Braille Display, which is made up of rows of pins that move up or down to form the pattern of raised dots for each letter.

WORLD FIRST FOR PARIS-BASED COMPANIES

French design of fixed head Multi-Track Video Recorder uses Kerr effect and optical detection scheme to record up to 10 channels on a single VHS tape. By Hazel Cavendish.

THE PACE of recent developments in world communications dictate a new responsibility for mankind to use the spectrum sparingly. A world first by a giant French consortium offers an exciting advance in electronic principles, still in the prototype, but so revolutionary and intellectually conceived that it is likely to be marketed within two to five years.

A multi-track fixed head recorder for a new digital VCR has been developed, which can record up to 10 TV channels on a single VHS video tape, based on a new concept evolved in the laboratories of Thomson CSF and the French Research and Development arm of Thomson Consumer Electronics.

Denis Jolivet, a senior research engineer at Thomson-CSF's Recording Physics Laboratory in Paris, says the source coding and modulation equipment developed by the company implements the transmission of four TV and one HDTV programme in a single standard TV channel. The four TV programmes, each encoded at 8 Mbit/s, are embedded into one 34 Mbit/s channel. A second 34 MBit/s channel conveys the HDTV programme.

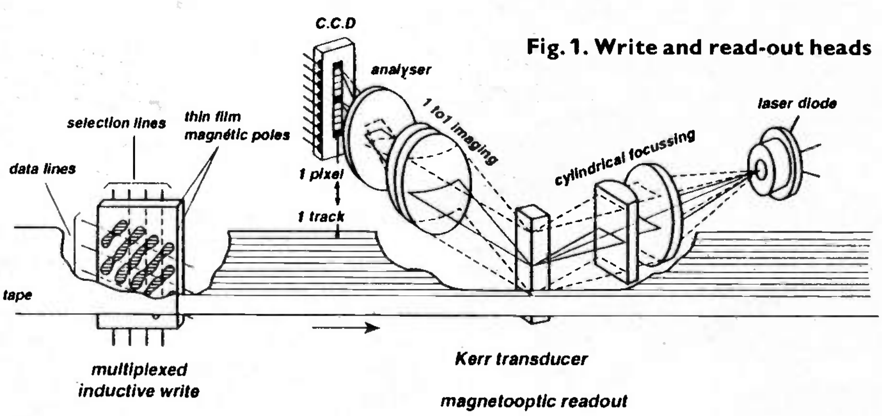


Fig. 1. Write and read-out heads

This new invention of massively parallel recording and playback is claimed by the company to have no equivalent anywhere in the world, and is based on matrix storage techniques for the "write" head and magneto-optical Kerr effect technology for the "read-out" head. This approach will make it possible to produce recorders able to record and play back simaltaneously several thousand parallel tracks at a data rate of several gigabits per second in consumer products as well as professional civilian and military systems.

While the concept of stationary head digital recording has been advanced in the audio field, conventional thin film head technology has limited the track density to 500TPI. The French have now developed a new matrix head design which allows head stack integration up to 5000TPI and has shown its ability to record digital video.

The main limitation in terms of size, ruggedness and reliability of video recorders has been the rotating drum. On one hand digital format enlarges the segmentation choice and allows the realisation of a smaller scanner, but on the other hand the need for high data rate requires a larger head to tape speed, or the use of more heads.

The two Thompson companies have combined in a radically changed VCR design, which has removed the scanning drum and increased dramatically the number of recording heads (up to 384 in the present prototype model.) The realisation of "write" and "read" head stack was only made possible by changing the head design, the head technology, and splitting the write and read functions, as shown in Fig. 1.

The new type of multi-track readout head uses an optical detection scheme associated with a high resolution magnetic readout of the tape. A Kerr effect transducer allows this magneto-optical readout, and measured performance proves that a CCD linear photo-detector can be used for this purpose – see Fig. 2.

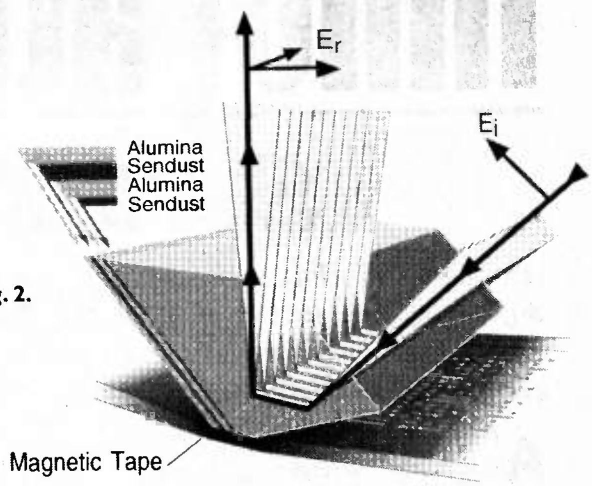


Fig. 2.

Optical Detection

The French team designed a very simple, two pole, thin film magnetic/optical head to allow the high resolution readout. Two thin films of sendust separated by a non-magnetic layer are deposited on a transparent substrate. The pole tips of these films are in contact with the tape.

Tape magnetisation reversal induces magnetisation variation in the thin film poles. This variation is detected using the longitudinal magneto-optic Kerr effect: i.e. rotation of light polarisation proportional to the magnetism in one of the two poles. In order to get as much signal as possible the light has to be focused very close to the pole tips, using a cylindrical lens.

After reflection by the megneto-optical pole, light is imaged on a CCD linear sensor. This reflected light has its polarisation rotated to the left or to the right, according to the direction of magnetisation. This rotated light is analysed by a polarising component.

384 continuous tracks are written on the tape using the multi-track matrix recording head. Data is coded using an eight to ten conventional modulation code recorded on each track. The readout signal coming from the CCD is then equalised using a finite impulse response filter in order to remove inter-symbol interference, so that the readout crosstalk between adjacent tracks is numerically estimated and removed.

Under Licence

It is possible that Thomson may license their digital VCR technology outside the company, following many demonstrations to manufacturers worldwide. What is certain is that their development is arousing keen interest worldwide.

ELECTRONICS FAIR

WITH the rather cumbersome title of *All Micro Show 7, Radio Rally and Electronics Fair* its no wonder the organisers shorten it to "AMS". Anyway, its celebrating its fifth year at Bingley Hall, Staffordshire Show Ground, Weston Rd., Stafford and will have over 60 trade stands.

The Fair covers the computing spectrum from PCs to Amigas and Ataris, including accessories, software, books, components, shareware, media, hardware and a "huge electronic bring and buy stall."

The entrance price is £2 (the same as charged for the first show five years ago!). There are also local charity stalls, free parking, a shuttle bus service from Stafford railway station plus a licenced bar and cafeteria.

The Fair is open from 10am to 4pm on Saturday November 13. The organisers are Sharward Services. Tel. 0473 272002, Fax. 0473 272008.

CATALOGUE DOWN

Electromail, the mail order arm of RS Components, is now offering its full colour catalogue at a reduced price of £2.95, for a limited period from the 1st November to 31st December 1993. The three part catalogue, usually priced at £6.50, gives its customers immediate access to the extensive range of RS electronic, electrical and mechanical parts and tools.

The catalogue consists of over 2,000 pages, giving product descriptions, photographs and useful hints on product usage.

Contact **Electromail** (Dept. EPE) P.O. Box 33, Corby, Northants, NN17 9EZ. Tel. 0536 204555, Fax. 0536 405555.

New Technology Update

Ian Poole investigates silicon germanium (SiGe) chips, hard disk developments and the latest on 3D LCD innovations.

TODAY silicon is the most widely used semiconductor. Even its nearest rival, gallium arsenide which is being used more widely is not nearly as common. However, germanium, once the most popular semiconductor, used in transistors like the OC44, and OC71 of yester-year, is very rarely used except in a limited number of applications.

This is despite the fact that it has a higher electron mobility than silicon and it offers the prospect of a much faster product. In fact if germanium could be used in integrated circuit manufacture then it would be able to compete with gallium arsenide in terms of performance whilst being much easier to handle in production.

To enable this to happen the use of a silicon germanium alloy consisting of up to 30 per cent germanium is being investigated. The exact mix of the two materials is a difficult balance to make. By increasing the amount of germanium, the performance is improved. However, it becomes more difficult to ensure the material remains free from defects during manufacture.

The groups investigating the new technique have been able to make some significant improvements. The basic technology has been proved and one group has been able to manufacture transistors with a cut off frequency of around 50GHz. The next stage is to incorporate these SiGe transistors into a 0·25µm CMOS process used in the manufacture of BiCMOS i.c.s. If all goes well then it is expected that the first chips will be available in two years.

Improved Hard Disks

Hard disks are very widely used throughout the computer industry. They are used in all manner of computers from the smallest PCs right up to the largest main-frames. This use has come about as a result of the performance and cost of these drives. When compared to other systems they have their limitations, but overall they offer excellent performance. However with many new types of memory being developed disk technology still needs to receive its share of development if it is to stay competitive.

This is exactly what is happening. Various developments are taking place to improve performance. Parameters like access time, size and cost are continuously being reduced whilst storage capacity, and data density are being increased. To achieve these improvements, the constituent parts of the drives have to be developed further. Obviously one of the most important is the disk itself. This is crucial because its performance governs many of the other aspects of the whole unit.

In view of this many companies are pumping millions of pounds or dollars into improving hard disk media. One interesting development which promises to give some significant improvements is the use of a glass ceramic base instead of the more common aluminium one.

The main advantage of this development is that it allows the disc head to fly very much closer to the disc. Currently distances of 2µ inches have been achieved and it is expected that this can be reduced still further. The advantage of being able to fly the heads this close to the disk is that it enables much higher data densities to be achieved. This can then be used in reducing the size of the disc or increasing its capacity.

The new substrate has a number of advantages over the older aluminium based media. Firstly it is far stronger, being able to handle far higher levels of stress before any damage is incurred. This is particularly useful for portable applications where drives are exposed to far higher levels of shock than in fixed systems. In fact the strength of the new disks is such that they can withstand shocks of up to 100G.

Another advantage of the new material is that it does not require a layer of nickel between the substrate and the base coat layers. This means that less stages are required in the manufacturing process resulting in significant production cost savings.

Disk drives using this new technology will be made by Seagate, the disk drive manufacturer based in California. Corning, who undertook much of the initial research will provide the basic disks. Now that most of the development is complete and the manufacturing agreements are in place it is expected that the first production items will be available later this year.

3D LCDs

A new and very interesting l.c.d. development which gives three dimensional viewing has been announced recently. Although the new idea only allows viewing over a limited angle it does not need special glasses like many other 3D systems, nor does it use the lasers required by holographic systems. Now at an advanced prototype stage the new idea has been developed by a company called Dimension Technologies Inc in New York.

The basic idea behind the system involves having two different images displayed on the same display, one for the left eye and one for the right. These two images are displayed in adjacent columns of pixels. To give the 3D effect a special backlighting panel is used. This generates a set of very bright, vertical lines which illuminate the display – see Fig. 1.

The key to the new idea lies in the positioning of the backlighting panel. It is positioned so that light from the lines passes through the odd numbered columns of pixels in the display to reach the left eye, and through the even numbered columns to reach the right eye. This means that two separate images need to be displayed. One for the left eye in odd columns and the one for the right eye in the even numbered columns.

The obvious drawback of the system is that the resolution of the display is effectively halved. In some instances this may not be a problem, however in others it might be necessary to double the definition of the display. This can be very costly because high definition displays are not cheap. To overcome this a cunning multiplex solution has been devised.

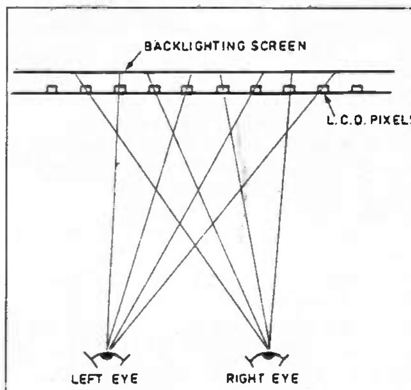


Fig. 1. Operation of the basic 3D LCD system.

In this the number of lines in the backlighting panel is doubled. The system is then operated so that when the first set of backlighting lines is energised the odd columns of pixels are seen by the left eye, and the even ones are seen by the right eye. Then with the second set of backlighting lines energised the conditions are reversed so that the even columns of pixels are seen by the left eye and the odd columns are seen by the right eye.

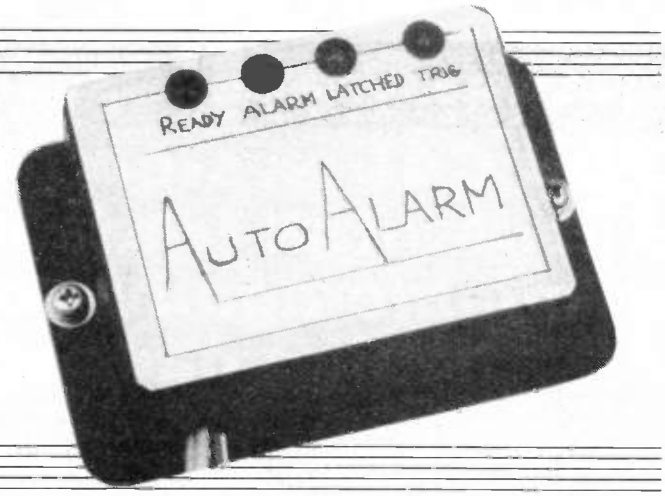
The two sets of backlighting lines are energised alternately and the images on the l.c.d. change to suit. In this way the full definition of the display is realised and, provided the switching rate is maintained above about 30Hz, the flicker is kept at an acceptable level.

It may appear that the processing required to implement the switching may be expensive. However the cost of high definition l.c.d.s is often such that this solution is very cost effective.

The development of this idea is still continuing. Once it is fully developed and ready for production it is likely that it will find uses in a wide variety of applications. This is because there are very few methods for producing 3D images in a satisfactory and cost effective manner.

Constructional Project

AUTO ALARM



M. G. ARGENT

Make life difficult for car thieves with this attention grabbing alarm. Includes an independent personal attack "Panic Button".

CAR ALARMS come in a multitude of types, each with varying complexities, and often end up baffling the consumer to the point of disinterest. It might even be debatable if much can be done to stop the professional car thief, but we can definitely go a long way in making it difficult for the common opportunists by providing either total demobilization of the car in the event of illegal entry, or the simpler method of sounding an attention-getting alarm to scare the intruder away.

The method of triggering this alarm is by way of the courtesy light switches in the car doors, and with the designed-in anti-bounce circuitry, there is little chance of a false trigger – to the delight of neighbours!

EXIT/ENTRY DELAY

A time delay of 20 seconds is provided for both Exit and Entry of the vehicle, and during these times, an internal sounder pulses. If the unit is not subsequently switched off, the pulsed alarm will sound for approximately one minute then automatically reset awaiting another door entry.

Four l.e.d.s are provided to indicate the current alarm state: Ready; Trig; Latched and Alarm – see Table 1. For ease of construction the circuit described uses just two integrated circuits and is constructed on a single printed circuit board (p.c.b.).

Also included in this design is a manually operated Personal Attack switch for use in the event of an intruder approaching menacingly. Operating the PA switch will sound the alarm at any time, even if the unit is switched off.

Table 1: Alarm Status

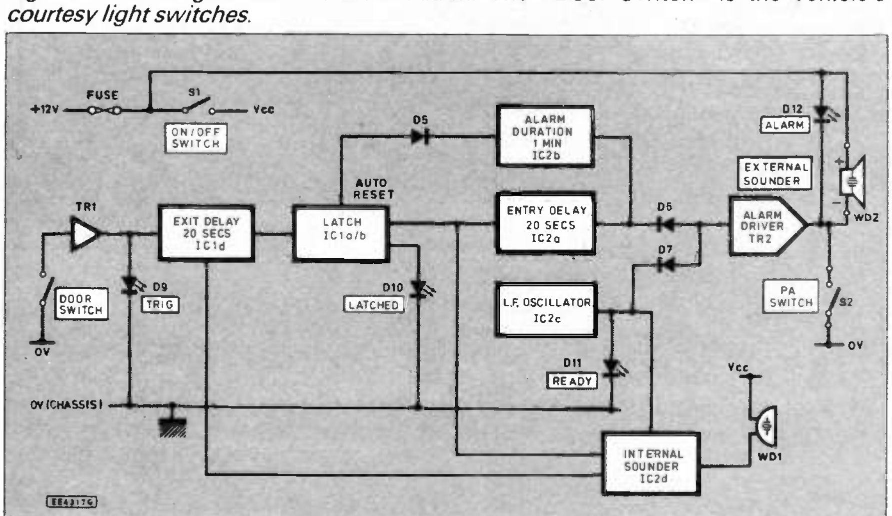
D9	TRIG	A door is open.
D10	LATCHED	The alarm is set, ready to go off in 20 seconds.
D11	READY	Continuously flashes to indicate the unit is on and also to deter opportunist intruders.
D12	ALARM	Lights in sympathy with the alarm. Useful for checking the unit when installing.

Due to some in-built car electronics, this unit might not be suitable for vehicles with courtesy light extenders or lights-on warning circuits.

HOW IT WORKS

The block diagram for the Auto Alarm is shown in Fig. 1. The door switch is fed,

Fig. 1. Block diagram for the Auto Alarm. The "Door Switch" is the vehicle's courtesy light switches.



COMPONENTS

Resistors

R1, R4, R14	10k (3 off)
R2, R3, R8, R12, R15	2k2 (5 off)
R5	470k
R6, R9, R13	1M (3 off)
R7, R10, R11	100k (3 off)

All carbon film 0·25W 5%

See SHOP TALK Page

Capacitors

C1	100μ radial elect. 25V
C2, C3, C9	10n disc ceramic (3 off)
C4, C6	1μ radial elect. 25V (2 off)
C5, C7	22μ radial elect. 16V (2 off)
C8	10μ radial elect. 35V
C10	47μ radial elect. 25V

Semiconductors

D1, D13	1N4002 1A 100V rect. diode (2 off)
D2 to D8	1N4148 signal diode (7 off)
D9 to D12	5mm l.e.d. (colours to suit), with clips
TR1	BC327 *npn* medium power silicon transistor
IC1, IC2	CD4093 CMOS quad 2-input NAND Schmitt trigger (see text) (2 off)

Miscellaneous

S1	Min. s.p.c.o. slider or toggle switch (On/Off)
S2	Pushbutton switch, push-to-make release to break (Personal Attack)
WD1	Low-voltage, p.c.b. mounting, piezoelectric transducer
WD2	Electronic siren (staccato), 6V to 16V d.c. (12V nominal) 300mA.

Plastic (ABS) box with base plate, size 82mm x 64mm x 28mm (base 105mm x 72mm); 14-pin low-profile i.c. socket (2 off); in-line fuseholder, with 1A fuse; single-core tinned copper wire for p.c.b. links, auto-type (6A) multi-strand connecting wire; solder pins (optional); solder etc.

Printed circuit board available from *EPE PCB Service*, code 854.

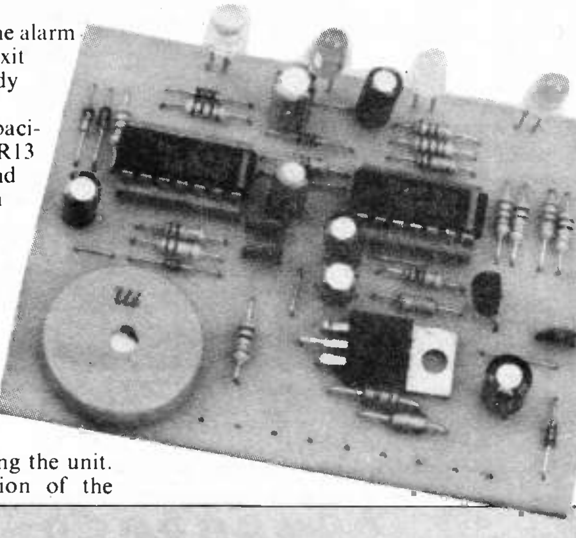
Approx cost guidance only **£19**

via transistor TR1 to the Exit timer circuit (IC1d) and on to the alarm latch (IC1a/b).

Opening the car door will light the Trig l.e.d. D9 but is inhibited from triggering the latch during the 20 seconds Exit time. After this time, if the door is opened, the latch will change state, light the Latched l.e.d. D10, and remain in this state until the unit is switched off or automatically resets.

At this time, the Entry delay timer of 20 seconds is started. If, during this time the occupant does not switch off, the alarm driver transistor TR2 will start the Alarm. This will continue for one minute and then automatically Reset the latch, waiting for any further door openings.

The free-running l.f. oscillator (IC2c) flashes the Ready l.e.d. D11 to indicate the unit is switched on to deter intruders, and pulses the Exit/Entry internal sounder oscillator and is used to pulse the alarm driver, the internal Entry/Exit sounder and also drive the Ready l.e.d. D11.



Once the alarm operates, capacitor C10 charges up via resistor R13 in approximately one minute and switches IC2b to reset the latch and, assuming that the doors are all shut, the whole car alarm will reset and wait obediently for another door entry.

If, however, any door is still open after 20 seconds, the unit will automatically retrigger and start the cycle all over again.

Diode D1 is included to prevent supply reversal damaging the unit. Note that the CD4093 version of the

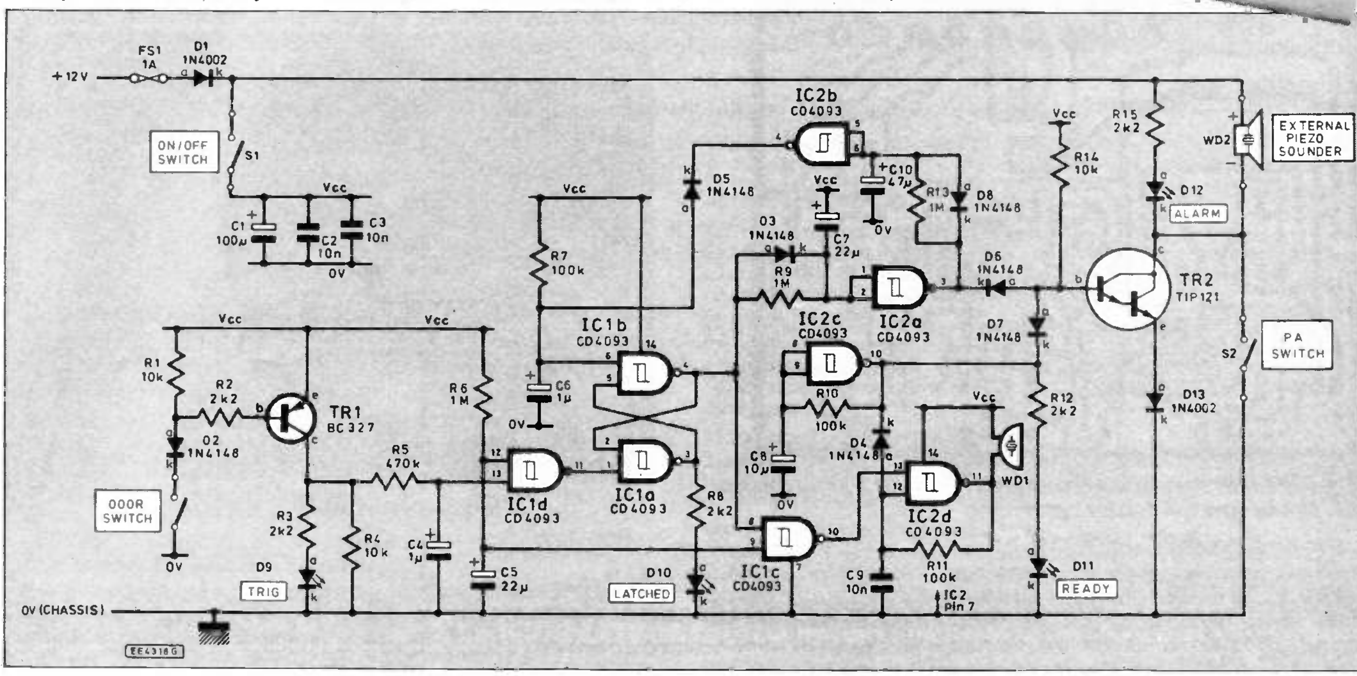


Fig. 2. Full circuit diagram for the Auto Alarm. The vehicle's "negative earth" (metalwork) is the 0V line.

IC2d/WD1. The output from this oscillator is also used to pulse the alarm driver TR2.

The Personal Attack switch will operate the alarm unpulsed, even when the unit is switched off.

CIRCUIT DESCRIPTION

The full circuit diagram for the Auto Alarm is shown in Fig. 2. The latch circuit is formed by the combination of IC1a and IC1b which drives the alarm circuitry.

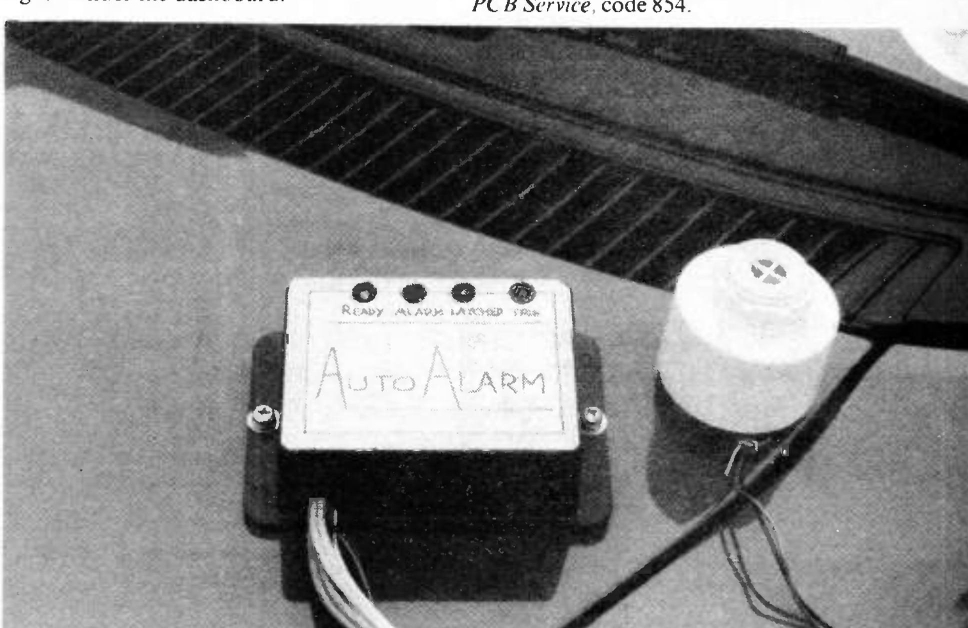
The input to the latch is connected to the Exit timer IC1d. When the unit is switched on, IC1d pin 12 will start off at 0V then rise as capacitor C5 charges up via resistor R6. This takes about 20 seconds, enough time for the driver to exit the car.

During this time, the door switch, via TR1, will have no effect on IC1, allowing the occupant to leave the car and shut the door. An internal piezo sounder IC2d/WD1, will pulse during this time to indicate that the alarm is about to latch. Included in the door switch circuit, around TR1, is a short time constant R5/C4 to avoid false triggering due to intermittent door switches.

When a door is subsequently opened for entry, the latch will trigger, and after the 20 second Entry delay period, determined by R9/C7, the alarm driver transistor TR2 will be enabled. IC2c is a low frequency Schmitt trigger NAND gate should be used here, not the Motorola MC14093 – spec. differs sufficiently to upset timing circuits. The On/Off (slider or toggle) switch S1 is the units supply/arming switch and should be hidden away out of sight – under the dashboard.

CONSTRUCTION

The Auto Alarm is built on a small single-sided printed circuit board and the topside components layout and underside copper foil master pattern is shown in Fig. 3. This board is available from the *EPE PCB Service*, code 854.



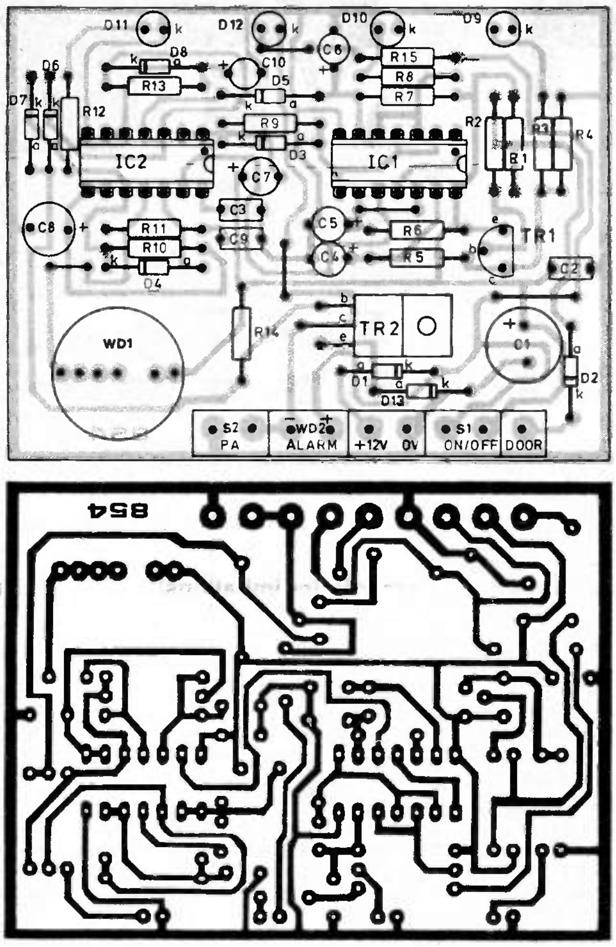
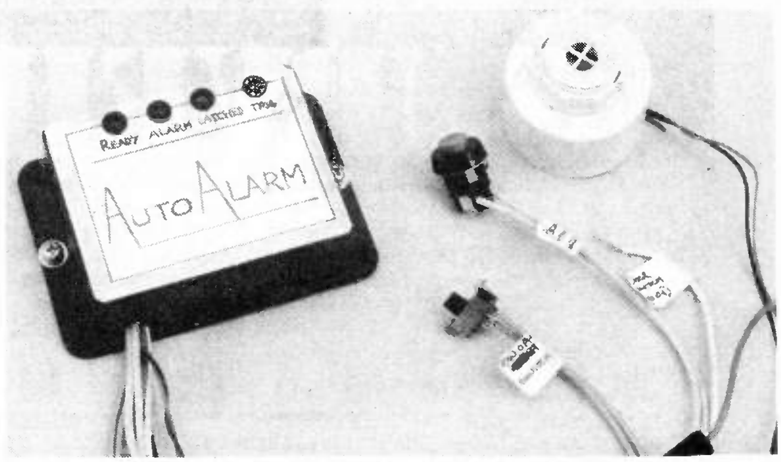
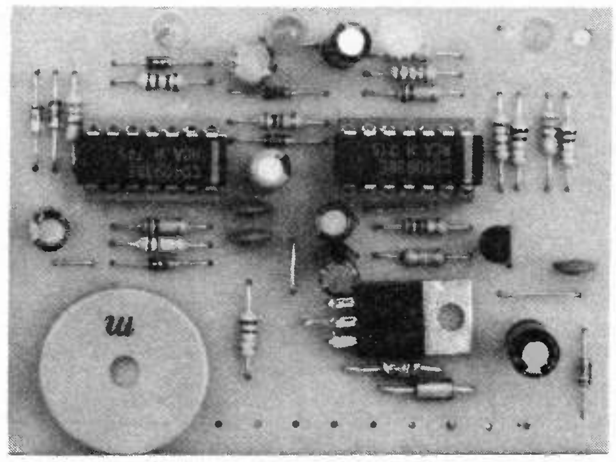


Fig 4. Printed circuit board component layout and underside full size copper foil master pattern.



The finished alarm ready for installation in the vehicle.



The completed alarm circuit board.

Following the component layout diagram in Fig. 3, insert and solder the components on the p.c.b. in the following order: wire links (five); resistors; diodes; capacitors; transistors; i.c.s; piezoelectric sounder and finally the l.e.d.s. Take particular care over the polarities of the diodes and electrolytic capacitors and also make sure of the correct orientation of the i.c.s. and transistors. The cathode (k) of the l.e.d. is usually denoted by a flat on the body of the device and a shorter lead.

When all the components have been assembled on the p.c.b., solder the connecting wires to the board. The wire used should be the multi-strand auto type rated at about 6A, the lengths will, of course, depend on the siting of the unit in the vehicle. Note that the +12V supply lead (red) must have an in-line fuseholder and 1A fuse wired in it.

TESTING

With the +12V supply connected, and assuming there are no wiring errors, the READY l.e.d. D11 will flash and the small, p.c.b. mounted, internal piezo transducer WD1 will pulse for 20 seconds. This is the Exit timer when vacating the car and, during this time, the car doors may be opened without triggering the main alarm.

While WD1 is sounding, momentarily short the TRIG wire to 0V (this simulates the door switch) and check that D9 lights and goes out when the wire is disconnected. No other l.e.d.s should come on because of this. Allow a short time when connecting the TRIG wire because of the anti-bounce circuit.

After WD1 stops sounding, the unit will be armed and ready to detect any further door openings. If the trigger wire is again momentarily connected to 0V, the LATCHED l.e.d. D10 will light and remain lit until the unit is switched off.

Also, WD1 will again sound for 20 seconds and if the unit is not switched off during this time the main alarm will start. This alarm will pulse at the same rate as WD1 and also the ALARM l.e.d. D12 will flash in sympathy.

If the alarm is allowed to keep sounding, it will carry on for approximately one minute then automatically reset itself, awaiting another door entry. □

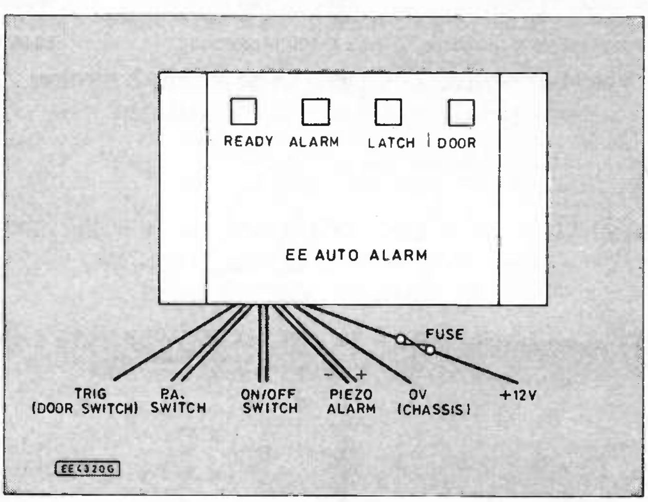
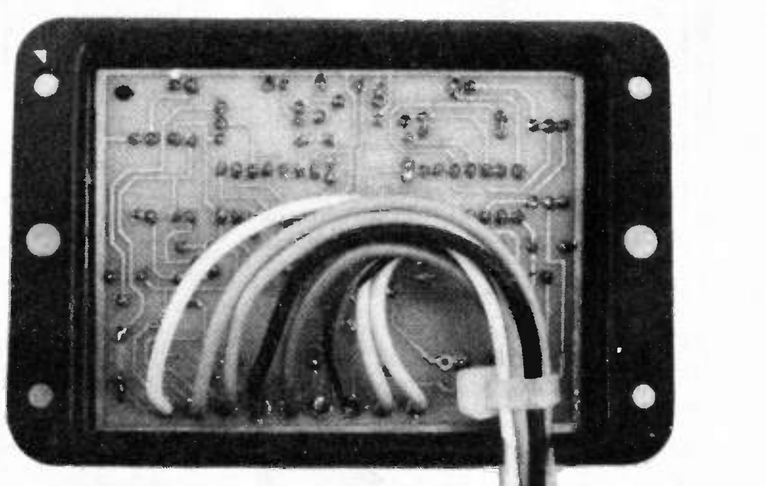


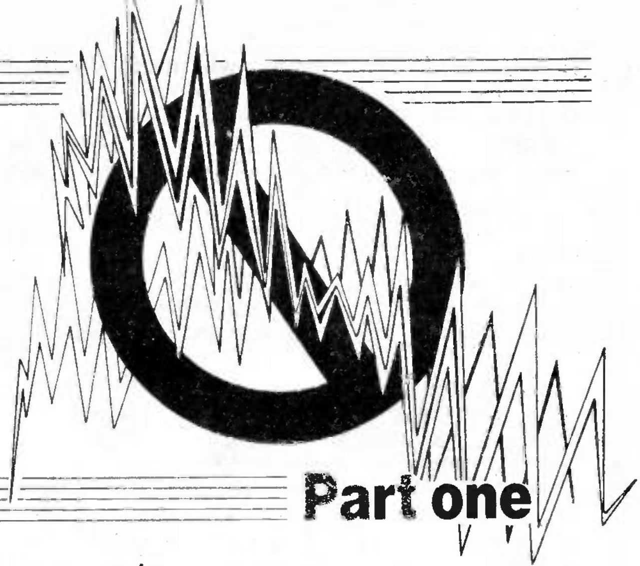
Fig. 5. General layout and wiring details. Note the line fuse.



