Easy to build projects for everyone

# Everyday ELECTRONICS

FEB. 81
60p


Australia $1·00 New Zealand $1·10 Malaysia $4·50

## SUPERSOUND 13 HI-FI MONO AMPLIFIER

A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz-30KHz ± 3db. Fully integrated pre-amplifier stage with separate Volume. Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3″ high × 6″ wide × $7\frac{1}{2}$″ deep. AC 200/250V. PRICE £18·40, P. & P. £1·60.

## HARVERSONIC MODEL P.A. TWO ZERO

An advanced solid state general purpose mono amplifier suitable for Public Address system, Disco, Guitar, Gram, etc. Features 3 individually controlled inputs (each input has a separate 2 stage pre-amp). Input 1, 15mV into 47k. Input 2, 15mV into 47k (suitable for use with mic. or guitar etc.). Input 3, 200mV into 1 meg. suitable for gram, tuner, or tape etc. Full mixing facilities with full range bass & treble controls. All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker. Output in excess of 30 watts music power. Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon. For ac mains operation 200-240 volts. Size approx. $12\frac{1}{4}$in wide × 5in high × $7\frac{1}{4}$in deep.

Special price £29·00 + £3·00 carriage and packing.

## "POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER

Size $11\frac{3}{4}$″ × $14\frac{11}{16}$″ × $1\frac{7}{16}$″ deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz-20kHz. Can be mounted on ceilings, walls, doors, under tables, etc., and used with or without baffle. Send S.A.E. for full details.

Only £9·20 each + p. & p. (one £1·20, two £1·50).

A brand new 22 transistor hi-fi stereo amplifier of superior design made by a well-known British manufacturer, for a now cancelled contract order. The unit is supplied new & tested on a printed circuit panel size approx. $6\frac{3}{4}$″ × $4\frac{3}{4}$″ × $1\frac{1}{2}$″ h. using high grade discrete components. Brief specification: 15 watts r.m.s. per channel O/P into 8 ohms. (o/p stages fully protected against s/c) I/P 60mV. for *ceramic cartridge. Provision for tape i/p & o/p. Only requires the addition of a 40 volt @ 2 amp. power supply & the bass, treble, balance & vol. control, (standard types). FULL Circuit diagram & connection details supplied. Price with edge connectors, Only £9.00 + 80p p & p. *Suitable 2 stage pre-amp. for mag. cart. RIAA corrected can be supplied @ £2.50 if ordered with amplifier. Suitable components for power supply can be supplied if ordered with amplifier—mains transfomer, rectifier, smoothing condenser. £4.00 + £1.80 p. & p.

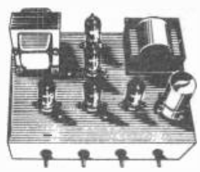
## MAINS OPERATED SOLID STATE AM/FM STEREO TUNER

200/240V Mains operated Solid State FM/AM Stereo Tuner. Covering M.W. A.M. 540-1605 KHz VHF/FM 88-108 MHz.

Built-in Ferrite rod aerial for M.W. Full AFC and AGC on AM and FM. Stereo Beacon Lamp Indicator. Built in Pre-amps with variable output voltage adjustable by pre-set control. Max o/p Voltage 600m/v RMS into 20K. Simulated Teak finish cabinet. Will match almost any amplifier. Size $8\frac{1}{2}$″w × 4″h × $9\frac{1}{2}$″d approx.

LIMITED NUMBER ONLY at £29·00 + £2·00 P. & P.

## 10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monoaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15 Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet. 50p + SAE (Free with parts). All parts sold separately. ONLY £18·40, P. & P. £2·00. Also available ready built and tested £22·50, P. & P. £2·00.

## STEREO DECODER MK.II

SIZE $1\frac{1}{2}$″ × $2\frac{7}{16}$″ × $\frac{1}{2}$″ ready built. Pre-aligned and tested for 10-16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions supplied. £7·00 plus 25p. P. & P. Stereo beacon light if required 40p extra.

Mullard LP1159 RF-IF module 470kHz £2·50 + P. & P. 40p. Full specification and connection details supplied. Pye VHF FM Tuner Head covering 88-108 MHz, 10.7 MHz I.F. output. 7.8V + earth. Supplied pre-aligned. with full circuit diagram with precision geared F.M. gang and 323PF + 323PF A.M. Tuning gang only £3.40 + P. & P. 60.p

STEREO MAGNETIC PRE-AMP. Sens. 3mV in for 100mV out. 15 to 35V neg. earth. Equ. ± 1dB from 20Hz to 20KHz. Input impedance 47K. Size $1\frac{3}{4}$″ × $2\frac{3}{4}$″ × $\frac{3}{4}$″ H. £3·20 + 22p P. & P.

## HARVERSONIC SUPERSOUND 10 + 10 STEREO AMPLIFIER KIT

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integral pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modity to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metalwork, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output: 14 watts r.m.s. per channel into 5 ohms. Frequency response: ±3dB 12-30,000Hz Sensitivity: better than 80mV into 1M Ω: Full power bandwidth: ±3dB 12-15,000Hz. Bass boost approx. to ±12dB. Treble cut approx. to —16dB. Negative feedback 18dB over main amp. Power requirements 35v. at 1·0 amp.

Overall Size 12″w. × 8″d. × $2\frac{3}{4}$″h.

Fully detailed 8 page construction manual and parts list free with kit or send 50p plus large S.A.E.

AMPLIFIER KIT .. .. £14·95 P. & P. £1·20
(Magnetic input components 33p extra)
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CABINET .. .. £6·20 P. & P. £1·50

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Full after sales service

Also avail. ready built and tested £32·20, P. & P. £2·80.

## HARVERSONIC STEREO 44

A solid state stereo amplifier chassis, with an output of 3-4 watts per channel into 8 ohm speakers. Using the latest high technology integrated circuit amplifiers with built in short term thermal overload protection. All components including rectifier smoothing capacitor, fuse, tone control, volume controls, 2 pin din speaker sockets & 5 pin din tape rec./play socket are mounted on the printed circuit panel, size approx. $9\frac{1}{4}$″ × $2\frac{3}{4}$″ × 1″ max. depth. Supplied brand new & tested, with knobs, brushed anodised aluminium 2 way escutcheon (to allow the amplifier to be mounted horizontally or vertically) at only £10·40 plus 90p P. & P. Mains transformer with an output of 17v a/c at 500m/a can be supplied at £2·15 + 70p P. & P. if required. Full connection details supplied.

All prices and specifications correct at time of press and subject to alteration without notice.

PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. SEND SAE WITH ALL ENQUIRIES. BARCLAYCARD WELCOME.

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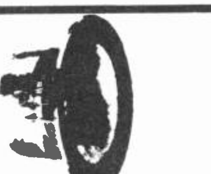

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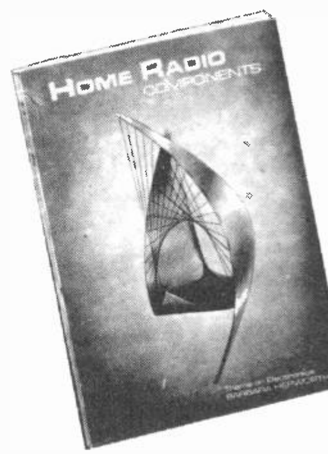


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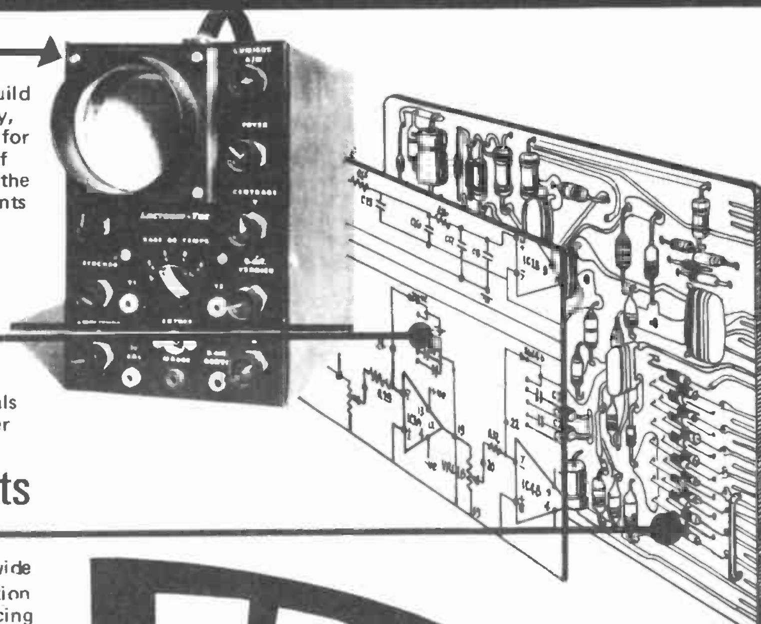

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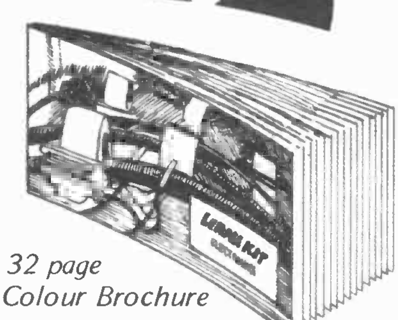

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# Why the Sinclair ZX80 is Britain's best-selling

## Built: £99.95

Including VAT, post and packing, free course in computing, free mains adaptor.

## Kit: £79.95

Including VAT, post and packing, free course in computing.


This is the ZX80. A really powerful, full-facility computer, matching or surpassing other personal computers at several times the price. 'Personal Computer World' gave it 5 stars for 'excellent value'. Benchmark tests say it's faster than all previous personal computers.

Programmed in BASIC – the world's most popular language – the ZX80 is suitable for beginners and experts alike. And response from enthusiasts has been tremendous – over 20,000 ZX80s have been sold so far!

**Powerful ROM and BASIC interpreter**

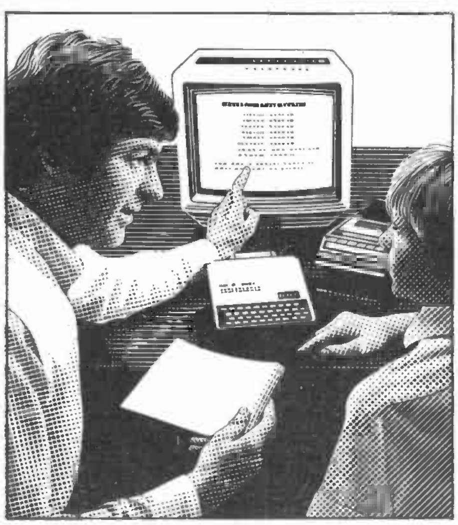
The 4K BASIC ROM offers remarkable programming advantages:

* Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.
* Unique syntax check. A cursor identifies errors immediately.
* Excellent string-handling capability – takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison).
* Up to 26 single dimension arrays.
* FOR/NEXT loops nested up to 26.
* Variable names of any length.
* BASIC language also handles full Boolean arithmetic, condition expressions, etc.
* Randomise function, useful for games and secret codes, as well as more serious applications.
* Timer under program control.
* PEEK and POKE enable entry of machine code instructions.
* High-resolution graphics.
* Lines of unlimited length.

**Unique RAM**

The ZX80's 1K-BYTE RAM is the equivalent of up to 4K BYTES in a conventional computer – typically storing 100 lines of BASIC.

No other personal computer offers this unique combination of high capability and low price.



*The ZX80 as a family learning aid. Children of 10 years and upwards are quick to understand the principles of computing – and enjoy their personal computer.*

**The Sinclair teach-yourself BASIC manual**

If the specifications of the Sinclair ZX80 mean little to you – don't worry. They're all explained in the specially-written 128-page book (free with every ZX80). The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs.

**Kit or built – it's up to you**

In kit form, the ZX80 is pleasantly easy to assemble, using a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9V DC nominal unregulated. If not, see the coupon.

Both kit and built versions come complete with all necessary leads to connect to your TV (colour or black and white) and cassette recorder. Plug in and you're ready to go. (Built versions come with mains adaptor.)

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## C·MOS (BUFFERED)

| | | | | | |
|---|---|---|---|---|---|
| HEF4000 | 22 | HEF4044 | 105 | HEF4512 | 138 |
| HEF4001 | 22 | HEF4046 | 133 | HEF4516 | 127 |
| HEF4002 | 22 | HEF4047 | 109 | HEF4517 | 478 |
| HEF4006 | 119 | HEF4049 | 57 | HEF4518 | 118 |
| HEF4007 | 22 | HEF4050 | 57 | HEF4519 | 69 |
| HEF4008 | 100 | HEF4051 | 87 | HEF4520 | 118 |
| HEF4011 | 22 | HEF4052 | 90 | HEF4521 | 235 |
| HEF4012 | 22 | HEF4053 | 90 | HEF4528 | 124 |
| HEF4013 | 57 | HEF4066 | 62 | HEF4532 | 150 |
| HEF4014 | 105 | HEF4067 | 475 | HEF4534 | 638 |
| HEF4015 | 100 | HEF4068 | 22 | HEF4539 | 138 |
| HEF4016 | 57 | HEF4069 | 22 | HEF4585 | 122 |
| HEF4017 | 100 | HEF4070 | 22 | HEF4724 | 214 |
| HEF4018 | 100 | HEF4071 | 23 | HEF40097 | 113 |
| HEF4019 | 58 | HEF4072 | 23 | HEF40098 | 92 |
| HEF4020 | 112 | HEF4073 | 23 | HEF40106 | 78 |
| HEF4021 | 107 | HEF4075 | 23 | HEF40160 | 149 |
| HEF4022 | 103 | HEF4076 | 130 | HEF40192 | 149 |
| HEF4023 | 22 | HEF4077 | 22 | | |
| HEF4024 | 78 | HEF4078 | 23 | **Voltage Regulators** | |
| HEF4025 | 22 | HEF4081 | 23 | | |
| HEF4026 | 244 | HEF4082 | 23 | | |
| HEF4027 | 57 | HEF4085 | 80 | LM309DA(K) | 119 |
| HEF4028 | 89 | HEF4086 | 80 | UA723CN | 42 |
| HEF4029 | 113 | HEF4093 | 63 | UA7805CU | 78 |
| HEF4030 | 58 | HEF4094 | 219 | UA7812CU | 78 |
| HEF4031 | 250 | HEF4104 | 208 | UA7815CU | 78 |
| HEF4035 | 138 | HEF4502 | 114 | UA7912CU | 97 |
| HEF4040 | 107 | HEF4505 | 714 | UA7915CU | 97 |
| HEF4041 | 94 | HEF4508 | 230 | UA78L05CS | 38 |
| HEF4042 | 83 | HEF4510 | 135 | UA78L12CS | 38 |
| HEF4043 | 100 | HEF4511 | 157 | UA78L15CS | 38 |

## LINEAR

| | |
|---|---|
| CA3046 | 84 |
| CA3080E | 77 |
| CA3130E | 99 |
| CA3140E | 48 |
| CA3189E | 293 |
| LM301AN | 34 |
| LM339N | 78 |
| LM380N | 104 |
| LM381AN | 198 |
| LM3900N | 75 |
| MC3403P | 156 |
| NE531 | 131 |
| NE536T | 259 |
| NE555N | 28 |
| NE556N | 66 |
| NE566N | 171 |
| NE570N | 486 |
| NE571N | 505 |
| RC4136 | 146 |
| TBA120S | 88 |
| TDA1022 | 713 |
| TDA1034B | 239 |
| TL081CP | 84 |
| TL084CN | 156 |
| UA741CN | 20 |
| UA741CT | 47 |
| **Zener Diodes** | |
| 400mW C4V7-C33 BZY88/BZX79 + Voltage | 9 |

## SEMICONDUCTORS

| | | | |
|---|---|---|---|
| IN914 | 5 | BC182L | 12 |
| IN4001 | 5 | BC184 | 11 |
| IN4002 | 5 | BC184L | 12 |
| IN4004 | 7 | BC212 | 11 |
| IN4007 | 9 | BC212L | 12 |
| IN4148 | 4 | BC214 | 11 |
| IN5402 | 15 | BC214L | 12 |
| 2N2369 | 21 | BC547 | 13 |
| 2N2646 | 46 | BC548 | 11 |
| 2N2926G | 13 | BC549 | 12 |
| 2N3053 | 19 | BC557 | 15 |
| 2N3054 | 55 | BC558 | 15 |
| 2N3055 | 55 | BCY70 | 15 |
| 2N3702 | 9 | BCY71 | 15 |
| 2N3704 | 9 | BD131 | 39 |
| 2N3705 | 10 | BD132 | 39 |
| 2N3773 | 297 | BD139 | 39 |
| 2N3819 | 22 | BD140 | 39 |
| 2N3820 | 39 | BFR90 | 333 |
| 2N3904 | 9 | BFX85 | 29 |
| 2N5457 | 39 | BFY50 | 17 |
| 2N5459 | 35 | BFY51 | 17 |
| 40673 | 88 | BRY39 | 50 |
| BC107 | 14 | BSX20 | 21 |
| BC108 | 14 | CL8960 | 2850 |
| BC108C | 18 | TIP31 | 48 |
| BC109 | 14 | TIP32 | 54 |
| BC109B | 19 | TIP41C | 78 |
| BC109C | 20 | TIP42C | 78 |
| BC148 | 10 | TIP2955 | 75 |
| BC158 | 10 | TIP3055 | 60 |
| BC177 | 17 | TIS43 | 38 |