The connecting leads wired to the copper pads.

Special Series

SAFETY FIRST!



T.R. de VAUX-BALBIRNIE

Part one

Staying alive with electrical equipment

A short four-part series concerned with electrical safety in the home and electronics work area. The electronics enthusiast should find this useful as will anyone who uses electrical equipment in and around the home and garden. The series covers everything from regulations and basic first-aid to chemical hazards from modern components and materials.

THE convenience and versatility of electricity as a form of energy is well known. It is difficult to see how many modern devices could operate in any other way. The whole range of *information technology* (*IT*) equipment is an example.

However, although electricity is a good slave of man, it is a very bad master. If certain basic rules are not followed electricity can be lethal. Even so, this series is not meant to dampen enthusiasm – rather to increase awareness. Electricity used carefully rarely causes problems.

REGULATIONS

Regulations exist in industry for the periodic inspection and testing of items of electrical equipment. There is a duty on the employer to ensure that electrical installations and equipment are correctly constructed, safely installed and properly maintained. In the domestic situation no such ongoing safety checks are imposed by law so, unless carried out voluntarily, the home can be a very unsafe place from the electrical point of view.

Readers should note that here we are concerned with *electricity in a domestic environment* and information is presented in a general way. Those working in industry or education *must* follow more specific guidance such as in the *Electricity at Work Regulations (1989)* and *Regulations for Electrical Installations* (IEE Wiring Regulations 16th Edition). Similarly, overseas readers will need to check their own national regulations.

DANGERS

Electricity presents two basic dangers *electric shock* and *fire.* Electric shock will be discussed this month and next, with fire over the following two months. There are also smaller dangers of direct and indirect burns and general injuries such as those caused by falling off a ladder.

Specific guidance on using mains-voltage electricity in a caravan will be covered in Part 3 and the dangers due to some chemical substances met in electronics work will be mentioned in Part 4.

Although much of this series will be concerned with the use of *mains* electricity, it would be a mistake to believe that this is the only source of danger. Electric shock and fire can be caused by low-voltage supplies – even batteries.

All this information will follow presently. However,

WHAT TO DO

1. On hearing a cry of pain, furniture falling over, etc. – act without delay.

2. Determine whether the cause of shock is still connected to the person – if you are not sure, act as if it is. To isolate the victim, unplug at the wall socket or switch off at the main fuse box.

If you must pull the person away from the source of shock, perhaps because it is not clear how to switch off or because it would take too long to go to the main fusebox, use something on your hands which is a good insulator and stand on something highly insulating – plastic bags, for example. ***Do not, under any circumstances, pull the victim clear with BARE hands because you could receive the shock yourself.***

A piece of wood, furniture for example, could be used but such material is often damp enough (even when it seems dry) to deliver a shock. If there is anyone else present, ask them to telephone for an ambulance telling the emergency service clearly that there is a case of electric shock.

3. With the victim isolated, it is necessary to check for (a) respiration (b) pulse. If breathing has stopped, apply mouth-to-mouth resuscitation without delay. If respiration does not return to normal, check for a pulse and, if necessary, apply external cardiac massage. ***Call an ambulance.***

4. If the heart is functioning and the person breathing but unconscious, place in the recovery position. ***Call an ambulance.***

recognising that some readers will not follow the whole series, it seems a good idea to suggest a plan of action for dealing with cases of electric shock this month.

With luck, this strategy will never be needed but accidents sometimes happen due to someone else's fault. It is therefore important for everyone to have a clear idea of what to do if they ever need to treat a victim of electric shock.

Electronics enthusiasts could be in more danger than most because fault-finding and experimentation are sometimes carried out with the lid of the equipment removed. Also, home-made devices may be less safe than commercial ones because details such as shielding exposed mains connections are often overlooked.

PLAN OF ACTION

It is important to brief *everyone* living in the house with you. It is not good enough for them simply to dial 999 – by the time the ambulance has arrived it is likely to be too late. This is definitely a case of *better safe than sorry*.

If you do not know how to perform any of the following emergency procedures or your knowledge is "rusty", go on a first-aid course (your local library or town hall will point you in the right direction) or at least look them up in a *modern* first-aid book.

As a general rule, and recognising that it is not always possible, try not to experiment with electrical equipment while on your own. The exception is battery-operated items (using up to 25 volts approximately) where the supply is not stepped up by internal circuitry (such as photoflash equipment). This is advisable whenever a *mains-operated* power supply is used and *most definitely where direct mains-voltage connections have been made by the constructor* – such as in a sound-to-light unit.

SHOCKING MISCONCEPTIONS

Although everyone uses electricity, most of us manage to avoid danger. However, research shows that this is often more by good fortune than any particular care. The occasional slight electric shock seems to the rule rather than the exception. How many of us can honestly say that neither we nor anyone we know has experienced a minor electric shock during the past few years?

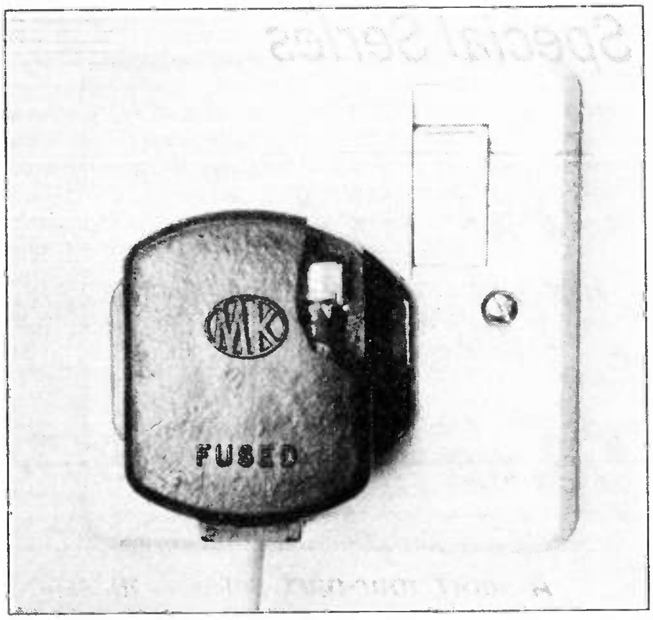
Who has checked all the plugs and socket outlets for cracks or breaks and for socket shutters being in position and operating properly? Who has inspected for loose cables including a check that they are properly gripped in the plug to provide strain relief? Who has replaced all old-style plugs with the latest pattern having sleeved (partially insulated) pins? Precious few probably.

Often an electric shock is nothing more than an unpleasant fright – many are not reported and most occur within the confines of the home and garden. A common misconception is to think that once a person has experienced an electric shock, he or she can "stand it" and will not come to any harm by another one!

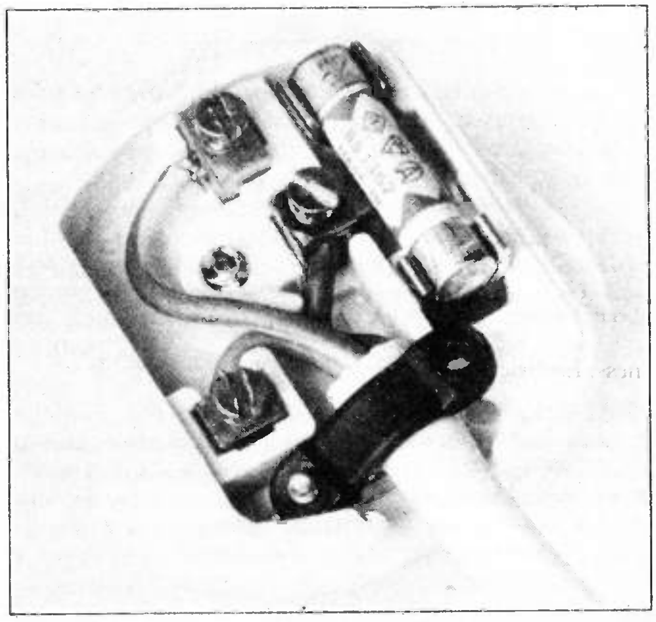
In the author's opinion, of all everyday dangers, electric shock is least well understood by the population at large. It is necessary to have a basic idea of its physiological effects, a knowledge of basic circuits, Ohm's Law and "earthing". This last point explains how it is possible to receive a shock by touching only one wire while standing on the ground – an *Earth loop shock*. This will be looked at next month.

PHYSIOLOGICAL EFFECTS

Electric shock is caused by current flowing through the body – that is the person becomes part of a circuit. The effect may be harmless, *painful* or *lethal* depending on the *strength* of the *current* and the *path* it takes. For example, a shock confined to the hand or arm (see Fig. 1a) is likely to have less effect than one which passes from one arm to the other with the heart between (see Fig. 1b). It is also particularly dangerous for the path of the current to involve the brain as when a live overhead wire is brushed by the head.



Never use a cracked plug – its lethal.



Poor cable gripping, no strain relief for wires.

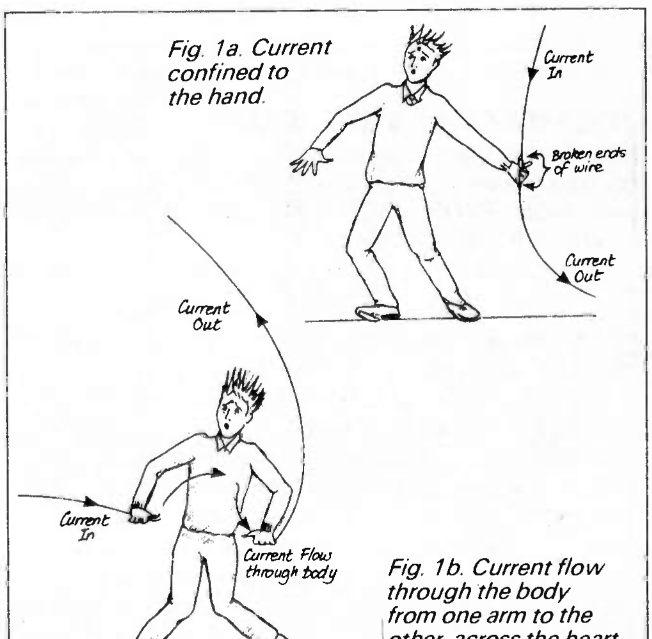


Fig. 1a. Current confined to the hand.

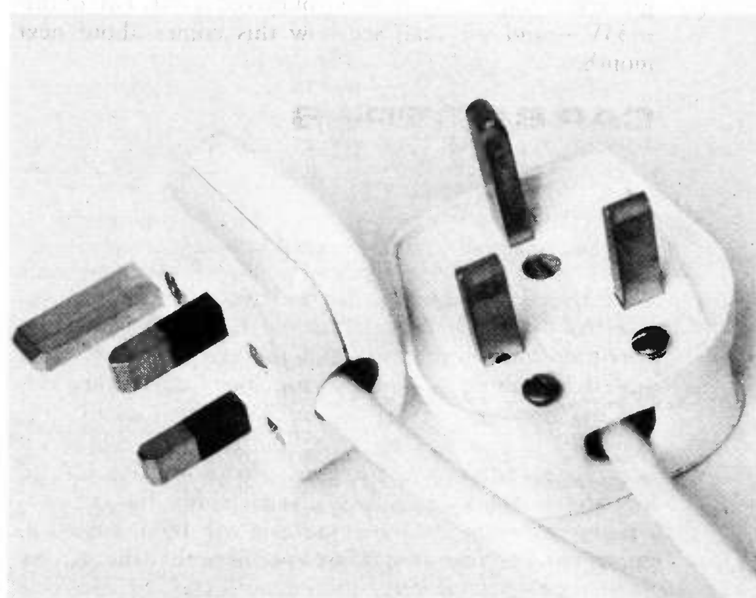
Fig. 1b. Current flow through the body from one arm to the other, across the heart.

Electric shock can cause pain, unconsciousness, cessation of breathing and/or heart activity with consequent death. Suffocation is the most common cause of death in electric shock cases. Electric shock affects the nervous system and can cause violent muscular contraction with subsequent injury. Table. 1 shows the likely effects of different magnitudes of current in a person. Note that current is measured in *amps* (A) but here small currents are involved so it is more convenient to talk about *milliamps* (mA) (1A = 1000mA).

Note that we have made no distinction between the effects of a.c. (alternating current) and d.c. (direct current). These differences exist but are too specialised to be discussed here.

Table 1: Shock Effect

Current (mA)	Effect
up to 1	No effect.
1	Just detectable.
5	Some pain – muscle spasm.
10	Severe pain and muscle spasm.
30	Respiration ceases.
75	Heart stops, breathing stops.



Old 13A three-pin plug and new Sleeved-pin plug.

As a general rule, any current over 20mA to 25mA may be regarded as potentially lethal. This may seem very small compared with, for example, the current flowing through a 240V 60W electric lamp which is 250mA.

A shock sufficient to cause muscle contractions can "throw" a person with considerable force and possibly cause indirect injury. This reflex action can sometimes save life by clearing the person from the cause of shock. Unfortunately, the same reflex action can sometimes cause the person to grasp the conductor more tightly so increasing the effect.

In Victorian times small electric shocks were said to be "healthy and wholesome". Electric shock machines were sometimes installed at fairgrounds with a control knob to increase the effect to the point where the subject could stand it no further! Until fairly recently, small induction coils – "shocking coils" – were sold at toy shops and these could increase battery voltage to a level where quite unpleasant shocks could be delivered between two handles held one in each hand.

Strangely enough, very large currents (in excess of 1A) are more likely to be survived than those around 75mA but these will not occur in a domestic situation.

USING OHM'S LAW

Ohm's Law can be applied to an electric shock because the human body conducts electricity. To predict the current we can use the following version of Ohm's Law which states:

$$I = V/R$$

Where I is the current in amps, V is the voltage of the supply and R the *skin contact resistance*.

Some typical values of skin contact resistance are given in Table 2. It can be seen from the above equation that the current will be greater if (a) the voltage is higher or (b) the skin contact resistance is lower. Most people realize the significance of a higher voltage – that is, the *higher* the voltage the more danger exists but forget the equally important point of skin contact resistance.

Thus, the current flowing *can be lethal* with a relatively low voltage supply if *low* skin contact resistance is present. Conversely, a fairly high voltage may cause only a small effect if the hands are *very* dry ("high resistance") and only brushing contact made with the live conductor.

The highest "safe" voltage – that is, where live conductors can be handled without taking any particular precautions, is the value which will not drive a harmful current through the body when the skin contact resistance is as low as possible. There are several interpretations of regulations and statements of good practice on this point. If we take 5mA to be the greatest "acceptable" current (see Table 1) and five kilohm (5k**Ω**) as the lowest likely skin contact resistance (see Table 2) it follows that the highest "safe" voltage will be 25V and this is a good figure to remember.

CURRENT AFFAIRS

The skin contact resistance depends on several factors chief of which are the tightness of grip, the area of contact and the presence of moisture (especially salty water as with sweaty hands). The resistance in each case will vary from subject to subject but the figures in Table 2 may be regarded as typical.

Table 2:

Situation	Resistance (kΩ)
Dry hands, light contact	100
Dry hands, tight grip	20
Wet hands, tight grip	10
Hands wet with salty water	5

Where mains voltage is used (240V in the UK), then applying Ohm's Law to the above resistance figures, the respective current values are: 2·4mA, 12mA, 24mA and 48mA. Referring to Table 1, it seems that the presence of moisture on the skin is likely to result in a lethal shock.

On building sites, portable power tools are often operated from a transformer providing a 110V supply. Thus, even if contact were made with wet hands, the current through the body would be approximately:

$$I = V/R = 110/10000 = \mathbf{11mA}$$

Although extremely unpleasant, the victim would probably survive. In fact, this is not the whole story – the greatest voltage likely to be encountered is only half of this – 55V – and we shall see how this comes about next month.

CAR BATTERIES

Consider a standard 12V car battery. If a person were to hold its terminals with wet salty hands (the worst case), the current will be:

$$I = V/R = 12/5000 = 2{\cdot}4\text{mA}$$

This could possibly be felt but would be unlikely to have any serious effect. Remember, this is the *worst* condition and, in practice, it is unlikely that any shock would be felt as a result of touching car battery terminals. Car project articles in EPE often advise the constructor to *disconnect the battery and remove it before installation work begins*. This is not because of any appreciable danger from electric shock but the possibility of *burning and fire* and this will be discussed in Parts 3 and 4. You should however note that the battery *must not* be disconnected when the vehicle is fitted with a coded audio system (unless you can reprogram the code) or when the engine management electronics may need resetting (as in some top of the range BMWs). This resetting can only be undertaken by the manufacturers service centre so "check before you disconnect".

Where otherwise safe mains-operated power supply units do not exceed 12V to 16V output, it is highly unlikely that any detectable shock will be given by touching bare conductors even under the "worst" conditions. In normal use, with dry hands, it will probably be safe to use supplies up to some 30V. Remember, however, that if a number of 9V batteries are connected together in series, a potentially lethal arrangement is soon reached – *experimenters beware!*

Bulk electricity is distributed around urban areas at 11,000V. A shock from this, even with dry hands and light contact (skin resistance = 100kΩ) will be lethal because Ohm's Law predicts that the current to be:

$$I = V/R = 110\text{mA}$$

Electricity is carried over the countryside at up to 400,000 volts. If a child flies a kite into these wires (even though the kite string is normally regarded as being made from insulating material) sufficient current will flow to cause death. For example, suppose a trace of dampness produces a resistance of 10MΩ, the current would be:

$$I = V/R = 400{,}000/10{,}000{,}000 = 40\text{mA}$$

Which is lethal.

TAKE CARE

Summarizing, to avoid electric shock in experimental work, everything must be kept dry and contact with exposed wires at a higher voltage than 25V or so avoided. Often the operating voltage is imposed by the design – mains voltage, for example, so it is necessary to concentrate on the other factors.

Reasons for accidental contact with live conductors are: frayed or spilt insulation on cable; wires partly pulled out of connectors; poorly-made (for example taped) joints; exposed terminals and poking metallic objects into electrical apparatus. These situations are easily avoided by adults but special thought must be given to children.

There is particular danger when using equipment where the connecting wire rubs against the work surface during use. Soldering irons come into this category as do standard household electric irons. Over a period of time the rubbing removes the relatively hard-wearing outer sheath (see photograph). At the first sign of this happening, the wire must be replaced otherwise the rubber will wear through eventually exposing the copper conductors.

In the case of an iron, the exposed live wire will perhaps touch the metalwork of the ironing board and the user will receive a shock when he or she touches it. Sometimes a hot soldering iron bit is left resting on the mains wire and it burns through the insulation exposing the wires underneath. Again, reasonable care and frequent inspection will reveal the problem before danger exists.

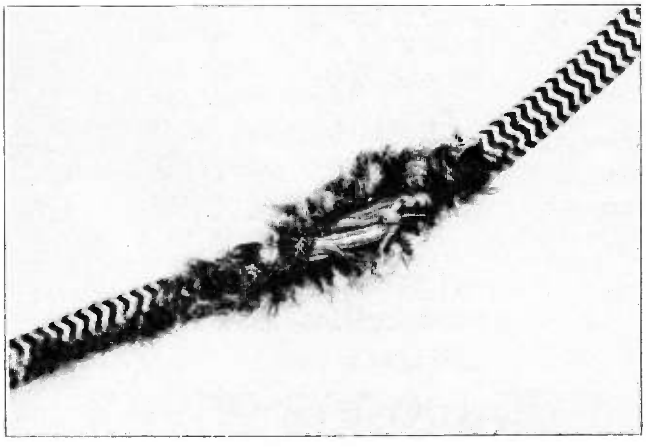
TIME FACTOR

Injury is caused to the individual because electricity is a form of energy. When any form of energy is released quickly it is likely to cause injury (for example, dropping a heavy weight on your foot). There is also a *time* factor involved. That is to say, if the current through the body passes for less than a certain time – lets say, a few milliseconds – it will be much less dangerous than if it flows continuously.

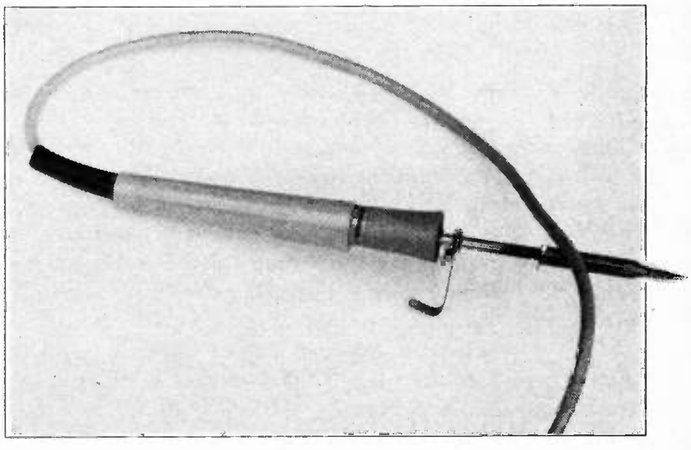
Sometimes a sharp shock is given when a water tap is touched after walking on a nylon carpet or similar situation. This is caused by a build-up of *static electricity*. The voltage is very high – perhaps several hundred volts – and the current correspondingly high but it only passes for a short time and so is generally harmless. Note that "static electricity" does not give a shock as many people suppose. Once it is moving through the body it is the same as any other electricity. In industry, large-scale generators of static electricity are regarded as dangerous and treated with respect.

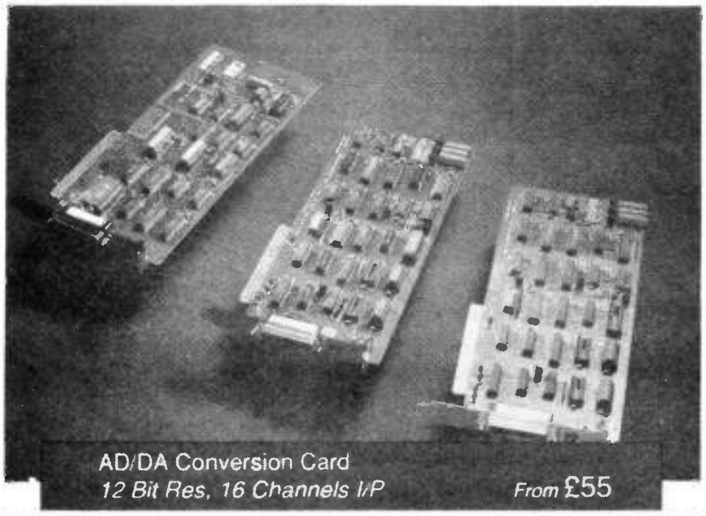
That's all for this month. Next time we shall continue with our discussion on electric shock, some further safety points and checks needed to stay clear of trouble.

Worn fabric wire can be very dangerous.



Avoid burning the soldering iron lead.





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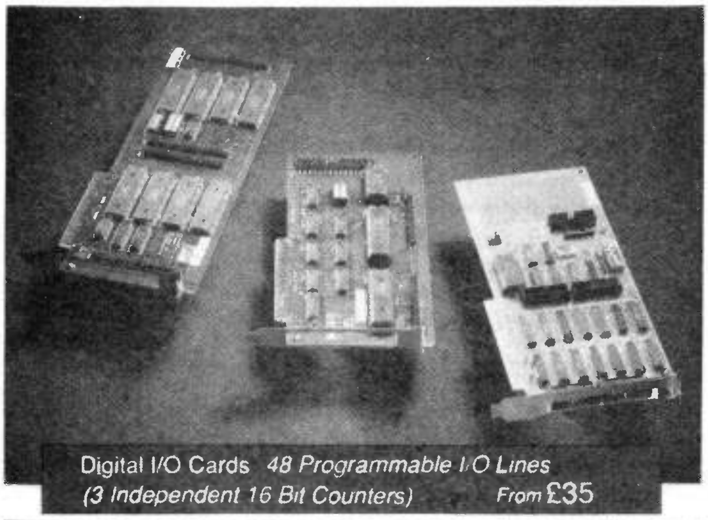

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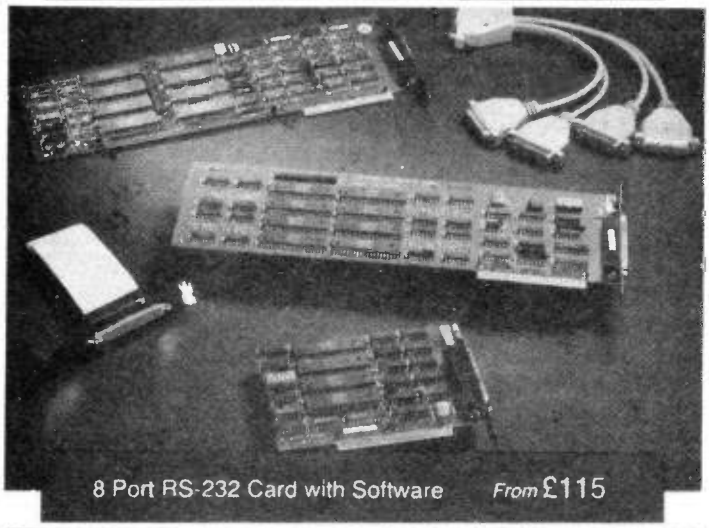

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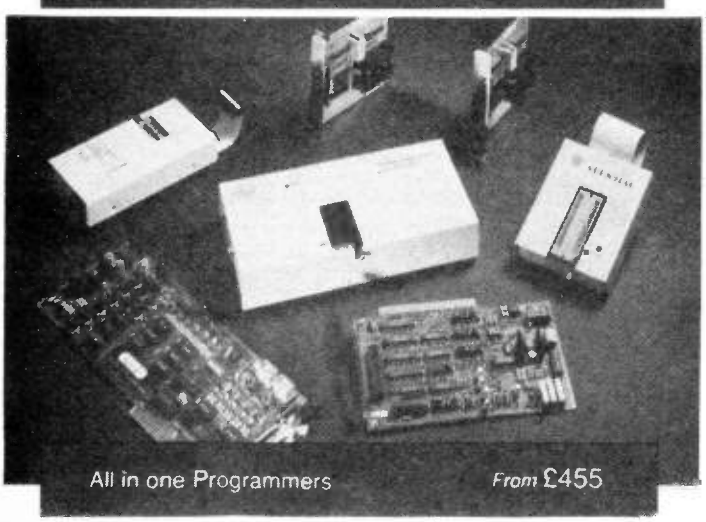

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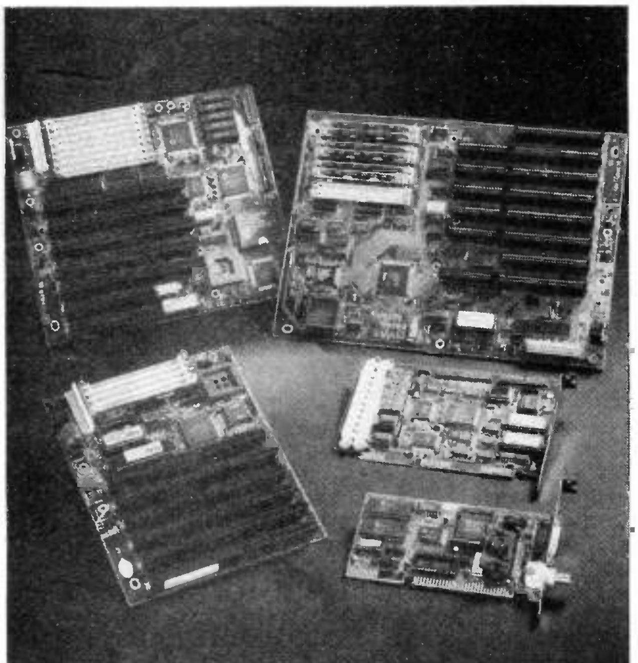

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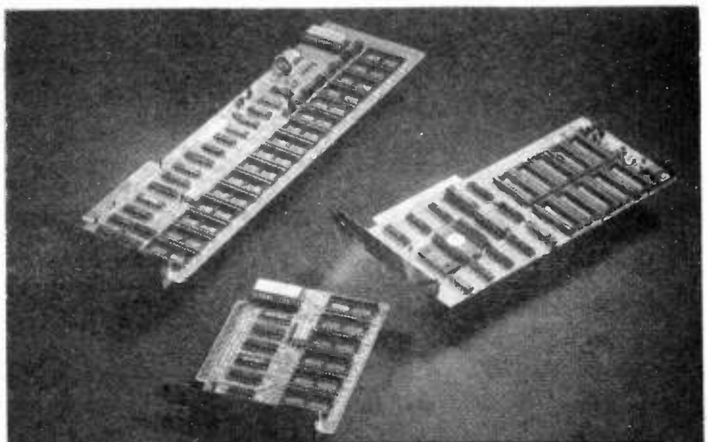

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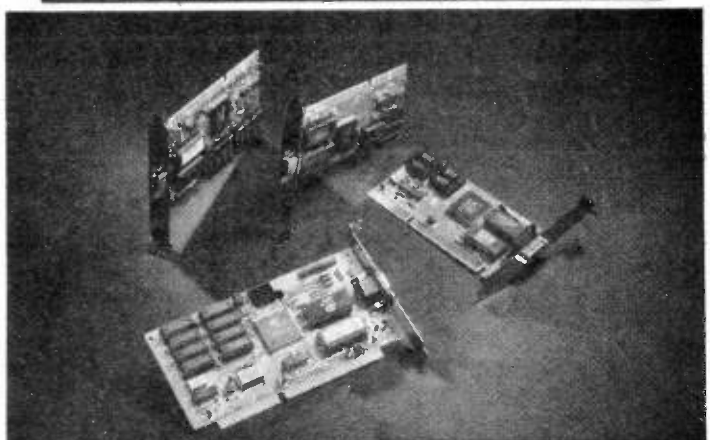

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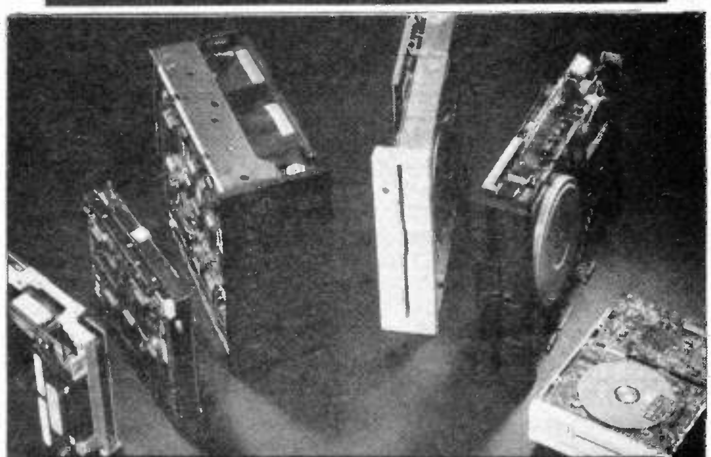

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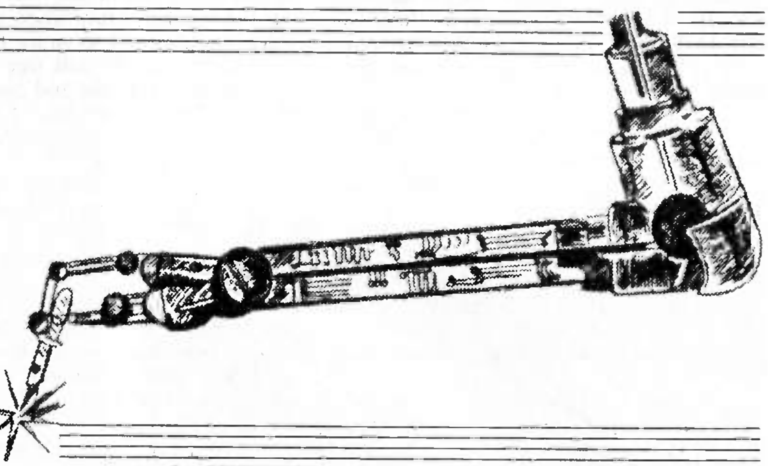


ALAN WINSTANLEY

Welcome once again to* Circuit Surgery*, our regular clinic devoted to readers' problems. This month we describe a circuit for taking the "thump" out of audio systems. We also offer a Simple Fuse Tester. We begin with a "con-fusing" question. . . .

Open all hours

I'm delighted to be behind the desk at *Circuit Surgery*, the monthly clinic to help resolve problems, pass on tips and share circuit suggestions. I'm sure readers have appreciated Mike Tooley's sterling work and I'll do my best to follow on by helping out with readers' queries and encouraging you to explore the truly fascinating world of micro-electronics. Unfortunately space at "The Surgery" is strictly limited, however I will try to appeal to *all* sectors of our readership, from absolute beginners (such as many *Teach-In '93* followers), upwards.

This is **your** column, so why not drop me a line with your ideas and queries for inclusion in *Circuit Surgery?* I'm also happy to pass on any readers' handy tips relating to constructional matters or circuit design. These will appear under the "Prescriptions" column from time to time – but I want **your** quick tips and ideas, so get writing! Meantime, stethoscope at the ready, here goes!

Con-fusing

Tom Baldwin of Romsey wrote in with a question on fuse ratings for low voltage power supplies:

A recent 12V-0V-12V p.s.u. caused much confusion – I calculated peak power output on the d.c. side as 96 watts, and worked back to give a current rating on the mains side, to get a fuse rating. I made some allowance for capacitor charging but the mains fuse blew on power-up. I eventually used a fuse of what I thought was a dangerously high rating - where did I go wrong?

Tom's circuit was a standard full-wave rectification and smoothing arrangement, driving a complementary pair of regulators with external pass transistors to boost the current output, giving ± 12V d.c. at some 4A. In general, the power dissipated in the primary (mains side) of a transformer is about equal to that in the secondary circuit (and power = voltage across the circuit × current through the circuit, remembering that these are *r.m.s. values* where a simple sinewave is involved), but you do need to allow for the high "inrush" which occurs on power-up, caused by the smoothing capacitor sucking in an initial charge. Ignoring the load on the p.s.u., this surge is determined mostly by the resistance of the transformer windings and the size of the smoothing capacitor.

The actual value of electrolytics could be 50 to 100 per cent higher than the marked value due to their poor tolerance, and this factor may also cause a higher switch on surge than expected. You have to allow a margin for nuisance surges and for all low power mains projects with up to say 2,200μF or so of smoothing, I generally employ a *maximum* of 1A "quick blow" as a safe rule of thumb – 500mA or less if possible – to give adequate protection in case of transformer or smoothing capacitor failure.

With heavier loads using larger smoothing capacitors (say 5,000μF or more), it's probably best to use an "anti-surge" fuse instead – these have a coil spring built into the fusewire which permits a high initial current to flow but will still rupture under sustained overloads.

It seems the most accurate way of deciding the fuse rating is actually to measure the average a.c. mains current with a *true r.m.s.* meter then add a margin of say 50 to 75 per cent, though for safety's sake I would not recommend that an inexperienced novice attempts a **mains** current reading **at all.** Such a meter automatically "corrects" the reading to compensate for the complex non-sinusoidal waveform present in, say, a power supply, whereas a "normal" multimeter on an a.c. range is calibrated to produce an r.m.s. value based on an assumption that a simple sinewave is involved – adequate for most purposes.

Your $P = IV$ calculation to obtain a current value is slightly misleading in this case because it inherently relates to a simple sinewave. In fact, the p.s.u. waveform is more complex and the average current is much higher in practice – hence the fuse kept melting!

Some more "con-fusing" data – quality cartridge fuses are generally marked with a letter indicating their type: a type "F" is a quick-blow, "FF" is super-rapid (for semiconductor protection) whilst "T" is anti-surge or time-lag. Incidentally, fuses can also "grow old" and it's not unusual for fuses to melt for no apparent reason – I repaired my colour TV which suddenly stopped working when an internal fuse aged and finally failed altogether. A 5p. fuse saved me a £50 call-out bill!

Testing fuses

Still on the subject of fuses, ***Peter Strong*** of Tiverton asks:

Should fuses be tested on the low or high resistance range of a multimeter? I would have thought the "low" range as a fuse is a low resistance device, but it seems that multimeters source ***more*** *current on the low ranges which seems curious. Any explanation?*

When checking resistance with a multimeter, you're actually causing a "test" current to flow through the unknown resistance. The ohmmeter scale is calibrated as a function of the voltage across the resistor divided by this "test" current which is derived from the meter's internal batteries. (Actually, the test current flows out of the *negative* terminal of your multimeter!)

A moving coil multimeter could source some 100mA or more on the lower resistance ranges, this current generally

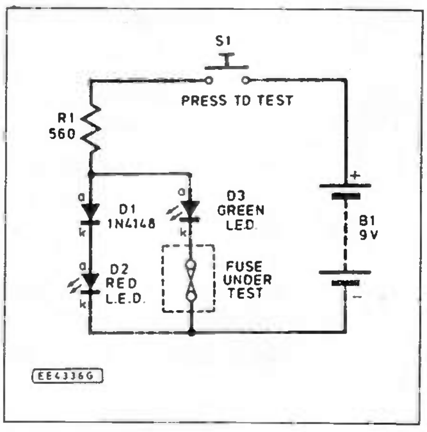


Fig. 1. Simple Fuse Checker circuit diagram.

reduces to just a few mA on the highest setting. However a digital multimeter (DMM) will typically only source a matter of microamps on its resistance range.

So if you're testing a really low current fuse using a moving coil multimeter, it might be best to stick to a higher resistance range where there is less likelihood of melting the fuse! But if the fuse is rated at say 250mA or more, then it should make no difference which range you utilise as there is little danger of damaging an intact fuse this way and you'll easily see the difference between virtually zero ohms and infinite resistance.

Using the test probes of a multimeter to test fuses can be tricky, so the Simple Fuse Checker of Fig. 1 will help to test whether glass or ceramic fuses are intact or not. It's ideal if your vision is impaired and it is handy to have on the bench as a very simple GO-NO-GO checker. It can be built into a small plastic box using a push switch, with two metal pads being used as "contacts" on the surface, spaced to accommodate both 20mm and 1¼ inch types.

To use the checker, just bridge the pads with the suspect fuse. An intact fuse will enable the green l.e.d. D3 to light, the forward voltage of which shunts diode D1 and l.e.d. D2 which cannot illuminate. A faulty fuse (open circuit) will illuminate the red l.e.d. instead.

Use it to test household light bulbs too!

Speaker Anti-thump

C.L. Quay from Kuala Lumpur, Malaysia wrote in – thanks for the picturesque postcard! – with an idea which might appeal to audio fans:

Building an amplifier is one thing, but to hear the "thumping" sound when you switch on is irritating. Can you help me with a simple "de-thump" circuit for my amplifier?

The Loudspeaker De-thump circuit of Fig. 2 is broadly universal and could be fitted onto many domestic systems. Adding anything between the amplifier and the speaker system might give rise to unacceptable distortion so in this simple but effective design, a set of heavy-duty relay contacts is driven by a short-period timer. The relay switches in a dummy load immediately on power-up and connects the speaker system once the amplifier has had time to settle to its quiescent operating condition, by which time the thump should have passed.

Integrated circuit IC2 is a MOSFET op.amp connected as a regenerative comparator or Schmitt trigger, with a degree of positive feedback provided by resistor R3. This gives a crisp switching action with no relay "chatter". The inverting input of the op.amp is connected to a simple *RC* network (VR1 and C3) which can be set for up to about four seconds delay. On applying power, the op.amp output switches high and transistor TR1 drives the power relay RLA.

The normally-open contacts thus connect a power resistor (R6) across the amplifier output terminals, simultaneously disconnecting the speaker. Only when the *RC* network has charged to more than 50 per cent of the supply rail (set by R1/R2) will the relay trip out and re-connect the speaker. This occurs after a short delay determined by the setting of VR1. Thereafter, the circuit draws little current.

A protected transistor type LP395Z was used for TR1. It has thermal shutdown and current limiting (100mA) features so it's nearly impossible to destroy. The l.e.d. D1 is a bit of a gimmick and could be omitted: it lights for the timing period. Fig. 2 shows the connections *for one audio channel only*, and the contacts RLA2 are used in a similar manner with another dummy load (not shown) for the other audio output.

It is probably best to power the circuit from the amplifier's existing d.c. supply which should manage the initial 100mA during timing (thereafter, hardly any current is consumed) and a typical 12V 100mA regulator (e.g. 78L12C) will withstand up to 35V d.c. absolute maximum input. Tap the supply from the main p.c.b. as near as possible to the amplifier's power supply smoothing capacitors, so that the de-thump circuit will trigger as soon as possible on power-up. Alternatively, build a *separate* mains power supply to provide about 12V d.c. 100mA maximum, linking a mains transformer from the mains input of the amplifier.

The load resistor R6 is not critical in value or power rating. It is unlikely to dissipate power of any significant level during the brief timing period, hence a relatively low power rating – say 5W minimum – should be adequate. You may actually be able to omit the dummy load altogether – there were no problems running my Marantz "open circuit" and most modern units will be protected against open or short circuits. However, choose a high-rated relay such as one with at least 10A contacts. A drop of contact lube may also help counter noise.

An enhancement may be to *reverse* the two inputs to the op-amp and also exchange the n/o and n/c circuits on the relay. Then, the 'speaker is never connected during powering up and will only switch in after a delay. However the circuit will then consume nearly 100mA as long as the speaker is connected because of the relay consumption, so make sure you are happy the power supply can cope with this extra loading.

Next month: A further selection of reader's letters to encourage you to dabble. I also hope to cover one or two *Teach-In* topics as well. If you have any particular queries, please write to me c/o The Editor, 6 Church St., Wimborne, Dorset BH21 1JH and where possible I will try to reply through this column.

Regrettably I cannot guarantee an individual reply or advise on the repair or modification of specific commercial equipment. I'm afraid there simply isn't room to handle lengthy topics, but I read every letter and assess them for appeal and complexity. If you have any ideas or queries which you think might interest others, then write in! Why not send a postcard or photo, too?

COMPONENTS

De-Thump Circuit

Resistors

R1, R2	100k (2 off)
R3	1M
R4	4k7
R5	680 (optional)
R6	22 ohms 5W (see text)

All 0·25W carbon film ± 5%

Potentiometer

VR1	2M2 enclosed carbon preset

See SHOP TALK Page

Capacitors

C1	0μ33 polyester
C2	0μ1 polyester
C3	2μ2 tantalum 16V

Semiconductors

IC1	78L12C 12V 100mA regulator
IC2	CA3140E MOSFET op.amp
TR1	LP395Z protected *npn* transistor
D1	red l.e.d. (optional)
D2	1N4148 diode

Miscellaneous

RLA	DPCO 10A relay 120 ohm (or greater) coil

Connecting wire; matrix or stripboard, solder etc.

Approx cost guidance only **£8**

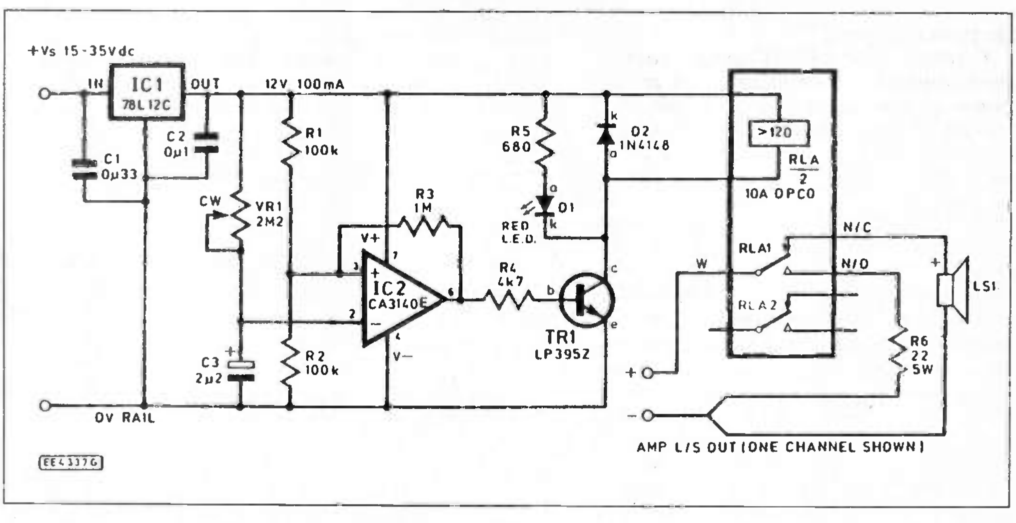
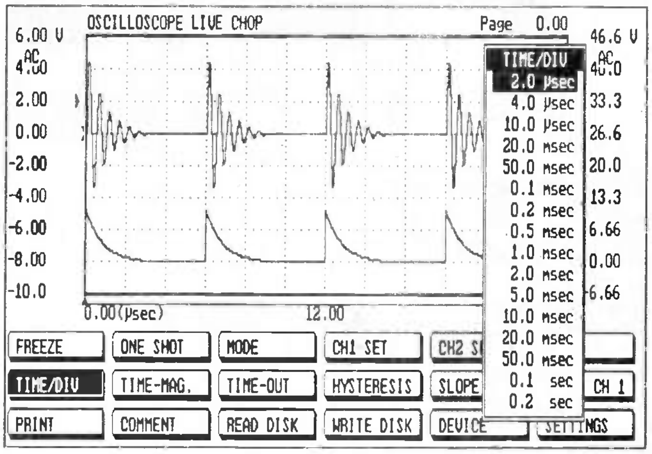


Fig. 2. Loudspeaker De-thump circuit diagram. The relay switches stereo channels, of which the switching circuit for only one audio channel is shown.

DATA ACQUISITION WITH THE PC



TiePie engineering manufactures a complete range of computer-controlled measuring instruments. Connecting these units to a PC (MS DOS 3.0 or higher) results in a number of comprehensive test instruments:

- oscilloscope;
- voltmeter;
- spectrum analyzer;
- frequency meter;
- transient recorder.

All measured data can be stored on disk or run off for documentation. Because of the many trigger possibilities, a variety of signals can be measured, while the powerful software enables a multitude of measurements to be carried out in a straightforward manner. Application areas include: service; medical research; automatic test systems; research and development; and education.

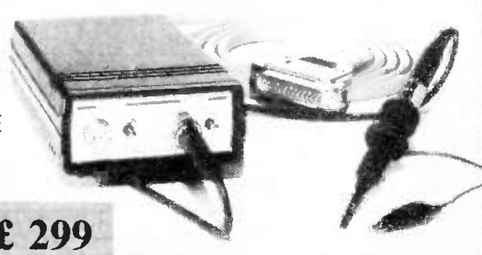
LOW COST: HANDYPROBE

Connect the HANDYPROBE to the parallel printer port of the PC and start the software. Measuring can be carried out at once. The HANDYPROBE does not need an external power supply. Some technical parameters: 0.5-400 V software select input range; one input channel; 8 bits resolution (overall accuracy 2%); A complete software program consisting of a digital storage oscilloscope, spectrum analyzer, voltmeter and a transient recorder is provided. The HANDYPROBE is eminently suitable for servicing and educational purposes.

£ 99

BEST PERFORMANCE: HANDYSCOPE

The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Because of its high resolution (12 bits), the HANDYSCOPE is a very accurate instrument. The measuring rate is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5-20 V (with a 1:10 probe up to 200 V). The advanced software enables many measurements to be carried out. Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors. The length of the cable linking the PC and the HANDYSCOPE is 1.8 m, which can be extended to 3.8 m.



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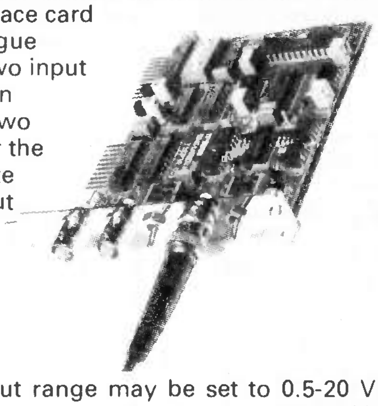
MULTIFUNCTIONAL: TP5008

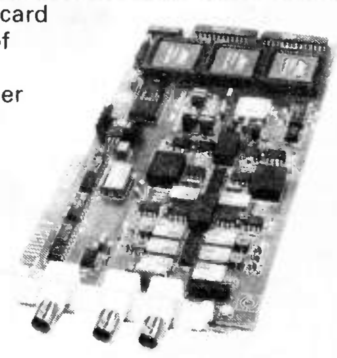
The TP5008 is an interface card that provides an analogue output in addition to two input channels. This output in combination with the two inputs may be used for the setting up of a complete control loop. The output may also be used as a function generator. The TP5008 has a resolution of 8 bits and a sampling rate of 200,000 samples/sec (200 kHz). The input range may be set to 0.5-20 V full-scale deflection. The output range covers 1.25-2.5 V. The TP5008 is fitted with BNC connectors and is delivered complete with a user manual and software. Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



£ 197

VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring speed of 2×20 Megasamples/sec (8 bits). Phenomena shorter than one millionth of a second can still be measured well. The completely digitized triggering ensures very stable triggering with many trigger possibilities. The TP208 has an input range of 5 mV/div to 20 V/div in 12 steps and an auto calibration function. Since both channels may be sampled simultaneously, phase differences can be measured very accurately. Even single phenomena can be measured since each channel has a 32 KByte memory. Comprehensive software is provided.



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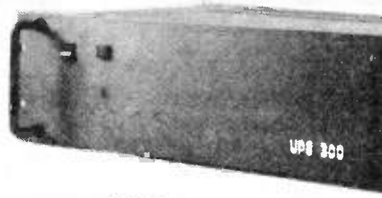


BATTERY TO MAINS INVERTER

AND UNINTERRUPTABLE POWER SUPPLY

MARK DANIELS **Part one**

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

PORTABLE mains power usually means large, noisy petrol or diesel generators which tend to be expensive, in terms of both capital and running costs, especially for smaller loads. The *Battery to Mains Inverter* published in the March 1991 issue of *Everyday Electronics* was developed to meet the requirement for a silent and portable source of mains voltage electricity. Unfortunately one or two of the components have recently become impossible to source, so a complete re-design has been undertaken.

IMPROVEMENTS

Looking back at the spec. sheet for the original design revealed several areas where improvement could be made. The power rating is one such area, but will obviously require the primary power source to be capable of sustaining a somewhat heavier current drain.

An investigation into the properties of car batteries and the type of loads likely to be used with an inverter reveals that it is possible, with care, to increase the inverter rating considerably. Specialist batteries with a deep cyclic discharge rating, such as caravan or traction batteries, are obviously ideal for this application, but tend to be quite expensive. Standard vehicle batteries are cheaper and, when loading is likely to be intermittent or of short duration, may be equally suitable. An 069 battery, as fitted to the author's Land Rover, is typical of the unit supplied with many modern cars. Its capacity of 63 ampere-hour* at the twenty hour rate enables it to supply 3·15 amps for twenty hours, delivering a total of 0·75kW hr of energy into the load.

Unfortunately, the energy available from an accumulator falls dramatically as the load current increases. Even so, we can expect this particular example, when fully charged, to be capable of sustaining a continuous current drain of 25 amps for 100 minutes*, i.e. it will still supply as much as 0.5kW hr.

A 250 Watt continuously rated inverter with a short term overload capacity of 400 Watts will run most portable power tools from a fully charged car battery for a useful length of time. A peak inverter efficiency of about 85 per cent ensures that the majority of the input energy is available to the load, with the battery supplying 25 to 40 amps to the inverter. As it is rarely necessary to run an electric drill for more than a few minutes at a time this level of current consumption is quite acceptable.

U.P.S.

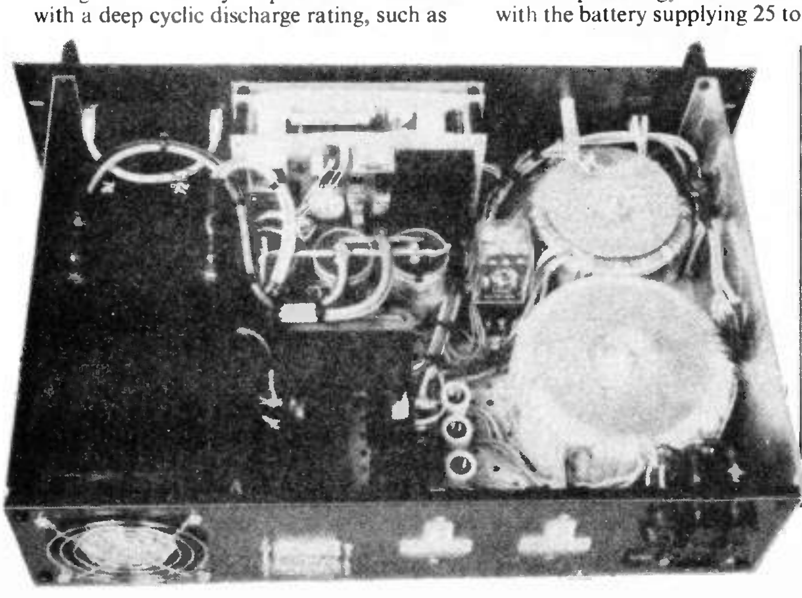
The 250 Watt continuous rating of this unit will enable it to power many small domestic appliances, including personal computers which may be shut down in an orderly manner when the mains fails. A U.P.S. (Uninterruptable Power Supply) add-on to be described in Part 3 takes care of the battery charging and the change-over from mains to battery when the power fails.

The inverter may be built as either a 50Hz or a 60Hz version and, in conjunction with the U.P.S add-on, may perform as a frequency changer to allow equipment of American origin to operate satisfactorily on British mains.

INVERTER CONFIGURATIONS

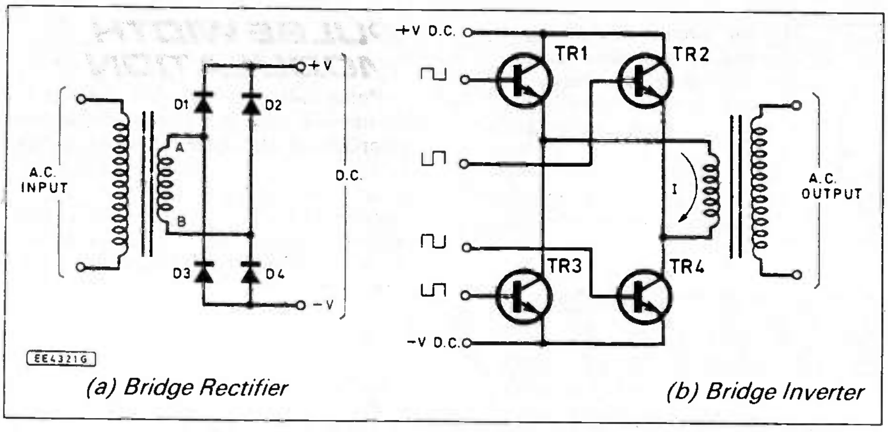
There are many ways of providing a.c. to a transformer from a d.c. power source, but for low, fixed frequencies only three of these are in general use: the Bridge, Half-Bridge and Bi-Phase (or Push-Pull). All three of these configurations have rectifier counterparts and a series of useful analogies may be made, which will be helpful in gaining an understanding of the process of inversion.

*Reference Source: Tungstone Batteries Ltd., Market Harborough.



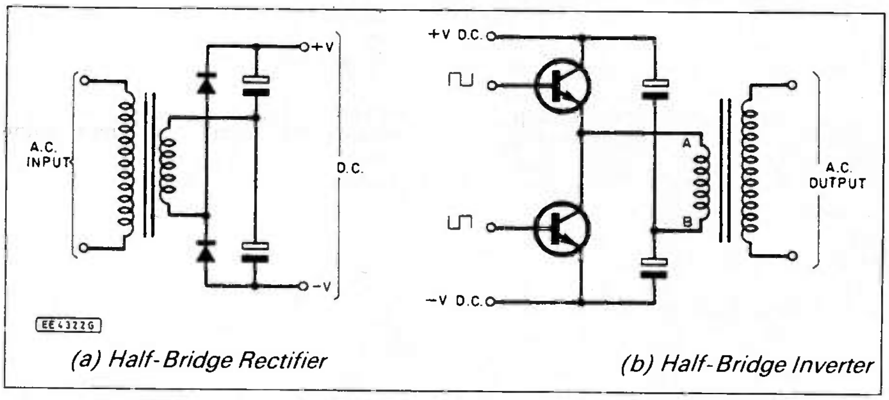
Specifications For 250W Inverter	
Power Rating, Continuous	250 Watts
Power Rating, Continuous with Fan	300 Watts
Instantaneous Power Rating	400 Watts
Input Voltage Range	10.5 to 13.8 Volts
Maximum Input Current	40 Amps Peak
Output Frequency Options	50Hz or 60Hz
Frequency Stability	< 50ppm
Output Voltage	240 Volts, regulated
Peak Efficiency	> 85 per cent
Weight	< 5kg

Specification for 600W Option (as above, with the following exceptions)	
Power Rating	600 Watts
Instantaneous Power Rating	1000 Watts
Maximum Input Current	100 Amps
Weight	< 10kg



(a) Bridge Rectifier (b) Bridge Inverter

Fig. 1. The bridge configuration.



(a) Half-Bridge Rectifier (b) Half-Bridge Inverter

Fig. 2. The half-bridge configuration.

BRIDGE CONFIGURATION

The bridge inverter is perhaps the easiest to understand, not being complicated by the need for a centre-tapped transformer or capacitors. Fig.1b shows the basic circuit for the bridge configuration, with a bridge rectifier shown in Fig.1a for comparison purposes.

In the bridge rectifier the diodes allow current to flow only when they are forward biassed. This will occur for D1 and D4 when point A is more positive than point B, current will then flow through D1, through the load and return to the supply via D4. When the polarity of the a.c. supply reverses and point B becomes more positive than point A the current will flow through D2, through the load, in the same direction as before and return to the supply via D3. The load will experience a unidirectional flow of current, equivalent to d.c.

In the inverter an electronic timebase controls the transistors which are turned on in pairs, TR1 with TR4 and TR2 with TR3, thus permitting the current to flow alternately in one direction and then the opposite through the transformer primary winding. If TR1 and TR4 are turned on (with TR2 and TR3 off) current will flow from the positive supply rail, through TR1, through the primary winding of the transformer in the direction indicated by the arrow and through TR4 to return to the supply via the negative rail. With TR2 and TR3 turned on (TR1 and TR4 will be off) the current flow in the winding will be in the opposite direction to that indicated.

The output voltage from the bridge rectifier and the bridge inverter is equal to the supply voltage, less semiconductor losses, in each case. Neither circuit requires a transformer in order to function, though both are commonly used in conjunction with one.

HALF-BRIDGE CONFIGURATION

The half-bridge rectifier is normally referred to as a voltage doubler circuit, since that is precisely what it does. Fig.2 shows the circuits for the rectifier and the inverter.

Capacitors are substituted for two of the diodes in the bridge rectifier resulting in the half-bridge. Now when current flows each of the capacitors will charge up to the peak a.c. voltage on opposite half cycles and, since they are connected in series, their voltages are arithmetically additive, giving a d.c. output voltage equivalent to double the peak supply voltage.

In the half-bridge inverter the two transistors are switched alternately driving point A of the transformer primary winding first negative and then positive with respect to point B which is held at half the d.c. supply voltage by the two capacitors. It is only possible for point B to remain at this voltage if a.c. is flowing in the winding. Any d.c. component will cause the voltage at B to shift, reducing the value of the a.c. presented to the load. This automatically compensates for asymmetry in the a.c. waveform supplied to the transformer.

The half-bridge inverter has an a.c. output voltage of only half the d.c. supply voltage.

THE BI-PHASE CONFIGURATION

All of the above circuits have made use of a single, untapped winding, achieving apparent simplicity. Adding a centre-tap to the winding would appear to complicate matters, but in practice it simplifies things considerably by reducing the component count and, in the case of the inverter, can also simplify the timebase design. The respective circuits for the bi-phase rectifier and inverter are shown in Fig.3a and 3b.

The operation of the rectifier is very simple; when point A is more negative than the centre-tap (C.T.), current will flow from C.T. through the load and return to the secondary winding via D1. On alternate half-cycles of the sine wave A will become positive with respect to C.T. and current flow will be blocked by D1 which is now reverse biassed. C.T., however, will be more positive than B and current will flow through the load and D2 in the correct direction. The resultant current flowing in the secondary winding will be an alternating one.

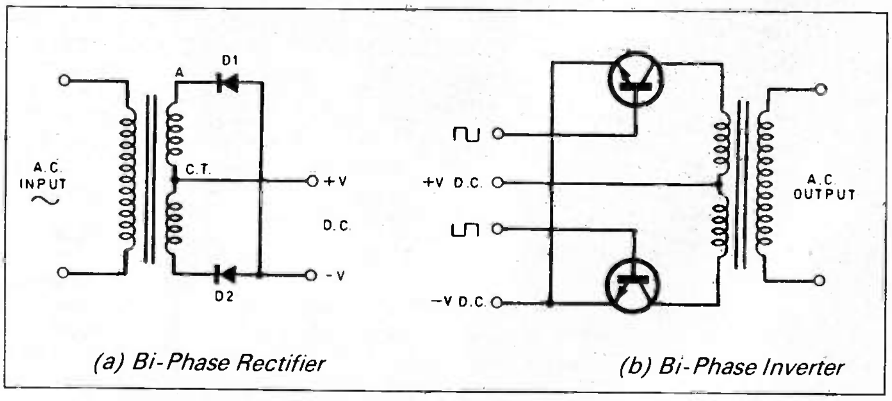
As in the previous two cases the reverse process may be applied to achieve inversion. The two switching transistors are supplied with square wave signals having a phase difference of 180 degrees thus producing a resultant alternating current in the secondary winding.

The voltage across the entire winding is twice the d.c. voltage for this configuration, thus enabling transformers of sensible electrical proportions to be used with a relatively low d.c. supply.

INVERSION

It is interesting to note that these configurations bear more than a little resemblance to three of the most familiar rectifier arrangements. This is hardly coincidence, since inversion is merely the reverse of rectification and similarly involves coupling of the d.c. circuit to the a.c. circuit through switches which are opened and closed at the appropriate times. In rectification the switches are, of course, diodes which are forced to switch at the correct time by the pre-existence of an a.c. waveform.

With inversion the pre-existence of an a.c. waveform cannot be taken for granted, as the primary source of power is normally d.c., so a method of forced switching has



(a) Bi-Phase Rectifier (b) Bi-Phase Inverter

Fig. 3. The bi-phase configuration.

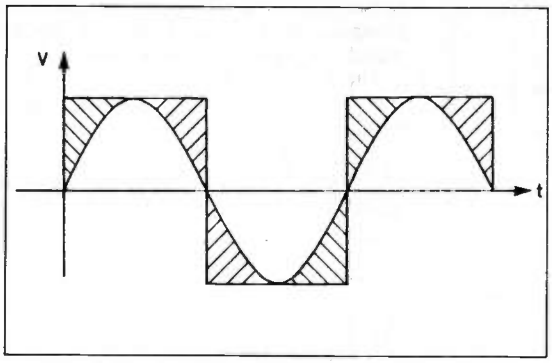


Fig. 4. Comparison of square and sine waves.

to be employed. This implies a necessity for controllable semiconductor switches in place of the rectifiers, e.g. thyristors or transistors. The standard thyristor (more correctly known as a "reverse blocking tetrode thyristor") is usually restricted to high voltage, high current applications on the grounds of cost and circuit complexity.

Complicated forced commutation methods are essential for proper circuit function and, unless correctly set up, can lead to premature device failure. Special types of thyristor, such as the gate turn off (G.T.O.) device alleviate the commutation problem, but tend to be even more expensive than standard devices and are generally only available with relatively low current ratings.

POWER TRANSISTORS

The bi-polar power transistor requires few of the circuit complications of the thyristor and is generally much simpler to use. Modern devices are available with current ratings comparable to mid-range thyristors (500 to 600 amps), and have switching speeds a factor of ten or more higher. The transistor also has a considerably lower forward volt drop when conducting (typically 0·2V when saturated, compared with more than 1V for a thyristor), which is a considerable advantage, particularly in low input voltage applications such as this. It offers greatly improved efficiency and reduced device heating, thus enabling smaller heatsinks to be employed.

The transistor, however, has no reverse blocking capabilities and external protection must be employed to prevent device breakdown, normally with an inexpensive silicon rectifier. The power devices also require a larger control current compared to the thyristor, requiring multiple stage amplification to reduce this to a suitable level. Even taking this into consideration use of transistors will usually work out considerably cheaper than an equivalent thyristor in this type of application.

Only the half-bridge has automatic symmetry correction, although this may also be applied to the bridge type by the addition of a capacitor in series with the primary winding. This is not very often seen as it requires the use of a large non-polarised component to carry the high a.c. current.

SQUARE WAVE VERSUS SINE

The normal mains electricity supply is an alternating one of sinusoidal waveform, which is characteristic of electricity generated in a rotating machine. The sine wave has the advantage that it is pure and free from harmonics, making it ideal for circuits containing inductive or capacitive reactance. It also simplifies many of the calculations which we take for granted, such as peak to r.m.s. conversion, although suitable equations may also be developed for other wave shapes as will be demonstrated later.

Unfortunately, the sine wave does have some serious disadvantages compared to another type of waveform, the square wave, when developed by means of analogue electronics. Most importantly an ideal square wave has zero rise and fall times and a peak value equal to the supply voltage, thus no energy is lost in converting d.c. into this form of a.c.

With a sine wave the voltage varies continuously and smoothly in accordance with a simple mathematical relationship. This requires a considerable amount of time for the transition from one peak to the other and causes the transistor to spend long periods of time in a state where it is dissipating a lot of power.

It may be seen from the drawing of Fig. 4 just how much of the energy is lost and why. The sine wave is totally enclosed by the square wave as is an additional area indicated on the drawing by the shaded area which represents the power lost in analogue methods of sine wave production. Simple graphical measurement techniques or analytical calculus methods show the area enclosed by the sine wave to be 70·7 per cent of that enclosed by a symmetrical square wave of similar amplitude.

REGULATION

The output voltage of an inverter is load and input voltage dependent, with the transformer regulation playing an important part in the load regulation. In a fixed voltage (unregulated) inverter it is necessary for the supply voltage to be absolutely stable and the core and winding losses of the transformer to be practically non-existent for the output voltage to remain constant under all conditions of loading.

Unfortunately, in real life these ideals are unlikely to be met and external regulation will generally be employed. This normally entails designing the transformer to provide a higher off-load output voltage than is required and controlling the input to the transformer in a manner which gives the desired output voltage under all normal load conditions.

The most obvious method is linear regulation, which may be employed to good effect in small inverters, the excess voltage being dropped across a series pass transistor and dissipated as heat. The basic principle is very simple, but in practice may not be quite as straight-forward as this, particularly with larger designs.

There are alternatives such as inductive control methods using chokes or magnetic amplifiers, but these require specialised wound components which tend to be expensive or difficult to produce at home and are generally unavailable through the usual sources.

Control via the switching transistors eliminates the need for extra components in the high current or high voltage sections of the circuit, and can be achieved quite simply by varying the duty cycle of the square wave.

PULSE WIDTH MODULATION

Pulse-width modulation (p.w.m.) is commonly used in switched-mode power supplies of the type fitted to virtually all personal computers. Although considerably more complex than linear regulation it offers several significant and important advantages, not least of which is the greatly improved efficiency. With less heat to dissipate smaller (and cheaper) heatsinks may be used, leading to a more compact and cooler running unit, which will ultimately be more reliable.

Pulse width modulation introduces into the standard square waveform a "dead-time" when neither switching transistor is permitted to conduct. The pulse width may be adjusted to alter the output voltage of the inverter, or, more usually, to keep the voltage constant as the load current or supply voltage varies. Fig. 5 shows some examples of typical output waveforms for a p.w.m. inverter, under varying conditions of load current and input voltage.

The dead-time gives the p.w.m. inverter its characteristic 3-level output waveform. Under no-load conditions the peak voltage may be quite high (Fig. 5a) and to compensate for this the pulse width will be fairly narrow. As the load is increased the output voltage falls and the pulse width is increased to maintain the r.m.s. voltage as in Fig. 5b. Full load conditions demand maximum power and consequently the pulse width must be increased to its maximum.

The expected (and desired, from the load's point of view) waveform to satisfy this condition would be one with zero dead-time as in Fig. 5c. Unfortunately, this does little for the life expectancy of the switching transistors which need a finite length of time in which to carry out the switching operation. The transformer primary winding is largely inductive and by its very nature will oppose any change in current. The combination of these two factors will result in large currents and voltages being generated which will ultimately destroy the transistors. In small

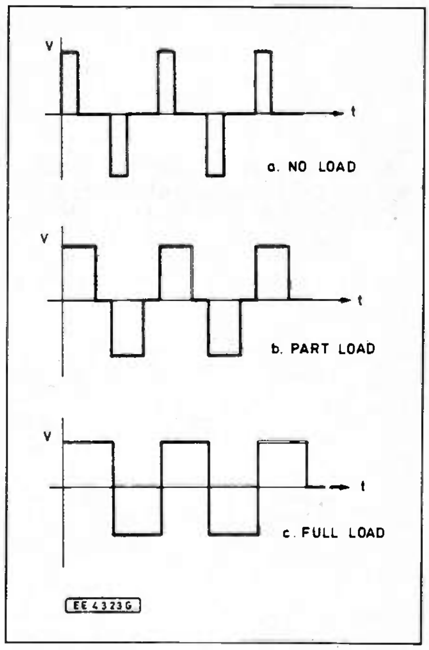


Fig. 5. Pulse width modulation waveforms.

inverters (up to 100 Watts) this effect is minimal and may usually be ignored.

To overcome the above problem the maximum output pulse width is normally limited to around 90 or 95 per cent of the half-cycle period, guaranteeing that both transistors will never be simultaneously conducting. This does limit the utilisation of the transformer slightly, reducing the maximum available output power by a small amount, but is unlikely to have any significant effect on the overall performance of the inverter.

ROOT MEAN SQUARE VALUE

The root mean square or r.m.s. value of an a.c. waveform is the voltage (or current) which will produce the same heating effect in a resistance as an equivalent direct voltage (or current) applied to the resistance and consequently has the same numerical value.

For a sinusoidal waveform (normal a.c. mains or generator output) the peak (V_{pk}) and r.m.s. ($V_{r.m.s.}$) values are related by the equation,

$$V_{r.m.s.} = \frac{V_{pk}}{\sqrt{2}}$$

This is a special case and cannot be applied as a general equation to our variable duty cycle square wave. Fortunately the square wave is relatively simple to analyse and a single equation may be used to describe all such rectilinear waveforms whose duty cycle is known.

The general expression relating the duty cycle and r.m.s. value of a square wave with its peak voltage is of the form,

$$V_{r.m.s.} = V_{pk} \times \sqrt{(\text{duty cycle})}$$

The waveform of Fig. 5b has a duty cycle of 50 per cent, or ½. Its r.m.s. value is thus given by the following equation,

$$V_{r.m.s.} = V_{pk} \times \sqrt{(1/2)}$$

This expression may be re-written in the more conventional form, where it will be seen that it gives precisely the same relationship between peak and r.m.s. values as the sine wave.

$$V_{r.m.s.} = \frac{V_{pk}}{\sqrt{2}}$$

This particular rectilinear waveform approximates some of the more important characteristics of a sine wave and may be an ideal choice in fixed duty cycle applications.

Regulation complicates matters somewhat, but this convenient duty cycle may still appear under some load conditions, with others being not too far removed from it.