## CAPACITORS

**Electrolytic Axial** −10% to +50% Tol. Order Code Cap 015 + µF

| µF \ V | 16 | 25 | 40 | 63 |
|---|---|---|---|---|
| 1.0 | | | | 9 |
| 1.5 | | | | 9 |
| 2.2 | | | | 9 |
| 3.3 | | | | 9 |
| 4.7 | | | | 9 |
| 6.8 | | | 9 | 10 |
| 10 | | 8 | | 10 |
| 15 | 8 | | 9 | 11 |
| 22 | | 8 | | 13 |
| 33 | 8 | | 9 | |
| 47 | | 8 | 11 | 13 |
| 68 | 9 | | | |
| 100 | | 9 | 13 | |
| 150 | 9 | 10 | | 31 |
| 220 | 13 | | 26 | 36 |
| 330 | | | 30 | 40 |
| 470 | | 23 | 32 | 47 |
| 680 | 21 | 30 | 39 | 54 |
| 1000 | 26 | 30 | 59 | |
| 1500 | 35 | 39 | | |
| 2200 | 42 | | | |

**Polyester Radial Leads** Order Code
Dipped Type, C280/352 Style — Cap 352
Moulded Type, 10.2mm Pitch — Cap 380
+ Value

| µF | 352 | 380 | µF | 352 | 380 |
|---|---|---|---|---|---|
| .001 | | 7 | .1 | 7 | 9 |
| .0015 | | 7 | .15 | 8 | 10 |
| .0022 | 6 | 7 | .22 | 9 | 11 |
| .0033 | 6 | 7 | .33 | 11 | |
| .0047 | 6 | 7 | .47 | 14 | |
| .0068 | 6 | 7 | .68 | 17 | |
| .01 | 6 | 8 | 1.0 | 21 | |
| .015 | 6 | 8 | 1.5 | 30 | |
| .022 | 6 | 8 | 2.2 | 35 | |
| .033 | 6 | 8 | | | |
| .047 | 6 | 8 | | | |
| .068 | 7 | 8 | | | |

**Electrolytic Radial Leads** −10% to +50% Tol. Order Code Cap 034 + µF

| µF \ V | 10 | 16 | 25 | 35 | 40 | 50 | 63 |
|---|---|---|---|---|---|---|---|
| 47 | | | | | | | 7 |
| 68 | | | | | | | 7 |
| 1.0 | | | | | | | 7 |
| 1.5 | | | | | | | 7 |
| 2.2 | | | | | | | 7 |
| 3.3 | | | | | | | 7 |
| 4.7 | | | | | 7 | | 8 |
| 6.8 | | | 7 | | | 8 | 9 |
| 10 | | 7 | | | 8 | | 9 |
| 15 | | 7 | 8 | | | 9 | 11 |
| 22 | 7 | 8 | | | 9 | 11 | |
| 33 | | 8 | 9 | | 11 | | |
| 47 | 8 | 9 | | 11 | | | |
| 68 | | 9 | 11 | | | | |
| 100 | 9 | | | | | | |
| 150 | 11 | | | | | | |

**D.I.L. Sockets**

| | | |
|---|---|---|
| 8 Pin Low Profile Socket Tin | 12 | DIL SKT 8 |
| 14 Pin Low Profile Socket Tin | 14 | DIL SKT 14 |
| 16 Pin Low Profile Socket Tin | 16 | DIL SKT 16 |

**P.C.B. Components**

Dalo Pen Blue Ink, Slow Drying 69

## RESISTORS

Order Code

**Carbon Film, Fixed**

| | | |
|---|---|---|
| 0.25W, E24 Values 1R0-10M, 5% Tol | 2 each 100/100 (Mult 10/Value) | Res RD¼ |
| 0.5W, E12 Values 1R0-4M7, 10% Tol | 3 each | Res RO½ + Value |

**Metal Film, Fixed**

| | | |
|---|---|---|
| 0.5W, E24 Values, 5R1-1M, 2% Tol | 8 each | Res MR30 |
| 2.5W, E12 Values, 10R-27K, 5% Tol | 16 each | Res PR62 + Value |

**Metal Glaze, Fixed**

| | | |
|---|---|---|
| 0.5W, E24 Values, 1M-33M, 5% Tol. | 16 each | Res VR37 + Value |

**Skeleton Presets, Miniature** — Order Code

| | | |
|---|---|---|
| 0.1W, E3 Values, 100R-1M, Lin. Vertical Mounting | 8 | Min Preset V |
| 0.1W, E3 Values, 100R-1M, Lin. Horizontal Mount | 8 | Min Preset H + Value |

**Skeleton Presets, Standard**

| | | |
|---|---|---|
| 0.3W, E3 Values, 100R-4M7, Lin Vertical Mounting | 11 | Std Preset V |
| 0.3W, E3 Values, 100R-4M7, Lin Horizontal Mount | 11 | Std. Preset H + Value |

**Potentiometer, Rotary**

| | | |
|---|---|---|
| 0.5W, E3 Values, 1K-2M2 Lin | 39 | Ro Pot Lin |
| 0.25W, E3 Values, 4K7-2M2 Log | 39 | Ro Pot Log + Value |

**Potentiometer, Slider**

| | | |
|---|---|---|
| 0.5W, E3 Values, 2K2-470 . Lin. | 45 | Sl Pot Lin |
| 0.25W, E3 Values, 1K0 - 1M0 Log | 45 | Sl Pot Log + Value |

## MAINS TRANSFORMERS

Order Code

Secondaries may be connected in series or parallel to give wide voltage range
Primaries 0-220, 240V

6VA - Clamp Type Construction 235 each
Approx 18% Regulation F C 54, H38, W35

0-4 5V, 0-4 5V Secondaries — Trans 6VA
0-6V, 0-6V
0-12V, 0-12V
0-15V, 0-15V
0-20V, 0-20V

20VA – Clamp Type Construction 360 each
Approx 16% Regulation F C 70, H48, W48

0-4 5V, 0-4 5V Secondaries — Trans 20VA
0-6V, 0-6V
0-12V, 0-12V
0-15V, 0-15V
0-17 5V, 0-17 5V
0-20V, 0-20V

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Moulded Box and Close Fitting Flanged Lid
ABS Box, C/W Brass Bushes, and Lid In Orange

| | | Order Code |
|---|---|---|
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| L150 W80 D50 | 131 | Case BIM2005 OR |
| L190 W110 D60 | 223 | Case BIM2006 OR |

**Plastic Boxes with Metal Lids**

Recessed Top Box
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey

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|---|---|---|
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| L111 W71 D42 | 150 | Case BIM4004 OR |
| L161 W96 D53 | 208 | Case BIM4005 OR |

**Diecast Boxes**

Diecast Box and Flanged Lid
Aluminium Box and Lid in Natural Finish

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|---|---|---|
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| SPDT | C/Off | 81 | SW 8A1021 |
| SPDT | Double Bias To Centre | 90 | SW 8A1041 |
| DPDT | | 99 | SW 8A2011 |
| DPDT | C/Off | 111 | SW 8A2021 |

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# Projects... Theory...

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THE (STILL) OPEN CHANNEL
The battle for Citizens' Band Radio goes on.

In August last year the Home Office issued a discussion document on "Open Channel". On December 18, Mr William Whitelaw, the Home Secretary, stated in Parliament that a large number of individuals wanted citizens' band radio at 27MHz to be legalised. On the other hand the electronics industry and institutions representing other interests such as broadcasting strongly advocated frequencies higher than 27MHz. The Home Secretary went on to say that he is disposed to allocate frequencies to Open Channel radio in the neighbourhood of 930MHz and that he is considering "whether it would be possible to exempt this facility from licensing if certain conditions are met".

The door has not been completely closed on a personal radio service on 27MHz (which would have a greater range than the proposed Open Channel on 930MHz could provide) for the Home Secretary intends "to continue consultations to examine this question further".

Prior to this official announcement, the Citizens' Band Association had issued its own response to the discussion document. It is critical of the proposals for use of u.h.f. since the cost of equipment would be too high and the range totally inadequate. The C.B.A. calls for a lower frequency (41MHz or 230MHz); failing that 27MHz operation should be legalised at once.

The C.B.A. is also critical of the Home Office concentration on the interference problem. Why? Against the small but well organised and vocal C.B. lobby there is the vast majority of the population which depends upon radio, television, tape and hi-fi for information and pleasure. It would be utterly intolerable were members of one household to be barred from listening to programmes of their choice because of break-through from a C.B. rig in an adjoining house. It is the very nature of C.B buffs to be garrulous so any such interference is likely to be suffered over long periods.

Naturally C.B. enthusiasts play down this aspect, but the authorities with their responsibilities to the public at large are perfectly right in seeking to keep interference to the absolute minimum. The frequency of 930MHz seems to offer the least danger of break-through on other domestic electronic equipment. If the rights of the majority can be best safeguarded by restricting the range of C.B. operation we think this is the best and fairest solution.

Fred Bennett

*Our March issue will be published on Friday, February 20. See page 111 for details.*

# Everyday ELECTRONICS

VOL. 10 NO. 2 FEBRUARY 1981

## CONSTRUCTIONAL PROJECTS



## GENERAL FEATURES



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*Circuit* **EXCHANGE IS NO ROBBERY**

See Page 129

# CAR – ACTUATED DRIVEWAY LIGHT

BY M. PLANT

THIS optoelectronic project will enable you to switch on an outside light before getting out of your car merely by operating your car main beam switch a preselected number of times. The driveway light remains switched on for a predetermined time, just long enough for you to lock up your car, enter the house and, if necessary, put the cat out with the milk bottles. After closing the door you can be confident that the light will be extinguished automatically.

## LIGHT BEAM

Of course sophisticated remote control systems which make use of ultrasonic or infra-red beams are designed for this purpose, but since a car has powerful headlights why not make use of these beams to control a device at a distance?

However, a simple opto-switch would be very unsatisfactory for this application because a chance illumination of the sensor by a passing car or a lightning flash would operate the light.

The circuit to be described avoids this possibility by the use of two essential design features: first, a six-position switch which enables you to select the number of flashes of the car head beam required to operate the relay which controls the mains lamp; second, a time delay which can be preset up to a maximum time of 2½ minutes during which the circuit must receive the correct number of light flashes. This is also the time that the mains lamp remains on.

## CIRCUIT DESCRIPTION

The circuit for the Car Actuated Driveway Light is shown in Fig. 1 and derives its 12V d.c. supply from the mains. The supply is stabilised by means of the Zener diode D1 and transistor TR1. The light sensor is a photocell, PCC1 which is coupled to a voltage comparator based on op-amp IC1. The switching action of IC1 is modified by components D6, R2, C2, R3 and C3 so that it operates as a monostable.

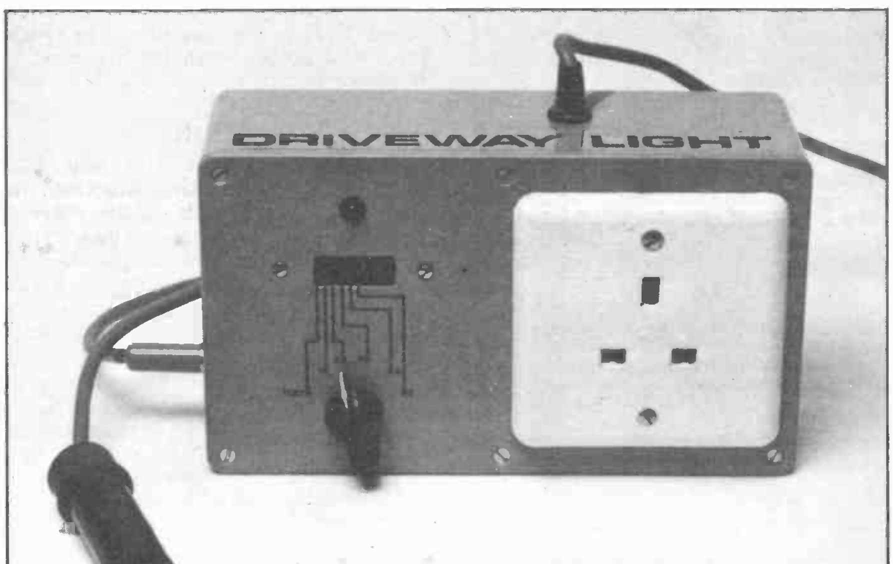
Normally the photocell will be in the dark and its resistance therefore will be high. If VR1 is set so that its resistance is about equal to the photocell "dark resistance", capacitor C4 will be charged to about half the supply voltage. The inverting input of the op-amp will be about 0·6V higher than this due to the action of diode D6. Thus the output voltage of the op-amp is 0V.

If the photocell detects a sudden increase in light intensity, its resistance drops sharply and the voltage on pin 2 falls below that on pin 3 which therefore makes the op amp produce a positive output voltage.

The small amount of positive feedback provided by R3 and C3 ensures that the output voltage changes sharply. This rise in output voltage produces an equivalent rise in the voltage on pin 3 but, since the photocell has returned to its normally "dark" state, capacitor C4 will discharge down through R2. The voltage on pin 3 therefore falls and when it drops below the voltage on pin 2, the output voltage returns to 0V. The time taken for the op-amp to drop out of its monostable state is largely determined by the values of C4 and R2 and is adjusted to be about one second.

The voltage changes on the output and the two inputs of the op amp are shown in Fig. 2. The circuit has the useful feature that, once a flash of light has reached the photocell, it ignores any spurious signals it might be receiving in the time it is in the monostable mode.

Furthermore the op-amp does not respond to slowly changing levels of illumination since its non-inverting input always remains 0·6V below the voltage on its inverting input. So the advent of dawn is ignored by the circuit and it "sleeps" during the day but becomes sensitive again at nightfall.




The completed unit with photocell tube.