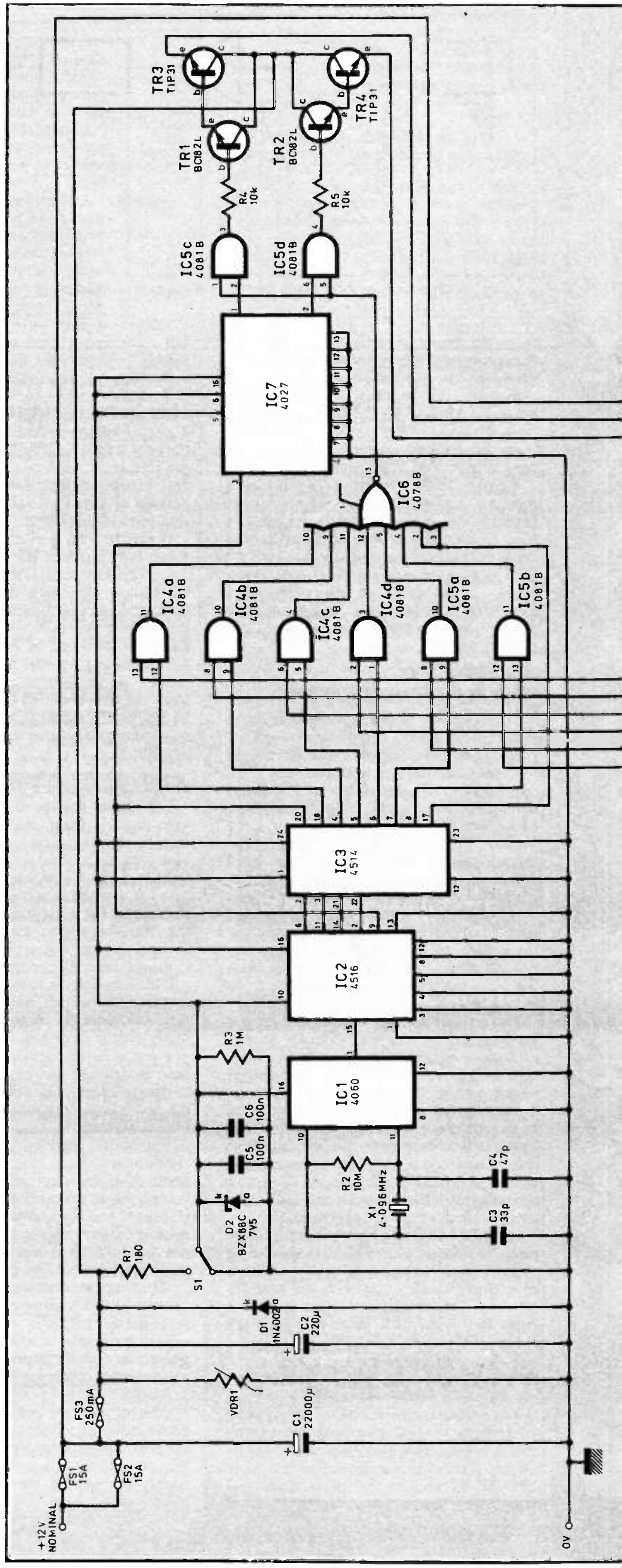
CIRCUIT DESCRIPTION

A simplified block diagram of the inverter is given in Fig. 6 which shows the five main blocks of the unit. These are the Timebase, the Pulse Width Modulator (p.w.m.), Output Stage, Output Filter and the Voltage Regulator.

The timebase provides an accurate timing reference from which the 50Hz (or 60Hz) output signal is derived. This is fed to a pulse width modulator which may vary the pulse width to control the output voltage. The voltage regulator circuit provides control signals to the p.w.m. in response to the output voltage, enabling it to be maintained at the preset r.m.s. level. A power output stage comprising power transistors and a power transformer provide current amplification and voltage step-up respectively, before passing through a low pass filter which cleans up the output waveform and removes high voltage spikes.

The full schematic for the P.W.M. Battery to Mains Inverter is given in Fig. 7 (NOTE:– This does NOT include the U.P.S. add-on circuit to be described in Part 3).

The supply to the inverter is via a double fuse link FS1 and FS2 providing limited overload protection. Two fuses are employed in parallel to obtain the required current rating without recourse to expensive industrial fuses and holders. They **MUST NOT, under *any* circumstance,** be replaced with a single larger current fuse of similar physical size. The fuse holders simply **will not take the current and would constitute an unacceptable fire risk!** If a single fuse is preferred a **fast acting** semiconductor protection fuse of the industrial ceramic cartridge type **mounted in the appropriate holder** is strongly recommended.



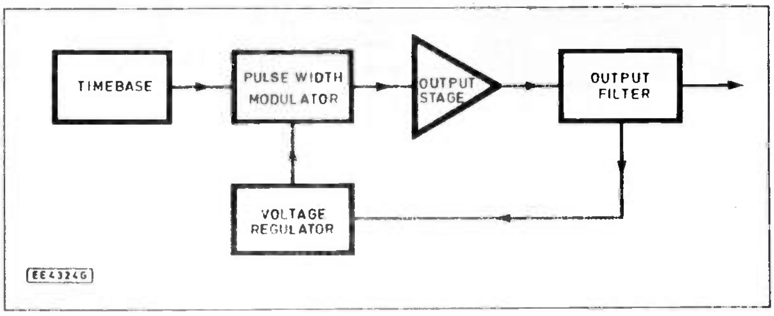
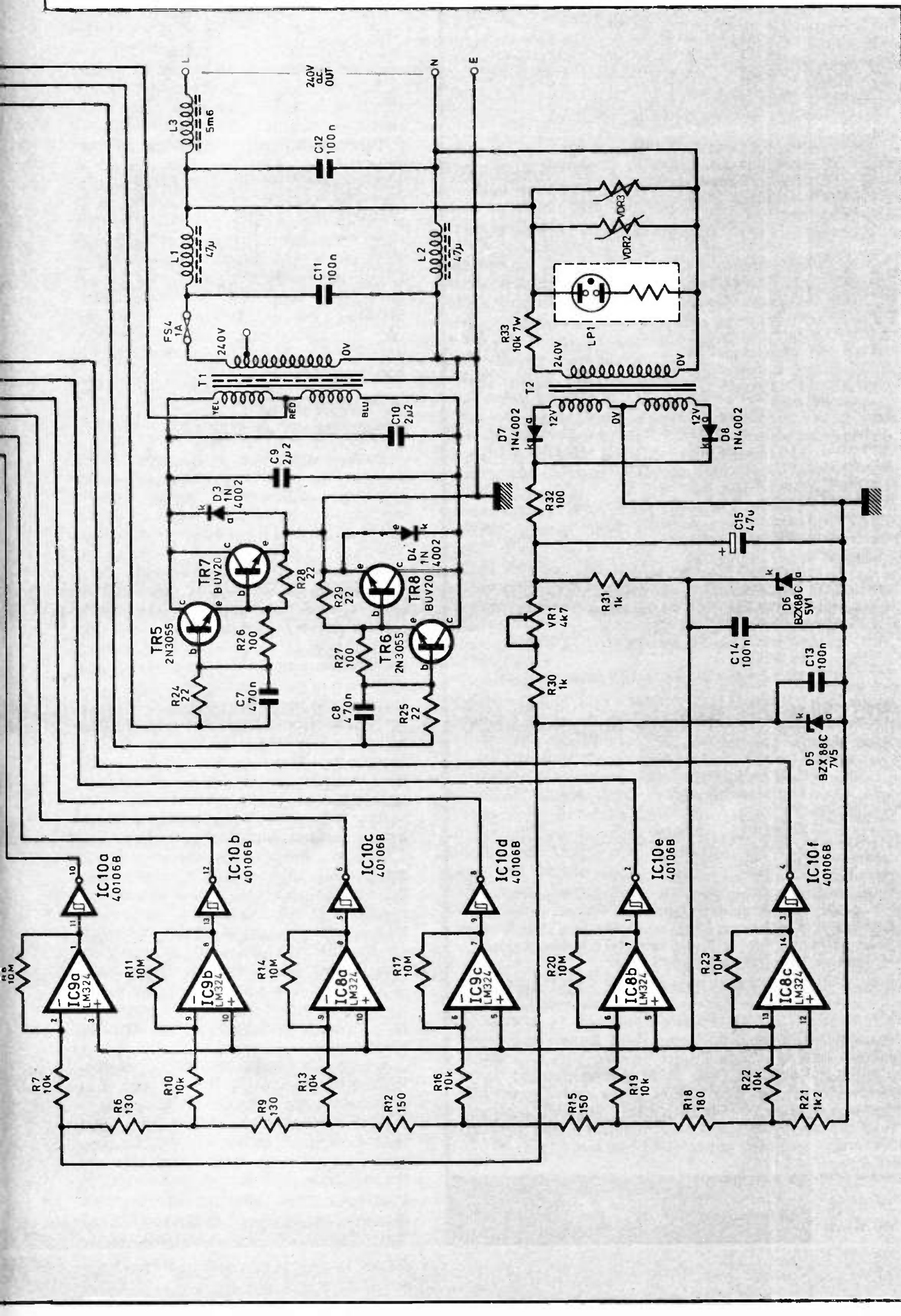


Fig. 6. Block diagram of the inverter.

Fig. 7. Complete circuit diagram of the inverter. Note that R24 and R25 are rated at 1W and R33 must be rated at 7W and be a wirewound (WW) type.



SUPPLY

Capacitor C1 is essential for decoupling the supply when long cables are used between the battery and the inverter.

A small increase in efficiency is obtained by its inclusion, but it may be omitted or replaced with one of smaller value if the cable length is minimised.

The power for the logic and control circuits is supplied via FS3. varistor VDR1, capacitor C2 and diode D1 maintain a clean, spike free supply for the sensitive CMOS circuits. The logic and control circuits are run at 7·5 volts from a simple Zener stabilised supply comprising resistor R1, Zener diode D2 and capacitors C5, C6.

On/off switching of the inverter is taken care of by switch S1 and resistor R3. The switch is a double-pole change over type with only one pole currently connected, the second pole being reserved for use with the U.P.S. add-on.

In the off position it shorts the Zener and the logic and control circuits to ground ensuring that any leakage currents in the power stage cannot power the low current circuits up. In the on position current is drawn normally via R1 which limits the Zener current.

During operation of the switch there is a brief time when neither way is closed leaving the circuits in a dubious state, where they are neither connected to the supply nor shorted to ground. To circumvent this highly undesirable condition a resistor R3 is connected across the supply rails and Zener, providing insurance for the CMOS.

TIMEBASE

The timebase is designed around three CMOS integrated circuits, IC1 to IC3. IC1, a 4060B, is a 14-stage ripple counter with an on board oscillator intended for direct coupling to an external quartz crystal. Various division ratios may be obtained by taking the output from any of the ten externally available stages of the counter. In this case a division ratio of 2^{13} (4096) is used to obtain a 1kHz (1·2kHz for the 60Hz version) output at pin 1 from a 4·096MHz (4·9152MHz for 60Hz output) crystal, X1.

IC2 is a 4516B, 4-bit binary up-down counter with reset. It is used here as a resetable up counter, counting to decimal 10 (binary 1010), then resetting to zero and repeating the cycle indefinitely.

COMPONENTS

Resistors

R1	180
R2, R8, R11, R14, R17 R20, R23	10M (7 off)
R3	1M
R4, R5, R7, R10, R13, R16, R19, R22	10k (8 off)
R6, R9	130 1% metal film (2 off)
R12, R15	150 1% metal film (2 off)
R18	180 1% metal film
R21	1k2 1% metal film
R24, R25	22 1W metal film (2 off)
R26, R27, R32	100 (3 off)
R28, R29	22 (2 off)
R30, R31	1k (2 off)
R33	10k 7W WW

All 0·25W 5% carbon film unless stated

See SHOP TALK Page

Potentiometer

VR1	4k7 sub min horizontal cermet preset

Capacitors

C1	22,000µ to 47,000µ elect. 16V*
C2	220µ radial elect. 16V
C3	33p ceramic
C4	47p ceramic
C5, C6, C13, C14	100n polyester 5mm pitch (4 off)
C7, C8	470n polyester 5mm pitch (2 off)
C9, C10	2µ2 63V polyester 23mm pitch (2 off)
C11, C12	100n 250V a.c. class X mains rated (2 off)
C15	47µ radial elect. 63V

*Value non-critical, may be omitted entirely if battery leads are kept very short ($<$1m).

Semiconductors

D1, D3, D4, D7, D8	1N4002 100V 1A rectifer diode (5 off)
D2, D5	BZX88C.7V5 Zener (2 off)
D6	BZX88C.5V1 Zener
TR1, TR2	BC182L *npn* transistor (2 off)
TR3, TR4	TIP31 *npn* transistor (2 off)
TR5, TR6	2N3055 *npn* transistor (2 off)
TR7, TR8	BUV20 *npn* transistor (2 off), (for 600W see Table 3 next month)
IC1	4060B, 14 stage divider with on board oscillator
IC2	4516B, 4 bit binary counter
IC3	4514B, 4 to 16 line decoder
IC4, IC5	4081B, quad 2 input AND gate (2 off)
IC6	4078B, 8 input OR/NOR gate
IC7	4027B, dual JK flip flop
IC8, IC9	LM324, quad op-amp. (2 off)
IC10	40106B, hex Schmitt inverter

Miscellaneous

X1	4·096MHz ±10ppm stability (for 50Hz), HC-18/U crystal, Farnell 170-691; (Alternative for 60Hz) 4.9152MHz, Farnell 103-882
T1	300 VA Inverter transformer, Jaytee 7E283 (600 VA alternative 9E284)
T2	3 VA mains transformer 0-12V, 0-12V secondaries, RS 207-780
L1, L2	47µH 2A axial choke (2 off)
L3	5·6mH choke: 110 turns 1.2mm enamelled wire on EC70 ferrite core, Electrovalue parts, EC70 core B66343-GX127 (2 off), bobbin B66278-B1011T1, mount B66278-B2002
FS1, FS2	15A 32mm fast acting glass fuse (2 off), Maplin DA33 (see text)
FS3	250mA 20mm time lag fuse
FS4	1A 20mm fast acting ceramic fuse, Maplin DA11
S1	Miniature d.p.d.t. rocker switch
LP1	Green panel mount mains neon lamp
PL1, PL2	6-way socket housing for p.c.b. locking connector (2 off), with terminals, (2 off)
SK3, SK4	BS1363 13A cruciform panel mount sockets (2 off)
TB1, TB2	2-way 10mm pitch (or 3-way 5mm) p.c.b.mount screw terminal connectors (2 off)

Case, 3U 19 inch Rack Case, 32mm screwdriver release panel mount fuseholder (2 off); 20mm screwdriver release panel mount fuseholder; 20mm chassis fuseholder; Heatsinks for TR5 to TR8, 1.85°C/W, Maplin KW50 (2 off); 10mm p.c.b. pillars (4 off); small heatsink for TR3, TR4; connecting wire mains rated 0.74mm², blue, brown and green & yellow, thin low voltage assorted colours, 2.5mm², red, yellow, blue and black, 6mm² black and red, welding cable as required (see Table 2 next month); large insulated crocodile clips, red and black (one off each); heat shrink sleaving, various sizes; TO3 silicone isolating kits with bushes (4 sets off); cable ties; M3 panhead screws (12mm, 20mm), plain washers, spring washers and nuts; M3 solder tags (10 off); acetate sheet (see text next month); large self adhesive square feet (6 off).

Approx cost guidance only **£95** plus case

PULSE WIDTH MODULATOR

The binary output of IC2 appears on pins 6, 11, 14 and 2 and is read by IC3, a 4514B CMOS 4 to 16 line decoder. IC3 outputs 0 to 3 are ignored, with 4 to 9 (pins 8, 7, 6, 5, 4 and 18) being logically ANDed with the regulation control lines by gates IC4a to d and IC5a and b. A reset pulse from output 10 (pin-20) at a repetition frequency of 100Hz (120Hz for optional 60Hz output) is used to reset the counter and toggle the flip-flop in IC7.

The flip-flop performs two tasks, firstly it divides the input frequency of 100Hz (120Hz) by two giving the required 50Hz (60Hz) output and, secondly, provides complementary outputs at pins-1 and 2.

The two remaining AND gates in IC5 are used to AND the outputs of IC7 with the NORed outputs of IC4 and IC5a,b which are logic 1 when their inputs are taken high in turn by IC3 and the regulation control inputs which are controlled by the op.amps in IC8 and IC9.

This obviously gives logic 0 at the outputs of IC5c,d when any of the outputs of IC3 are logic 1, and the appropriate regulation input or pin-17 of IC3 is logic 1. It should be noted that when pin-17 (output 9) of IC3 is high the gating control signal to IC5c and IC5d is unconditionally low and is not affected by the pulse width modulator. This occurs twice per output cycle, allowing a maximum duty cycle of 90 per cent thus giving the required dead-time as noted under the section on Pulse Width Modulation above.

VOLTAGE REGULATION

Voltage regulation is by pulse width modulation as already described. The regulation, in this design, is performed in discrete steps by applying simple analogue to digital (A to D) conversion techniques. The output voltage at the secondary of the power transformer, T1 is monitored using a small mains transformer, T2. The resistor, R33 in series with its primary keeps the current drawn by it down to an acceptable level. Diodes D7 and D8 provide full-wave rectification with the 0V return taken to the centre tap of the secondary winding.

Before the signal can be applied to the A to D converter it has to be smoothed to provide a continuous level for satisfactory monitoring. This is carried out by an *RC* filter, comprising R32 and C15, with R33 in series with the primary. Adjustment of this voltage is by preset potentiometer VR1 allowing the final output voltage to be set.

Voltage clamping is provided by a simple Zener shunt regulator ensuring that the voltage presented to the operational amplifiers in IC8 and IC9 does not exceed the supply voltage. A stable reference voltage for the A to D converter is provided by D6, a 5·1 volt Zener diode which has a low temperature coefficient, thus ensuring that the output voltage will remain stable under all normal ambient temperatures.

A potential divider comprising resistors R21, R18, R15, R12, R9, R6 and R30 provides the appropriate reference voltages relating the peak voltage to the r.m.s. value for the respective op.amps to monitor. The amplifiers are used in the inverting mode for maximum stability so each amplifier output will swing low when the voltage on its inverting input is higher than the 5·1 volt reference on its non-inverting input.

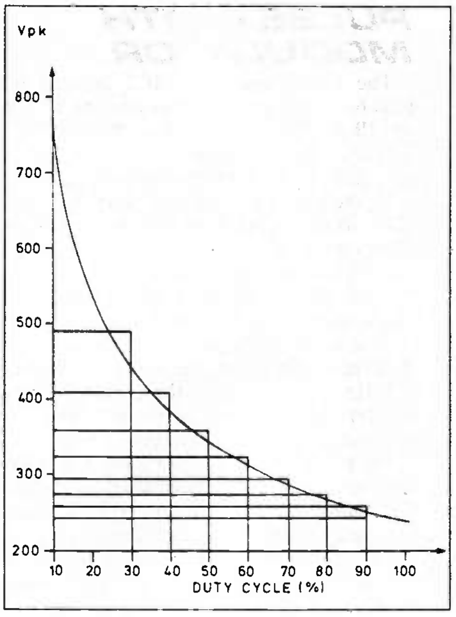


Fig. 8. Step regulation function.

To operate the logic correctly and increase (rather than decrease) the pulse width as the voltage falls the output of each op-amp. must be inverted. For maximum reliability Schmitt inverting buffers are specified in IC10 and provide the logic level signals required by the AND gates in IC4 and IC5. Thus as the peak voltage monitored by the op.amps rises the control signals to the AND gates are switched on one by one, reducing the pulse width by 10 per cent per gate.

The r.m.s. voltage remains substantially constant while the peak varies since the resistor values specified for the potential divider chain correctly relate the peak voltage and pulse width to its r.m.s. value. The correct relationship between peak voltage and pulse width are shown in Table 1 for a 240V r.m.s. output at both 50Hz and 60Hz.

PEAK VOLTAGE

A graph of peak voltage against duty cycle for a constant 240 volts r.m.s. is plotted in Fig. 8 as a smooth curve, showing how rapidly the peak voltage increases at low duty cycles. Ideally, these low duty cycles, accompanied by correspondingly high peak voltages, should be avoided wherever possible as they may cause damage to electronic equipment connected to the inverter. The step regulation function also plotted on the same set of axes is shown only from 30 per cent to 90 per cent, but this will still peak at over 400 volts. In normal operation with the inverter running from a battery which is off charge the duty cycle will stay within the range 50 per cent to 90 per cent and the peak voltage, from the graph, will remain below 370 volts.

The graph also shows how the voltage can vary within each of the six steps of regulation. The intersection of the vertical lines with the curve gives the peak voltage shown in Table 1 for the particular value of duty cycle. The horizontal lines show clearly the minima and maxima for each regulation point. The 30 per cent duty cycle is also shown as having a maxima at approximately 490 volts, which is of course complete nonsense, this point being open ended as the narrowest pulse width available to the p.w.m. It does illustrate that, should there be another regulation point below this, *its* minima would occur at this value. In practice, if a 30 per cent duty cycle is ever attained, the peak voltage is unlikely to rise above this value anyway. The minima for the 90 per cent duty cycle is also open ended (at least down to zero volts) but is shown on the graph at 240 volts for similar reasons.

OUTPUT STAGES

The outputs of the low power circuits used in the timebase and control circuits are incapable of providing more than a few milliamps of output and need substantial buffering before they will drive the power transformer.

Transistors TR1 to TR4 form two Darlington pair emitter followers to buffer the low current complementary outputs of the flip-flop, providing sufficient drive current for the high current output stage.

The power stage is made up of two identical common emitter amplifiers TR5, TR7 and TR6, TR8 driven in anti-phase by TR3 and TR4. A description of either will be sufficient for an understanding of the complete output stage.

Transistors TR5 and TR7 with resistors R26 and R28 form a standard common emitter Darlington stage offering a maximum collector current rating of 50 amps and providing a minimum gain of 400 at a collector current of 25 amps. Diode D3 is included for transistor protection keeping the reverse collector voltage experienced by the transistor below its reverse breakdown voltage and absorbing high voltage spikes which would otherwise appear on the secondary of the transformer T1.

Base current for the Darlington power stage must be limited to a suitable, safe value and is supplied via a base resistor R24 which allows approximately 215mA of base drive. Bipolar transistors have base capacitance which must be charged and discharged rapidly when the transistor is employed in a fast switching application.

Rapid charge and discharge of a capacitor requires large currents for short periods of time and the 215mA of base drive is inadequate for the required speed. Shunting the base resistor R24 with a capacitor, C7, will enable a much higher current to flow very briefly as C7 charges and discharges.

Transformer T1 has a centre tapped primary winding with the centre tap (Red) connected to the 12 volt supply rail. TR7 switches one end (Yellow) of the primary to ground for a maximum of 9ms (7·5ms for 60Hz) (subject to p.w.m. permitting) allowing current to flow in half of the primary winding from Red to Yellow. When TR7 switches off there is a minimum period of 2ms (1.67ms) when neither transistor conducts, this is the reset period for the transformer during which the magnetic field set up in its core can collapse making it ready for the next pulse.

SAFETY

Read this section very carefully before commencing work on the inverter since this project involves dangers of a kind infrequently encountered in home electronics construction.

The electrical safety aspect should be familiar to all but deserves special mention in connection with this project. Although the inverter is in no way connected to the mains electricity supply its output is at a high voltage and low impedance, IT IS EASILY CAPABLE OF DELIVERING SUFFICIENT CURRENT TO KILL! Always switch off and disconnect from the battery before making any adjustments.

Car batteries contain sulphuric acid which is highly corrosive, and great care must be taken to avoid spillage. Spilt acid should be diluted with copious quantities of water and cleaned up immediately. Skin contact should be avoided and is dealt with in a similar manner to above followed by washing with soap. In case of eye contact flush with clean cold water and seek medical attention IMMEDIATELY.

The danger of heavily loaded batteries gassing and the consequent explosion risk as mentioned next month in the main text is very real and should not be underestimated. An exploding accumulator can do considerable chemical and mechanical damage.

The electrical energy content of a car battery is very high and, in conjunction with its extremely low internal resistance, can sustain a short circuit current of SEVERAL THOUSAND AMPERES. A spanner placed across the terminals will rapidly become too hot to touch and, when removed, will cause a spark of sufficient magnitude to ignite the hydrogen liberated by the extremely vigorous chemical reactions initiated in its cells!

Transistor TR8 provides the next current pulse, which is of the same duration but the current now flows from Red to Blue reversing the polarity of the magnetic field setup in the transformer core by the previous pulse. The induced voltage in the secondary winding follows the alternating magnetic field and has the same period and consequently the same frequency, 50Hz (60Hz).

EFFICIENCY

Capacitors C9 and C10 perform two functions, improving the shape of the waveform presented to the transformer and increasing the overall efficiency of the inverter. This also reduces the power dissipated in the transistors during the

Table 1. Relationship between peak and duty cycle for 240V r.m.s. "square" waves.

Duty Cycle	Pulse Width (50Hz)	Pulse Width (60Hz)	Peak Voltage
10%	1ms	833µs	758V
20%	2ms	1.67ms	536V
30%	3ms	2.50ms	438V
40%	4ms	3.33ms	379V
50%	5ms	4.17ms	339V
60%	6ms	5.00ms	310V
70%	7ms	5.83ms	287V
80%	8ms	6.67ms	268V
90%	9ms	7.50ms	253V
100%	10ms	8.33ms	240V

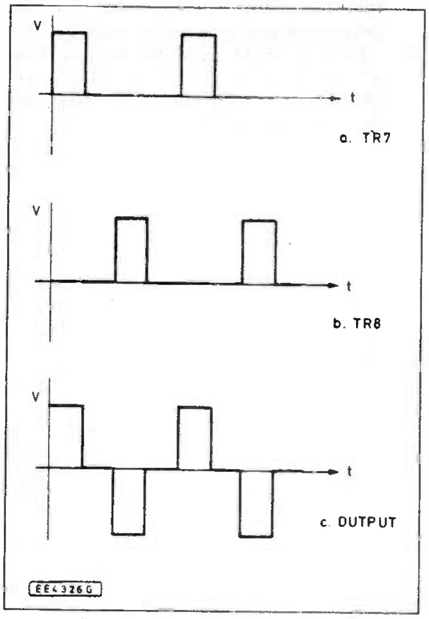
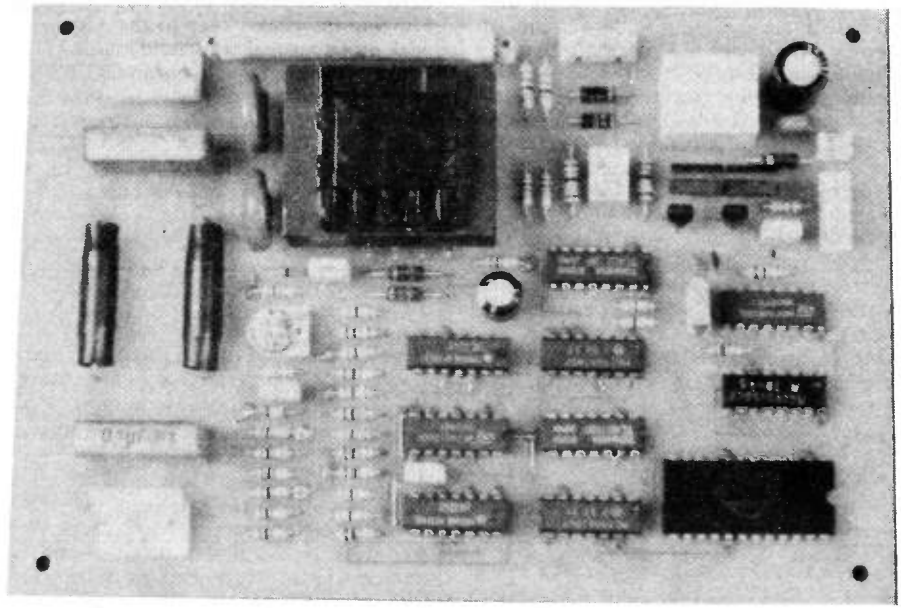


Fig. 9. Waveform synthesis.



switching time, giving them improved life expectancy.

The turns ratio of the transformer provides a voltage step up to approximately 240 volts and (to comply with the principle of conservation of energy) a corresponding step down in current. In an ideal transformer the power out of the secondary winding should equal the power supplied to the primary, but with unavoidable winding resistances and losses in the magnetic circuit some power will inevitably be wasted, typically 5 or 10 per cent.

The relationship between the input waveforms and the induced voltage in the secondary for a 50 per cent output duty cycle is shown in Fig. 9. Each transistor is able to operate at a maximum duty cycle of 45 per cent when inverter loading and input voltage demand. This, of course, translates to a 90 per cent overall duty cycle in the transformer.

OUTPUT FILTER

The waveform at the secondary of T1 is fairly clean and should be suitable for running the majority of appliances. For only a small outlay it is possible to clean it up quite considerably making it acceptable for use with sensitive equipment, such as computers, hi-fi systems and video equipment.

A very simple two stage low pass *LC* filter connected to the output removes the majority of noise produced by the switching circuits, virtually eliminating any spikes having a fast rise time.

Capacitor C11 and the secondary winding inductance of T1 form the first stage of the network removing lower frequency noise while leaving the 50Hz (60Hz) component virtually unaffected.

A second stage comprising miniature radio frequency (r.f.) chokes L1, L2 and a second capacitor C12 remove higher frequency noise including r.f. providing some degree of radio frequency interference (R.F.I.) suppression. Elimination of R.F.I. is essential if the inverter is to be connected to computing equipment otherwise random data loss may occur.

A pair of varistors (voltage dependent resistors) VDR2 and VDR3 clamp

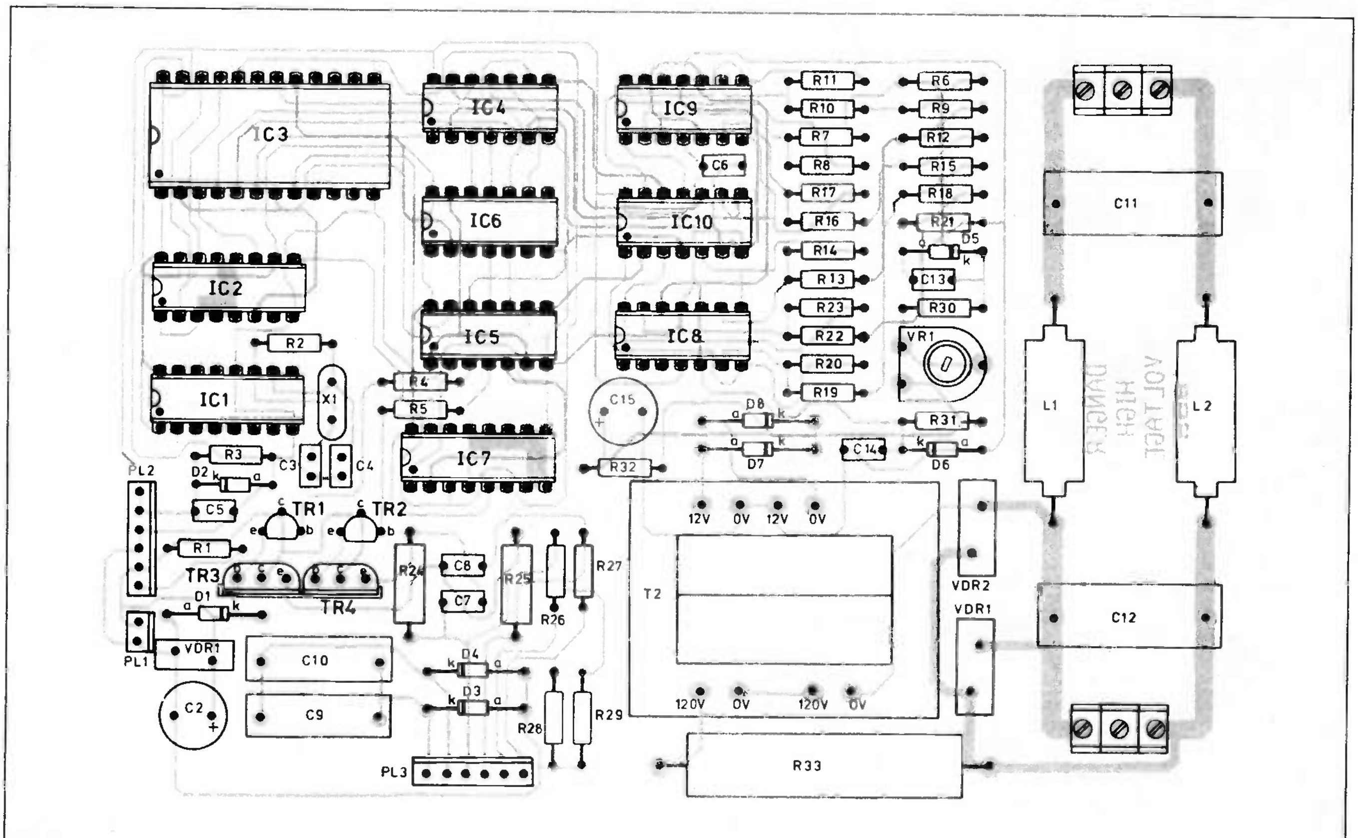


Fig. 10. P.C.B. component layout and (right) the topside and underside p.c.b. copper foil patterns. Only the necessary part of the topside area is shown.

the remaining high voltage spikes and can dissipate a considerable amount of energy over a very short period of time. The resistance of the varistors is normally very high but when the breakdown voltage is exceeded the resistance falls sharply and literally short circuits the spike before it has chance to cause damage to the load.

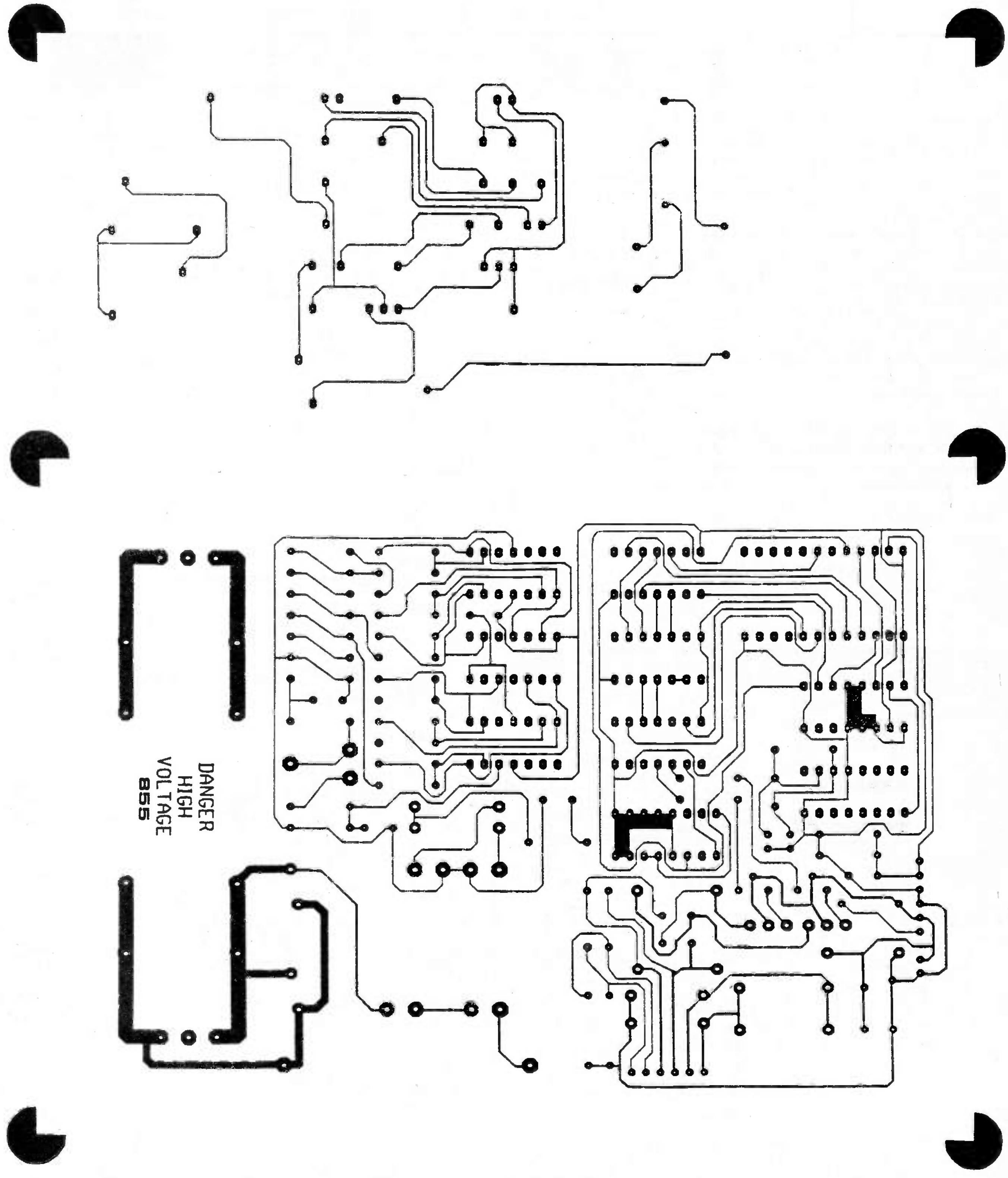
A 5·6mH high Q choke, L3 may be fitted as a final stage filter to remove a large portion of the harmonics present in the square wave output of the transformer, presenting a waveform to the load which should not be too far off sinusoidal. This will also reduce the ratio of the peak to r.m.s. voltage, particularly with the narrow pulses present under light loading, bringing the peak closer to the 340 volts peak of the normal household mains.

The choke is wound on an EC70 ferrite core which gives plenty of room for thick winding wire, keeping the resistance low whilst providing plenty of inductance. This gives the inductor a high Q value which aids overall inverter efficiency.

P.C.B. PRODUCTION

The majority of the low power components are mounted on a double-sided glass fibre printed circuit board. Owing to the complexity of this board home production is not recommended for the inexperienced and it is suggested that the *EPE PCB Service* (code 855) is used. For those who wish to produce their own board the upper and lower foil patterns are provided in Fig. 10.

If you make your own p.c.b. the majority of the holes should be drilled 0·8mm, many of the rest will need opening up to 1mm. In general, the pad sizes are indicative of the required hole size, i.e. the larger the pad the greater the hole diameter. A few of the holes should be drilled at 1·3mm, notably for TR2, VR1 and the p.c.b. power connectors. The board mounting holes in each corner should be drilled 3mm.



P.C.B. ASSEMBLY

The component overlay for the printed circuit board is shown in Fig. 10 and should be assembled in accordance with the following. Fit and solder all the resistors, capacitors, inductors, connectors, varistors and the preset in place first, leaving R33 until later. The thick tracks around L1 and L2 should be heavily tinned after the components have been soldered in place, as they will have to carry the full output current of the inverter without overheating.

The discrete semiconductors should be fitted next taking great care to correctly position and orientate them in accordance with Fig. 10.

For maximum reliability, and to avoid the necessity for through plating of the p.c.b. holes, the i.c.s are soldered directly into position *without* the use of sockets. Eight of the ten integrated circuits are CMOS devices and require special handling (i.e. use an earthed soldering iron and avoid touching the pins). All of the i.c.s are similarly orientated, with pin-1 located top left when in position. Solder two pins at opposite corners on each device and recheck its orientation and positioning before finally soldering the rest of its pins.

Fit the correct crystal for X1 (4.096MHz for 50Hz, 4.9152MHz for 60Hz) and solder it in place very quickly as excessive heating will alter its operating frequency permanently, rendering the final output frequency of the inverter inaccurate.

The small mains transformer, T2 can now be fitted along with R33 which should be spaced 10mm above the board as it will get hot when the inverter is running. Heat resistant sleeving or ceramic spacers should be fitted to its leads before mounting since it will be at 240 volts above ground potential during operation. **Note: it is most important for correct circuit function that the specified transformer be used for T2,** since its winding resistances come into the regulation equations for the completed inverter.

Next month: The remaining inverter construction details plus setting up, fault finding and modifications.

Acknowledgement: Front cover photograph and text photographs by Ryck Markiewicz.

SHOP-TALK

with David Barrington

250W/600W Battery to Mains Inverter

Before tackling any work on the Battery to Mains Inverter it is ***vitally important*** that anyone undertaking this project reads the "Safety Panel" first. Also, it should only be attempted by a person skilled in electronic construction work.

The toriodal inverter transformer was specially made up for this project by **Jaytee (☎ *0227 375254*)** and will cost about £28 for the 300VA version, code 7E283. We have not received a price for the 600VA transformer (code 9E284) for the 600W version, but more details will be given next month. The 3VA mains transformer is an RS component stocked by **Electromail,** code 207-780.

We have been unable to locate any source for the 4·096MHz (50Hz) or the 4·9152MHz (60Hz) crystals other than **Farnell (☎ *0532 636311*)**. If they are unwilling to supply, then someone like **Greenweld (☎ *0703 236363*)** might be persuaded to order for you.

The 5·6mH choke was made up on a EC70 ferrite coil kit from **Electrovalue (☎ *0784 442253*)**, order codes B66343-GX127 (core 2 off), B66278-B1011T1 (bobbin) and B66278-B2002 (mount). The 47μH 2A axial choke is listed by Maplin (UM12N). The BUV20 transistor varies in price quite considerably from just over £4 up to about £8. The ones used in the model were purchased from **JPG Electronics (☎ *0246 211202*)** and cost £4.50 plus p&p each.

The double-sided printed circuit board can be obtained from the *EPE PCB Service,* code 855. The 7W wirewound resistor and mains rated X-class capacitor should be generally available.

Auto Alarm

The most expensive item needed to complete the line-up of components for the *Auto Alarm* is the external "staccato" siren. The staccato sounder (**Maplin** YZ03D) cost nearly £9 and, although it has not been tried, we can see no reason why their Micro Siren (code JK42V) could not be used in this circuit – saving about £5.

The case (Maplin YN36P) does not have to be the one shown in the article but, depending on location, should be one that can easily be sealed against moisture if necessary. The small printed circuit board is available from the *EPE PCB Service,* code 854.

Three-Way Christmas Tree Lights Flasher

The only item that could cause concern when sourcing components for the *Three-Way Christmas Tree Lights Flasher* is the double-spaced p.c.b. mounting terminal block. These were ordered from Maplin and are their interlocking 300 series, codes JY93B (10mm), JY94C (5mm) and JY95D (10mm).

Whichever type of case is used it ***must*** be tamper proof. Also, make sure the supply lead plug is fused with a **1A fuse.** The printed circuit board is available from the *EPE PCB Service,* code 853.

Stereo Tone Control plus 1W Stereo Amplifier

No real component buying problems have come to light when checking down the list of requirements for the *Stereo Tone Control* and *1W Stereo Amplifier,* this month's audio modules in our *Multi-Purpose Audio System* series. The LM1035 d.c. operated dual tone/volume/balance i.c. used in the tone circuit should be widely available. However in case of difficulties, the one used in the model was purchased from **Maplin,** code QY19V.

The constructor has three possible module variations to choose from and all three options are covered by the *EPE PCB Service* and printed circuit boards are available as follows: code 849 (Tone/1W Amp.); 850 (Tone only) and 851 (1W Amp. only). See page 943.

Waterproof Delay Switch

The relay used in the *Waterproof Delay Switch* is the "Ultra Miniature High Power Mains Relay" purchased from **Maplin**. This relay is rated at 10A and is listed as code YX97F.

The waterproof plastic box also came from the above company, code YM90X. Likewise, the encased reed switches (YW46A). These magnet operated switches are burglar alarm/security types for recessing into doors and window frames and similar products are stocked by **Suma Design, Autona, Mailtech** and **Marco.**

Circuit Surgery

Some readers may experience difficulty when trying to purchase the LP395Z overload protected transistor for the "Loudspeaker De-Thump" circuit, one of this month's *Circuit Surgery* subjects. This is an RS device from **Electromail (☎ *0536 204555*)**, code 640-068.

VIDEOS ON ELECTRONICS

Everyday with Practical Electronics is pleased to bring you a range of videos designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They should prove particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part one; D.C. Circuits. This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part two; A.C. Circuits. This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part three; Semiconductors. Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**

VT204 56 minutes. Part four; Power Supplies. Guides you step by step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part five; Amplifiers. Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 56 minutes. Part six; Oscillators. Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

By the time you have completed VT206 you have completed the basic electronics course and should have a good understanding of the operation of basic circuit elements.

VCR MAINTENANCE

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

Now for the digital series of six videos. This series is designed to provide a good grounding in computer technology.

VT301 56 minutes. Digital One begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 56 minutes. Digital Three is your next step in obtaining a solid understanding of the basic circuits found in todays digital design. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 57 minutes. Digital Four shows you how the computer is able to communicate with the real world. You will learn about digital to analogue and analogue to digital converter circuits. **Order Code VT304**

VT305 56 minutes. Digital Five introduces you to the technology used in many of todays memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

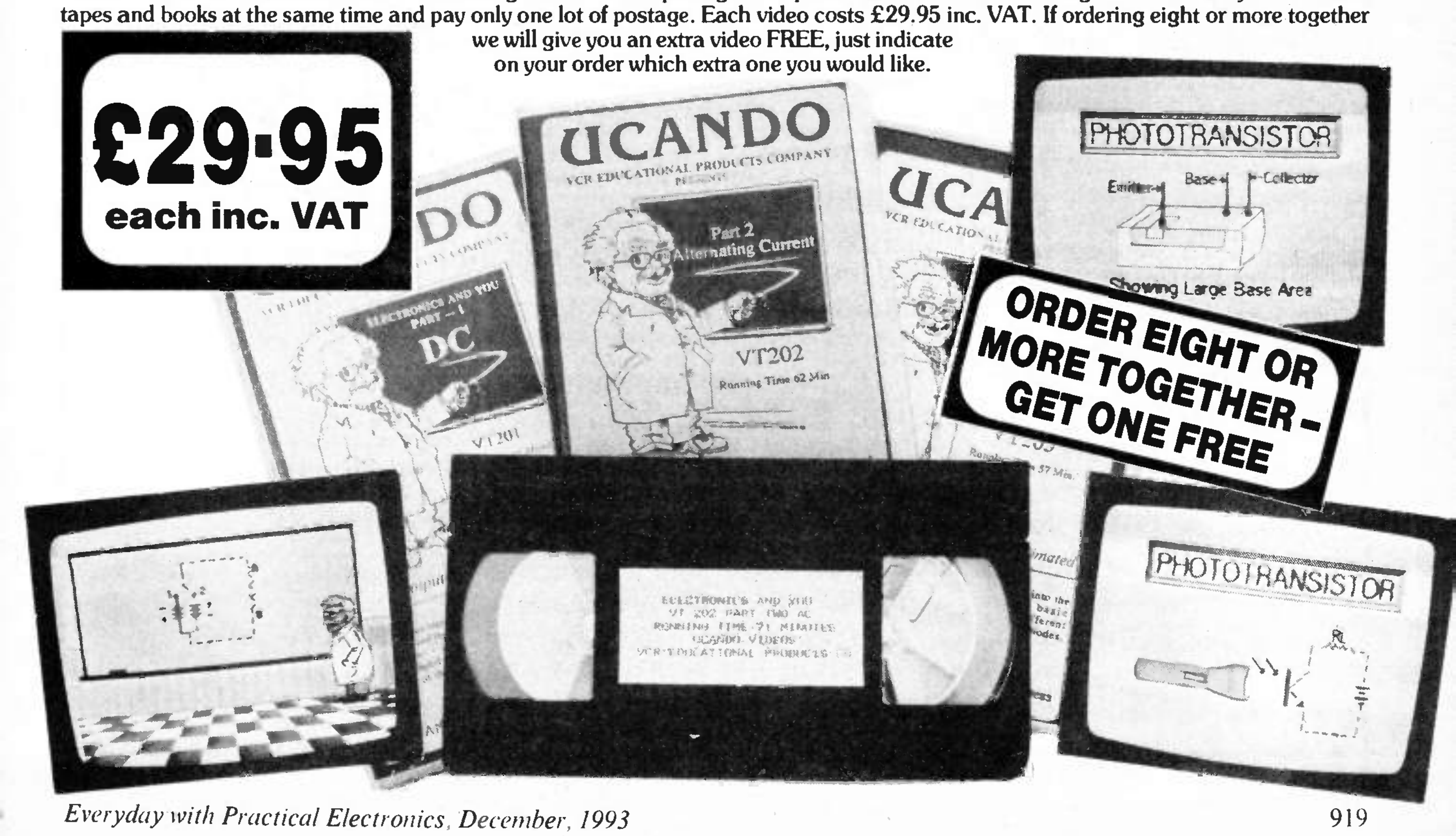
By now you should have a good understanding of computer technology and what makes computers work. This series is also invaluable to the computer technician to understand the basics and thus aid troubleshooting.

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier.

(All videos are to the UK PAL standard on VHS tapes)

ORDERING

To order see our *Direct Book Service* "Ordering Details" – the postage for tapes is the same as for our range of books and you can order tapes and books at the same time and pay only one lot of postage. Each video costs £29.95 inc. VAT. If ordering eight or more together we will give you an extra video FREE, just indicate on your order which extra one you would like.



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★ Frequency and Tuned Circuits
★ Using Numbers
★ Complex Numbers, Phase Angles
★ P.N. Junction Diode
★ Transistors
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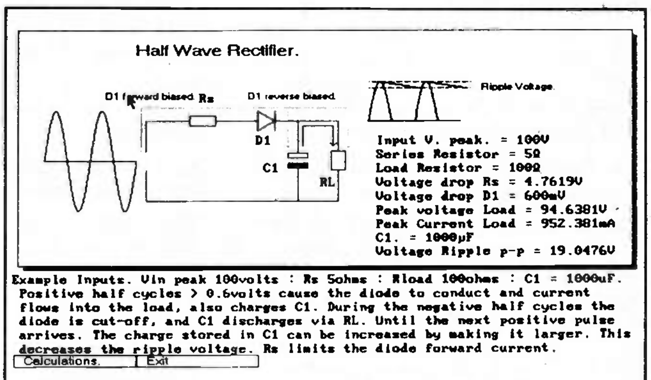
★ Logic Gates
★ Digital Number Systems
★ Combinational Logic
★ Flip Flops
★ Counters and Shift Registers
★ Memory



Half Wave Rectifier screen

Having reviewed a dozen, or more, educational software packages designed to "teach" electronics, I was more than a little sceptical when I first heard about Electronics Principles: *there seemed to be little that could be done that has not been done elsewhere. 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 out for themselves!*

MIKE TOOLEY B.A.
Dean of Faculty of Technology,
Brooklands Technical College

Over 200 menu driven screens with interactive graphics enabling a learning by doing approach to encourage experimentation.

Electronics Principles requires a PC (or fully compatible system) running DOS with an 80286 or better processor and VGA (ideally colour) graphics. In addition you must have 4Mb of hard disk space, a high density (1·44Mb) floppy drive and at least 640K of RAM. We also recommend the use of a mouse with this program. The program is supplied on three 3·5 inch disks.

Complete package

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FOX REPORT

by Barry Fox

Domesday for Domesday

On a radio phone in recently a caller asked what PC she should buy for her children. I knew I was in for trouble the moment I recommended an IBM-compatible. Sure enough, an Acorn dealer was on the line within minutes reminding me that at least 90% of schools use the BBC Micro, and telling me how bad DOS, Windows and PC software are. He also took me to task for being enthusiastic about Philips' CD-I system, when Acorn and the BBC were pioneering multimedia with the Domesday system back in the eighties.

Well let me stick my neck out further.

The Domesday system relied on a non-standard 12 inch Laser Video disc, running on a player controlled by a BBC Micro. Images were analogue. CD-I uses a 5 inch CD, running on a standalone player. The images are digital.

The Domesday system was subsidised by the DTI. It should never have been launched because the ongoing development of CD-ROM and CD-I had made Domesday clearly obsolete before it was ready. Of course schools that bought players may still be using them, but this does not make the system a success. It was a failure and most people have not even heard of it. There has been no new software for several years. If the Domesday programme material has any educatonal value it should now be transferred to CD-ROM or CD-I.

Learning Problem

Likewise the fact that cash-strapped schools are still using BBC Micros, does not prove the system is the right teaching tool for the future. It just proves that schools cannot afford to replace them. Of course the Micro was ahead of its time, of course it helps children get to grips with computers and of course engineers play some clever tricks with their Micros. But what we are talking about here is giving school children the best possible preparation for working life in the real world.

I do not like DOS, or Windows or much of the software available for the PC. I preferred Beta to VHS. But the world is as it is, not as we would like it to be. In the real world VHS is the home video standard and offices use IBM-compatible PCs.

School-leavers who become office secretaries will be expected to use DOS or Windows wordprocessors and databases. Higher flyers will need to know how to recover lost or corrupted DOS files, install new Windows applications, juggle Autoexec and Config system files and fine tune memory management. DOS/Windows is like a language. If you are going to work in Japan, you learn Japanese, not Chinese. If you are going to work in Holland, you learn Dutch not German or Austrian. So why, if children are going to work with DOS and Windows, teach them to work with the BBC Micro?

Relative merits are not the issue, any more than the relative merits of VHS and Beta were the issue ten years ago.

When anyone writes in to tell me about the wonders of the BBC Micro, will they please answer me a question. If the BBC Micro is so wonderful, and ideal for use as a real life working office tool, why do I never see anyone in a BBC office using one?

No Contest

While on the subject of challenges, a magazine reader recently challenged me on the oft-repeated statement that Beta was technically better than VHS, but VHS won through better marketing.

Unsupported myth, he argued.

Not so. The facts speak for themselves.

The Beta system used a clever juggle of low tape speed (1·87cms a second), narrow track pitch (33 micrometres) and large video drum (74·5mm diameter) to give high tape-to-head writing speed (5.8 metres/second) and 3 hours 15 mins playing time from a small cassette.

Early Beta machines gave poor pictures because early tape could not match this very demanding specification.

But as soon as the tape improved Beta pictures were visibly clearer than VHS, which placed less demand on the tape by using a larger cassette and shorter playing time (3 hours), while running the tape at higher linear speed (2.34cm/s) over a smaller drum (62mm diameter) which writes wider tracks (49 micrometres) at slower speed (4.85 metres/second).

Tolerances are not so tight for VHS, which makes the system able to cope with poor tape, but the penalty is reduced potential.

By leaving the tape continually threaded, Beta machines could start recording or playback far quicker than VHS, provide fast search pictures and read cue code tracks from the tape at fast winding speed.

Common sense told that because the tape was fast winding over the heads, they must wear faster. But despite many early predictions of doom, there was never any hard evidence of Beta heads wearing out faster than VHS heads. Sony's engineers had designed out the problem with clever tensioning that created an air cushioning effect.

The VHS manufacturers have spent the last fifteen years tweaking their system, to provide faster start times and fast search pictures, and to get clearer pictures out of slow writing speeds. Note also that the broadcast industry has almsot universally adopted the professional Betacam formats which build on domestic Beta technology, whereas professional versions of VHS have never been anywhere near as successful.

VHS now works well. But how do you suppose Beta would be working if Sony had done a better job of selling it particularly with granting licences for other firms to make machines and being more forthcoming with information on what improvements were already in the laboratory.

I know for a fact that it was Sony's secrecy, and JVC's open-ness, that tipped Ferguson into backing VHS rather than Beta. Ferguson had already fallen out badly with Philips, over the poor reliability of the Dutch company's early VCR's and the appalling arrogance of its UK sales staff – one man in particular. Ferguson was just itching to teach Philips a lesson. It had to be VHS or Beta and Ferguson chose VHS. Ferguson was then still part of Thorn-EMI, and still had immense clout in the UK market. After that Beta never stood a chance.

Spoilsport

If you travel to a country like the USA, where there is no teletext, you soon realise how lucky we in the UK are to have such a valuable source of free, up-to-date information news. Local newspaper, and local radio news rooms, rely heavily on the news pages.

It provides up to date share prices for financial institutions. So offices often have TV sets and, as often as not, the set is used to watch cricket or football.

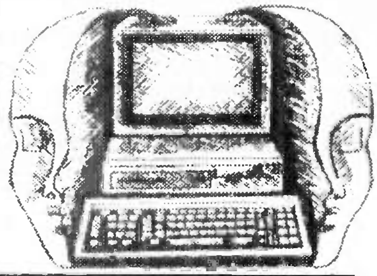
Even if it is used only for teletext, staff use it to check the sports scores. The same thing happens if office PCs, or office networks, are fitted with teletext decoders.

Computer systems company Digithurst of Royston in Hertfordshire has seen this and come up with a spoilsport answer. For around £500 the MicroEye lets companies use the free broadcast teletext service to provide staff with business information, but without anyone being able to waste working time on watching entertainment pages. Digithurst calls it "removing the play element".

Digithurst's MicroEye is a TV tuner and teletext decoder that plugs into whichever personal computer is serving information to the office network. MicroEye software lets the office system supervisor program the decoder to receive only selected pages. It then strips out the the information from these pages and puts it in an indexed store.

Anyone on the network can then call up and read pages of teletext information that relate to their job. But they cannot call up any pages with a play element or watch any television pictures.

INTERFACE



Robert Penfold

IT MIGHT be more appropriate if this feature was renamed something like "PCB CAD Of The Month". Several low cost programs of this type have been reviewed in *Interface* over the past few months, and this month brings a review of another. Like the ones covered previously, this program is for IBM PCs and compatibles. The program in question is "Quickroute", and three versions of the program are available. All are available at inclusive prices of under £100.

The cheapest of these is "Quickroute 1.5" for DOS. At a somewhat higher cost there is "Quickroute 2.0 Standard Edition" which runs under Windows 3.0 or 3.1. The Windows version is quite similar to the DOS version, but it has some additional features. Also, it ensures compatibility with the vast range of high resolution screens, printers, etc. that will operate with Windows.

The most expensive version is the "Quickroute 2.0 Professional Edition". This is exactly the same as the normal Windows version of the program, except it has the ability to import and export Gerber Photo-plotter files. Also, an NC drill export facility is provided. The export facilities enable the user to produce files that can be used for commercial p.c.b. production. The Gerber import facility might permit designs to be imported from other printed circuit CAD programs, but this type of thing tends to be fraught with difficulties in practice.

Windows Versions

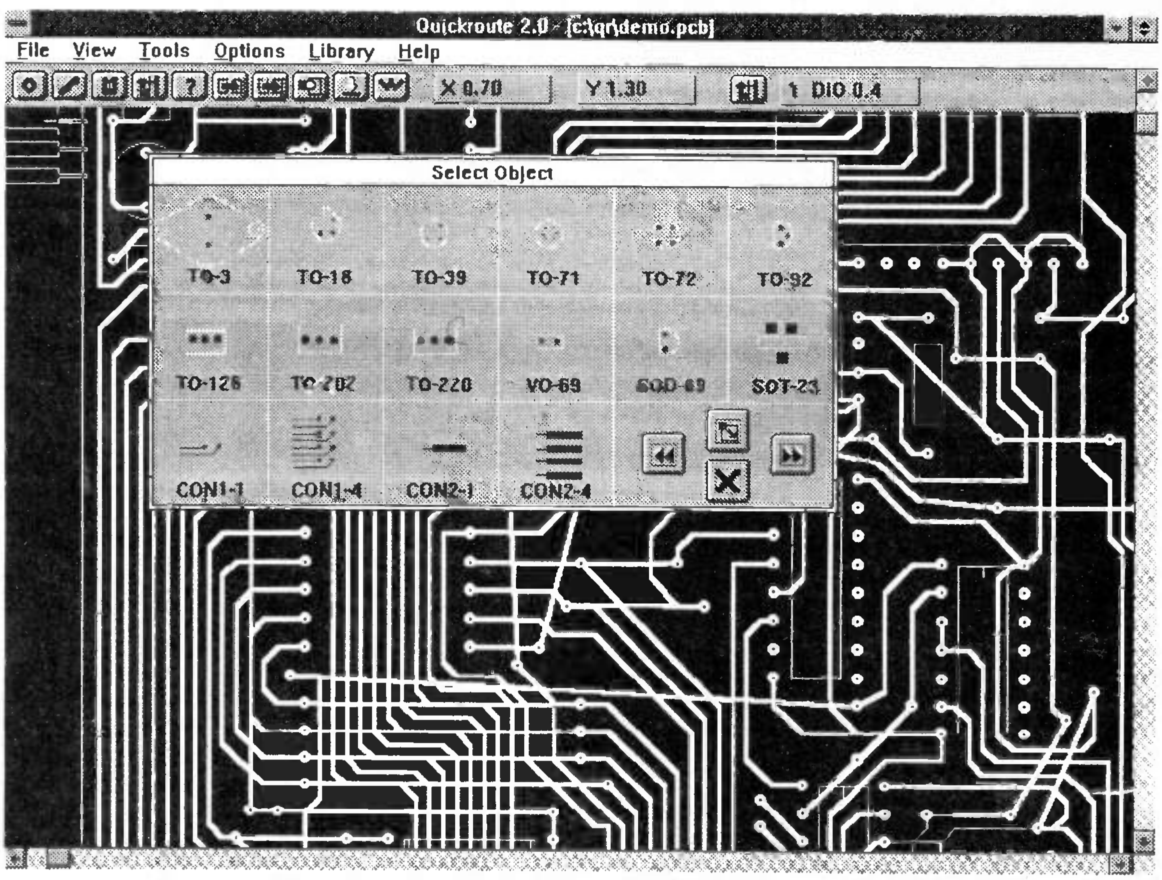
There is an installation program which makes it very straightforward to load the program onto the hard disk from the single high density disk. In this respect the program is rather less slick than the "PCB Designer" program reviewed last month. However, anyone who is reasonably familiar with Windows should soon have "Quickroute" up and running. The manual does not seem to give details of minimum system requirements, but the program will presumably run on any PC that can use Windows 3.0 or 3.1.

The screen layout and basic method of controlling the program is similar to that of "PCB Designer". There is the usual menu bar, and this gives access to facilities such as saving, loading, zooming, and snap grid size. A toolbar below the menu bar gives access to the most frequently use commands, which are mainly those used when actually drawing the board design. These include track and pad drawing, and adding d.i.l. clusters or pre-drawn symbols.

A limited but useful range of symbols are supplied with the program, but custom symbols can be drawn-up and added to these. The "?" button is used to change to a different track width, pad size, symbol, or d.i.l. cluster. It brings up a window which makes selection of the new drawing object very easy. A good range of track and pad sizes are available, and they are all user adjustable.

Some block editing commands are available via three of the toolbar buttons. These permit areas of the board to be copied, moved, or deleted. Alternatively, individual objects can be picked and processed in the same ways. It is also possible to add "elbows" into tracks, and blocks can be rotated through 90 degree increments or mirror-imaged. However, nothing beyond these basic editing commands are provided, and this is one respect in which "Quickroute" is inferior to most of the competition.

With most other printed circuit design programs it is very easy to reroute a track. With no means of moving track "elbows", most rerouting is awkward or not possible



Screen dump from "Quickroute 2·0" showing a symbol selection window.

using "Quickroute". It becomes a matter of deleting the old track and drawing the new one from scratch. Another point worth mentioning is that the block move command does not preserve interconnections between the objects inside the block and those outside it. This can leave some tidying up to do after a block move has been completed.

Other Facilities

"Quickroute" has a number of facilities in addition to the drawing and editing tools. These include a simple auto-router that can handle single-sided or multi-layer boards. This works about as well as most other simple auto-routers, which means that it will not achieve anything like a 100 per cent success rate, particularly with single-sided boards. It is a useful feature though, especially if you will be producing a lot of double-side boards.

Component overlays can be produced on top and bottom silk-screen layers. Ellipses and arcs can be used, making it possible to design symbols having quite realistic overlay shapes. Two styles of text are available, one of which is the standard Windows Helvetica font. The other type is the "Quickroute" vector text, which is available in four sizes. The vector text can be rotated through 90 degrees and mirror-imaged, but this is not possible using the Windows font. It is possible to produce good quality overlays quite quickly and easily.

The program is not limited to drawing printed circuits, and it can also be used to produce circuit diagrams. The quality of the diagrams produced is not quite up to general CAD program standards. However, it is possible to produce circuit diagrams that are more than adequate for most purposes.

Schematic Capture

"Quickroute" has a schematic capture facility, which is an advanced feature that one would not expect to find in a program at the budget end of the market. It permits a set of interconnections in a circuit diagram to be carried through to a printed circuit layout. The netlist generated by the schematic capture facility can be converted into a SPICE compatible type.

The netlist can also be used to produce a "rats nest". This is a board layout which has the tracks simply running straight from one pad to the next, probably crossing over several other tracks on the way. Component placement is automatic, but simply follows the layout of the circuit diagram. The positions of the components can be adjusted by the user, after which automatic and (or) manual routing is carried out.

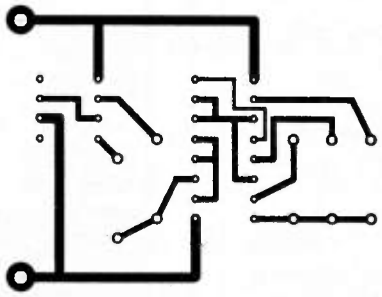
This method of working can get a bit involved in practice, but it produces very quick results once the process has been mastered. In theory at any rate, it ensures that the finished board is free from connection errors. I did not extensively test the "Quickroute" schematic capture facility, but a quick trial did not bring to light any major flaws. In fact it seemed to work very well.

Other Facilities

"Quickroute" has the usual drawing aids such as a visible grid of on-screen dots, and a variable snap grid. Various preset zoom levels are provided, or the user can enter a zoom level. Also, it is possible to zoom in on a selected area of the screen. Panning is accomplished using the scroll bars, or pressing the right hand mouse button centres the screen on the current cursor position.

Screen redrawing is very fast by Windows standards, and rivals some DOS based printed circuit CAD programs. A "Turbo Draw" option permits faster redrawing by showing tracks and pads only as outlines. This could be useful when designing large boards using a relatively slow PC.

Finished designs can be printed using any output device that is supported by Windows. Provided your printer or plotter is up to the task, hard copy of a very high standard can be generated. The scaling of printouts is controlled by the screen zoom factor. Similarly, the selection of layers to be printed is also governed by displaying the appropriate layers on the screen.



Quickroute a 1:1 output from a laser printer at 300 d.p.i.

The custom zoom facility makes it possible to precisely scale printouts to compensate for any errors in the printer or plotter. No mirror image facility is available, but it would presumably be possible to generate a mirror image of the design on the screen, and then print it out.

Comparisons

With the standard Windows version of "Quickroute" at an inclusive price of £59-00, and "PCB Designer" selling at an inclusive price of £49-00, the two are in direct competition. Although the two programs are similar at a superficial level, they are really very different "under the skin", and are aimed at different types of user.

If you require a program that permits printed circuits to be designed very quickly and easily with no real learning time being required, "PCB Designer" is the obvious choice. If you require a program that is more powerful, and you are prepared to put rather more effort into mastering it, then "Quickroute" is probably the better choice. It offers an amazing range of facilities for the price, and the only disappointing aspect of the program is its relatively weak editing facilities. Despite the absence of good track rerouting commands, it should still be possible to produce quite large and complex board designs using this program.

At an inclusive price of £99-00 the "Professional Edition" is in direct competition with well established programs such as "Boardmaker", "Ranger 1", and "Easy PC". Anyone buying printed circuit design software in this price range should compare the specifications very carefully to determine which program best suits their requirements. They are all good programs, and in my opinion there is no obvious "winner".

DOS Version

The DOS version of "Quickroute" will run on practically any PC that has a standard graphics display of some kind. It is not necessarily particularly usable on a very basic PC though. The recommended minimum system is a PC having an 80286 or better processor, 512K of memory, and a Microsoft mouse.

A V.G.A. display is highly desirable for any program of this type. Super V.G.A. displays are supported, but can be problematic with any program. My super V.G.A. display worked with "Quickroute", but (as often happens) the mouse driver only gave access to a small portion of the screen. The normal V.G.A. mode gave good results.

The DOS version is surprisingly similar to the Windows versions, and it has what is basically the same set of menus and the same toolbar. However, the DOS version does lack some of the facilities available on the Windows versions of "Quickroute". There is no box zoom facility for instance, but zooming to a custom zoom factor is included. The right hand mouse button provides the only means of panning around a design.

The most important difference is that the DOS version lacks the schematic capture facility, but the auto-router is included. Screen redrawing is reasonably fast, but (unusually) the DOS version does not seem to be any faster than the Windows versions.

Hard copy can be produced on an HPGL compatible plotter, or a useful range of printers. Epson 9 and 24-pin printers, IBM 9 pin types, and HP Laserjet printers are catered for. Most other printers are compatible with one or other of these. However, my Epson laser printer failed to produce results when used to emulate an HP Laserjet. Using a printer emulation always brings a risk of compatibility problems.

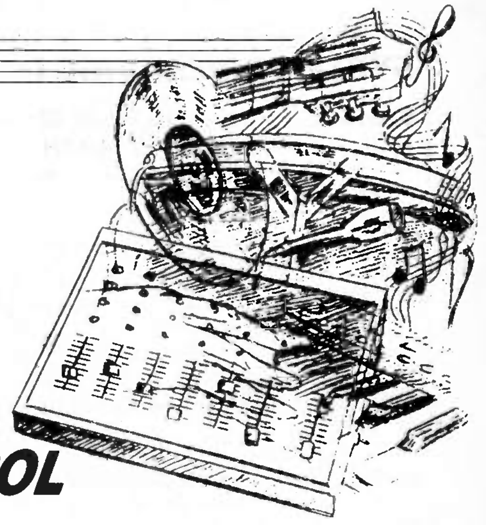
"Quickroute 1.5" is probably the cheapest printed circuit design program for the PCs, but it works well and is suitable for the production of quite large and complex boards. Like the Windows versions, it lacks good track editing facilities, but it is still quite usable, and represents really good value for money.

For those who have a PC which is equipped with Windows 3.0 or 3.1 it is probably worthwhile paying the extra money for the standard Windows version. This has some useful extras, and it should avoid any problems with screen or printer incompatibilities. For those with relatively basic PCs the DOS version should give good results for a minimal outlay.

The "Quickroute" programs are available from Powerware, Dept. EPE, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD (Tel. 061 449 7101). The inclusive prices for customers within the U.K. are £39-00 for the DOS version, £59-00 for the standard Windows edition, and £99-00 for the professional Windows version. There is a £5-00 postage and packing charge for customers outside the UK. All versions are supplied complete with an adequate manual, and telephone support is available.

Constructional Project

MULTI-PURPOSE AUDIO SYSTEM



Part 3 – STEREO TREBLE/BASS VOLUME/BALANCE CONTROL Plus 1W STEREO AMPLIFIER

MAX HORSEY **P.C.B. Design JAMES GREEN**

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.

THE Tone Control module is available with or without a Stereo 1W Amplifier on the same p.c.b. The amplifier does not significantly increase the area required, and is useful in providing a respectable quantity of sound through loudspeakers, or a healthy response via headphones. Both the Tone Control and 1W Amplifier modules are also available as separate p.c.b.s.

Two prototype versions have been produced, the first housing the Tone Control Module *and* 1W Stereo Amplifier in a single case, and the second (to be described next month) which employs the Tone Control Module, without the 1W amp. but with a separate 10+10W Power Amplifier and System Power supply.

TONE/VOLUME/ BALANCE CONTROL MODULE

The Tone Control module is based on the very useful audio control i.c. type LM1035. The i.c. has two inputs (for left and right stereo channels) and two outputs.

All the settings for treble, bass etc., are controlled by d.c. voltages applied to the appropriate pins of the i.c. The i.c. is therefore ideal in remote control applications, but the suggested module applies d.c. voltages from potentiometers. An accurate Zener control voltage is provided from pin 17 and this is used via the potentiometers ("pots") to set the various functions.

An important point to note is that the audio signal is not transmitted via any of the control potentiometers, and the quality of the sound is therefore not affected by using a poorly screened pot. or a pot. with a dusty track. The potentiometers required are inexpensive linear single types, even though they are used to control a stereo signal.

The block diagram of the dual d.c. operated tone circuit i.c. is shown in Fig. 1. The main control pins are as follows:

- Pin 4 Treble Control – provides 15dB of cut or boost at 16kHz.
- Pin 7 Loudness Compensation – boosts the treble and bass which is helpful when listening at low volume.
- Pin 9 Balance Control – balances the left and right channels. Something difficult to do with ordinary potentiometer circuits.
- Pin 12 Volume Control
- Pin 14 Bass Control – provides 15dB of cut or boost at 40Hz.