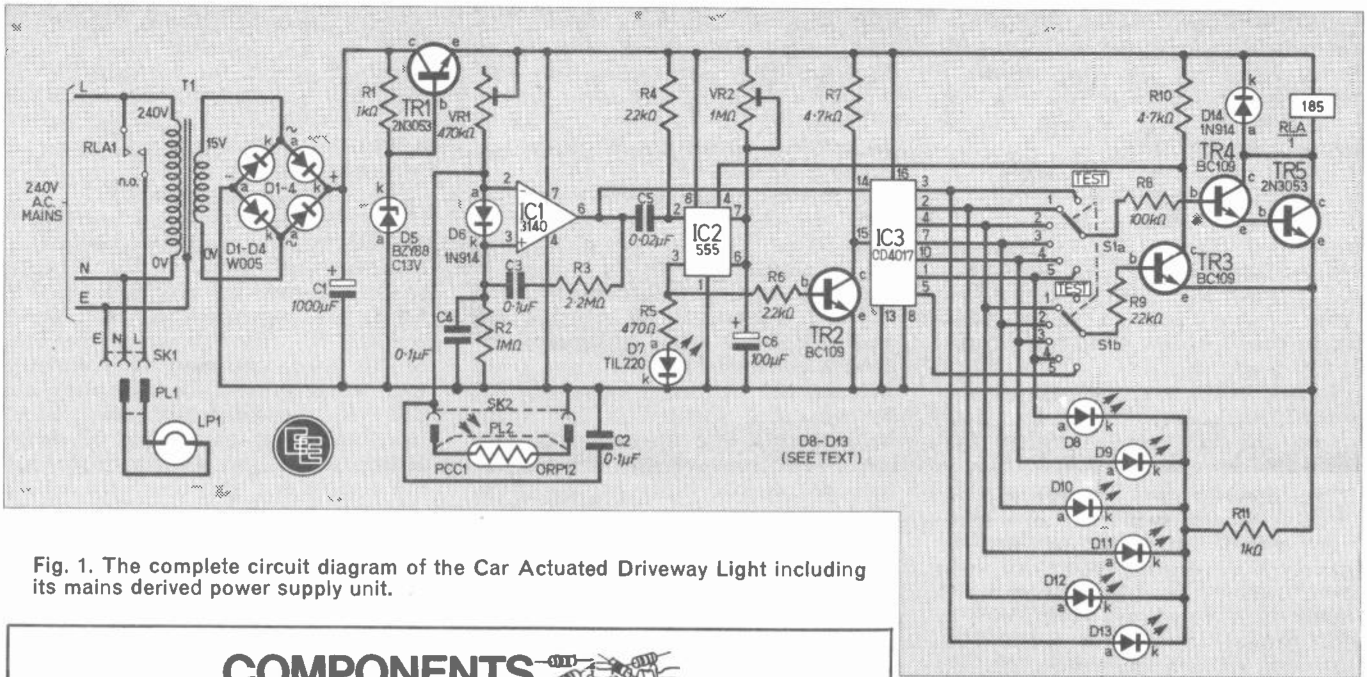



**Fig. 1. The complete circuit diagram of the Car Actuated Driveway Light including its mains derived power supply unit.**

## COMPONENTS

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 1kΩ | R7 | 4·7kΩ |
| R2 | 1MΩ | R8 | 100kΩ |
| R3 | 2·2MΩ | R9 | 22kΩ |
| R4 | 22KΩ | R10 | 4·7kΩ |
| R5 | 470Ω | R11 | 1kΩ |
| R6 | 22kΩ | | |

All ¼W carbon ±10%

**Capacitors**

- C1 2200µF 16V elect.
- C2 0·1µF polyester
- C3 0·1µF polyester
- C4 0·1µF polyester
- C5 0·022µF polyester
- C6 100µF 16V tantalum bead

**COMPONENTS approximate cost £22**

**Semiconductors**

- D1-D4 1A 50V diode bridge
- D5 BZY88C13V 13V 400mW Zener diode
- D6 1N914 small signal silicon
- D7 TIL220 red l.e.d.
- D8-D13 decade l.e.d. array (d.i.l.) or discrete l.e.d.s, e.g. TIL220 (6 off)
- D14 1N914 small signal silicon
- TR1 2N3053 *npn* silicon
- TR2 BC109 *npn* silicon
- TR3 BC109 *npn* silicon
- TR4 BC109 *npn* silicon
- TR5 2N3053 *npn* silicon
- IC1 CA3140 m.o.s.f.e.t. op-amp (8-pin d.i.l.)
- IC2 555 timer i.c.
- IC3 CD4017B CMOS decade counter
- PCC1 ORP12 or similar light dependent resistor

See Shop Talk page 93

**Miscellaneous**

- VR1 470kΩ sub-miniature preset
- VR2 1MΩ sub-miniature preset
- S1 2-pole 6-way rotary switch
- T1 mains primary/15V 200mA secondary
- RLA miniature relay 12V 185 ohms coil with at least one set of mains contacts rated to suit lamp used.
- SK2 3·5mm jack socket
- SK1 3-pin mains socket
- PL1 3-pin mains plug
- PL2 3·5mm jack plug

Stripboard: 0·1 inch matrix, 36 strips × 34 holes; case, Bimbox type 2006/16 size 190 × 110 × 60mm plastic, or similar; i.c. sockets 8-pin d.i.l. (2 off), 16 pin d.i.l. (1 off); TO-5 heatsink; socket for relay; bush for panel mounted l.e.d.(s) aluminium for relay bracket; 6BA fixings; control knob; three-core mains cable; grommet to suit mains cable; solder tag; short length of plastic tube to act as collimator for PCC1.

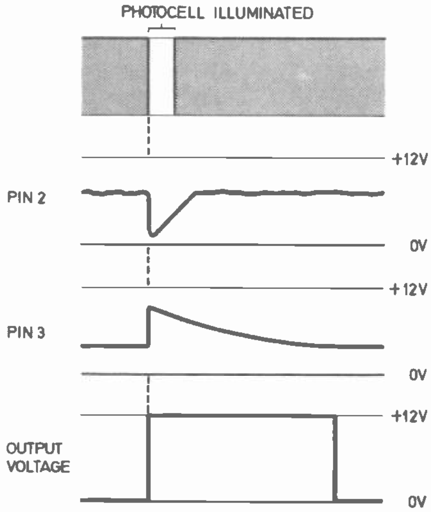



**Fig. 2. Voltage changes occurring at IC1 input and output when the photocell is illuminated.**

## TIMER AND COUNTER

Integrated circuits IC2 and IC3 have equally interesting functions to perform. IC3 responds to the sharply rising edge of the output voltage from IC1 while IC2 responds to the sharply falling edge of this same voltage change. The 555 timer, IC2 connected as a second monostable, determines whether the decade counter, IC3, should count or not. If its output is at logic low, it switches TR2 off which in turn takes the reset terminal, pin 15, to IC3 to a logic high, i.e. near the supply voltage. A logic high on the reset terminal sets the voltage at IC3 output pin 3 also high, all the other nine outputs of this decade counter being at logic low.

Should the output voltage of IC2 be high, transistor TR2 is switched on and the reset terminal of IC3 goes to logic low which allows this decade counter to count pulses received at its count input, pin 14. Thus counting takes place when the output of IC2 is at logic high, that is, when it is in its monostable "on" state.

During this period, each rising edge of the pulses from IC1 successively sets the ten decade outputs of IC3 logic high. Thus, after the counter has been reset and pin 3 is high, next pin 2 goes high, all other outputs being low and each successive pulse brings output pins 4, 7, 10 and 1 logic high in turn.

Switch S1a selects any one of the first six outputs of IC3, the other four outputs of this decade counter not being used in this application.

By means of the Darlington pair made up of transistors TR4 and TR5, a mains relay is energised when the switch selects a logic high from IC3. Thus if the switch is in position 1, as shown in the circuit, the relay is energised after the first pulse is received from IC1. Pin 2 remains high and the lamp remains lit for the time that IC2 is in its monostable state. Once pin 3 of IC2 falls to its normal low state at the end of its monostable period, determined by the product of the VR2 and C6 values, pin 15 of IC3 goes high and resets the counter so that its pin 3 is high.

Thus, trigger pulses from IC1 must be passed on to the counter during IC1 monostable on period, which is adjustable up to about 150 seconds, if the lamp is to be switched on. Suppose S1a has been set to its fourth position. The chance that three random flashes of light are received by the photocell in the monostable period is small. However, it is easy to flash the headlamps of your car three times quite rapidly in order to switch on the lamp by bringing the output, pin 7 to logic high. The reason for providing five switch positions in addition to the reset position, is so that user can find the position best suited to their environment. If your house is situated near a busy road junction it might be necessary to select a high number of required flashes while country dwellers might only need to set S1a to position 2 or 3.

## TIMER OVERRIDE

Should you want to switch off the lamp before the termination of IC2 monostable period, S1b which is ganged with S1a allows you to do this. S1b is wired in advance of S1a by one step. So once the light has been turned on by the flashing sequence, the counter high output can be picked up on S1b pole by backstepping S1. This turns on TR3 whose collector drops towards 0V. A low voltage to pin 4 of IC2 resets this i.c. and its output falls to 0V and stays there. TR2 is thus off resulting in a high level to IC3 reset, setting the first output pin 3 in the high state. This facility is not available for the single flash system, position 1.

Remember to return switch S1 to its original position to maintain the required flash count.

Assembly of the circuitry on 0·1 inch stripboard is shown in Fig. 3. The layout includes the d.c. power supply which uses the large smoothing capacitor C1. A heat sink is essential for transistor TR1. Use of i.c. sockets for the three integrated circuits is recommended, particularly for IC1 and IC3 which are CMOS devices. Do not plug these i.c.s into their holders until you are ready to test the circuit and certainly do not insert or remove them at any time when the circuit is being supplied with power.

# CONSTRUCTION starts here

## CIRCUIT BOARD

Begin by cutting the board to size, drilling the fixing holes and making the breaks on the underside as shown in Fig. 3. Mount the i.c. sockets followed by the wire links, presets, resistors and capacitors. Leave C1 until last for ease of construction. The semiconductors should be mounted next—remember to fit TR1 heatsink before connecting it to the board.

Finally connect sufficient lengths of flying lead to the circuit board to reach the case mounted components when positioned. Ribbon cable was used in the prototype but is not essential. In fact this assembly is too rigid and lightweight cable would be better except of course for the mains wiring where heavier duty insulated wiring is essential.

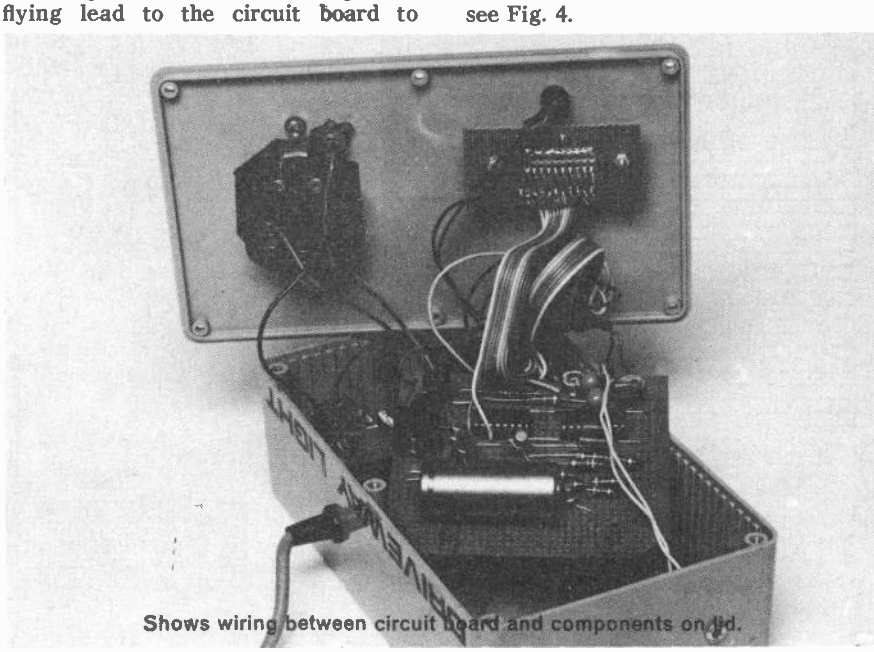
The internal arrangement of the circuit board, switches, transformer and the relay in the prototype unit is also shown in Fig. 3. Decide whether to use a decade bar display for l.e.d.s D8 to D13 or individual l.e.d.s and prepare the front panel of the box to suit. As can be seen the prototype used a bar type of l.e.d. display and this for convenience has been mounted on a small piece of stripboard. A d.i.l. socket for mounting the display was also used. The board was bolted to the front panel below a suitable rectangular cut-out.

Note that a relay is mounted in a suitable socket and held in place on a small aluminium bracket in a corner of the box adjacent to the transformer and near to the three-pin socket which accepts the connection to the mains lamp. Connect the flying leads to the relay base and fit all the case mounted components in position and wire up to the circuit board.

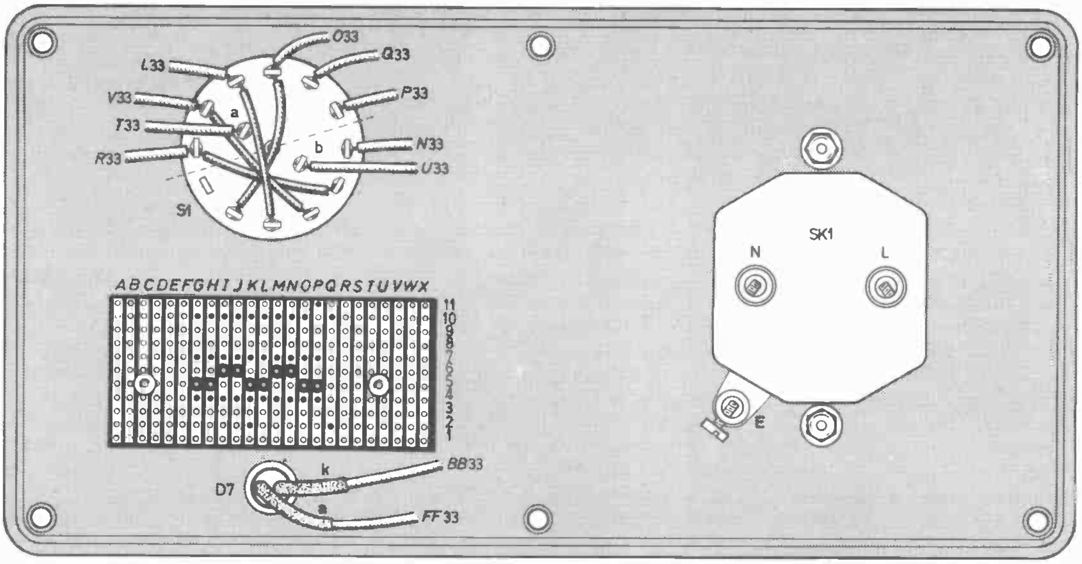
The circuit board should be mounted firmly just off the bottom of the box on short stand-off pillars or similar.

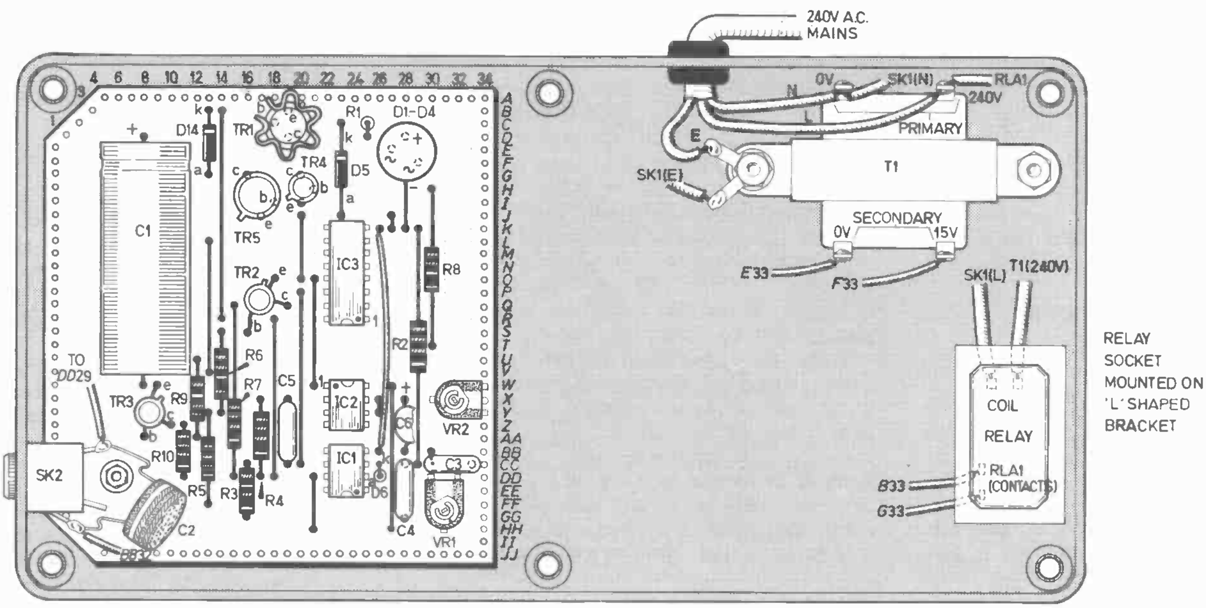
## PHOTOCELL TUBE

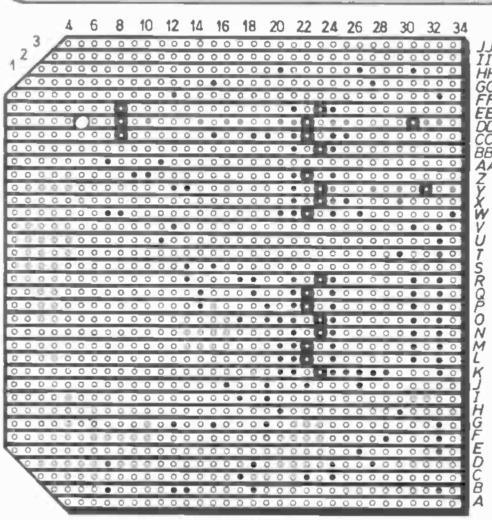
The photocell was situated in a short length of plastic tube so that in operation it can be lined up with the headlights of your car. The tube limits the angle of view of the photocell and reduces the chance that the circuit is operated by chance flashes of light, for only light directed along the axis of the tube will be effective, see Fig. 4.



Shows wiring between circuit board and components on lid.