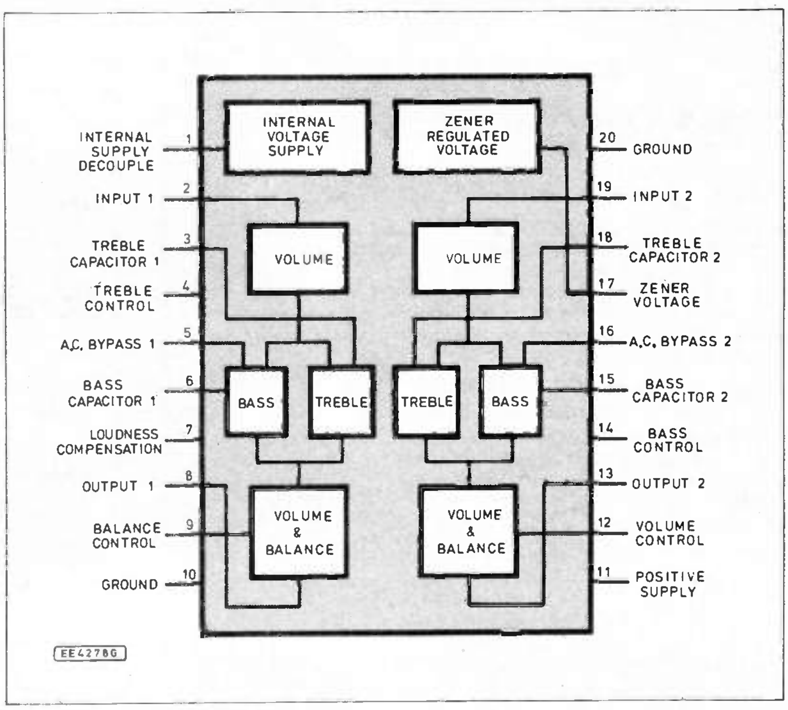


Fig. 1. System block diagram for the LM1035 dual tone/vol./bal. i.c.

The figures quoted for treble and bass control assume that the tone control capacitors (C4 and C12 for the treble, and C7 and C10 for the bass) are the values specified. It is possible to modify the amount of cut or boost by changing the values of these capacitors.

Pin 17 is a "Zener output voltage" which provides 5·4V. This may be used with potentiometers to set the amount of treble, bass, volume and balance.

Taking the Treble control pin 4 as an example, if 5·4V is applied to this pin, the treble response will be boosted by the amount set by C4 and C18, the treble set capacitors (connected to pins 3 and 18). If 0V is applied to pin 4, maximum treble cut will be applied.

A voltage of 2·7V applied to pin 4 will provide a flat response (i.e. no treble boost or cut). The same applies to the bass response, controlled by pin 14.

The same Zener control voltage may be used to control the volume level and balance between the left and right stereo channels.

INPUT/OUTPUT IMPEDANCE

The input impedance is about 30 kilohms and the output impedance is 20 ohms. These figures enable the module to be interfaced to virtually any other audio circuit.

CIRCUIT DESCRIPTION

The full circuit diagram for the Stereo Treble/Bass/Volume/Balance Control is shown in Fig. 2. The power supply for IC1 is via pins 11 (positive) and pins 10 and 20 ("ground" or 0V).

The left and right audio inputs (pins 2 and 19) are fed via d.c. blocking capacitors C1 and C15. The left and right outputs (pins 8 and 13) are via d.c. blocking capacitors C2 and C16. The purpose of d.c. blocking capacitors is to allow the audio (a.c.) signal to pass freely, but prevent the flow of d.c. from or to another module.

Capacitor C3 is required to decouple the internal supply for IC1. Capacitors C4 (left channel – pin 3) and C12 (right channel – pin 18) are the treble set capacitors, which determine the amount of treble boost or cut applied to their respective channels. Capacitors C7 (left – pin 6) and C10 (right – pin 15) determine the amount of bass boost or cut. It is difficult to fabricate large value capacitors within the i.c. and the other external capacitors are required to enable IC1 to function correctly.

Remembering that pin 17 supplies an accurate 5·4V. this is used by all the control potentiometers VR1 to VR4. Potentiometer VR1 controls the Balance between the left and right hand stereo channels. An almost perfect response is obtained; if the control is set mid-way, both channels are at virtually full volume (as set by VR3).

Control VR2 sets the Treble boost or cut, and VR4 achieves the same with the Bass. Each potentiometer has a 47 kilohm series resistor to prevent the respective pin being connected directly to 0V or pin 17.

Loudness compensation (pin 7) provides additional treble and bass boost which is useful when listening at low volumes.

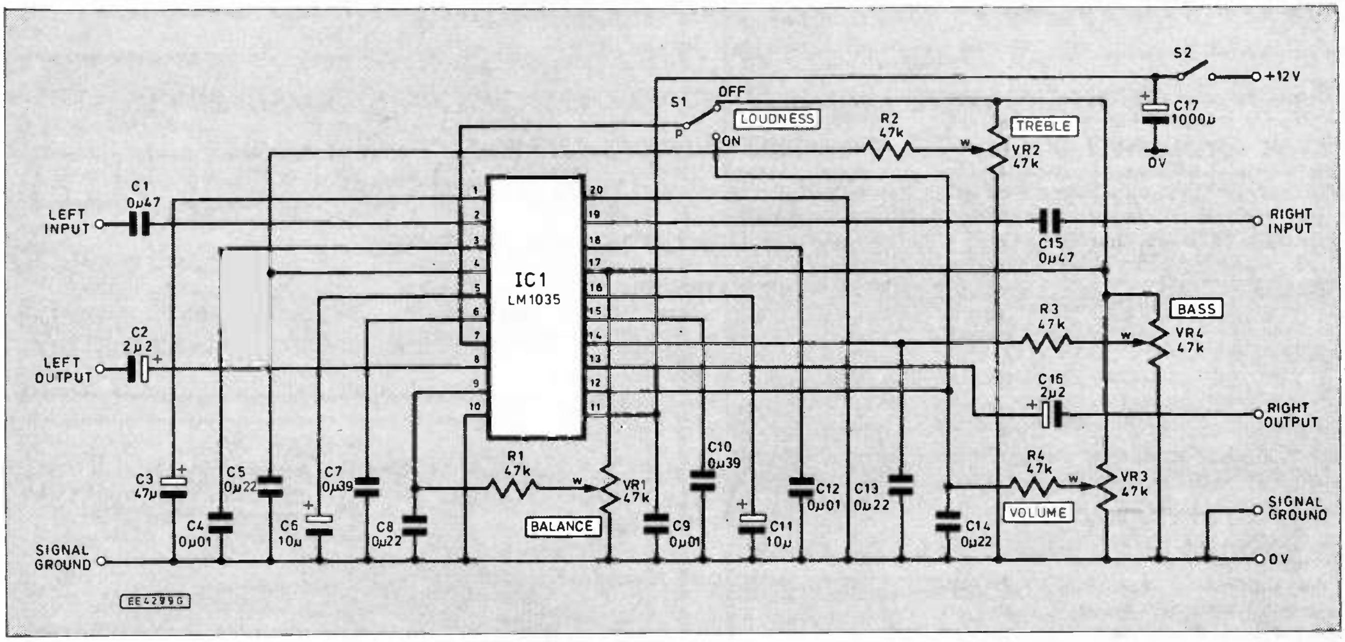


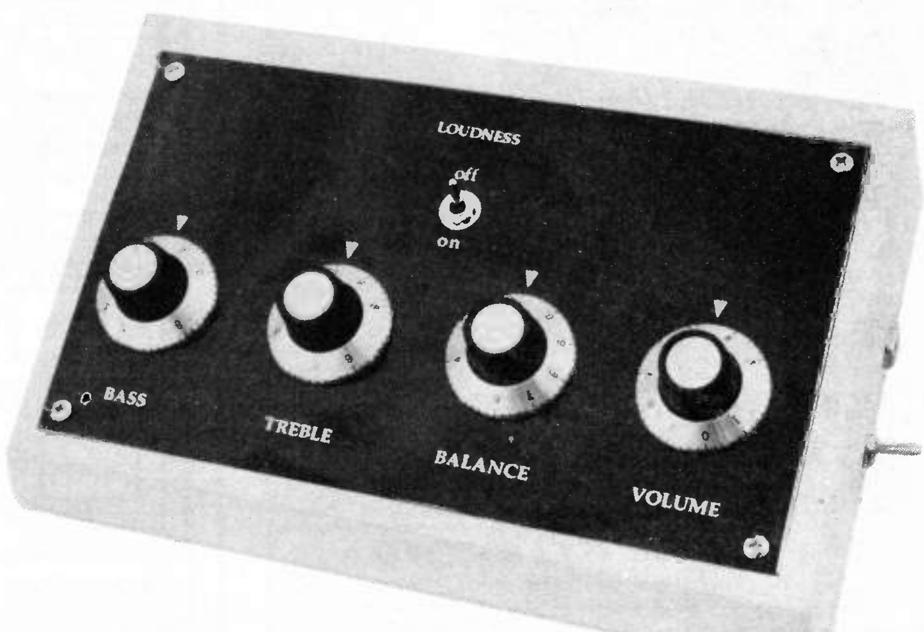
Fig. 2. Complete circuit diagram for the Stereo Treble/Bass/Volume/Balance Control module.

SUPPLY VOLTAGE

The i.c. is designed to operate on any supply from 8V to 18V, but the maximum signal handling capability is reduced at 8V. On the 12V supply specified for this module the input and output signals can have a maximum value of 2·5V r.m.s. It is important to note that if the circuit is modified, and the bass or treble levels are boosted significantly, the output maximum could be exceeded, resulting in distortion.

The supply current is about 40mA. It would be possible therefore to run the unit from a battery pack (e.g. 8 × AA cells), but for long term use an inexpensive but ***regulated*** 12V battery eliminator is recommended.

If this project is to form part of a larger system, it is worth considering the use of a single power supply for all the modules. The audio mixer and this project could easily be powered from a small 300mA battery eliminator, but a larger power supply should be considered (say 500mA or 600mA) if it is to also power the 1W Amplifier, and a *much* larger power supply for the 10W + 10W amp!



Completed Tone Control Unit.

When pin 7 is connected to pin 17 there is no loudness compensation, but when pin 7 is connected to pin 12, treble and bass boost are applied.

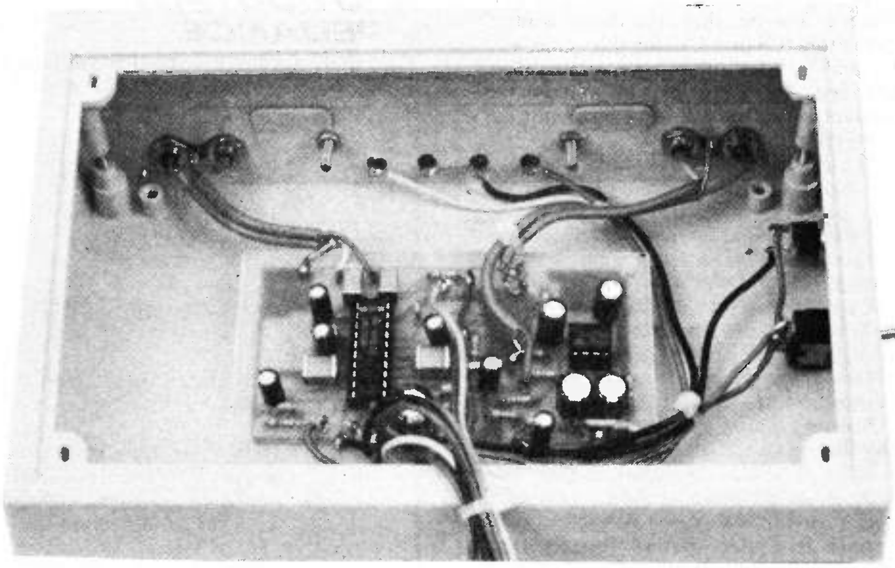
These connections are achieved via switch S1. Note that the loudness compensation does *not* boost the treble and bass further than that achieved by fully advancing the treble and bass controls, it is simply provided for convenience to prevent the loss of treble and bass sounds at low listening levels.

Capacitors C9 and C17 ensure that the circuit receives a smooth supply.

OUTPUTS

The left and right outputs from the Tone Control Module are available on both versions of the p.c.b. However, on the version incorporating the 1W Amplifier, the outputs are also connected via copper tracks to the inputs of the amplifier.

The Tone Control Module is capable of driving several power amplifiers if required. Note that volume controls are not required on the power amplifiers since volume is controlled by the tone control module.



Wiring to the Tone Control rear mounted input and output sockets. Screened leads should be used for these connections.

ONE WATT STEREO AMPLIFIER

The circuit diagram for the 1W Stereo Amplifier is shown in Fig. 3. The inset diagram, with components prefixed with an X, is for the combined Tone/Amp module. This circuit may be built as a self contained unit, or combined with the tone control module.

Based on the power amplifier TDA2822 i.c., this stereo amplifier requires very few external components to make a one watt per channel amplifier. Although 1W may appear rather low compared with the 40W or 60W systems currently in fashion, the relationship between "wattage" and sound output is not that simple. A one watt per channel system is often adequate for normal listening levels in an average room and more than sufficient for a pair of headphones.

OUTPUT POWER/ SUPPLY

The output power depends upon the supply voltage used with the circuit, and the impedance of the speakers. For example with a 3V supply, the amplifier will provide 20mW into 32 ohms, which is ideal for use with headphones. With a 9V or 12V supply the amplifier will provide 1W per channel into 8 ohms.

High power amplifiers require elaborate and therefore expensive power supply systems. This 1W amplifier can be driven from a battery pack, or an inexpensive *regulated* 12V 300mA battery eliminator.

If other audio modules are to be driven from the same supply, choose a 12V 500mA or 600mA battery eliminator. Never drive the amplifier or any audio module from an *unregulated* supply since the voltage will fluctuate as the supply current changes, resulting in sound distortion or even damage to the modules.

VOLUME CONTROL

If this module is used exclusively with the audio mixer, the "master fader" on the audio mixer acts as a Volume control, and VR1 and VR2 may be omitted. Similarly if the amplifier is used exclusively with the Tone Control Module, then VR1 and VR2 may also be omitted since the tone control already includes a volume control.

If VR1 and VR2 are omitted, the signal is fed via a potential divider resistor pair comprising RA and RB (left channel) and RC and RD (right channel). Resistors XRA and XRC may be reduced in value if a higher maximum signal is required.

If the circuit is not used with the modules mentioned before, or if flexibility of use is required, then VR1 and VR2 should be included. They could be separate potentiometers, allowing the user to "balance" the stereo image without the need for a "Balance" control, or they could be ganged i.e. joined so that operation is by means of a single knob.

Having decided upon "single" or "dual" potentiometers, the next choice is between rotary pots or sliders. This choice is discussed later.

The prototype unit housed the Tone Control Module and 1W Stereo Amplifier in the same case, and therefore VR1 and VR2 were omitted. However, the diagrams show both methods.

CIRCUIT DESCRIPTION

How the power amplifier IC1 is connected to form the complete circuit for the 1W Stereo Amplifier is shown in Fig. 3. The i.c. contains two amplifiers which form the stereo pair. The amplifiers are drawn like op.amps, but they are much more elaborate and contain feedback resistors, gain set resistors and power output devices.

The left and right hand audio input signals are fed to potentiometers VR1 and VR2 respectively or via fixed resistors as discussed earlier. The output from pin 1 (left) and pin 3 (right) is fed, via d.c.

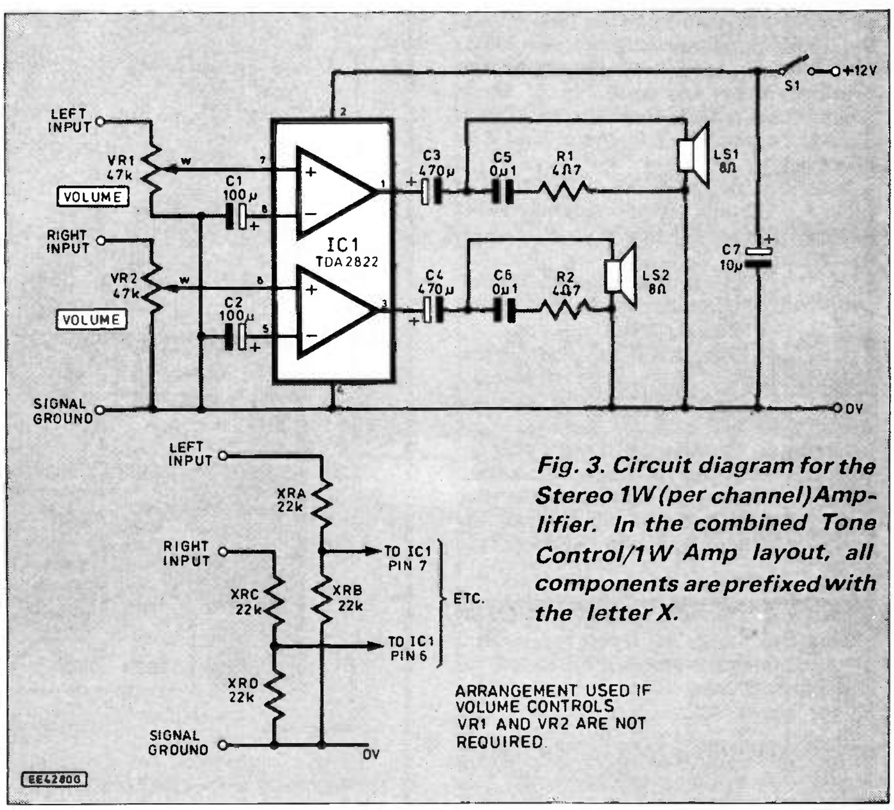


Fig. 3. Circuit diagram for the Stereo 1W (per channel) Amplifier. In the combined Tone Control/1W Amp layout, all components are prefixed with the letter X.

blocking capacitors C3 and C4, to the loudspeakers.

Capacitor C7 decouples the supply to provide a steady voltage for the circuit.

CONSTRUCTION – TONE CONTROL

Since the whole purpose of the circuit is to provide control over the sound, some attention should be given to the layout and type of controls. Also consider at an early stage whether the 10W + 10W Power Amplifier (next month) is to be included within the same case, and of course, decide whether to build the separate or combined Tone Control and 1W Stereo Amplifier p.c.b.s. Note that in the combined layout diagram, the amplifier components are prefixed with the letter X.

The details of the case and front panel layout are designed for the combined Tone Control and 1W Stereo Amplifier. A case which is similar in style, though smaller than the Six-Channel (12 mono) Stereo Mixer (last month) case has been chosen.

SLIDERS OR ROTARY

The present fashion appears to be in favour of rotary controls, although a set of sliders might look more elegant if the project is to be used in conjunction with the audio mixer. Sliders are much more difficult to fit and tend to be more expensive. Rotary potentiometers were chosen for the prototype circuit.

Having made this decision it is helpful to note that all the control pots are connected to 0V at one side, and pin 17 IC1 on the other side. This greatly simplifies the connections required between the pots and the circuit.

TONE CONTROL BOARD

The printed circuit board (p.c.b.) topside component layout and underside copper foil master pattern for the *combined* Tone Control and 1W Stereo Amplifier is shown in Fig. 4. This board may be used even if the amplifier components are not fitted. However, a layout without the amplifier is provided, and is shown in Fig. 6. These boards are available from the *EPE PCB Service*, codes 849 (Tone/Amp) and 850 (Tone only).

In either case, begin by fitting the i.c. socket(s) followed by the smallest components such as resistors. Ensure that all the electrolytic capacitors are fitted the correct way round. The negative lead is indicated on the capacitor body and the positive lead is normally the longer one.

Screened cable should be used for the *audio* connections although all the connections to the potentiometers and switches can be made with ordinary insulated wires as shown in the diagram. Ensure that all the leads connected to the p.c.b. are long enough to allow neat routing in the case and enable the p.c.b. to be removed for servicing without having to disconnect the leads.

POTENTIOMETERS

Note that a more tidy layout is possible if the potentiometers and switch S1 are fitted into the front panel *before* connecting them to the board. Although all the pots. are provided with three pads on the p.c.b., it is probably more convenient to connect a common 0V lead from all the controls to a single 0V pad on the p.c.b.

COMBINED STEREO TREBLE/BASS/VOL./BALANCE

Front panel control layout and lettering.

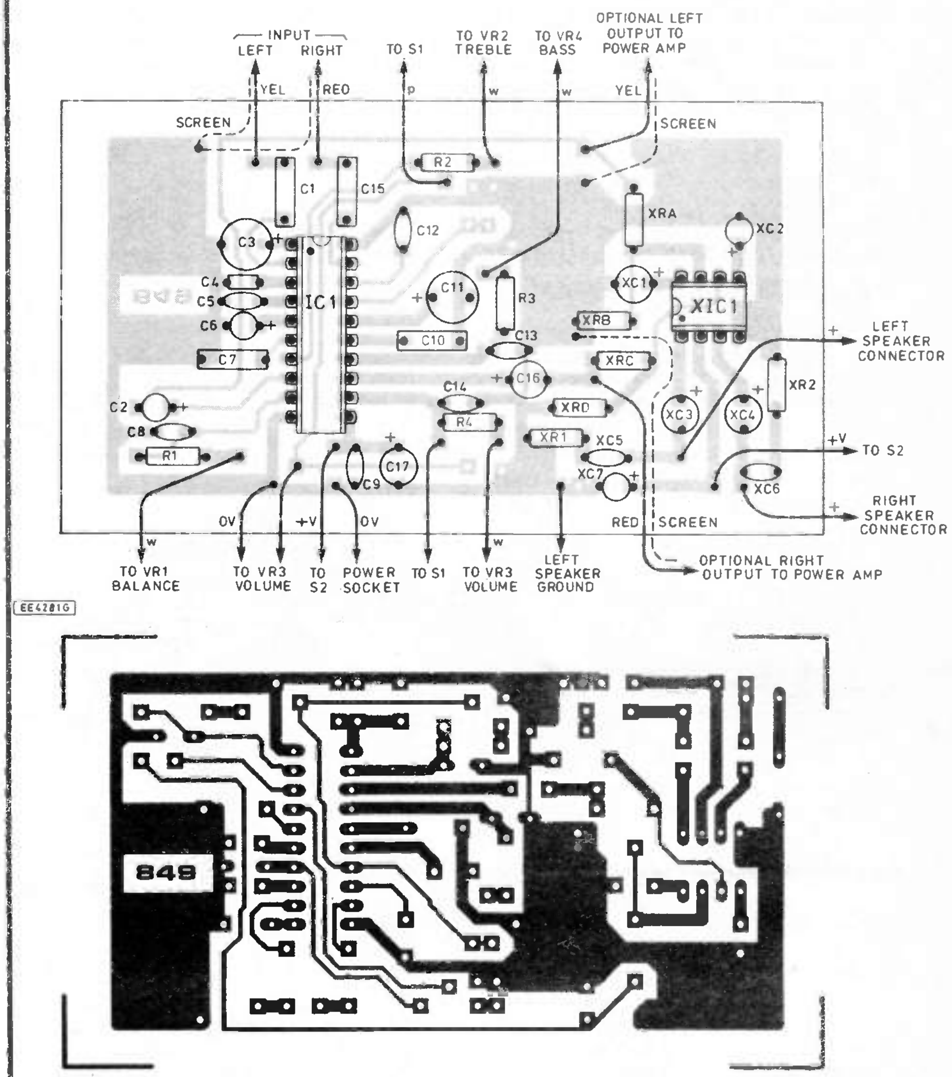


Fig. 4. Combined Tone Control and 1W Stereo Amplifier printed circuit board component layout and underside copper foil master pattern.

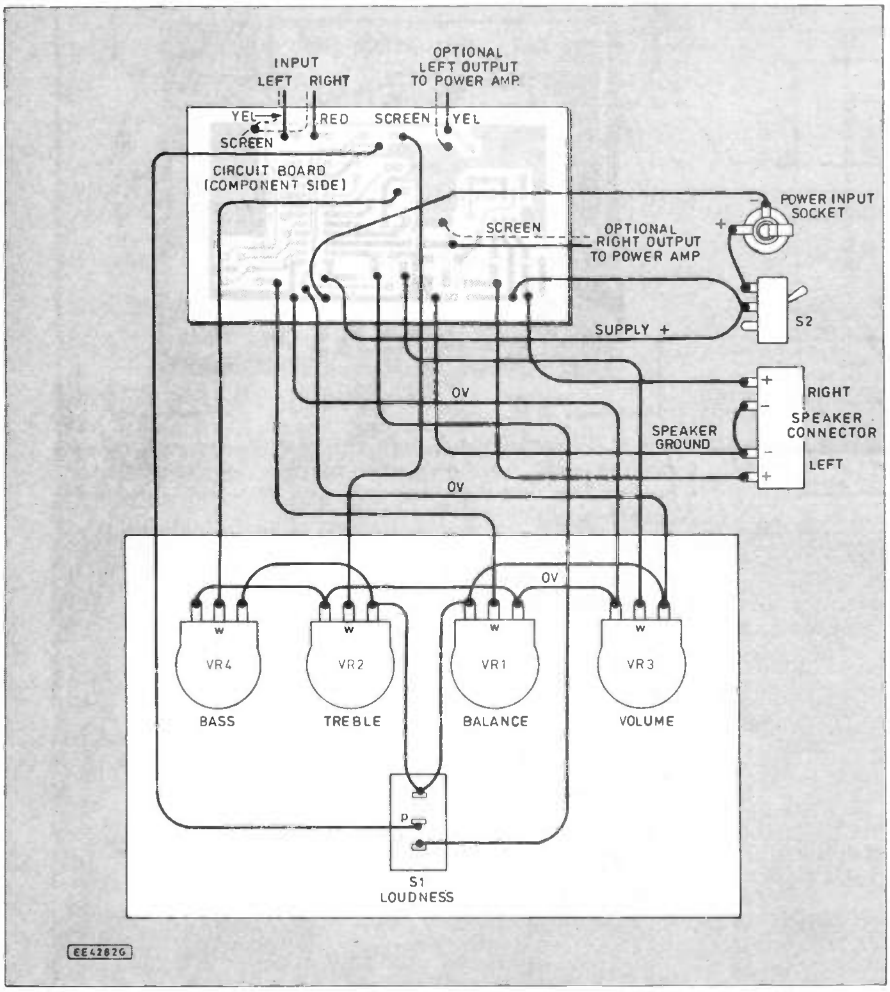
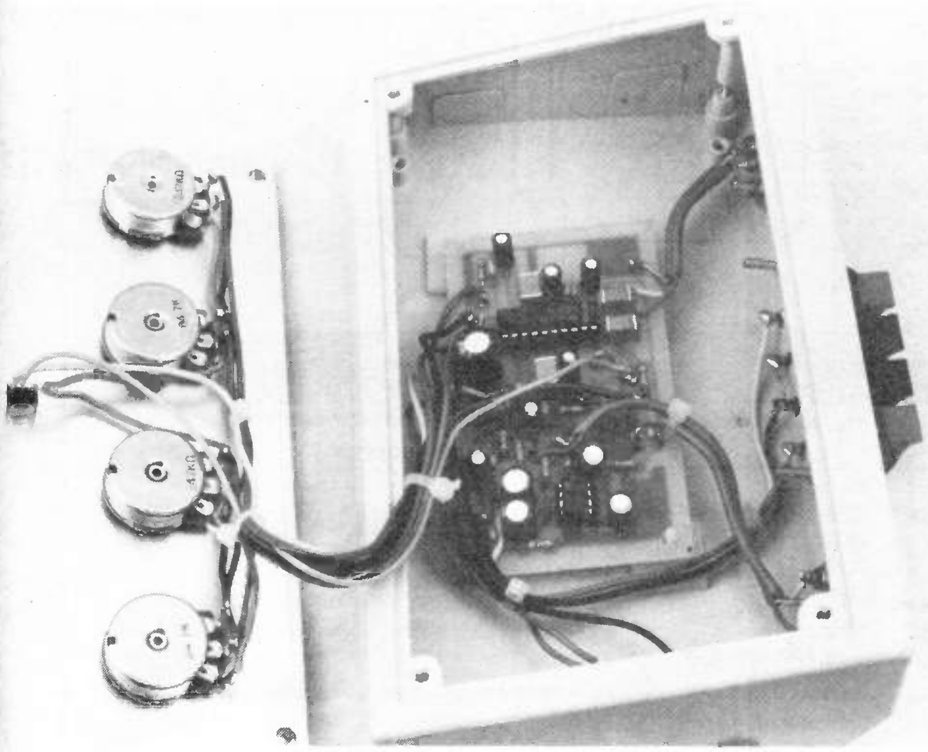


Fig. 5. Interwiring from the off-board components to the combined Tone/Amp. p.c.b.



Wiring from the tone controls to the combined Stereo Tone Control/1W Stereo Amplifier circuit board.

COMPONENTS

STEREO TONE CONTROL

See SHOP TALK Page

Resistors
R1 to R4 47k (4 off)
All 0·25W 5% carbon film

Potentiometers
VR1 to VR4 47k slider or rotary carbon, linear (4 off)

Capacitors
C1, C15 0µ47 polyester layer (2 off)
C2, C16 2µ2 radial elect. (2 off)
C3 47µ radial elect.
C4, C9, C12 0µ01 disc ceramic (3 off)
C5, C8, C13, C14 0µ22 disc ceramic (4 off)
C6, C11 10µ radial elect. (2 off)
C7, C10 0µ39 polyester layer (2 off)
C17 1000µ radial elect.
All electrolytics can be 16V or greater.

Semiconductors
IC1 LM1035 d.c. operated, dual tone/volume/balance circuit

Miscellaneous
S1 S.P.D.T. toggle switch
S2 S.P.S.T. toggle switch
Printed circuit board available from the *EPE PCB Service*, code 849 (Tone/1W Amp) or 850 (Tone only); 20-pin d.i.l. socket; console case (with metal sloping front), size 190mm x 100mm x 62mm; phono chassis sockets (4 off); power socket; loudspeaker 4-way lever terminal; knobs for potentiometers; screened cable; connecting wire; soolder, etc.

1W STEREO AMP

Resistors
R1, R2 4Ω7 (2 off)
RA, RB, RC, RD 22k (required if VR1 and VR2 are not fitted) (4 off)
All 0·25W carbon film

Potentiometers
VR1, VR2 47k slider or rotary carbon (one dual or two single) log. (optional – see text)

Capacitors
C1, C2 100µ radial elect. (2 off)
C3, C4 470µ radial elect. (2 off)
C5, C6 0µ1 disc ceramic
C7 10µ radial elect.
All electrolytics can be 16V or greater

Semiconductors
IC1 TDA2822 1W stereo power amp.

Miscellaneous
S1 S.P.S.T. toggle switch (optional – see text)
LS1, LS2 8 ohm loudspeakers (pair)
Printed circuit board available from the *EPE PCB Service*, code if combined with Tone Control 849 (Tone/1W Amp) or 851 (1W Amp only); 8-pin d.i.l. socket; loudspeaker 4-way lever terminal connector; screened cable, connecting wire; solder.
Optional items: input phono sockets; case; power socket; knobs for potentiometer (2 off).
Note 1: Most of the optional items are not required if the amplifier is to share a case with the Mixer or Tone Control.
Note 2: All components are prefixed with the letter X in the layout diagram (Fig. 4) when combined with the Tone control Module.

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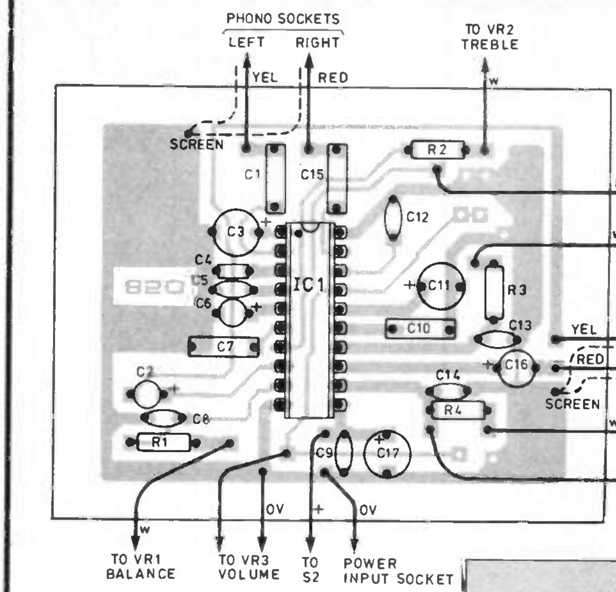
STEREO TREBLE/BASS/VOLUME/BALANCE CONTROL – CONSTRUCTION



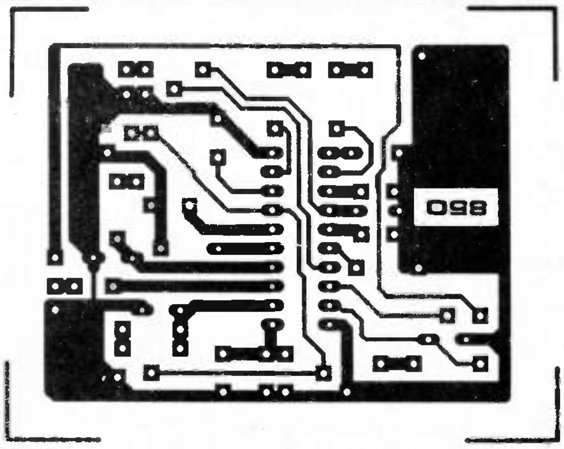


Fig. 6. Printed circuit board component layout and underside copper foil master pattern for the Tone Control only board. This board is used with the 10+10W Amplifier (next month).

The balance control is connected the ***opposite*** way round to the other controls. The wiring diagrams Fig. 5 and Fig. 7 show this. Likewise, pin 17 of IC1 provides the "Zener" supply to all the controls and Loudness switch S1. Separate pads are provided for each pot., but it is generally easier to use a single pad as shown. Ordinary connecting wire may be used since the pots. control only the d.c. levels applied to the i.c.

Separate power switches are included for the modules so that the amp can be switched off when not required to save power. This is important if batteries are used.

TESTING

The tone control module may be tested at this stage (whether or not it shares a p.c.b. with the 1W amp.) assuming that a direct output from the tone control module has been fitted. It may be more convenient to test the combined version when the 1W amp. is built although there is much to be said for testing individual modules of a circuit independently.

Testing may be accomplished using a signal generator and oscilloscope, or alternatively by using an audio signal source such as a cassette recorder, and a pair of headphones or amplifier and speakers. Either way, connect the audio source to the left input, and monitor the left output. Adjust the Volume and Balance controls, and check that the tone controls have an effect. Repeat with the right hand channel.

If the circuit fails to work at all, check the power supply to IC1 by measuring the voltage across pin 11 and pin 10, and then pin 11 and pin 20. In both cases a reading of about 12V should be obtained. Check that the inputs and outputs have been connected correctly and that the electrolytic capacitors have been fitted the correct way round.

Partial failure of the circuit can be checked by measuring the d.c. voltage at various points. A good quality voltmeter should be used such as a digital type, or the voltages will be affected by the meter.

Connect the negative lead of the meter to 0V in the circuit and use the positive lead as a probe; the readings (approximate) shown in Table 1 should be obtained. If any reading is incorrect, check the connections in that area for dry joints, bridged tracks etc.

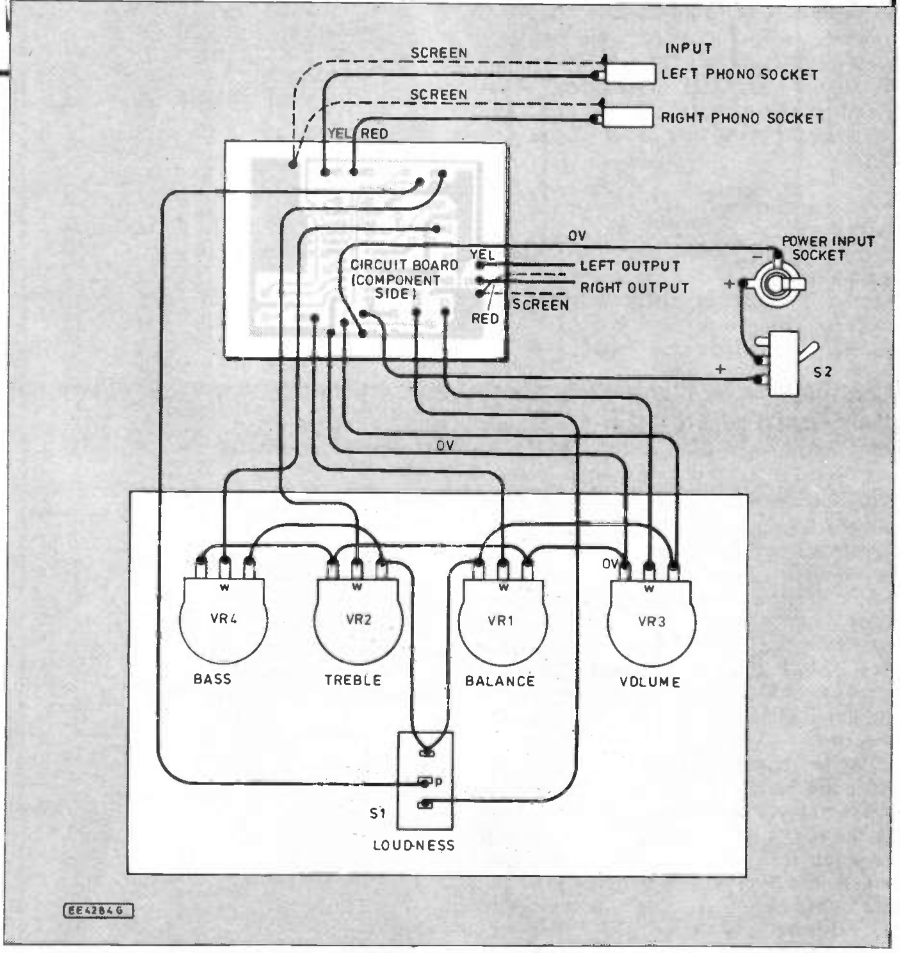


Fig. 7. Interwiring from the Tone only p.c.b. to off-board components.

Table 1: Test Voltages (approx.)

Pin 2	left input	6V
Pin 4	treble control	as Treble pot. is turned, varies from 0V to 5·4V
Pin 7	loudness compensation	with Loudness switch S1 off = 5·4V/with S1 on varies from 0 to 5·4V as Volume pot. is turned
Pin 8	left output	6V
Pin 9	balance	as Balance Pot is turned, varies from 0V to 5·4V
Pin 11	positive supply pin	12V
Pin 12	volume control	as Volume pot. is turned, varies from 0 to 5·4V
Pin 13	right output	6V
Pin 14	bass control	as Bass pot. is turned, varies from 0V to 5·4V
Pin 17	Zener voltage	5·4V
Pin 19	right input	6V

USING THE CONTROL UNIT

The tone module is designed for use at "line level" audio signals of around 1 Vr.m.s. This is the type of signal provided from a cassette deck or CD player, or the mixer described in the previous article. The control unit should therefore be connected between say the CD player or mixer, and a power amplifier.

Although "remote control" has not been a feature of this article, the LM1035 i.c. lends itself towards remote control applications since its functions are controlled by a d.c. voltage at the various control pins. This voltage could be obtained from a source other than the potentiometer indicated.

Alternatively, the control potentiometers could be positioned at some distance from the circuit if necessary – the advantage being that the audio signal would have a direct route, but be controlled at a distance via ordinary unscreened leads. The four pots would require six leads in total.

CASE DETAILS

Two prototype units were made, one housing the combined Tone Control and 1W Stereo Amplifer, and the other (to be described next month) to house the Tone Control, 10+10 watt amplifier and power supply.

The combined Tone Control and 1W Stereo Amplifier may be housed in quite a small case, but note that there are five controls, plus the on/off switch. A sloping front console case which matches the 6-Channel Stereo Mixer case was chosen for the prototype, but is one size smaller and measures 190mm across the back.

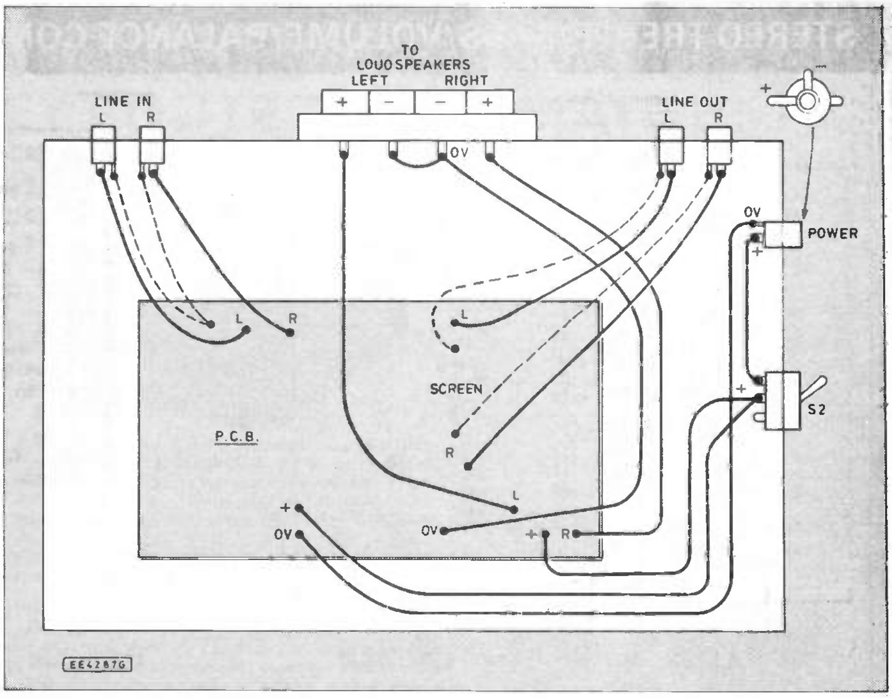


Fig. 8. Approximate positions of the case mounted components and circuit board. The tone controls and Loudness switch are mounted on the aluminium front panel.

Begin case preparation by marking and drilling the case for the input and output sockets as shown in Fig. 8. Phono sockets are convenient and compatible with most other equipment. for "line level" signals. Loudspeaker sockets will be required and these may be "speaker DIN sockets" (which seem to have gone out of fashion), phono sockets, terminal blocks or the type used in modern amplifiers known as "Quick Connection Lever Terminals".

When deciding on the positions for the controls, take care to allow for the necessary clearance *inside* the case. Next fit the power supply socket and the power switch S2.

Complete all the interconnections on the front panel mounted components, checking that the p.c.b. and/or the front panel can be

1W STEREO AMPLIFIER – CONSTRUCTION

If a separate 1W Stereo Amplifier is required, the printed circuit board component layout and underside copper foil master pattern is shown in Fig. 9. (This board is available from the *EPE PCB Service*, code 851.). All the components are housed on the p.c.b., apart from the extra potentiometers (either separate or stereo dual) which may be required if for example, the 1W amp. is used as a headphone amplifier and a separate volume control is required.

Begin construction by inserting and soldering the i.c. socket in position followed by the smallest components. Next fit the electrolytic capacitors, noting that they must be inserted the correct way round. The negative side is indicated on the capacitor body, and the longer wire indicates positive. C5 and C6 are not electrolytic and may be fitted either way.

WIRING

Screened wires should be used for the audio signal input connections, and both input screens (i.e. the outer "braid" of the cable) should be connected to "signal ground" or 0V. The loudspeaker outputs should be via 2-pin DIN sockets, terminal blocks or loudspeaker connectors

A single loudspeaker may be connected either way round, but a stereo pair should be connected so that both loudspeakers "pump" in the same direction at the same time. This is achieved by observing the polarity marked on the loudspeakers.

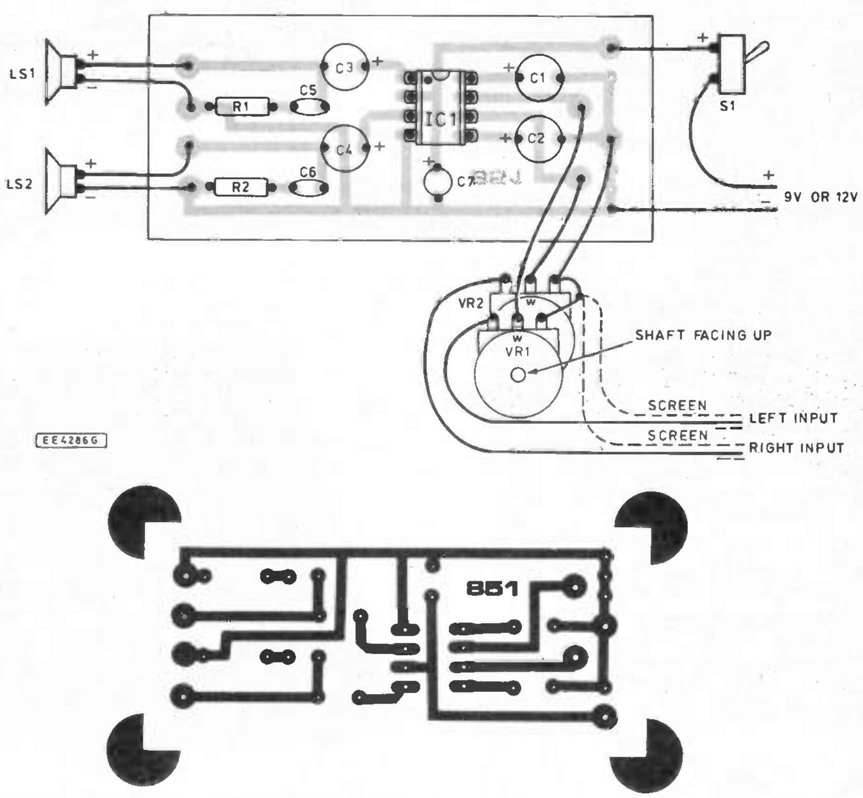


Fig. 9. Printed circuit board component layout and underside copper foil master pattern for the separate individual version of the 1W Stereo Amplifier.

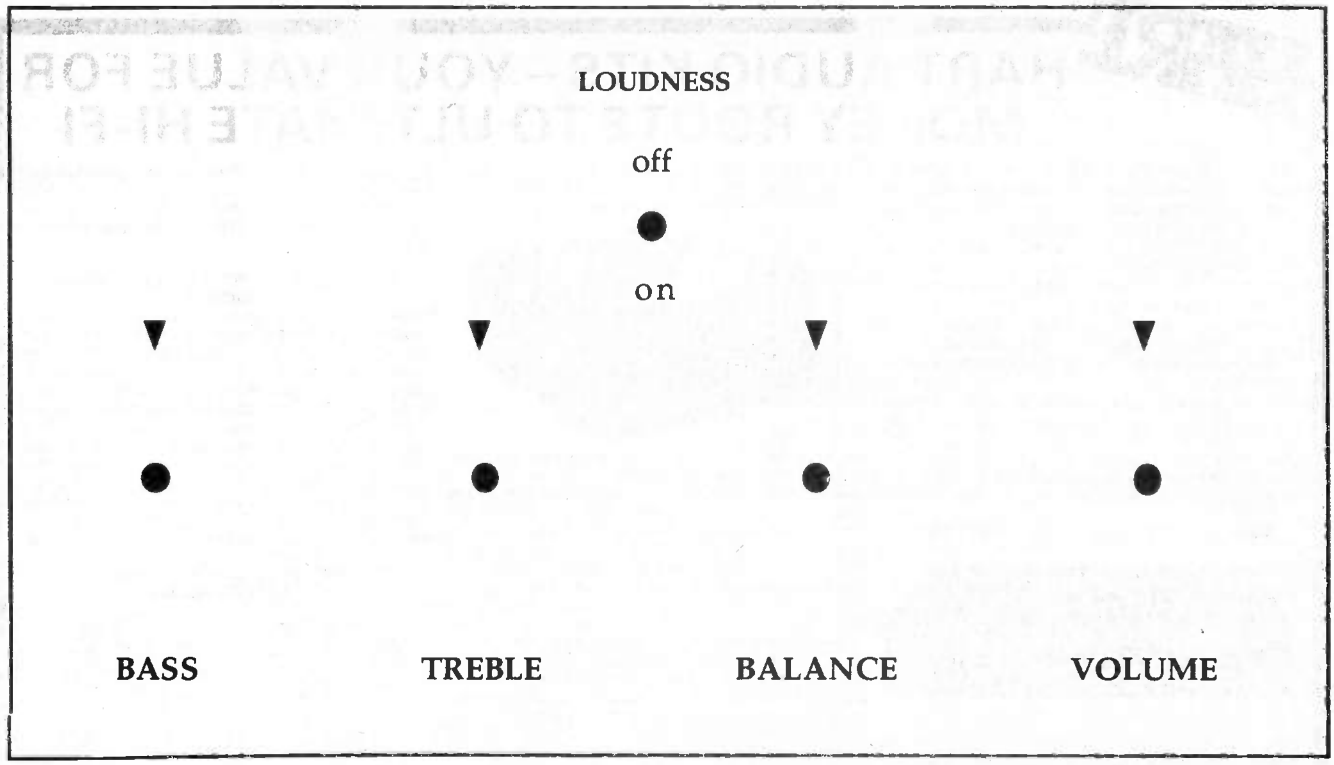


Fig. 10. Full size front panel drilling template.

removed without disconnecting the leads. Note that the balance control is connected the opposite way round to the other controls. The p.c.b. may be mounted using self-adhesive p.c.b. supports.

The i.c.(s) should be inserted the correct way round, assuming this has not already been done.

AMPLIFIER TESTING AND FAULT FINDING

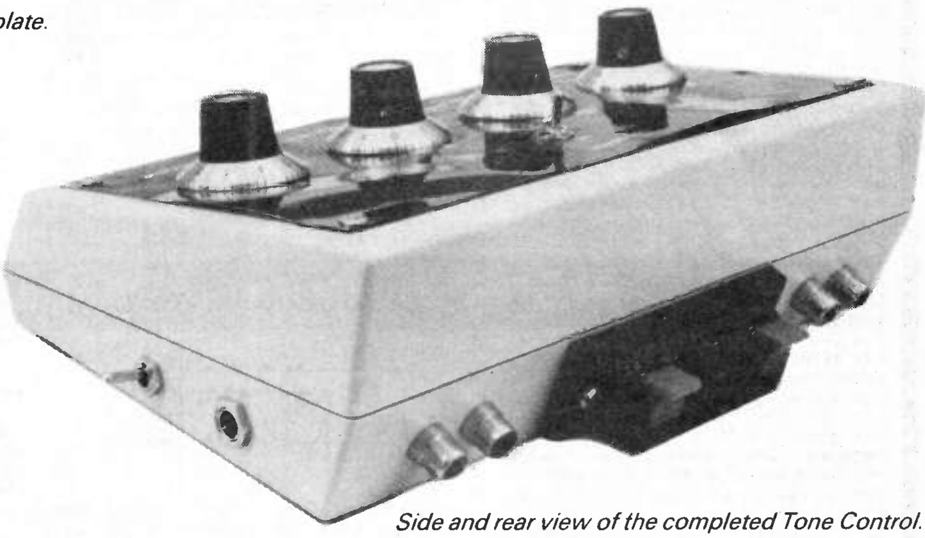
Connect the speakers, and a 3V to 12V supply to the amplifier and switch on. Input a signal from one of the other modules, or a cassette recorder or CD player. Adjust the Volume control (if fitted). Hopefully the circuit will work with little difficulty. If it fails to work, disconnect the power supply in case a short circuit has occurred.

Check the voltage provided by the power supply when it is not connected to the amplifier. Then connect it to the amplifier and check that there is no voltage drop. A drop would indicate a short circuit; check the p.c.b. for bridged tracks, capacitors round the wrong way etc.

Assuming all is well so far, leave the power supply connected, and check the voltage across pin 2 (positive) and pin 4 (negative) of XIC1. Further testing is difficult without an oscilloscope and signal generator; however a finger placed against pin 7 (left hand channel) or pin 6 (right) should induce hum into the respective loudspeaker. If this is the case then the input signal is not arriving at the i.c.

DISTORTION

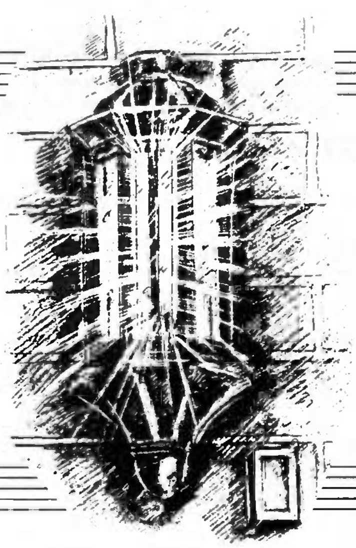
All audio systems will suffer from distortion if the signal at any part of the circuit is driven beyond the voltage at the supply rails, or if so much current is required that the power supply voltage dips. It is possible to accidentally drive the amplifier beyond its one watt per channel limit, and so the Volume control should not be advanced to a point where distortion is obvious. □



Side and rear view of the completed Tone Control.

Next Month: 10W + 10W Amplifier and power supply. Included in the amplifier will be the Tone Control Module.

Constructional Project



WATERPROOF DELAY SWITCH

T.R. de VAUX-BALBIRNIE

Do not leave your outside light on all night!

THIS waterproof switch will control any exterior lighting of up to 750W rating on 240V mains – for example a 500W security-type quartz halogen light. Since the wiring to the switch unit may be of a light-duty inexpensive type, this part may be situated any reasonable distance from the lighting it controls and since it is waterproof, it may be mounted on an outside wall of the house.

Stand-by current consumption of the Waterproof Delay Switch is negligible. In use, the unit may be used to switch the light on and off manually or, if left switched on, the light will go off automatically after some preset time between half a minute and one hour approximately.

This system is unusual in that it uses *magnetically-operated* switches – one to switch the light *on* and the other to switch it *off*. These switches are operated *through* the front cover of the switch unit by applying a small magnet to the appropriate place. Large dots – green for *on* and red for *off* in the prototype – painted on the front of the box clearly show the correct positions. The operating magnet could be carried on a key ring.

The Waterproof Delay Switch comprises two sections. The first is the wall-mounted switch unit. This contains the magnetically-operated switches and a terminal block to which the connections are made. The second – main section – contains the control circuit and mains connections.

The main unit is situated indoors and preferably close to the lighting which it controls. This minimises the amount of mains-type cable needed and so reduces costs.

SAFETY

Important note: There are several safety points incorporated in the design and, for this reason, it is important that the circuit is not modified. Anyone unsure about having the necessary skills to make mains-operated equipment must seek professional assistance.

Permanent wiring needs to be installed for the mains input and for the light. This wiring terminates at a fused and double-pole switched mains outlet. The main section is wired to the mains outlet using 4-core flexible wire of adequate rating for the light. Note that it is not satisfactory to wire rigid p.v.c. cable direct to the terminal block inside the main unit case.

The switch section is built in the special plastic *waterproof* box specified. Since conventional switches have been avoided, the number of holes needing to be drilled in the box is minimised. There will be no problems with corrosion as might happen with most types of switch if rain water entered. The switches used are easily-obtainable *magnetic reed switches* of the type used in burglar alarms.

CIRCUIT DESCRIPTION

The complete circuit for the Waterproof Delay Switch is shown in Fig. 1. Mains current is supplied to step-down transformer T1 primary winding through fuse, FS2. Neon indicator, LP1, shows the *on* state.

A nominal 12V a.c. output is obtained at the transformer secondary and after passing through fuse, FS1, it is rectified by bridge rectifier REC1 and smoothed by capacitor, C5. This provides a nominal 15V d.c. supply for the rest of the circuit.

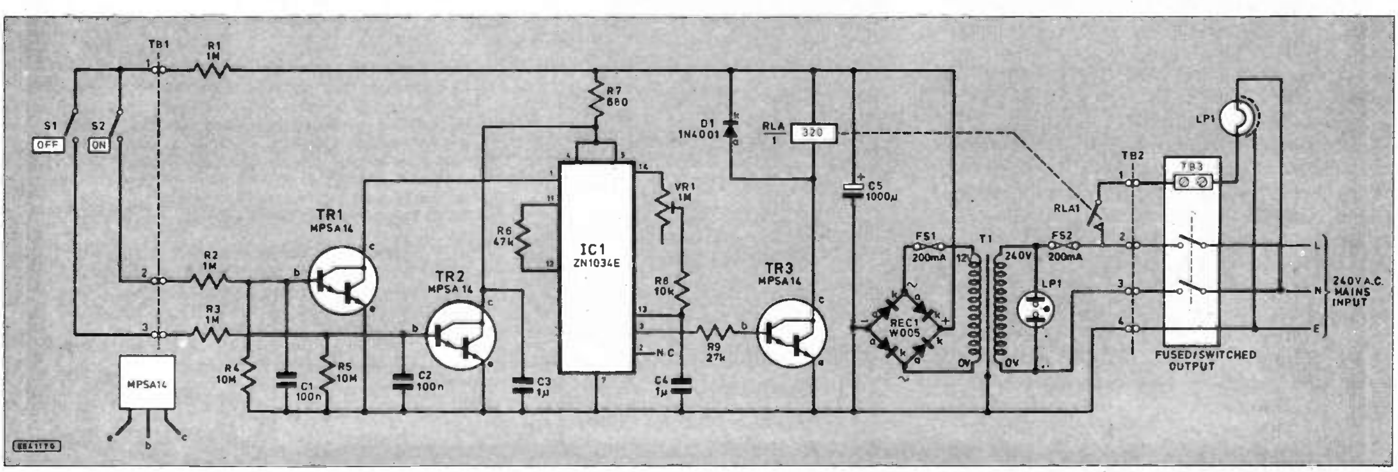
The principle component is IC1, a sophisticated integrated circuit timer type ZN1034E. This has an on-chip voltage stabilizer which operates in conjunction with resistor R7 to provide a precise 5V supply which is needed for correct operation. The excess voltage over that of the supply (nominally 10V) is dropped across this resistor and thereby "lost" as far as the i.c. is concerned.

While IC1 pin 1 (trigger input) remains *high* (due to the effect on an on-chip pull-up resistor) the twin outputs, pins 2 and 3, remain in their natural states, *high* and *low* respectively and nothing further happens. Note that in this design, only pin 3 output is used with pin 2 left unconnected.

By making pin 1 low for an instant (as described later), pins 2 and 3 change state for a certain time – that is, pin 2 becomes low and pin 3 high (positive supply voltage). With pin 3 high, current flows through resistor, R9, to the base of Darlington transistor, TR3. The collector current then operates the coil of the relay and the "make" contacts, RLA1, switch mains current through to the lamp load.

After a certain time, pins 2 and 3 revert to their former states, TR3 and hence the relay and lamp then switch off. The operating time is determined by the values of fixed resistor, R8, preset VR1 and

Fig. 1. Complete circuit diagram for the Waterproof Delay Switch.



capacitor, C4. VR1 provides the adjustment whereby the time period is set as required at the end of the construction.

TIMING

Timing occurs in the following way. Pin 14 provides a precision 2·6V reference voltage output which charges C4 through R8 and VR1. When the voltage across C4 reaches a certain level, it is discharged and begins a further cycle. An internal binary counter keeps check of the number of charge/discharge cycles and on the 4095th one, (2^{12} – 1 cycles), pins 2 and 3 revert to their former states.

The advantage of this system over less sophisticated one-shot timer circuits is that the individual timing cycles are kept short – even for a one hour delay, each timing cycle is less than one second. For this reason, timing capacitor, C4, need only have a relatively small value.

This means in practice that an electrolytic capacitor (normally needed to provide a high value) is avoided and this helps in providing accurate and reliable operation. Electrolytic capacitors are subject to a high leakage current and a wide tolerance range which makes them poor for timing applications.

TRIGGER HAPPY

Timer, IC1, is triggered by operating S2, the ON magnetic reed switch, for an instant. This allows current to flow from supply positive through resistor R1 and switch S2 "make" contacts, hence to the base of Darlington transistor, TR1, via resistor R2.

A Darlington contains two transistors connected together internally – this provides the equivalent of one transistor having a very high current gain. Thus, an extremely small base current, as will flow through high-value resistors, R1 and R2, is sufficient to turn on the Darlington and for the collector to go *low*. This low state is applied to IC1 pin 1 and the device is triggered in the manner already described.

To cancel the operation before the natural timing cycle is complete, magnetic reed switch S1 (Off) may be operated momentarily. This allows current to flow through resistor R1, S1 "make" contacts and resistor R3 to the base of Darlington transistor, TR2.

The collector of TR2 now goes low and with it IC1 pins 4 and 5. No current therefore flows through the i.c. and the internal binary counter resets ready for further operation when the supply is restored.

Capacitor C3, is required for stable operation of the i.c. It also prevents the voltage at pins 4 and 5 from rising too quickly when the supply is restored or when first switched on – this could possibly cause unwanted triggering.

Diode D1 bypasses the reverse high-voltage pulse which occurs when the magnetic field collapses in the relay core. Without this, semiconductor devices in the circuit could be damaged. capacitors C1 and C2 remove the mains hum which tends to be picked up by the long interconnecting switch wires – this could otherwise cause false triggering.

In the event of some very unlikely and unforeseen catastrophic failure of the circuit where mains voltage appears in the low-voltage section, high-value resistors R1, R2 and R3 would limit the maximum possible current flowing to the external unit to an extremely low and therefore safe value. This should never happen since the transformer, correctly "Earthed", provides

COMPONENTS

Approx cost guidance only excl switch box £25

See SHOP TALK Page

Resistors

R1, R2, R3	1M (3 off)
R4, R5	10M (2 off)
R6	47k
R7	680
R8	10k
R9	27k

All 0·25W 5% carbon film

Potentiometers

VR1	1M sub-min. carbon preset, vertical

Capacitors

C1, C2	100n ceramic (2 off)
C3, C4	1µ ceramic (2 off)
C5	1000µ radial elect., 25V

Semiconductors

D1	1N4001 50V 1A rect.
TR1, TR2, TR3	MPSA14 Darlington transistor (3 off)
IC1	ZN1034E precision timer
REC1	W005 1·5A 50V bridge rec.

Miscelleaneous

RLA	Relay with 320 ohm 12V coil and "make" or change-over contacts rated at 10A resistive or 3A inductive.
S1, S2	Plastic cased reed switches (burglar alarm type) (2 off)
LP1	Miniature mains neon indicator with integral resistor for 240V operation
FS1	20mm chassis fuseholder with 200mA slow-blow fuse
FS2	20mm panel fuseholder with 200mA slow-blow fuse
T1	Transformer with mains primary and 12V secondary (or twin 6V sec.) rated at 250mA
TB1/TB4	6-way 3A screw-terminal block
TB2/TB3	5-way 5A screw-terminal block

Waterproof plastic box, size 100mm x 100mm x 50mm; aluminium box, size 133mm x 102mm x 38mm; stripboard 0·1in. matrix, size 17 strips x 32 holes; 4-core mains cable (6A rating); 3-core (or 4-core) light-duty wire (burglar alarm or telephone type); small magnet (burglar alarm type); strain relief bushes (2 off); stranded connecting wire; small fixings; solder tag; solder; stand-off insulators; heat shrinkable sleeving; waterproof gland.

Mains double-pole switched outlet fitted with 3A fuse. Materials for fixed wiring.

isolation of the mains supply from the rest of the circuit. Also, since the on and off switches are *inside* the switch section and controlled *through* the plastic front panel, there are no exposed metal parts to touch anyway.

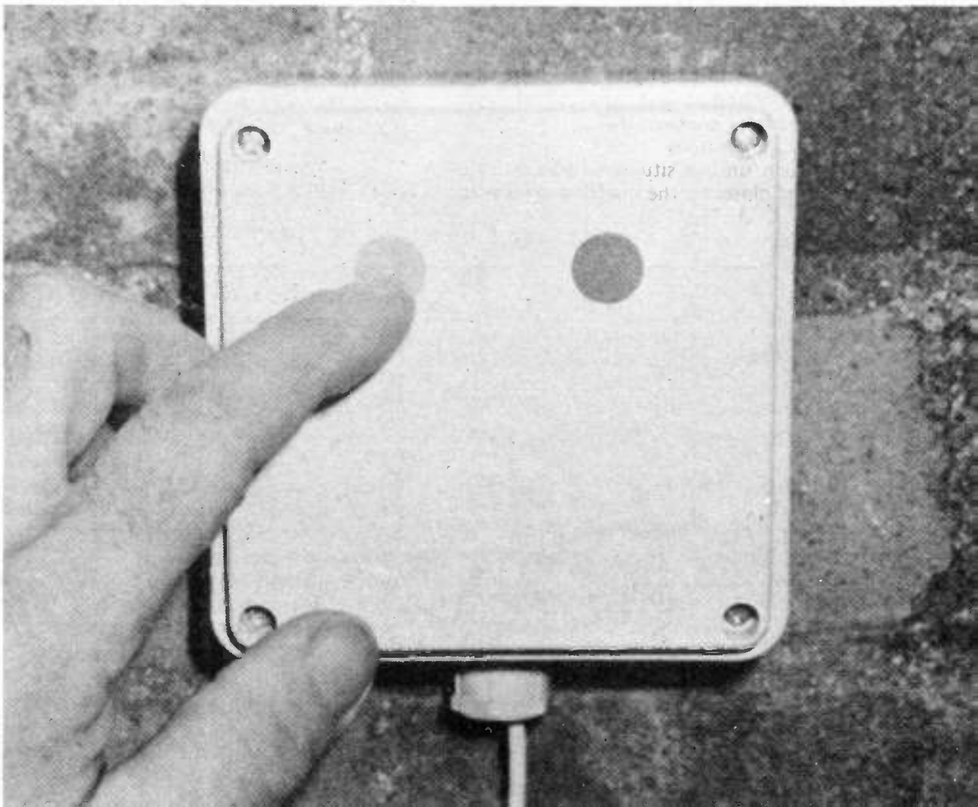
MAKING CONTACT

It is essential for the relay contacts to be adequately rated and this point must be borne in mind if any other relay to that specified is used. Filament lamps have a much lower resistance when cold than when hot so that, at the instant of switching on, current flowing through the filament will be several times higher than when it has heated up to normal temperature.

This only takes a fraction of a second but it puts the relay contacts under strain at the instant of touching. Any *resistive* switching rating is therefore likely to be too low and using this figure would probably lead to short life for the relay.

In practice, the contacts should have a current rating several times higher than the maximum nominal load. It is usually satisfactory to use the figure quoted for an *inductive* load – in the case of the specified relay, this is 3A.

Unfortunately, suppliers data often quotes a resistive figure only. In test on the prototype unit under full-load, the system behaved perfectly over a period of repeated switching.



SAFETY FIRST

Before beginning construction work, note particularly the following safety points:

(a) The main section must be built in an *Earthed* aluminium box and mounted in a *dry indoor location.*

(b) Mains transformer, T1, must be a high-quality component and be amply rated (250mA minimum) – see components list. This will ensure that it remains cool in continuous operation.

Note that the transformer body must be *Earthed* by bolting it securely to the metalwork.

(c) Flexible 4-core *mains-type* wire of 6A *minimum* rating must be used for the connections between the main unit and wall-mounted flex outlet,

(d) Resistors R1 to R3 must have the value (1M) specified and be mounted in the manner to be described later.

CONSTRUCTION

Construction of the Waterproof Delay Switch is based on a circuit panel made from a piece of 0·1in. matrix stripboard, size 17 strips x 32 holes. Fig. 2. shows the topside component layout and breaks required in the underside copper strips.

Begin by drilling the three mounting holes and making all track breaks as indicated. Follow with the soldered on-board components noting the polarity of capacitor C5 and diode D1. Note also the orientation of the three Darlington transistors, TR1 to TR3, and bridge rectifier, REC1.

Do not insert the i.c. into its socket yet. Make a careful check for errors – particularly ensure that all breaks in copper strips are complete and that *double-breaks* are used where indicated.

Sleeve one end of resistors R1, R2 and R3 and solder them as shown to strips *A*, *D* and *K* on the left-hand side of the circuit panel. Solder 10cm pieces of *mains-rated* wire of 5A minimum rating *direct* to the relay *make* contacts – i.e. not through the copper strips. Make absolutely certain that the soldered joints are properly formed and that the wires cannot become detached in service.

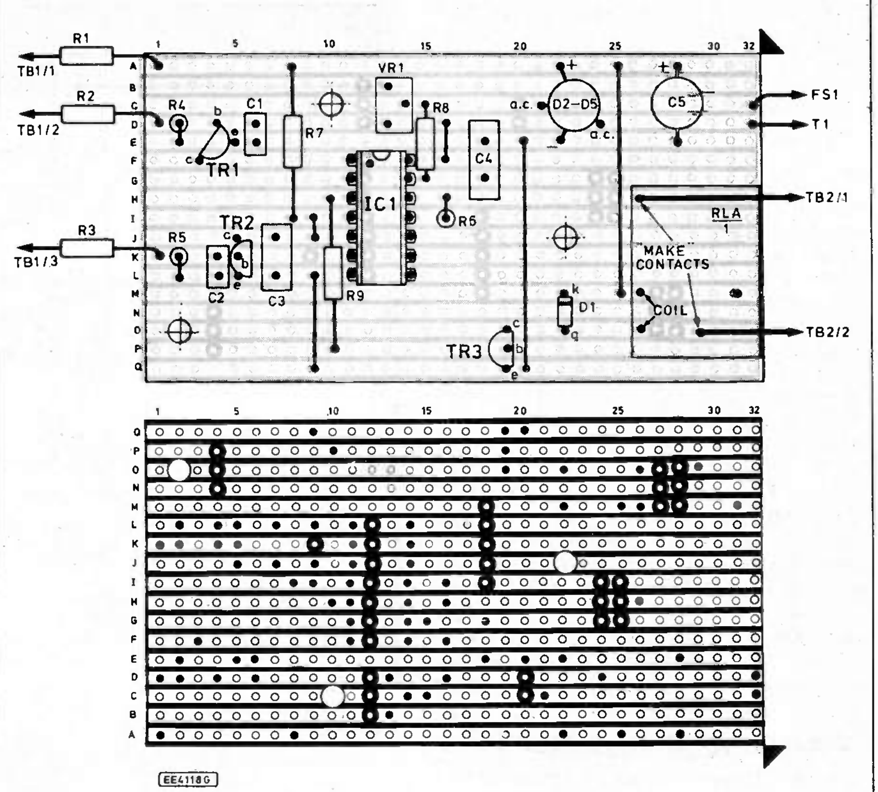
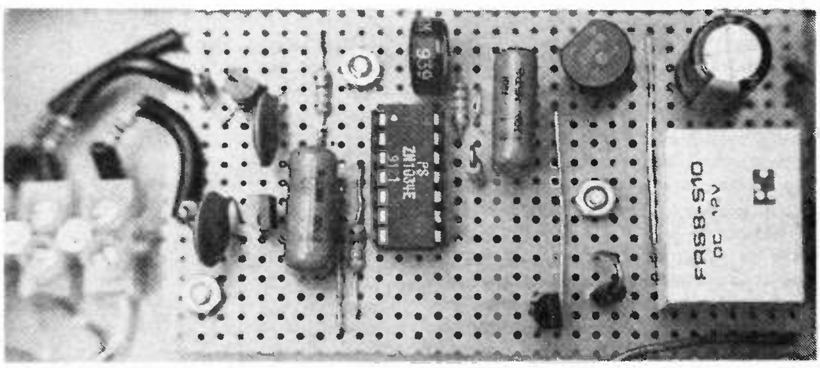


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks.



PREPARING THE BOXES

Prepare the main unit aluminium box by making holes for transformer T1, terminal blocks TB1 and TB2, fuseholders FS1 (chassis type) and FS2 (panel type) and for circuit panel mounting. Carefully measure the position of the hole needed in the lid for neon indicator, LP1 and drill the hole. For safety reasons, it is essential for the lower end of LP1 to remain clear of all components when the lid is in position.

Drill two holes in the back for wall mounting if required. Make a hole for entry of the mains wire leading to the fused outlet and for the light-duty wire leading to the switch section. Make these holes the correct size to accommodate the strain relief bushes required for the wires. It is important not to use makeshift methods for strain relief here.

Make the transformer secondary connections to strips *C* and *D* on the right-hand side of the panel via fuse FS1. Many 12V transformers have twin 6V windings and if the transformer is of this type, these windings should be connected together in series as shown in Fig. 4. If it is of the type described as having a "6V-0-6V" secondary, the "0V" wire is simply cut-off short, taped over and ignored.