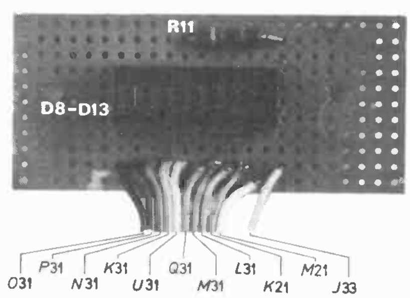
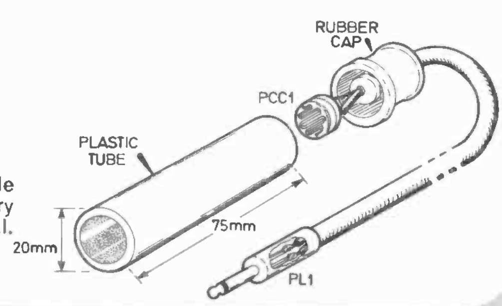
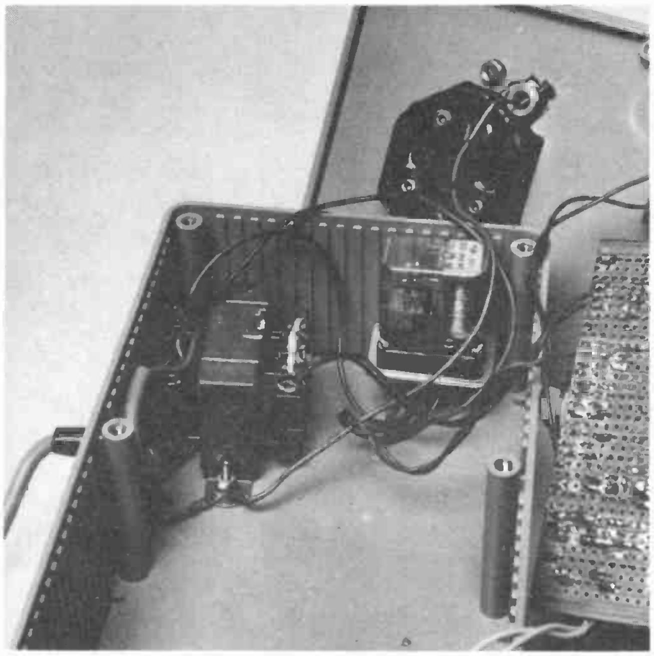


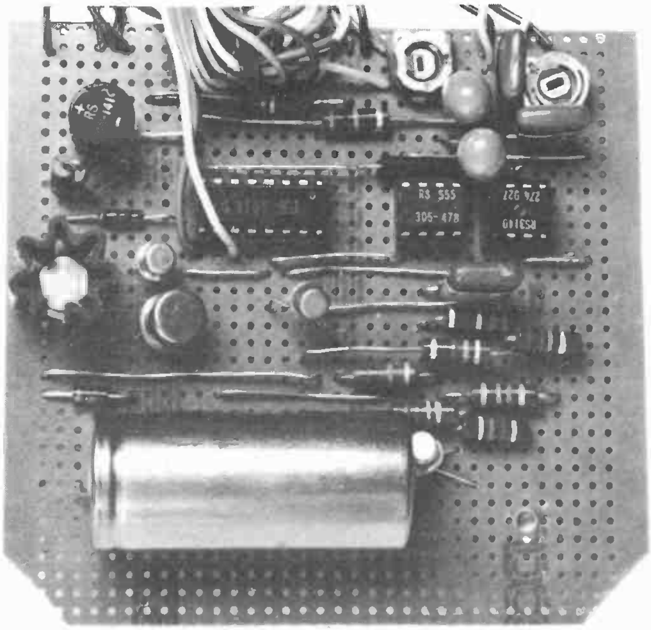

Fig. 3. The layout of the components on the stripboard and the breaks to be made on the underside. The two chamfered corners on the larger board are necessary to clear the mounting pillars in the specified case. The bar l.e.d. fitted in a d.i.l. socket on the smaller board is seen in the photograph.

Fig. 4 (below). The photocell collimator construction details.





Position and wiring of transformer and relay fitted in the case.



The completed prototype circuit board. Here C6 is constructed from two 47$\mu$F capacitors wired in parallel.

Provide the photocell with two to three metres of connecting wire so that it can be mounted in a position suitable for receiving light from your car headlamps. The photocell is plugged into the unit via a 3·5mm jackplug/socket arrangement.

## SETTING UP

The operation of the unit can be checked out either by using a torch in a darkened room or merely by using the light from a window. The only adjustment which is necessary is to VR1 so, with the lid of the box carefully supported, make sure you can gain access to this component with a small screwdriver or the correct adjustment tool. **Take care that you do not inadvertently touch any bare mains connections, especially those on the transformer, when you are making this adjustment.**

First set switch S1 to the TEST position and plug a lamp into the socket on the front panel, e.g. a table lamp which is terminated with a three pin plug. When the unit itself is plugged into a mains socket, the lamp should light. Now set S1 to position 1 and the lamp should turn off. Cover the tube of the photocell with your thumb and quickly uncover it and cover it up again. Adjust VR1 until the mains relay is heard to click on accompanied by the lamp turning on. Now expose the photocell to one more brief period of illumination and the lamp will be extinguished and the first l.e.d. in the chain will relight. Note that D7 comes on after the first flash of light and sets the start of the first monostable period and will also light up after the lamp has been switched off by the second flash of light. However, if the lamp is allowed to continue alight until the end of the delay period, D7 will go out.

Check the operation of the circuit for the other positions of S1 and adjust the value of VR2 until the required time delay is obtained. Note that you can increase the value of C6 to increase the maximum time delay in the circuit but make sure that you use a tantalum type capacitor for reliable results.

## INSTALLATION

When the circuit is working correctly, the unit needs to be installed in a suitable position. It is a good idea to mount the photocell just inside a window at a height which can be illuminated by your car headlights when you enter your drive. If the photocell has to be mounted on a wall, make sure you protect it from the effects of the weather. Similarly, just behind a window is a good position for the unit itself so that you can see the l.e.d.s at night. An existing outside light will need to be adapted so that it can be plugged into the unit's three-pin socket. ⌑


# 3-CHANNEL STEREO MIXER

by D. J. EDWARDS

SIMPLE TRANSISTOR CIRCUIT
IDEAL FOR HOME RECORDING OR DISCOS

THE AUDIO mixer is an essential part of any recording or P.A. installation. To the professional this means row upon row of knobs and sliders and of course enormous expense.

However, there are often cases when a simple unit is required to mix two or three inputs perhaps for home recordings or disco use and the unit described here is designed to fill such a function.

There are three stereo channels each with different sensitivities and level controls and a final amplifier with master output. A headphone amplifier is also provided.

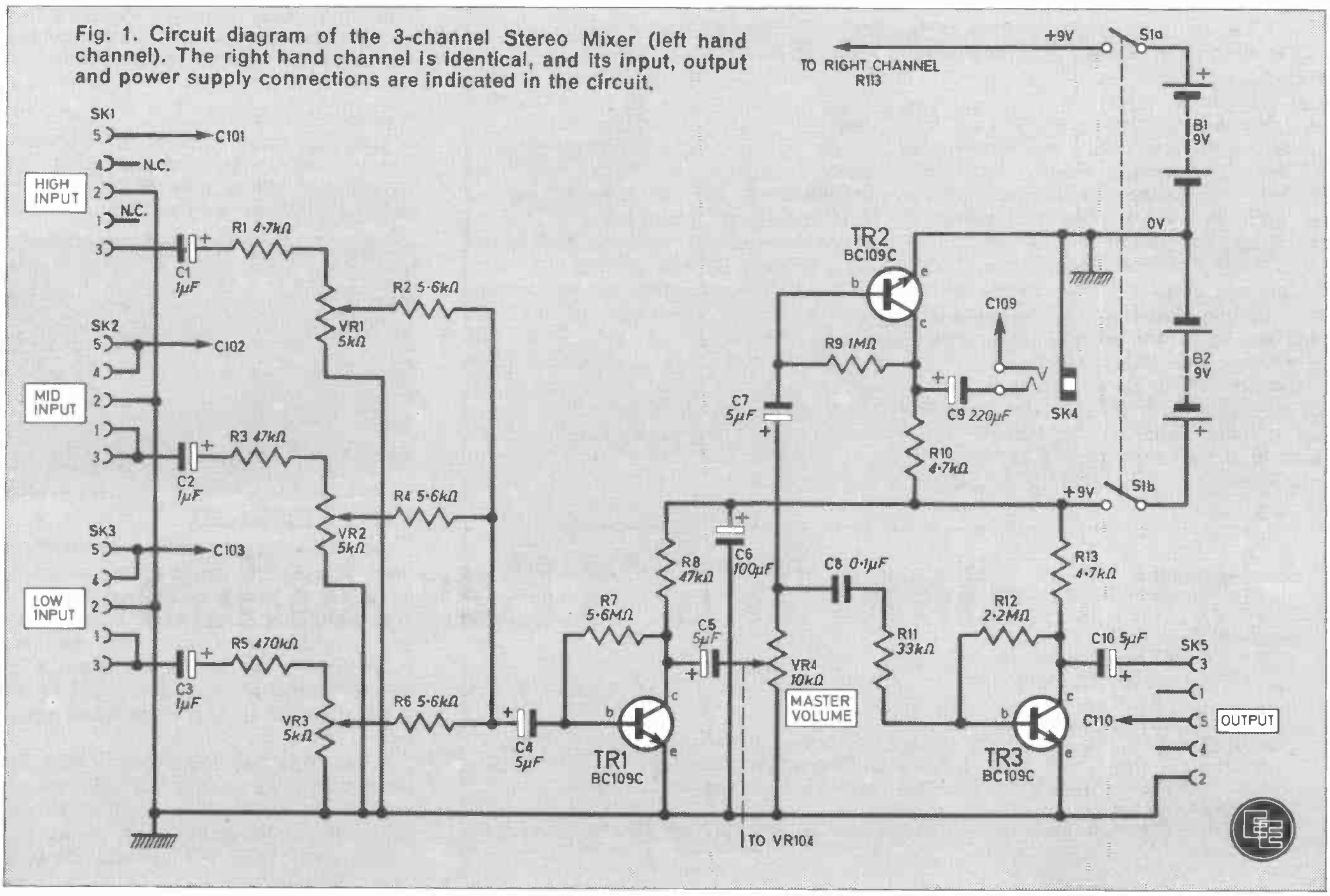
## CIRCUIT DESCRIPTION

The circuit of the left hand channel of the Stereo Mixer can be seen in Fig 1. The other channel is identical to this.

The input signals enter the unit via SK1, 2 or 3. Resistors R1, R3 and R5 are designed to attenuate the signal so that it does not overload the next stage.

The level of each input is controlled by variable resistors VR1 to VR3 and their counterparts in the right hand channel. It should be noted that there are separate controls for left and right channels as well as

Fig. 1. Circuit diagram of the 3-channel Stereo Mixer (left hand channel). The right hand channel is identical, and its input, output and power supply connections are indicated in the circuit.



separate ones for the three inputs, making six in all.

## PRE-AMP

The input signals now pass via a 5·6kΩ resistor and d.c. blocking capacitor to TR1. This is a standard common emitter circuit with negative feedback applied via R7.

Output level is controlled by VR4 and its equivalent in the right hand channel. These two are ganged together and form the master volume.

Further amplification of the signal is provided by TR3 also connected in common emitter mode and the output is terminated at SK5.

## HEADPHONES

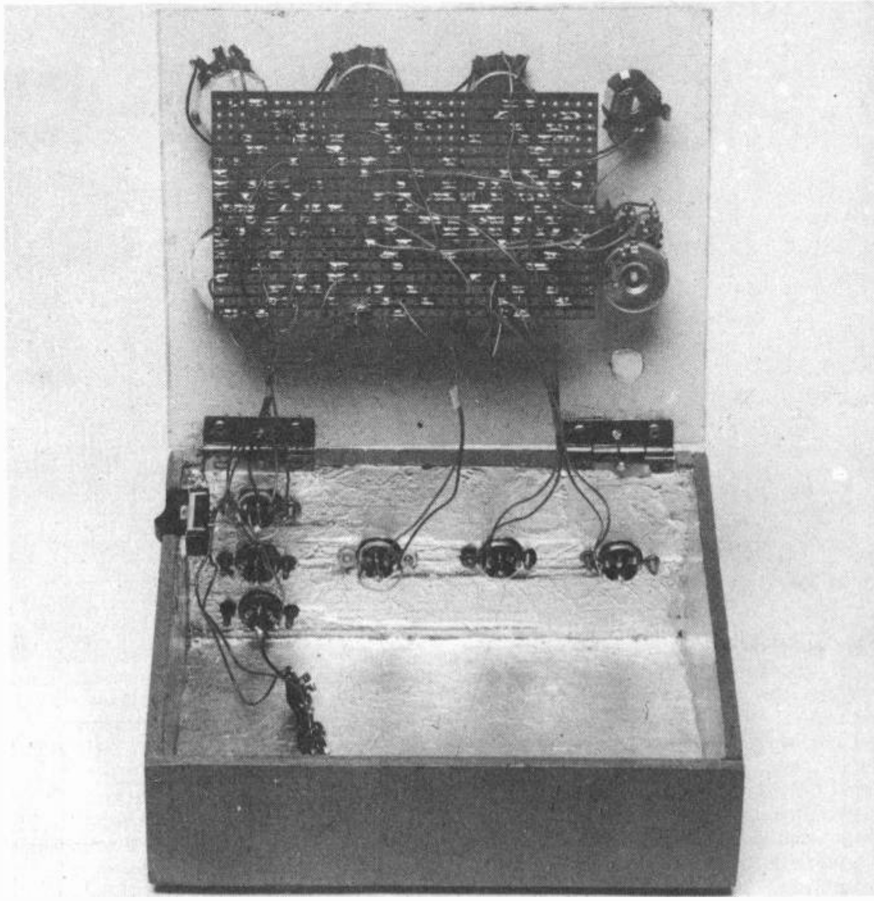
Headphone monitoring is provided by TR2. The signal is taken from one end of VR4 and applied via C7 to the base of TR2. This is again connected as a common emitter amplifier.

The output is taken via C9 to a stereo jack. This is shared with the right hand channel. Because of the design, only high impedance headphones can be used.

## POWER

Battery power is provided by two PP3 batteries one for each channel and the on-off switch S1 is a two pole type because of this.

This may seem a novel arrangement but it does mean that batteries last longer and the effects of low battery voltage are less pronounced.



The prototype 3-channel Stereo Mixer with front panel raised to expose circuit board, other components and interwiring. The plywood cabinet is lined with aluminium foil.

## COMPONENTS

**Resistors**

| | | | |
|---|---|---|---|
| R1, 101 | 4·7kΩ | R8, 108 | 47kΩ |
| R2, 102 | 5·6kΩ | R9, 109 | 1MΩ |
| R3, 103 | 47kΩ | R10, 110 | 4·7kΩ |
| R4, 104 | 5·6kΩ | R11, 111 | 33kΩ |
| R5, 105 | 470kΩ | R12, 112 | 2·2MΩ |
| R6, 106 | 5·6kΩ | R13, 113 | 4·7kΩ |
| R7, 107 | 5·6MΩ | | |

All ¼W carbon ±5%

See Shop Talk page 93

**Potentiometers**

| | |
|---|---|
| VR1-VR3, 101-103 | 5kΩ log. carbon (6 off) |
| VR4, 104 | 10kΩ log. carbon dual gang (1 off) |

**Capacitors**

| | |
|---|---|
| C1-C3, 101-103 | 1μF 25V elect. (6 off) |
| C4, C5, 104, 105 | 5μF 25V elect. (4 off) |
| C6, 106 | 100μF 25V elect. |
| C7, 107 | 5μF 25V elect. |
| C8, 108 | 0·1μF polyester |
| C9, 109 | 220μF 25V elect. |
| C10, 110 | 5μF 25V elect. |

**COMPONENTS approximate cost £14·50 complete**

**Semiconductors**

| | |
|---|---|
| TR1-TR3, 101-103 | BC109C *npn* silicon (6 off) |

**Miscellaneous**

| | |
|---|---|
| SK1, 2, 3, 5 | 5-pin DIN 180 degree (4 off) |
| SK4 | 0·25 inch stereo jack |
| S1 | d.p.s.t. rocker |
| B1, 2 | 9V PP3 type (2 off) |

Stripboard 0·15 inch matrix, 19 strips by 39 holes; battery clips (2 off); 4mm plywood for case; 4BA nuts, bolts and collars for mounting circuit board; aluminium panel, 185 × 50mm for front panel; foil for lining case; interconnecting wire.

Note that all component references prefixed by 100 refer to the right hand channel.

# CONSTRUCTION starts here

## CIRCUIT BOARD

All the components are assembled on a piece of 0·15 inch stripboard 19 strips by 39 holes, according to Fig. 2. All right hand channel components are numbered from 100 so, for example, R1 is the input resistor in the left hand channel and R101 is the same resistor in the right hand channel.

After this has been completed the next stage is to assemble the cabinet and front panel. The cabinet in the prototype was made from 4mm plywood size 185×140×75mm sloping down to 40mm.

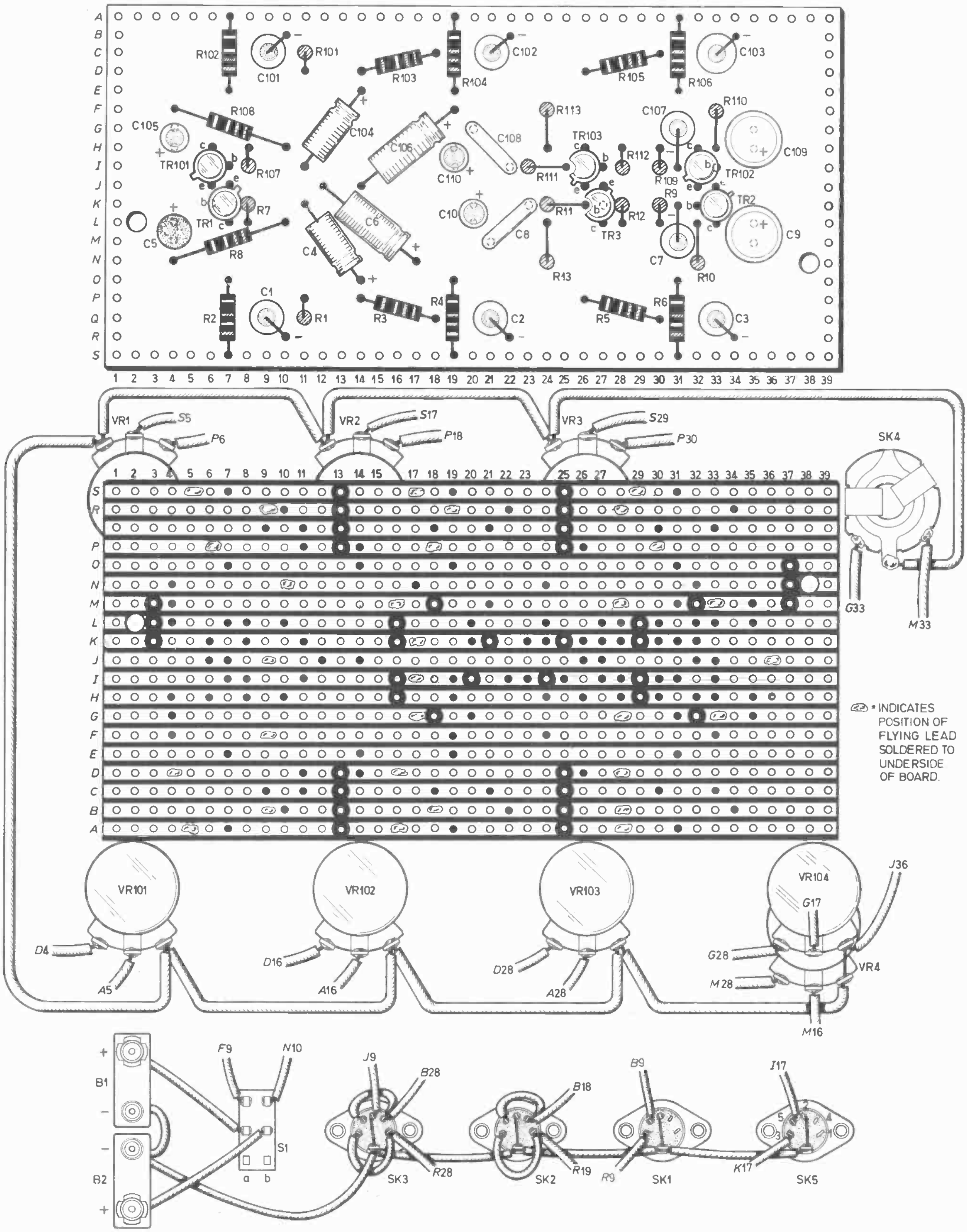



Fig. 2. The circuit board of the 3-channel Stereo Mixer. (Top) topside of board showing all components in situ. (Below) strip-side of board showing all breaks in copper strips. Also, note that the interconnecting leads are soldered to the strips as indicated by the solder "blobs".

## FRONT PANEL

The front panel is made from 16 s.w.g. aluminium and is fastened onto the cabinet by means of brass hinges. This makes access to the interior very easy.

Once all the off board components are mounted in place, the interwiring between them should be completed. This includes the sockets mounted in the back of the case.

The board should then be mounted in position above the controls using 4BA nuts, bolts and spacers. This was done using stiff wire in the prototype but the nuts and bolts are much better.

The wiring from the controls can now be completed. This project is unusual in that wiring to the board is taken to the reverse, that is copper coated side. Make sure that connections from VR1 and 2 and 3 are as short as possible and that every joint is a good one, otherwise you will get hum pick up and noise.

The front panel should be earthed and additional screening can be provided by lining the case with tin foil.

## FINISHING OFF

All that remains now is to check the construction thoroughly and label up the front panel.

Possible modifications would be using separate sockets for the right and left inputs on each channel or providing two or three outputs all connected in parallel, though these haven't been tried.

A point to bear in mind when using a tape recorder as a signal source is that the standard DIN socket arrangement is to have input and output of the recorder on the same socket.

This means that if pins 4 and 5 and pins 1 and 3 are wired together in the input socket on the mixer, then you will be feeding the output of the recorder straight back into its recording amplifier. This will affect the quality and magnitude of the signal actually entering the mixer.

The only way round this is to make sure that such a link does not exist and that the input only goes into pins 1 and 4. ⌘

---


### Looking Ahead

Now is the time of year, when Old Moore Young carries out his famous trick of foretelling the future by looking through the bottom of an empty beer glass. My fellow Astrologers tell me that crystal balls and beer glasses are now "Old Hat", that all they do now, is to pop some questions into their computers and wait for the answers.

I was about to hire one of these monsters for half an hour, when I suddenly remembered that only recently, a computer operator, who happens to be a friend of mine, was popping questions into his computer one day, when suddenly without a word of warning it started firing questions back at him. He grabbed his coat and hat and started to run, and as far as I know he is still running.

So back to my beer glass. Ah! here we go. February, Government Minister announces Microwave Ovens are now one hundred per cent safe! March, Government Minister announces the opening of two thousand more Microwave Oven Testing Stations!

April, The Electricity Board announces that central heating with storage heaters is very cheap, and they will be delighted to install one for you for, £250. May, Dustmen demand extra pay for having to cart away storage heaters weighing half a ton. June, householders told to bury their unwanted storage heaters in the garden, as all refuse dumps are full!

This is terrible! At this point I reluctantly left my beer glass and decided I would ask an old Chinese Sage I know, called Dai Ling, if he could tell me whether these predictions would come true.

After I had put the question to him, he uttered just one mystical Chinese word, which sounded like "Famfino". I will translate it for the benefit of the one or two of my readers who don't speak Chinese, it is an expression of extreme dubiety!

There is one other forecast that I will guarantee will come true. The customers who write queries on their order forms, will be the last to receive their goods.

### Good Criticism

I am always pleased to have letters from readers, especially when they contain constructive criticism. A case in point, is a charming letter from Mr. E. F. Good (see *Letters* page December).

I recently suggested that you write your address in block capitals. Mr. Good says they look uncouth.

The point I was trying to make, is that your address should be clearly legible to us. Quite often the addresses look as though they have been written in Sanskrit or Cuneiform, and all we can do is to cut the address off the order and stick it on the parcel. I must make it abundantly clear, that Mr. Good's own writing is so perfect, that I thought at first it had been done with a special typewriter.

I also said "send the exact money". Nothing at all complicated was intended here, simply that you work out what the price should be, and send just that. Mr. Good's suggestion that the customer should send an open cheque limited to a certain amount, is an excellent one, and many customers already adopt this procedure.

It is particularly valuable at the presen time, as price lists are usually wrong before the ink has dried. However, I must take exception on his last point, where he says that catalogues tell lies, by showing goods that are not available.

While I sympathise with his disappointment, he can take it from me, that none of us, would put a single item in our catalogue, if we thought that there was the slightest chance of it not being freely available for the life of the catalogue. Remember that the life of a catalogue is probably a year, because it is necessary to print that number in order to obtain a reasonable price. Also remember that our suppliers are not going to tell us if they intend to drop an item, for very obvious reasons.

The type of letter that delights me, is one like the following:

> Dear Sirs,
>
> If "Jenny" misses her battered old 1978 catalogue complete with coffee stains and her name written on it, tell her I have it, and am most willing to return it.
>
> I received an out-of-date old catalogue, with a price list dated Jan 1979. (The back page is so badly printed, I cannot read it.)
>
> On top of that, I had to pay the postman 7p surcharge as it was understamped.
>
> If things are as bad as that I will let you have this catalogue back free *and* pay full postage.
>
> Yours faithfully

One can never resist a little humour. By the time our friend reads this, Jenny will be too busy cleaning up the stains caused by her new baby, to worry about sending coffee stained catalogues to customers.

### Buzz Off

Finally, I recently had an order from a customer made out on a firm's headed note paper. The firm was called "Audio Buzz" and when I looked at the name on the cheque, it was, "Hornet", and it was un-signed!

I felt very tempted to write and say, "You can't sting me!", but I changed my mind in case Mr Hornet should take umbrage.

Wishing you all a successful constructional year in 1981.


**By Dave Barrington**

## New Publications

The new edition of the 1981 Maplin catalogue contains well over 5,000 products in its 320 pages. Of these over 1,000 are new items to this edition.

A new feature is the inclusion of a sectionalised alphabetical "thumb" index system to aid location of lines. This is in addition to the normal component index.

Having run out of superlatives to describe the Maplin Catalogue, price £1·25 mail order or £1·00 from W. H. Smiths, we can only add the following: BUY IT!

Two new publications which give details of practical designs for a 10/20W and a 25/30W hi fi power amplifiers using Darlington Devices has just been published by Mullard Ltd.

Copies are available from Technical Publications Department, Mullard Mitcham, New Road, Mitcham, Surrey, CR4 4XY.

## Capacitors

Before we press on with this month's component buying we should like to make a general point regarding capacitors used in all constructional projects.

When ordering capacitors you may be given one with greater working voltage than specified. This is quite in order. Most of our projects are low power and a good "rule of thumb" approach to apply here is to never accept one which has a lower rating than the voltage of the circuit.

Also, capacitors come in all shapes and sizes so make sure the component being supplied will fit on the circuit board or within the case.

## CONSTRUCTIONAL PROJECTS

### Car-Actuated Driveway Light

The *Car-Actuated Driveway Light* uses a RS decade bar display, type Bar LED 586-706. Another suitable red 10 segment "bargraph" l.e.d. is listed by Watford Electronics. Only six segments are used.

It is quite in order to use individual l.e.d.s for the display. These could be the TIL 209 or TIL 220 types. A small saving will be made by purchasing individual l.e.d.s and are more readily available.

Any relay with a coil resistance greater than 185 ohms and mains rated contacts at 2A to 3A according to the driveway bulb.

### Four-Band Radio

The coils, aerial, filters and amplifier i.c. required for the *4-Band Radio* are all available from Ambit International. The tuning capacitor and trimmers are available from Ambit, Home Radio, Watford Electronics and Maplin.

### Simple 3-Channel Stereo Mixer

All components for the *3-Channel Stereo Mixer* are readily available and should not be troublesome to obtain.

The front panel controls are all "log." types and the master volume control is a dual-ganged item.

### Ni-Cad Charger

The mains transformer used in the prototype unit of the *Ni-Cad Charger* was a RS type 196-381. It is possible to replace the 1mm range plugs and sockets with a multi-way rotary switch.

The TIP 3055 power transistor is available from most advertisers but be sure to mount it on the metal heatsink as indicated.

### I.C. Uniboard Power Supply

Looking through the "Comp" list for the *I.C. Uniboard—Power Supply*, the first items we come across that could cause problems are the wirewound resistors, rated at 4 watts.

Most suppliers seem to stock 3W and 7W types. However, the RS4 range stocked by Electrovalue are listed as 4W rating. Also the E24 wirewound series from Watford Electronics are claimed to be 5 watt types and would be suitable.

For a more even power dissipation (heat), the values of the wirewound resistors R2 and R3 could be changed to 4·7 ohms and 3·3 ohms 4 watts respectively.

It is strongly recommended that the TO-5 can voltage regulator type LM317H be used. The "H" denotes the TO-5 package. This device is available from Watford Electronics.

The TO-3 version can be used but will require a complete mica washer insulating bush kit.

The panel mounting TO-5 heatsink must be purchased with the insulating mounting pieces. These are listed in the Maplin catalogue as TO-5 Chassis Heatsink number WR34M.

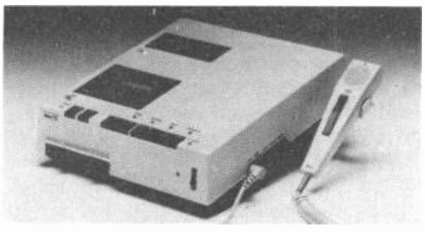
A suitable mains transformer and bridge rectifier can be purchased from most advertisers, such as J. Bull, Magenta, Electrovalue, Maplin and Watford.

### Signal Tracer

When ordering the potentiometer VR1 for the *Signal Tracer* be sure to specify a log. (logarithmic) type with switch.

No other component problems should be encountered.

# NEW PRODUCTS



Doro 721QA from Ansamatic


Enviro Systems Cruise Sentry

## Getting the Message

If you think that talking to a machine is a sign of impending madness—beware. The latest answering machine from Ansamatic is more than a glorified message taker.

This new model adds a new dimension to telephone answering by leading a caller through what might be a very complex message by asking questions and giving the caller time to answer; and if that is not enough it also acts as a dictation/transcription unit during the day. It is even set up so that if you make a mess the first time round you can go all the way through your message again.

Full details of the Doro 721 QA can be obtained from Ansamatic, Dept EE, Viatron House, 928 High Street, Finchley, London N12 9SL.

## Fuel Economy

Cruise controls for the motor car are nothing new and at one time or another all sorts of ideas have been tried with varying degrees of success. However, the Cruise Sentry, marketed by Enviro Systems Ltd claims to be the "worlds first 100 per cent electronic cruising control".

Various safeguards have been built into the design such that the system can be disengaged quickly and the preset cruising speed can be modified at any point without first disengaging the unit.

The Cruise Sentry is available in the UK directly from Enviro Systems Ltd, Dept EE, Hempsfell Road, Grange-over-Sands, Cumbria LA11 6BE, price £78·50 plus VAT.

## Light Probe

The "Lite Probe" from Edward Fletcher and Partners consists of a small hand-held torch and a 230mm long flexible Fibre Optic Light Guide. It can be used for illumination and inspection in inaccessible areas or wherever a direct light source will not penetrate.

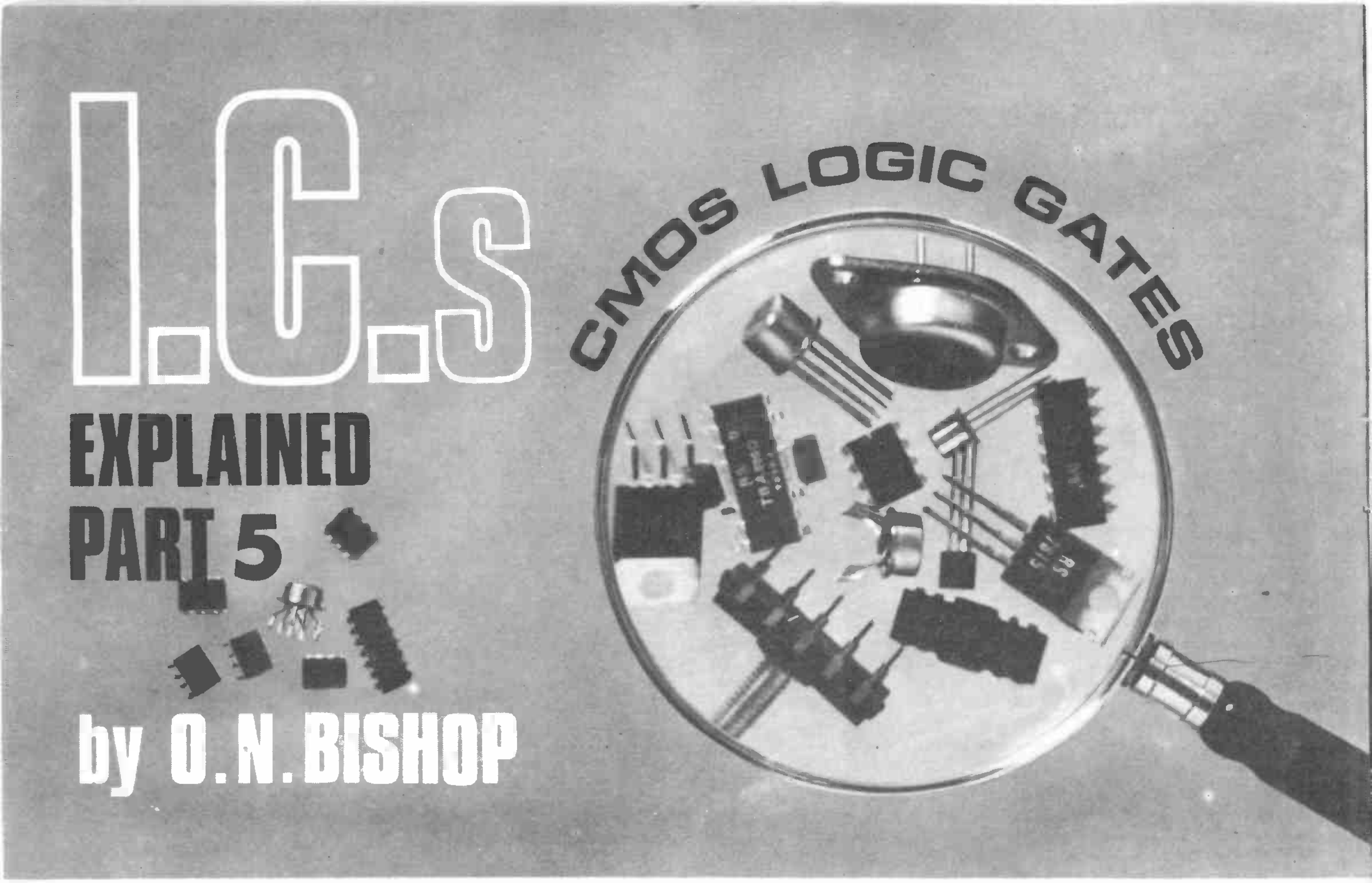
It is easy to see who will benefit from such a device and the electronics constructor will find it especially useful when it comes to looking in dark corners.