Mount the circuit panel on the base of the box as shown in the photograph. Use plastic stand-off insulators of sufficient length to keep all the soldered joints a few millimetres clear of the metalwork. As an additional precaution, place a piece of thick plastic or cardboard between the case and the circuit panel.

Mount all components and, referring to Fig. 3, complete the internal wiring. All wiring shown in bold must be made with mains-type wire of 3A rating minimum. Note the solder tag at one of T1 fixings – this forms the earth connection to the box and transformer core and is essential for safety reasons.

Sleeve the connections to fuseholder, FS2, and to neon indicator, LP1, using heat-shrinkable sleeving – use a hair dryer to make it shrink firmly around the mains connections. The terminal black TB1 (3A block) is used for the connections to the switch section while TB2 (5A block) is used for the mains connections.

Sleeve the free ends of resistors R1, R2 and R3 with narrow-bore insulation and connect them to terminal black, TB1 (see photograph). Adjust preset VR1 fully anticlockwise (as viewed from the relay end of the circuit panel). Finally, insert IC1 into its socket with the correct orientation.

SWITCH BOX

Prepare the external (outdoor) section by drilling holes in the back of the box for wall mounting. These should be only just large enough to accommodate the screws. The screws themselves should be of the round-headed type and tight-fitting plastic washers should be used to waterproof the entry points. Drill a hole in the box for the waterproof gland or tight grommet used for the interconnecting wire to pass through.

The switches used in the prototype unit had *four* lead-out wires. Two of these are simply a continuity loop and may be cut off short. The other two are the actual reed switch contact connections. A multitester set to Ohms or having a buzz-test facility or a simple battery and bulb circuit will soon identify the correct wires.

Mount the switches on the rear of the front panel, using strong adhesive, and paint large circles (or otherwise mark) on the outer face of the panel, using exterior grade paint, to show clearly the positions needed for the magnet to switch the light on and off – see photograph. The 3-way section of terminal block, TB4, is simply left loose inside the box (so removing the need to drill a further hole).

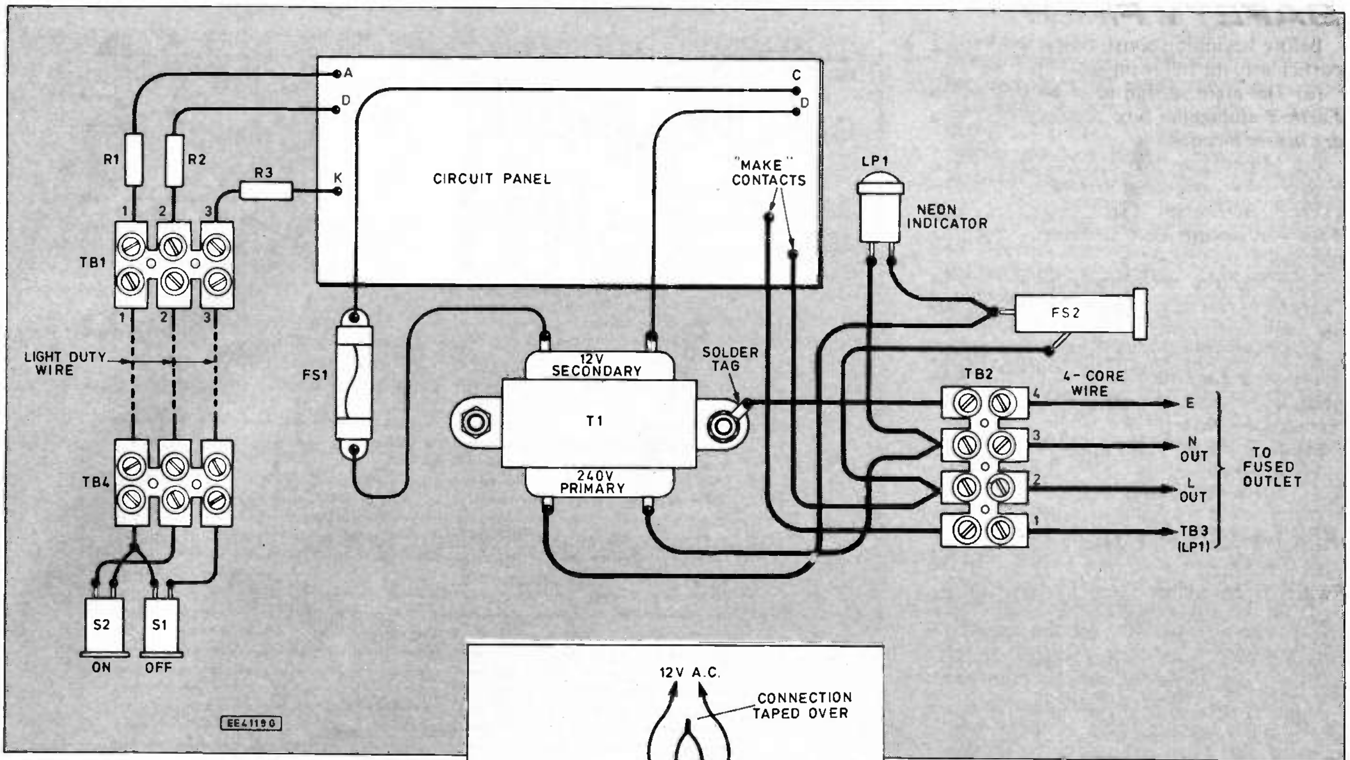


Fig. 3. Interwiring between all off-board components and circuit board. Wire mains rated (5A min.) leads directly to the relay make contacts.

The switch wires are connected to terminal block TB4 as shown in Fig. 3. Note that two of the switch wires are connected together and both connected to TB1. Choose the best position and mount the unit on the wall with the gland entry point at the bottom.

MAINS WIRING

Important safety notice: Before carrying out the mains wiring, the supply must be switched off at the fusebox and the fuse removed. If necessary, a qualified electrician should do the fixed installation work.

Decide on the best positions for the light and main unit. Mount the light. The mains inlet cable and wiring leading to the light should now be installed and should terminate in a wall-mounted, fused and double-pole switched mains outlet located close to the main unit.

The mains input wires are connected to the outlet as follows: Red (Live) to the Live input terminal, Black (Neutral) to the Neutral input terminal and the bare copper (Earth) wire, after insulating with a piece of green/yellow sleeving, connected to the Earth terminal. The lighting wires are connected as follows: Black (Neutral) to the neutral output terminal, the bare copper wire sleeved as above should be connected to the terminal already occupied by the mains input Earth wire. The as-yet unconnected wire – the Live (red) lighting wire – should be connected to a single piece of 5A screw terminal block, TB3, inside the box.

The piece of 4-core flexible mains wire should now be cut to size and each end stripped of about 10cm of its outer sheath. One end should be passed through the hole in the main unit and secured using the strain relief bush. This wire should be connected to TB2/1, 2, 3, and 4 as follows, shortening any wires as necessary: Brown (Live in) to TB2/2; Black (load – i.e. Live out) to TB2/1; Blue (Neutral in) to TB2/3; Green/Yellow (Earth) to TB2/4.

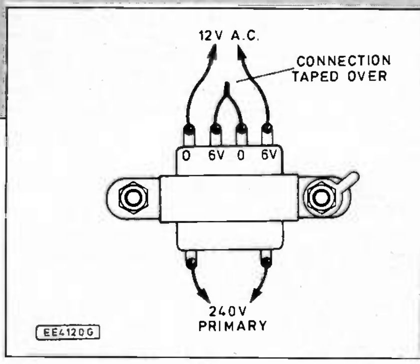


Fig. 4. Using a mains transformer with twin 6V secondary windings.

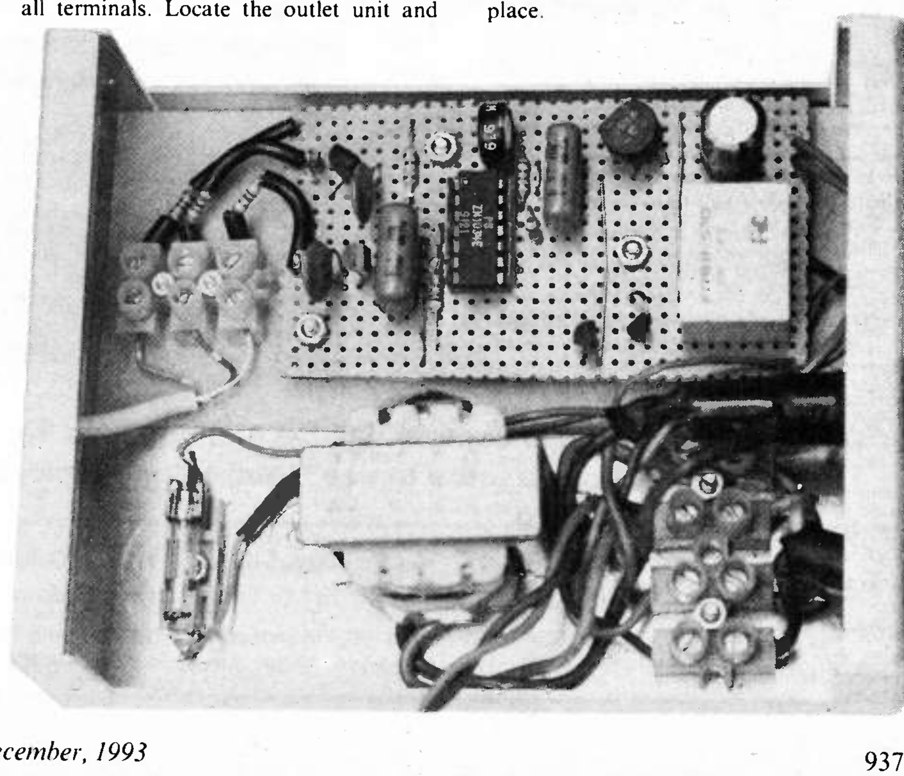
Now make the connections to the fused outlet end making sure that the wire is correctly clamped. Connect the Brown wire to the Live output terminal; Blue to Neutral output and Green/Yellow to the Earth terminal. Connect the remaining wire – the black one – to the free terminal of the block connector, TB3, inside the outlet box.

Check the wiring carefully and tighten all terminals. Locate the outlet unit and tighten the attachment screws. Fit the fuses in the main unit.

Cut off and install the piece of wire needed to interconnect the main unit and switch box. Any light-duty 3-core type cable may be used for this. An inexpensive solution would be to use 4-core burglar alarm or telephone-type wire with one of the wires ignored.

Pass the cable through the waterproof gland or tight grommet at the switch end and the strain relief grommet at the main unit. It may be necessary to use some additional sleeving where the wire passes through the waterproof gland if the fit is not tight enough.

Connect TB1/1, 2 and 3 in the main section to the corresponding terminals in TB4/1, 2 and 3 in the switch unit. Tighten the gland, secure the lid to the switch section and check that no wires are trapped and that the sealing gasket is in place.



TESTING

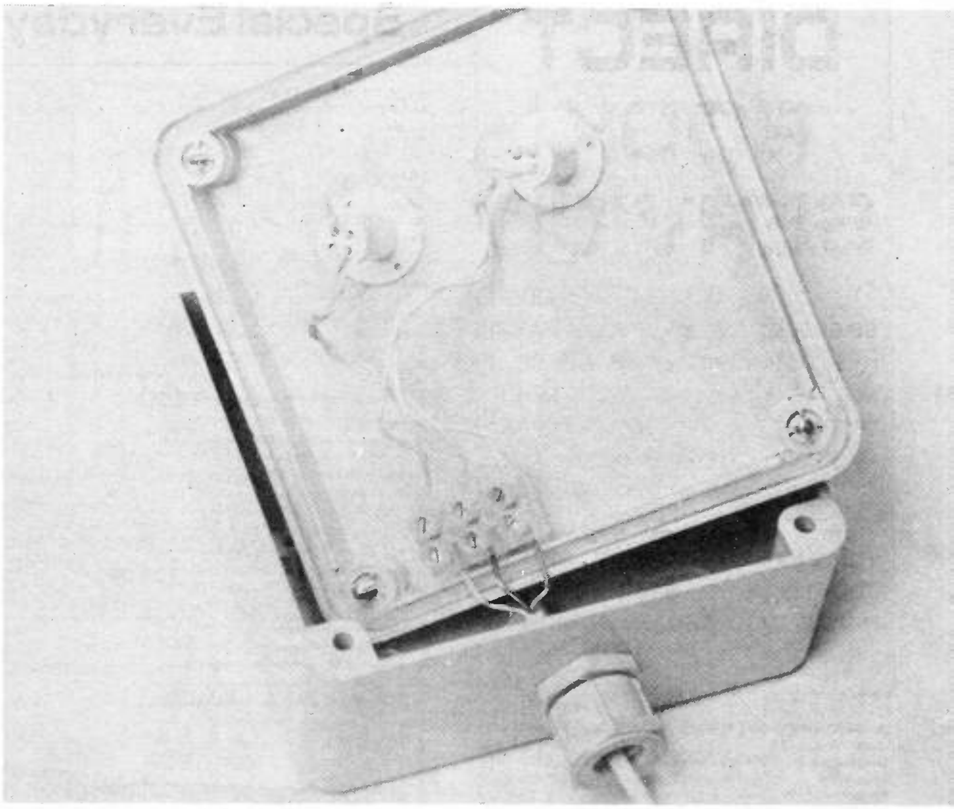
Due to the possibility of touching exposed mains connections inside the main unit, all adjustment to preset VR1 must be made with the unit isolated from the mains (switched OFF at the main switch and the FUSE REMOVED). The lid MUST be replaced before connecting the mains.

If necessary, secure the unit to the wall using two wall plugs and screws through the holes drilled in the back for the purpose. Fit the lid, checking carefully for trapped wires or any connections touching the case which could possibly cause short-circuits.

Insert a 3A fuse into the outlet, then switch on the mains at the fusebox and at the outlet. Trigger the unit *on* by holding a magnet near the green spot and *off* near the red spot on the switch box front panel. Check this a few times to ensure that the switching action is reliable.

Now switch the unit on and leave it for up to one minute. The light should go off spontaneously. Check this a few times then, observing the safety instructions mentioned earlier, adjust preset VR1 for the required operating time. Clockwise rotation of the sliding contact (as viewed from the relay end of the circuit panel) increases the timing.

If there is any tendency towards false triggering, this often occurs when a fluorescent light is switched on nearby. Check this point. The prototype showed no such problems even when used with very long and rambling interconnecting wires. If there are any such problems, capacitors C1 and C2 should be increased in value. □



The magnet-operated reed switches mounted on the rear of the switch box lid.

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Published by *Everyday Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
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ELECTRONICS TEACH-IN No.5 GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by EVERYDAY ELECTRONICS
Due to the demand from students, teachers and hobbyists we have put together a range of articles from past issues of *Everyday Electronics* that will assist those involved with the construction of electronic projects.
The book contains the complete *Project Development for GCSE* series.
Contents: Features – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Project Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; Actually Doing It – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.
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Mike Tooley BA (published by *Everyday Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
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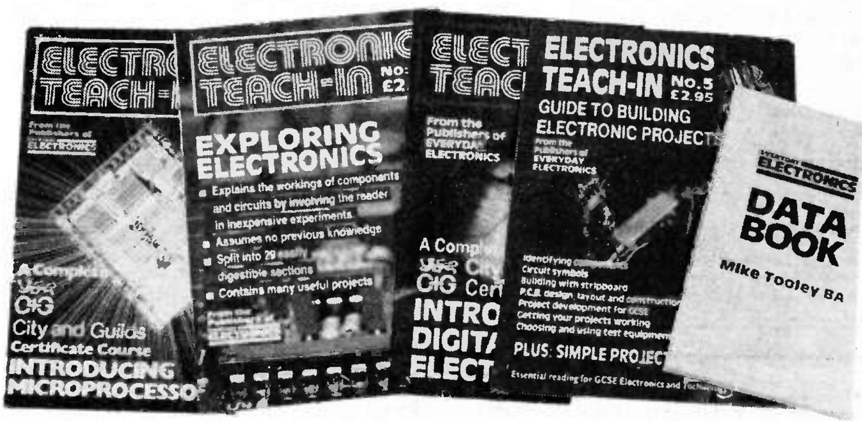

Computers and Computing

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.
The text contains many useful tips and some warnings (which could save much effort and expense).
114 pages **Order code BP323** **£4.95**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.
This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM: RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
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AN INTRODUCTION TO 68000 ASSEMBLY LANGUAGE
R. A. & J. W. Penfold
Obtain a vast increase in running speed by writing programs for 6800 based micros such as the Commodore Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.
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THE ART OF PROGRAMMING THE ZX SPECTRUM
M. James, B.Sc., M.B.C.S.
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A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PC's. It covers both floppy disc-based systems and hard disc-based systems.
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MAKING MS-DOS WORK FOR YOU
N. Kantanis & P. R. M. Oliver

This book was written with the busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the book has also been designed to be circular, which means that you don't have to start at the beginning and go to the end.
The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meaning of some simple assembler mnemonics.
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R. A. Penfold
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Audio and Music

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Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Order code BP310** **£3.95**

PRACTICAL MIDI HANDBOOK
R. A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

128 pages **Order code PC101** **£6.95**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

The preamplifier circuits featured include:– Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include:– Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls

92 pages **Order code BP309** **£3.95**

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages **Order code BP256** **£2.95**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Order code PC110** **£8.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. penfold

Practical constructional details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. Includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.95**

Project Building

HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. Penfold

We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

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HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s
R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

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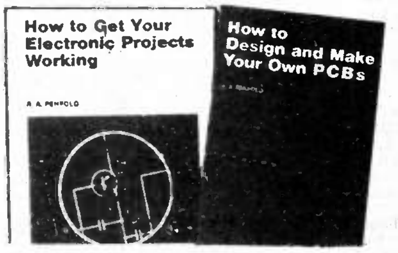


A BEGINNERS GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

166 pages **Order code BP285** **£3.95**

BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS
R. A. Penfold

Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also include examples in the form of simple projects.

112 pages **Order code 227** **£1.95**

ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Especially written for those who wish to participate in the intricacies of electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day one can read intelligently and handle simple tools.

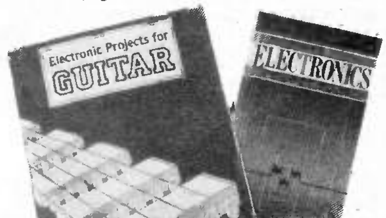
80 pages **Order code BP92** **£1.75**

GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by *Everyday Electronics*

See the first page of books – ELECTRONICS TEACH-IN No.5 – for full details.

ELECTRONICS PROJECT BOOK
Published by *Everyday Electronics* in association with Magenta Electronics.

See the first page of books for full details.



Theory and Reference

ELECTRONIC HOBBYISTS HANDBOOK
R. A. Penfold

Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular seimiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.

88 pages **Order code BP233** **£4.95**

FROM ATOMS TO AMPERES
F. A. Wilson

Explains in crystal clear terms the absolute fundamentals behind electricity and electronics. Really helps you to discover and understand the subject, perhaps for the first time ever.

Have you ever: Wondered about the true link between electricity and magnetism? Felt you could never understand the work of Einstein, Newton, Boltzmann, Planck and other early scientists? Just accepted that an electron is like a little black ball? Got mixed up with e.m.f. and p.d.? Thought the idea of holes in semiconductors is a bit much?

Then help is at hand with this inexpensive book, in as simple a way as possible and without too much complex mathematics and formulae.

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ELECTRONICS – A "MADE SIMPLE" BOOK
G. H. Olsen

This book provides excellent background reading for our *Introducing Digital Electronics Teach-In* Book and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.

330 pages **Order code NE10** **£5.95**

A REFERENCE GUIDE TO PRACTICAL ELECTRONICS TERMS
F. A. Wilson

Electronic devices surround us on all sides and their numbers are increasing without mercy. Ours is the problem therefore in keeping up with this relentless expansion. unfortunately we cannot know it all and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. Here is an answer, an inexpensive reference guide which explains briefly (but we hope, well) many of the underlying electronics features of pratical devices, most of which, to a certain extent, control our lives.

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.

For those who also wish to get right down to the root of the matter, there is a second volume entitled *A Reference Guide to Basic Electronics Terms* (BP286), each of the books referring to its companion as necessary.

A reference guide for practically everybody concerned with electronics.

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NEWNES ELECTRONICS POCKET BOOK
E. A. Parr

Newnes Electronics Pocket Book has been in print for over twenty years and has covered the development of electronics from valve to semiconductor technology and from transistors to LSI integrated circuits and microprocessors. To keep up to date with the rapidly changing world of electronics, continuous revision has been necessary. This new Fifth Edition takes account of recent changes and includes material suggested by readers of previous editions. New descriptions of op.amp. applications and the design of digital circuits have been added, along with a totally new chapter on computing, plus other revisions throughout.

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ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS
Owen Bishop

This book describes over 60 modular electronic circuits – how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

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R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits. plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

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Circuits and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
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ELECTRONIC ALARM CIRCUITS MANUAL
R. M. Marston
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.
Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.
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ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS
R. A. Penfold
The projects consist of various types of interface and controllers, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control etc.
The use of computers does not have to be restricted to massive layouts. Something as simple as an oval track with a single siding can be given a new dimension by adding computer control and much fun can be had from these relatively simple set ups.
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DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages **Order code PC106** **£8.95**

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS
Robert Penfold
Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kit and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.
92 pages **Temporarily out of print**

ELECTRONIC POWER SUPPLY HANDBOOK
Ian R. Sinclair
This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.
The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.
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50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
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CIRCUIT SOURCE BOOK 1 **NEW**
R. A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages **Order code BP321** **£4.95**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers, decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
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HOW TO USE OP-AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
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MICRO INTERFACING CIRCUITS – BOOK 1
MICRO INTERFACING CIRCUITS – BOOK 2
R. A. Penfold
Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.
Book 1 is mainly concerned with getting signals in and out of the computer; Book 2 deals primarily with circuits for practical applications.
BOOK 1 *112 pages* **Order code BP130** **£2.75**
BOOK 2 *112 pages* **Order code BP131** **£2.75**

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.
The circuits covered include:– An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap for combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.
Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and usefull circuits for short wave enthusiasts.
92 pages **Order code BP304** **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.
This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
150 pages **Order code BP257** **£3.50**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
88 pages **Order code BP275** **£3.95**

AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES
A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies, even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.
There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
102 pages **Order code BP290** **£3.95**

AERIAL PROJECTS
R. A. Penfold
The subject of aerials is vast but in this book the author has considered practical aerial designs, including active, loop and ferrite aerials which give good performances and are relatively simple and inexpensive to build. The complex theory and mathematics of aerial design have been avoided.
Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and tuning unit.
96 pages **Order code BP105** **£2.50**

INTERNATIONAL RADIO STATIONS GUIDE
P. Shore
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

LESS UK AMATEURS

According to the annual report of the Radiocommunications Agency 1992-93, there were fewer amateur radio licences on issue at 31st March 1993 than twelve months previously. The figures (with 1992 figures in brackets) are Amateur Class A, 32,410 (33,280); Amateur Class B, 25,791 (27,738); Amateur Novice A, 106 (46); and Amateur Novice B, 935 (378).

Until last year there had been a slow but continuing increase in licence numbers. The rate of increase had been causing concern however, hence the introduction of the Novice licence in 1991 which made initial entry into the hobby easier. (Information about the Novice licence, including details of courses available nationwide, can be obtained by sending an s.a.e. to the Radio Society of Great Britain, Lamba House, Cranborne Road, Potters Bar EN6 3JE.)

There are gains in the Novice licences, but overall there is a total reduction of 2,200. The greatest gain, in the Novice B class, which requires only limited study and no knowledge of the Morse code, is clearly not enough to counter the shortfall in other classes.

No doubt there will now be pressure within the higher echelons to see what further concessions can be offered to make the hobby more attractive to newcomers. The options are limited, though, unless the international regulations can be changed to allow full privileges on the h.f. bands without the need for too much study of radio theory and the need to know Morse code.

There has been much debate on these possibilities already, with strong views expressed both ways. If the downward trend continues, it could eventually become a question of how far can numbers be allowed to drop before it becomes necessary to reduce standards to reverse the trend.

We had a lot of correspondence in EPE on this very subject some months ago and I invited the Radio Society of Great Britain to respond to some of the points made. Unfortunately they never did, and I can only assume that they don't know the answer any more than anyone else!

There was an even greater drop in the number of Citizens' Band licences, with 53,926 compared to 64,944 in 1992. As I forecast last year, for the first time since the legal introduction of CB, when there were around a quarter of a million licences, there are now more amateur than CB licences on issue in the UK.

GLOBAL OVERVIEW

Despite the UK reversal, there are still large numbers of people in amateur radio and, like a lot of other hobbies, it is enjoyed in many countries round the world. Unlike most others, it is governed by international regulations, interpreted by individual governments to suit local requirements. This results in different sets of rules in different countries, some more liberal than others, but all within the overall framework of the ITU regulations.

What happens in one country often influences later developments in others. This is particularly true of those countries with well organised and influential national radio societies, which is why I often mention developments in the USA and elsewhere as well as those in the UK.

The overall administrative body of amateur radio is the International Amateur Radio Union, and this month I'm taking a look at some recent news items from around the world reported in its occasional newsletter, *IARU NEWS*, to demonstrate how 'local' events integrate into the international scene.

COUNTRY CHANGES

The changing face of Europe has resulted in more new countries and callsigns appearing on the amateur radio map. From ex-Czechoslovakia, for instance, the new Czech Republic has prefixes OK and OL; the new Slovak Republic has prefix OM, and both countries have been elected recently to membership of the IARU.

The independent republics of Slovenia (prefix S5) and Croatia (prefix 9A, formerly used by San Marino, now T7) and their national radio societies are also now members of the IARU. Other former Yugoslav republics were reported as continuing to use their old prefixes (YT, YU, YZ, 4N and 4O), but no doubt this will change in due course.

More applications for membership of the IARU have come from the Ukraine Amateur Radio Union and the Association of Amateur Radio Operators of Macedonia.

NOVICE LICENCE IN SWEDEN

Sweden has introduced a new "Class N" (Novice) licence to encourage young students to become radio amateurs. The licence can be held from the calendar year the licensee becomes 10 years old, but until age 14 he or she must remain under the supervision of an older amateur holding a standard licence. They must upgrade to a standard licence within six years. They can operate on the 2m and the 70cm bands with limited power, and the licence examination covers regulations, safety standards and common amateur radio procedures.

LESOTHO

A club station, 7P8NUL, has been established at the National University of Lesotho using a complete h.f. station presented to the University Amateur Radio Club by the IARU Region 1 Working Group for the Promotion of Amateur Radio in Developing Countries (PADC). The Managing Director of Lesotho Telecommunications Corporation said that the Corporation supports this new thrust to establish amateur radio on a more local footing, and he was committed to easing regulations to make the hobby more accessible to the youth of his country.

The Royal Omani Amateur Radio Society (ROARS) recently celebrated its 20th anniversary. This very active IARU society participates regularly in IARU Region 1 conferences and has mounted DXpeditions to a number of choice locations in the Gulf area. In 1992, ROARS and the Omani telecommunications authorities sponsored a week-long IARU course in Amateur Radio Administration.

The Quatar Amateur Radio Society (QARS) has recently been formed. It reports that it is ably supported by its telecommunications administration, the Quatar Public Telecommunications Corporation, and its objective is to represent its members on a global level.

UGANDA BAN LIFTED

The Uganda Posts and Telecommunications Corporation has advised the ITU and the IARU that a ban on amateur radio communication, imposed in the early 1970s, has been lifted. Visiting amateur operators can obtain a letter of authority to operate in Uganda for the duration of their stay, within the provisions of their home licence and to the extent that those provisions do not conflict with Uganda's radio regulations.

The Nigeria Amateur Radio Society (NARS) has introduced packet radio in Lagos, on 144.675MHz. According to NARS Secretary, Oyekunle B. Ajayi, 5N0OBA, there are plans to establish a h.f. link soon.

Swaziland has introduced a new licence permitting operation in the two-metre band without the need to pass an examination in the Morse code. The new licence is aimed at the development of the Amateur Radio Service by encouraging young people to take up the hobby while at school.

China is now permitting operation by individual amateur stations using BA, BD, and BG prefixes. Previously, operation was permitted only from club stations. The new arrangements result from years of patient effort by the Chinese Radio Sports Association.

Ten years ago there was only a handful of radio amateurs in Thailand, and even today there is only a comparatively small number with licences to operate on the h.f. bands. The number of v.h.f. licences, however, has grown enormously. Two years ago there were 30,000 licensed amateurs. Earlier this year, according to a report by IARU President Richard L. Baldwin, W1RU, the figure was 60,000 with a further 100,000 waiting for completion of the required paperwork! He comments "Thailand is a shining example of what can be accomplished by a first-class IARU society and a supportive administration which recognises the value of the Amateur Service."

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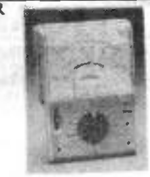

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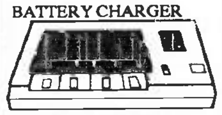

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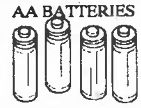

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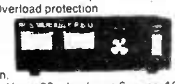

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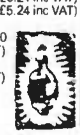

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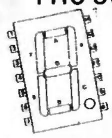

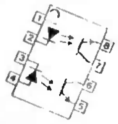

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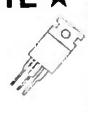

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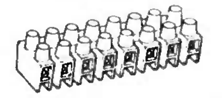

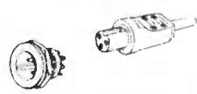

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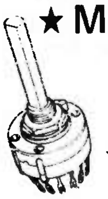

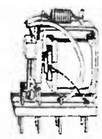

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Mains indicator neons with 220k resistor 10p
20mm fuses 100mA to 5A. O. blow 6p. A/surge 10p. Holders, chassis, mounting 6p
High speed pc drill 0.8, 1.0, 1.3, 1.5, 2.0mm - 40p. Machines 12V dc £15.00
HELPING HANDS 6 ball joints and 2 croc clips to hold awkward jobs £3.50
AA/HP7 Nicad rechargeable cells 90p each. Universal charger unit £6.50
AA/HP7 zinc/carbon batteries in packs of 4 .... £1.10 per pack
Glass reed switches with single pole make contacts - 8p. Magnets 15p
0.1" Stripboard 2½" x 1" 9 rows 25 holes - 25p. 3¾ x 2½" 24 rows 37 holes 70p
Jack plugs 2.5 & 3.5m – 14p; Sockets Panel Mtg. 2.5 & 3.5m. 10p
Ear pieces 2.5 & 3.5mm, dynamic – 20p; 3.5mm crystal £1.50
Multi cored solder, 22G – 8p yard, 18G – 14p yard.
TRANSISTORS
BC107/8/9 - 12p. BC547/8/9 - 8p. BC557/8/9 - 8p. BC182, 182L, BC183, 183L, BC184, 184L, BC212, 212L - 10p.
BC327, 337, 337L - 12p. BC727, 737 - 12p. BD135/6/7/8/9 - 25p. BCY70 - 18p.
BFY50/51/52 - 20p.
BFX88 - 15p, 2N3055 - 55p, TIP31, 32 - 30p, TIP41, 42 - 40p. BU208A - £1.50, BF195, 197 - 12p
Ionisers with seven year guarantee, list price £16.95 .... £12.50

All prices are inclusive of VAT. Postage 30p (free over £5). Stamp for list.

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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

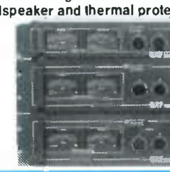
THOUSANDS PURCHASED BY PROFESSIONAL USERS

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

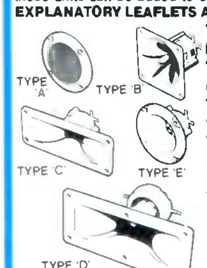
STEREO DISCO MIXER SDJ3400SE
★ ECHO & SOUND EFFECTS★

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

POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.

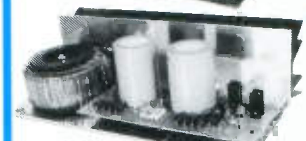
OMP MOS-FET POWER AMPLIFIER MODULES
SUPPLIED READY BUILT AND TESTED.

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

TRANSMITTER HOBBY KITS

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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FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 46mm, SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

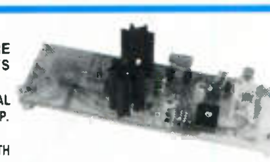

PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONICS

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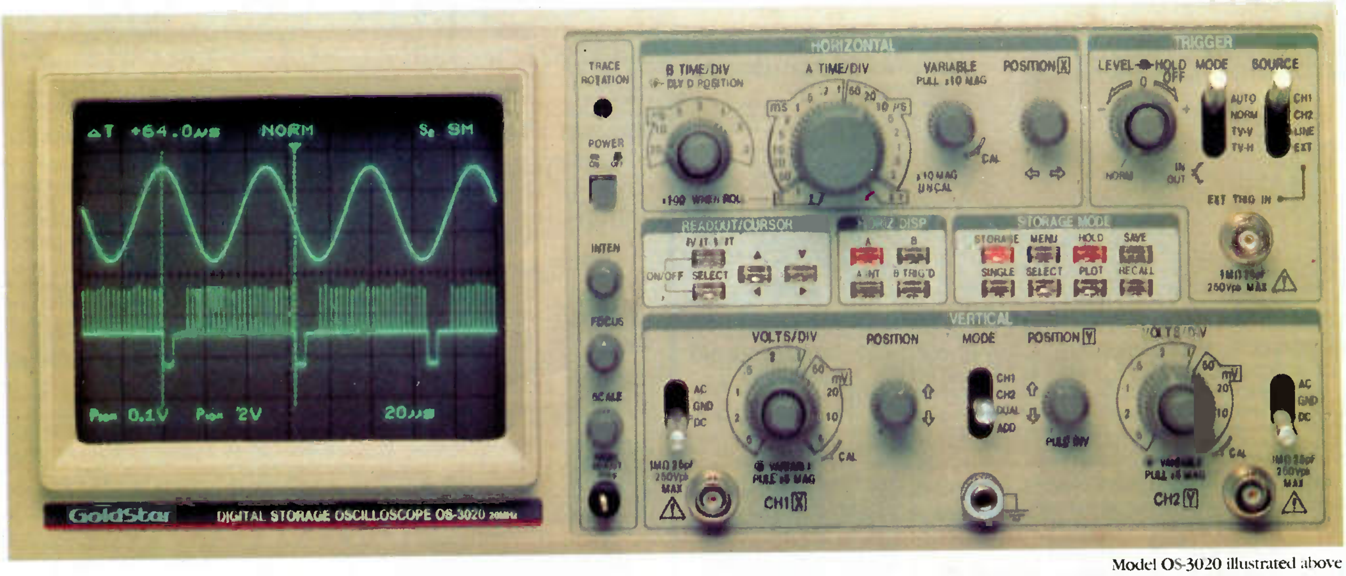
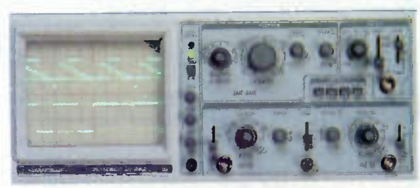
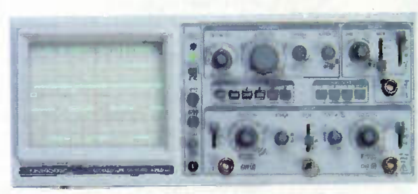


Model OS-3020 illustrated above

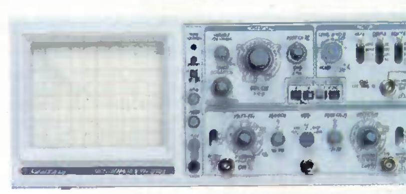
OS-9020A GW03D £269.95



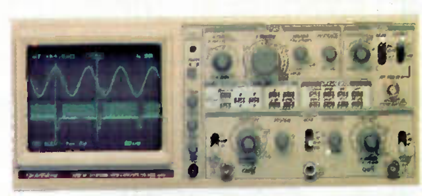
OS-9040D GW04E £399.95



OS-904RD GW06G £499.95



OS-9100D GW05F £699.95



OS-3020 GW07H £749.95