The Lite Probe is available by post from the manufacturers: E. Fletcher and Partners Ltd, Dept EE, 25 West Park Road, Kew, Richmond, Surrey TW9 4DB, price £1·99 including post and packing and VAT.

# I.C.s EXPLAINED PART 5

## CMOS LOGIC GATES

by O. N. BISHOP

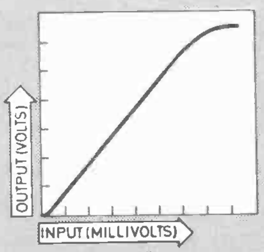


SO FAR in this series the i.c.s described have all belonged to the group known as *linear* i.c.s. For the remainder of the series we shall be concerned with the other main group, the *digital* i.c.s. The essential difference between the two groups may be understood by looking at the way in which we describe their action.

### LINEAR/DIGITAL

The action of a typical linear i.c., such as an amplifier is described in Fig. 5.1a. The input to the amplifier consists of a voltage that can vary over a given range of a few millivolts. The output of the amplifier varies correspondingly over a range of a few volts. For each value of input voltage there is a corresponding output voltage and Fig. 5.1a is the graph that shows their relationship. The input and output voltages can take any of the infinite number of pairs of values within their ranges. The graph is a *line*, straight or perhaps curved, giving us the name *line*ar for this type of circuit.

The action of a typical digital i.c. is described in Fig. 5.1b. It has two input terminals and one output terminal. The circuit operates properly only when its inputs are at one of two definite voltages. One voltage is 0 volt, the same voltage as the 0 volt rail of the power supply to the i.c. We often refer to this as "low" or use the symbol "0" as in Fig. 5.1b. The other voltage is a positive voltage, the same voltage as the positive power supply to the i.c. We refer to this as "high" or use the symbol "1". Voltages below low or higher than high usually damage the i.c. and voltages *between* low and high produce rather unpredictable results. So we are concerned with only two types of input—low or high, 0 or 1. Similarly the output of the circuit can be only low or high.




(a)

| INPUT A | INPUT B | OUTPUT |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

0 ≡ 0V    1 ≡ +9V

(b)

Fig. 5.1. Describing the action of integrated circuits (a) a graph illustrates the action of a linear i.c. (b) a truth table illustrates the action of a digital i.c.

The behaviour of a digital circuit is not described by a graph but by a table. In this we list all possible combinations of low and high inputs, together with the resulting output. Rather than write the words low and high or 0 volt and 9 volt we find it easier and clearer to use the symbols 0 and 1. The section of the i.c. is thus described by a table of *digits*, giving us the name *digital* for this type of circuit.

The action listed in Fig. 5.1b can be described in another way. It will be noticed that the output is high only when input *A* AND *B* are high. For all other input conditions, the output is low. In other words, the output is the result of applying the logical AND operation to the input conditions.

### LOGICAL RULES

Digital circuits behave according to logical rules. This is why they are so important for performing logical operations and are the working elements of pocket calculators and digital computers. The table of Fig. 5.1b is identical with the *truth table* for AND, as it would be written out by a mathematician.

If we use the binary system, we can represent numbers by a series of 0s and 1s. For example, seven is represented by 111 in binary and 353 by 101100001. The voltages in our digital circuits can be used for logical operations, including arithmetical operations, having only two definite voltage

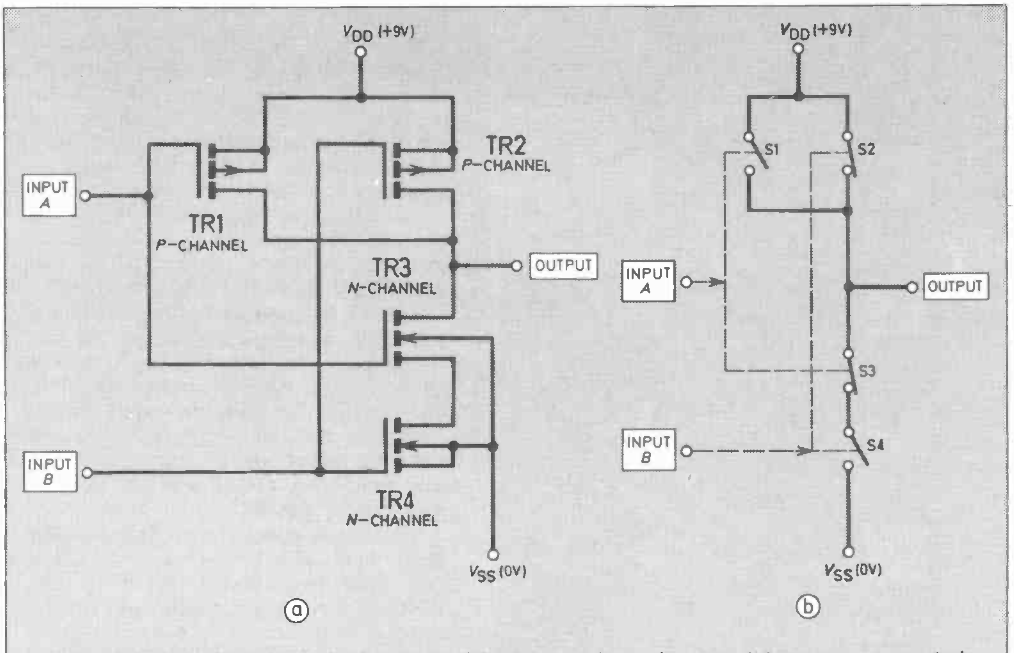



Fig. 5.2. A typical CMOS logic circuit (a) showing how the transistors are connected (b) equivalent circuit employing pairs of switches.

Table 5.1. Truth table for the action of circuits in Figs. 5.2 and 5.3.

| INPUT A | INPUT B | OUTPUT |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

levels. Digital i.c.s are reliable and fast acting, making them ideal for computers. This is why digital computers work in the binary system. Digital i.c.s are grouped into families according to their method of manufacture and operation. One of the earliest was DTL (diode-transistor logic) but this was quickly superseded by TTL (transistor-transistor logic); TTL (often known as the "7400 series") is widely used in computers because of its high speed of action. It requires relatively large amounts of power, but there are sub-families of TTL, such as the 74LS series (Low Power Schottky) which requires only one fifth of the power of standard TTL yet operates twice as fast. The TTL i.c.s employ ordinary bipolar transistors.

## CMOS DEVICES

Another large family is CMOS, which is based upon field effect transistors of the metal oxide silicon (MOS) type. Switching is performed by two complementary transistors, making the full name of this family "complementary metal oxide silicon" or CMOS for short. The CMOS family is the subject of the remaining articles of this series.

Each complementary pair of transistors consists of a *p*-channel MOS field effect transistor and an *n*-channel MOS field effect transistor. A *p*-channel transistor is switched on by a low input; an *n*-channel transistor is switched on by a high input.

In Fig. 5.2a we see how two complementary pairs of CMOS transistors are connected in an integrated circuit to perform a logical action. The "gate" electrode of each transistor is insulated from the rest of the transistor by a film of silicon oxide, so the input impedance of each transistor is extremely high. This means that virtually no current is required to turn the transistor on or off. The result is that this family of i.c.s operates on only a few microamperes.

A further result is that the output of one circuit can be used as input to a hundred or more similar circuits. With TTL, the maximum number of circuits that can be so driven is usually limited to eight.

Low current consumption means small dissipation of power. This factor, combined with the ease with which hundreds of circuits may be interconnected, means that extremely complex logic circuits can be fabricated on a single slice of silicon. In short, the properties of CMOS make it ideal for large-scale and very-large-scale integration (LSI and VLSI), providing us with microprocessors, memories and many other complex logic circuits.

## CMOS PRINCIPLES

The principle of the simple logic circuit of Fig. 5.2a is shown in Fig. 5.2b. The switches are controlled in pairs, and are such that when one switch of a pair is off the other one is on. This follows from the fact that each pair consists of one *p*-channel and one *n*-channel transistor. Fig. 5.3 shows what happens for all possible combinations of inputs. The output is connected either to the positive supply line or to the 0 volt line, depending upon how the switches (i.e. the transistors) are set. The truth table of this action is seen in Table 5.1 and shows that for any given pair of inputs, the output is the opposite or

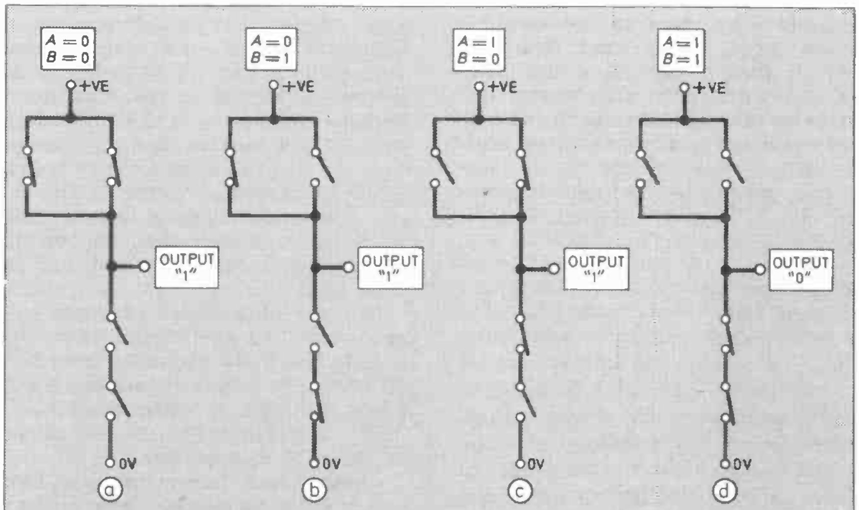



Fig. 5.3. Switching action of the logic circuit for all four possible combinations of input conditions. "0" = 0V and "1" = +9V.

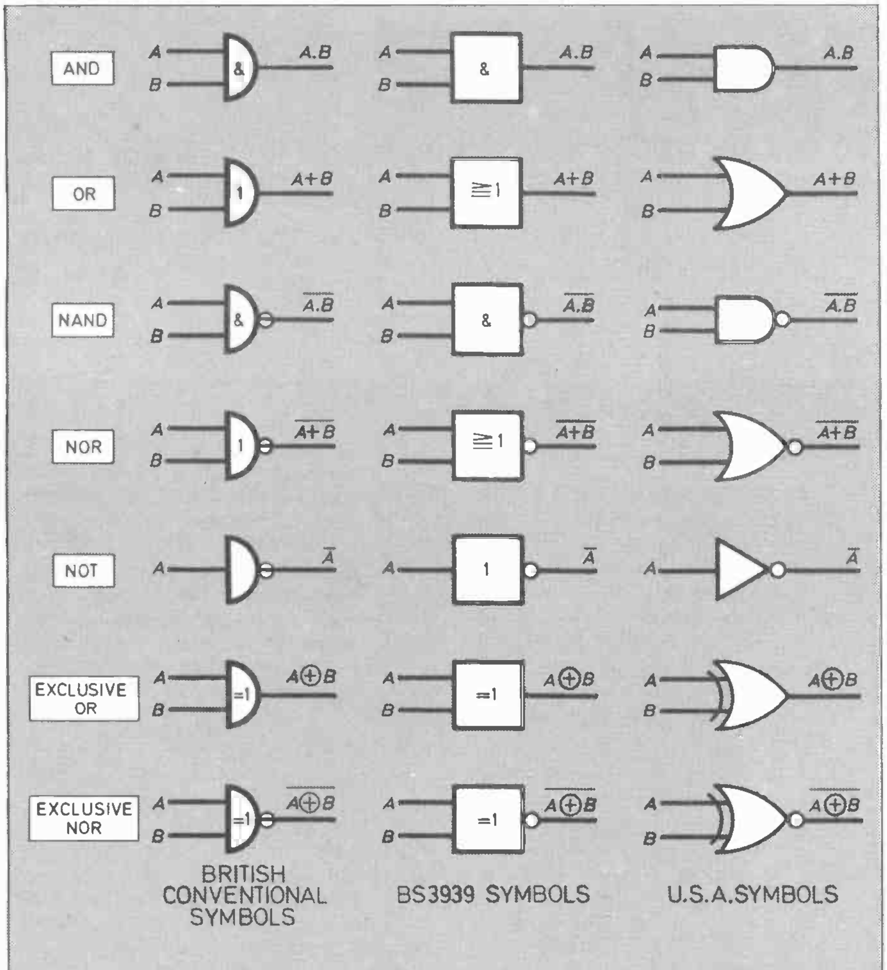



Fig. 5.4. Symbols for logic gates and their logical operation.

*inverse* of the output of an AND circuit (Fig. 5.1b). The output is INVERT-AND or NOT-AND, usually shortened to NAND.

The terms $V_{DD}$ and $V_{SS}$ need some explanation. Each MOS transistor has a "source" terminal through which electrons enter the transistor when a current flows. These come from the negative rail of the supply (0 volt) and the voltage at the source terminals of all transistors is called $V_{SS}$. The electrons drain away from each transistor by way of the "drain" terminals, toward the more positive voltage, $V_{DD}$. The difference between $V_{DD}$ and $V_{SS}$ ($V_{DD}-V_{SS}$) can be anything between 3 volts and 18 volts and need not be regulated. This makes the CMOS family very convenient for use in battery-powered portable equipment (e.g. pocket calculators, digital wrist-watches). The third terminal to each transistor is the "gate", mentioned earlier. In speaking of logic circuits we often use the term gate to refer to a complete logical unit, such as the circuit of Fig. 5.2a. It is in this sense that the term will be used in the remainder of the series.

## LOGIC GATES

When we draw circuit diagrams of logic circuits we do not normally draw the individual transistors. Instead we use symbols to represent the gates (Fig. 5.4). The OR operation produces a high output when either $A$ OR $B$ (or both) inputs are high; NOR is OR followed by the NOT (or INVERT) operation. In Fig. 5.4 the outputs are written according to the notation of Boolean algebra in which "." means AND, "+" means OR and "$\overline{A}$" means "NOT $A$". On the symbols, NOT is indicated by the small circle at the output. These simple gates occupy little space on a silicon chip and an i.c. normally contains several gates of the same kind.

The pin connections of commonly-used CMOS i.c.s are illustrated in Fig. 5.5. Members of this family from RCA all bear type numbers beginning with 40 or 45. This is often prefixed by "CD", signifying i.c.s manufactured by the RCA Corporation.

Another well known family of CMOS i.c.s is from Motorola. Their prefix is MC1 followed by 40, 41 and 45. Generally these are pin compatible with those from RCA, e.g. MC14001 and CD4001, but check with data sheets first.

The first i.c.s to be produced belonged to the "A" series (CD4000A etc.), but these have now been replaced by the "B" series (CD4000B) which has greatly improved operating characteristics. In the full designation, the final letter indicates the type of package. The only kind likely to be met by the amateur is the dual-in-line plastic pack, indicated by the final letter E, as in CD4000BE.

All the B- series have buffered outputs. For example, the output of the NAND gate is followed by two NOT gates of the type shown in Fig. 5.6. The output is thus inverted twice, restoring it to its original form but with the advantage of more rapid rise and fall times, giving a better defined and crisper action.

The same NAND circuit followed by three NOT gates produces an AND output. Four gates of this type are supplied as the 4081BE, quadruple 2-input AND i.c. Buffering of outputs is a great improvement, but it increases the time that the gate takes to act (delay time) and makes it less suitable for operating at high frequency. Therefore certain i.c.s in the 4000 range are available with unbuffered outputs. These are designated by a "U" as in 4011UBE. Specialist CMOS i.c.s such as clocks, microprocessors and memories have their own type of numbering systems.

## FUNCTIONS

The 4000 i.c. is unusual in having two kinds of gate. Note that the NOR gates on this i.c. have three inputs. Their output is low when any one or more of their inputs are high. The single NOT (or inverter) gate is useful but it is often simpler to build such a gate from a NAND or NOR gate as in Fig. 5.7.

If a large number of inverters is required, the 4069 contains six such gates. Another i.c. containing inverters is the 4049, illustrated in Fig. 5.5. This is not only an inverter but also is a buffer. Note that it has no $V_{DD}$ terminal but has a $V_{CC}$ terminal instead. This i.c. can be used as a straightforward inverter i.c., the $V_{CC}$ terminal being connected to the $V_{DD}$ line.

Its special purpose is for interfacing between CMOS and other logic systems, such as TTL. The latter requires a 5 volt supply ($V_{CC}$). By using this i.c., with pin 1 connected to +5 volt the inputs may be taken from CMOS, operating at *any* voltage in their range, and the maximum output voltage of any gate becomes +5 volts, which is compatible with TTL.

If buffer function is required, without the NOT action, there is the 4050 buffer i.c. which gives high output when its input is high and vice versa.

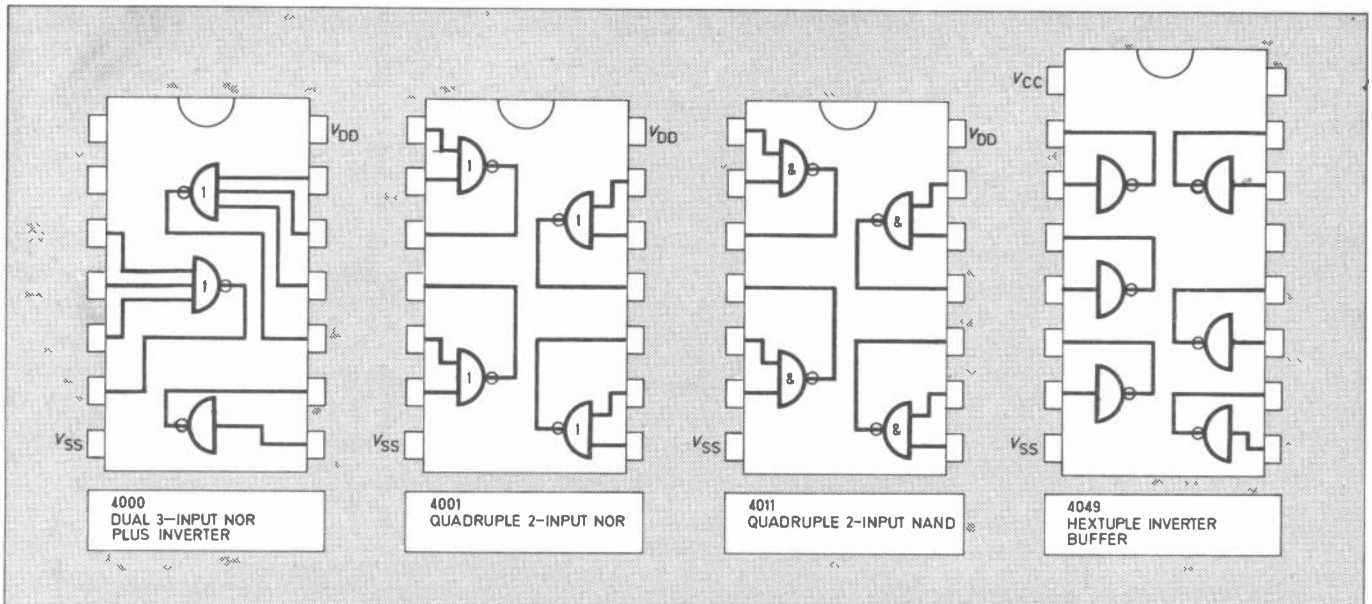



Fig. 5.5. Outlines of some common i.c.s containing simple gates.

Table 5.2 lists the logic gates currently available in the CMOS family. In addition, there is the 4007 "do-it-yourself" logic gate i.c. that will be described in a later part of this series. Certain devices, such as the 4078 and 4041 appear under two headings. They have two outputs, one output being the normal or "true" output and the other being the inverse of this. The 4078 can therefore be used as a NOR gate and as an OR gate at the same time.

**Table 5.2 Logic gates in the CMOS 4000 series.**

| Function | No. of inputs | Series number | No. of gates per package |
|---|---|---|---|
| AND | 2 | 4081 | 4 |
| | 3 | 4073 | 3 |
| | 4 | 4082 | 2 |
| | 8 | 4068 | 1 |
| NAND | 2 | 4011 | 4 |
| | 3 | 4023 | 3 |
| | 4 | 4012 | 2 |
| | 8 | 4068 | 1 |
| OR | 2 | 4071 | 4 |
| | 3 | 4075 | 3 |
| | 4 | 4072 | 2 |
| | 8 | 4078 | 1 |
| NOR | 2 | 4001 | 4 |
| | 3 | 4025 | 3 |
| | 3 | 4000 | 2* |
| | 4 | 4002 | 2 |
| | 8 | 4078 | 1 |
| NOT | 1 | 4049 | 6** |
| | 1 | 4069 | 6 |
| | 1 | 4502 | 6*** |
| | 1 | 4041 | 4** |
| NON-INVERTING BUFFERS | 1 | 4050 | 6*** |
| | 1 | 4503 | 6*** |
| | 1 | 4041 | 4** |
| EXCLUSIVE-OR | 2 | 4070 | 4 |
| EXCLUSIVE-NOR | 2 | 4077 | 4 |

* plus one NOT gate
** buffer
*** tri-state output

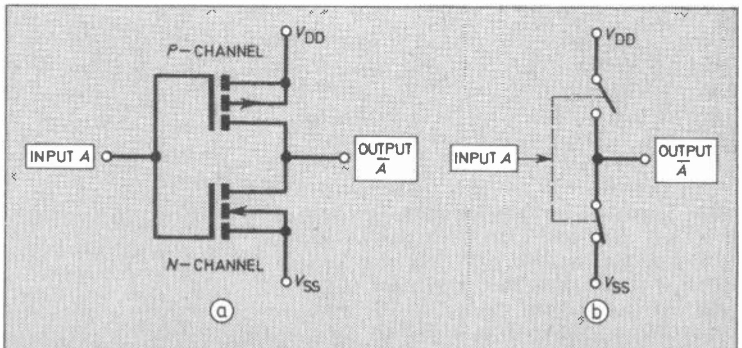



Fig. 5.6. A complementary pair, forming an INVERT or NOT gate (a) as in the i.c. (b) equivalent circuit.

Another logical function that is often used is EXCLUSIVE-OR. The gate has two inputs and differs from OR in that output is high when either *A* OR *B* but *not both A and B* are high. In other words, its output is low when both *A* and *B* are low or when both *A* and *B* are high. Identical inputs give a low output.

A set of such gates is often used to compare one set of binary digits with another, one gate being used for the corresponding digits of each set. If both sets of inputs are identical, all outputs are low.

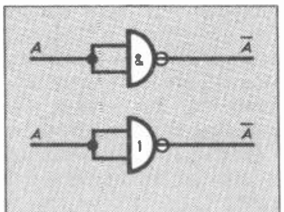



Fig. 5.7. Two ways of making a NOT gate.

## TRI-STATE OUTPUTS

The 4502 and 4503 buffers differ from the others in that they have what is known as a "tri-state" output. This may seem nonsense after it has been stressed that logic i.c.s have only two states—high and low. The third state is "high impedance". As Fig. 5.8 shows, in the high impedance state the output stage of the gate is isolated from the earlier stages.

This type of output is particularly useful in computers and microprocessor systems when we want to be able to use the same sets of lines (or buses) for transferring data between various parts of the system. The output terminals of all parts of the system are permanently wired to the

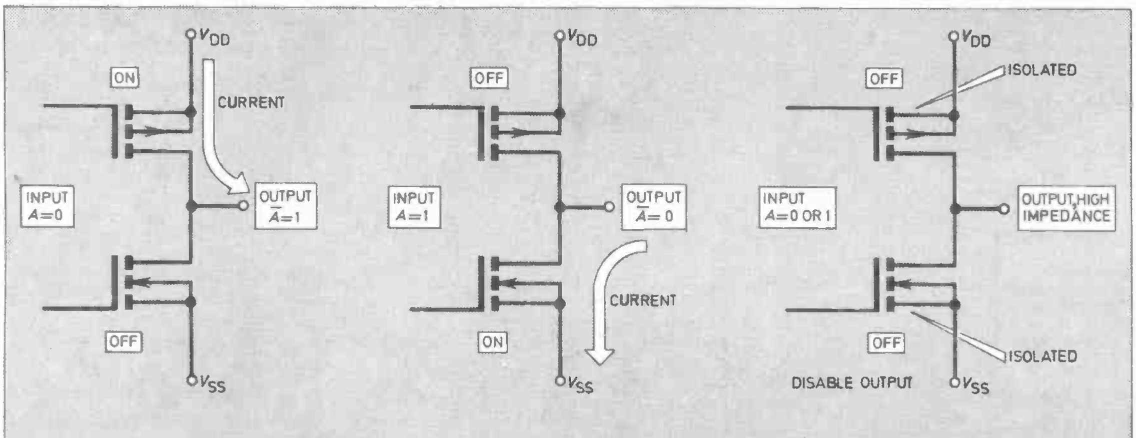



Fig. 5.8. Action of a high impedance output.

buses, but can be in effect disconnected under electronic control whenever necessary. When one i.c. is connected to the bus and transmitting data signals, the outputs of all other i.c.s wired to that bus are in the high impedance state so that they act as if they were not really there.

Perhaps the most versatile logic gate i.c. is the 4048. Not only does it have tri-state output but it has three control inputs that cause it to perform the AND, NAND, OR or NOR functions with up to eight inputs. Further functions are two 4-input gates, their outputs going to a 2-input gate, giving OR/AND, OR/NAND, AND/OR or AND/NOR.

Furthermore the i.c. has an expander input to which a second 4048 can be connected, giving a 16-input gate. For details of how to use this gate, see the manufacturer's data sheets.

## WORKING WITH CMOS

Apart from the well known precaution of avoiding static charges that could damage the i.c., working with CMOS presents no problems. They can be powered by battery or from an unregulated mains power-pack at any voltage between 3 volts and 18 volts. Their inputs can be connected directly to 0 volt or the positive rail. Indeed, it is essential to do this for any unused inputs, otherwise the i.c. will not function properly. The optimal operating voltage is around 10 volts; a 9 volt PP3 battery is suitable for portable equipment and, since current consumption is low, (0·01$\mu$A per gate when quiescent) the battery will last a long time.

Currents of a few milliamperes can be drawn from the output terminals. A convenient way of indicating the state of an output is to wire an l.e.d. between the output and $V_{SS}$ (0 volt). No series resistor is needed if the supply is below 6 volts.

For switching on filament lamps or other devices, the output can be fed directly to the base of a transistor. For high-power switching, one of the VMOS field-effect power transistors is ideal (VN66AF for example).

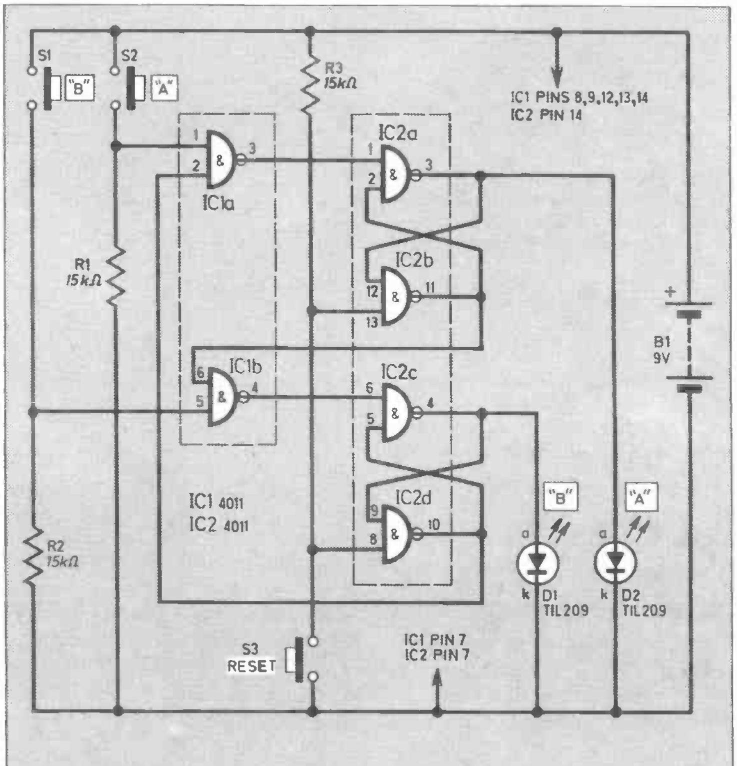



Fig. 5.9. Circuit diagram of a "Who-was-first" monitor.

## TWO FOR YOU TO TRY

The delay time of CMOS gates is less than a microsecond, so they are ideal for timing operations. In the circuit of Fig. 5.9 we use them for split-second timing, to indicate which of two buttons was the first to be pressed. This circuit could be useful as a judge in "snap" or other games where it is essential to know "who was first".

The l.e.d.s are turned on by pairs of gates cross-connected to make flip-flops. To begin with, push-button S3 is pressed to make inputs to pins 8 and 13 low. When the button is released they are held high by pull-resistor R3. Resetting makes outputs at pins 3 and 4 go low, so the l.e.d.s are not lit. To switch an l.e.d. on, a low pulse must arrive at pin 1 or 6. The gates in IC1 control the inputs to IC2. Since pin 1 is low (because of R1) and 2 is high (from IC2 pin 10) output of IC1 pin 3 is high. If S1 (player *A*) is pressed first, the output becomes low, triggering the flip-flow to change state and lighting D2. Now pin 11 of IC2 is low, so both inputs to player *B*'s gate in IC1 are low. If button S2 is pressed, the output at pin 4 stays low. *B* is too late!

If *B* is pressed before *A*, the reverse happens: D1 lights and D2 remains dark.

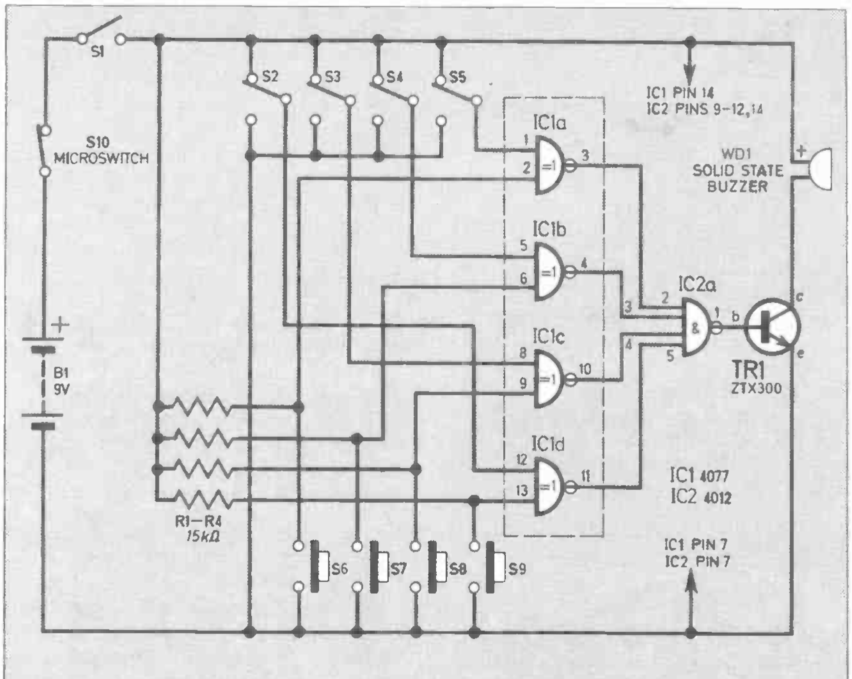



Fig. 5.10. Circuit diagram of a simple combination alarm.

The combination alarm of Fig. 5.10, can be used as the basis of many kinds of combination lock circuits. Here it is used to sound the alarm when a person not in the know opens the door of a room or cupboard. S1 is the master switch, hidden just inside the doorway. S10 is a microswitch, open when the door is closed, but closing whenever the door is opened. S2 to S5 are switches inside the room that may be set to any one of 16 high-low combinations. S6 to S9 are push-buttons mounted outside the door or on its outer surface. When leaving the room, set the combination on S2 to S5; then close S1. The alarm will probably sound, but stops when the door is shut (opening S10).

Since the circuit is now off, no battery current is being wasted. The door cannot be opened again without sounding the alarm and, unless the intruder knows were S1 is hidden, the alarm sounds until the door is closed again. However, if the *one* correct combination of buttons S6 to S9 is pressed, the inputs to pins 2, 6, 9 and 13 will match those at pins 1, 5, 8 and 12. In this event all outputs from IC1 are high.

An all-high input to the NAND gate of IC2 makes its output go low. No other combination of inputs causes this to happen. The circuit is automatically switched on (by S10) as the door is opened but, since the output of IC2 is low, no alarm sounds. S1 should be in reach of the doorway so that the circuit can be turned off. However, if even one button is pressed (or not pressed) incorrectly, one of the pairs of inputs fails to match, one exclusive-NOR gate gives a low input and the output of IC2 goes high, sounding the alarm.

For simplicity this circuit uses a solid-state buzzer. This may be mounted outside the room or elsewhere. By using an extra i.c. a flip-flop could be provided so that, once triggered, the alarm would sound indefinitely. This circuit has only 16 combinations, but has the advantage that a single mistake makes the alarm sound as soon as any attempt is made to try to open the door. It could be extended to eight buttons (256 combinations) by using a second 4077 and by substituting an 8-input NAND gate (4068) for IC2.

**Next Month:** Multivibrators and Flip-Flops.

# BOOK REVIEWS

**TRANSISTORS—QUESTIONS AND ANSWERS (4th Edition)**

| | |
|---|---|
| **Author** | Ian R. Sinclair |
| **Price** | £1·75 |
| **Size** | 165 × 110mm 104 pages |
| **Publisher** | Newnes Technical Books |
| **ISBN** | 0 408 00485 1 |

IT MAY COME as quite a surprise but the transistor has now been with us for over thirty years and although vast strides have been made in design and applications, semiconductor principles still form the backbone of virtually all modern electronic equipment.

It is against this background that Questions and Answers—Transistors by Ian Sinclair has been re-released. Unfortunately, it's not quite so easy as you might imagine to answer a question such as "What is a transistor?" in half a page and some answers have been oversimplified to the point of making them difficult to follow.

However, the book does cover a lot of ground and could be used as a quick reference volume. Whether it provides the "simple and concise answers" quoted on the back cover is another matter. S.E.D.

**TELEVISION AND RADIO 1981 (19th Edition)**

| | |
|---|---|
| **Editor** | Eric Croston |
| **Price** | £2·90 |
| **Size** | 190 × 229mm 224 pages |
| **Publisher** | Independent Broadcasting Authority |
| **ISBN** | 0 900485 39 6 |

EXPANSION is the theme of this year's book, as the IBA looks forward to the Fourth Channel, due to commence in the autumn of 1982. New horizons and fresh opportunities are discussed, and the plans for the next decade outlined. Packed with background facts, figures and photographs this colourful and informative publication gets better every year; without a single advertisement!

The seven main sections include a focus on Radio, Education, Drama, Sports, Science, Religion, The Arts and Regional Broadcasting, all presented in a lively format with plenty of well produced colour photographs of the stars and presenters, technicians and crew.

Technical details include radio reception area maps for each local station, showing transmitter sites for m.w. and v.h.f. together with frequency data. D.G.

# SIGNAL TRACER

BY F. G. RAYER

A QUICK means of locating faults in radio frequency, intermediate frequency and audio frequency stages of receivers, or in amplifiers used with microphone, pick-up or other input, is to use a signal tracer. The tracer described here can be switched at once for r.f. or a.f. circuits, and has enough sensitivity for low signal levels.

## AMPLIFIER AND PROBE

From the circuit in Fig. 1 it will be seen that there are two main items—the probe, with its isolating and detector circuits, and amplifier. The latter has an input gain control VR1, and preamplifier TR1.

Amplified signals from TR1 collector pass to TR2, which is directly coupled to the output transistor TR3. The output is taken from the emitter of TR3 to a 75 ohm speaker, and will be found to provide easily adequate volume. The whole amplifier has considerable gain, though needing relatively few components.

Switch S1 selects a.f. or r.f. conductors of the twin screened flexible lead to the probe. With S1 in the a.f. position, audio signals are taken via C2 and R1 in the probe. When S1 is set to the r.f., audio is obtained via R2, after detection by D1 in the probe, C1 being an isolating capacitor.

## CONSTRUCTION starts here

## AMPLIFIER BOARD

The amplifier is built up on a piece of 0·15 inch stripboard, size 10 strips by 22 holes and components are positioned as in Fig. 2. Place a few items at a time, turn the board over and solder the projecting leads, and snip off excess wire. Locate C5, C7 and C8 with the polarity shown.

A few points should be noted. Breaks in the copper strips are needed as shown in Fig. 2. These can be made with a cutter, or with a few turns with a sharp drill. Check that each break is complete, and that fragments of foil are not turned out to touch adjacent strips.

Later, the board will be fixed to the metal panel by two bolts, with extra nuts to give clearance.

Provide flying leads for the speaker, and red and black for positive (via S2) and negative battery connections. Connections should also be made to VR1 slider and a wire is taken from the negative line to one end of VR1 to form a common earth point.

## PANEL ITEMS

The front panel is made from sheet aluminium, 165 x 85mm. An aperture to match the speaker cone is cut with an adjustable tank or washer cutter, and perforated metal or fabric is cemented behind it, then the speaker cemented in place. The switch S1 and VR1/S2 are located as in Fig. 2.

The screened lead passes out through a grommet, as does a flexible wire fitted with a crocodile clip, used for earthing when necessary.

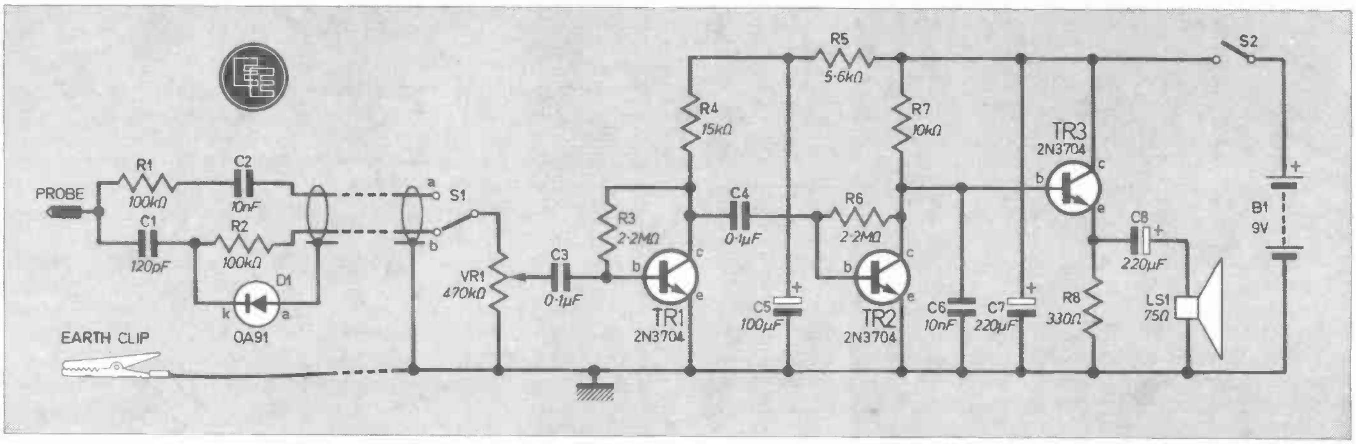
## CASE

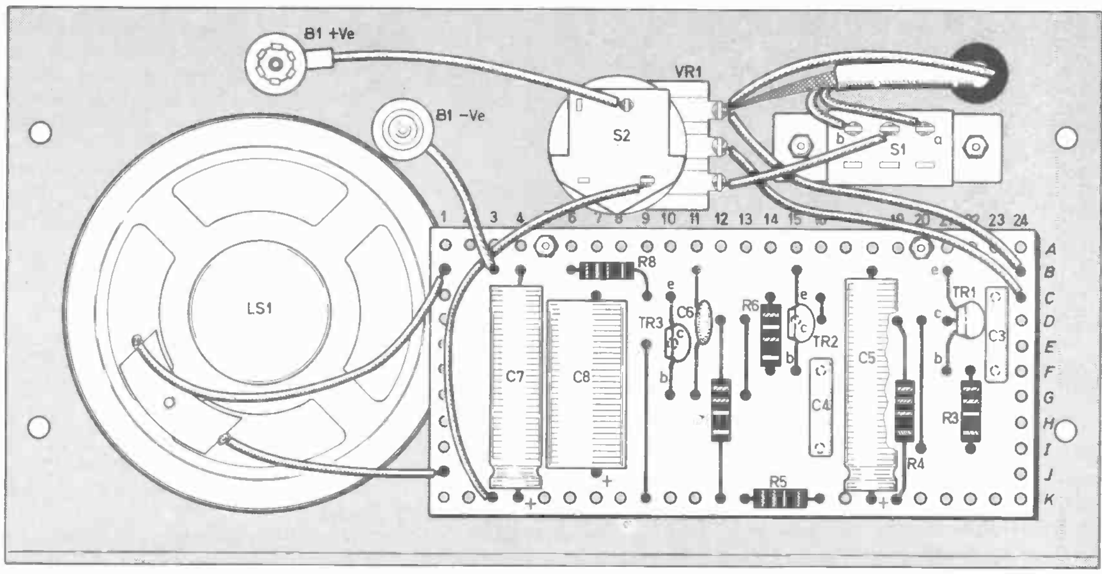
This was made from wood. The bottom is 100 x 165mm and top 75 x 165mm. Thin plywood is suitable here. Each side is made from 8mm plywood, 100mm wide at the bottom, sloping to 75mm wide at the top, and 73mm high. Four screws hold the panel in place. A PP7 or other 9V battery is accommodated.

## PROBE ASSEMBLY

This was made from a felt-tipped pen case, with the inside contents removed. Components are first

Fig. 1. Full circuit diagram of the Signal Tracer. Note that position a on S1 selects the a.f. components and position b the r.f.





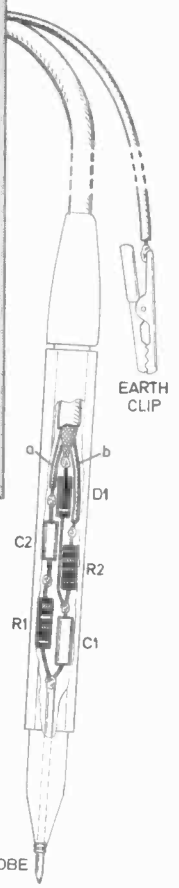
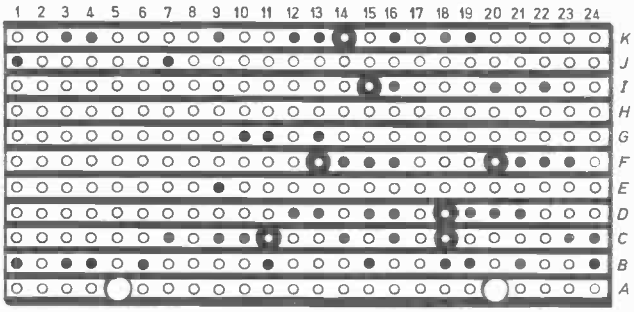




Fig. 2. Circuit board layout and component interwiring. Note that several components are mounted in the probe. Connections to the probe are made via twin-core screened cable to minimise signal loss. Conductor *a* in the probe corresponds to wire *a* at S1, and similarly with conductor *b*.
Care must be taken when drilling the mounting holes as these are close to the edge of the board and could easily cause the board to crack.



# COMPONENTS

See **Shop Talk** page 93

**Resistors**
R1 100kΩ
R2 100kΩ
R3 2·2MΩ
R4 15kΩ
R5 5·6kΩ
R6 2·2MΩ
R7 10kΩ
R8 330Ω
All ¼W carbon ± 5%

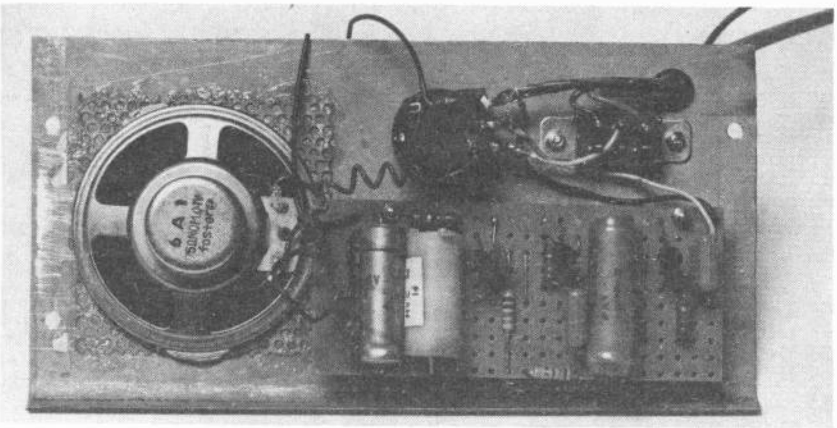
**Capacitors**
C1 120pF polystyrene
C2 10nF polyester or polystyrene
C3 0·1μF polyester
C4 0·1μF polyester
C5 100μF 25V elect.
C6 10nF polyester or polystyrene
C7 220μF 25V elect.
C8 220μF 25V elect.

**Semiconductors**
TR1-TR3 2N3704 *npn* silicon (3 off)
D1 OA91 small signal germanium diode

**Miscellaneous**
VR1/S2 470kΩ log. potentiometer with s.p.s.t. switch
S2 s.p.d.t. slide switch
LS1 75 ohm, 2·5 inch diameter speaker
B1 9V PP7 type with connectors
Stripboard, 0·15 inch matrix, size 10 strips by 22 holes: 8mm plywood for cabinet; aluminium panel, size 165 × 80mm, for front panel; screened cable; interconnecting wire; empty pen shell for probe housing; nail for probe; crocodile clip; knob; expanded metal mesh for speaker covering.


Exterior of the completed unit showing earth lead and probe in foreground.

**COMPONENTS approximate cost £7**



View of the rear of the front panel showing circuit board in position.

arranged as in Fig. 2, and soldered together. Use sleeving where necessary, though most joints can be kept clear of bare connections and other joints.

The probe is a piece of very stout wire, and is initially left long enough to pass down through the case. The pen top should have already been threaded on the screened lead. Draw items into the case as in Fig. 2, and solder a small washer or loop of wire round the probe, at the end of the case, to prevent it going back in. Cut the wire so that about 10mm projects. Fit the case top.

## TRACER USE

For all audio equipment, set S1 to the a.f. position. With non-working apparatus, test systematically from the earlier point at which the audio signal will be available. This could be the microphone itself.

Move the probe progressively along through the audio circuits, to take in leads, plugs and jack sockets, connections from sockets to switches or controls, coupling capacitors, and so on.

If the signal ceases to be heard in the tracer speaker, the interruption must arise between the point the previous test was made, and this point.

As pre-amplifiers and other stages are introduced, gain will have to be reduced by VR1, to avoid overloading. Where a signal is found at the base of a transistor, but not its collector, investigate the stage in detail by checking resistors and other components.

The earth clip is used to earth the tracer to the equipment being tested. Attach this to the earth line of the latter.

## I.F. AND R.F.

With receiver i.f. circuits, set S1 to the r.f. position. The signal can then be detected and traced through the intermediate frequency transformers, and associated components. In this way, the stage at which signals cease to be heard can quickly be found.

Radio frequency circuits allow some tests in a similar way, depending on the signal level. To test an aerial circuit alone, an external aerial will usually need to be coupled to it, to provide a signal for the detector. This coupling can often be provided by means of a few turns of insulated wire on the ferrite rod aerial, where used, and connected to aerial and earth.

*The tracer is intended only for use with transistor equipment where no high voltages are present.* ⌑

# BOOK REVIEWS

### UNDERSTANDING COMMUNICATIONS SYSTEMS

| | |
|---|---|
| **Authors** | Don L. Cannon and Gerald Luecke |
| **Price** | £3·50 Limp |
| **Size** | 210 × 134mm 288 pages |
| **Publisher** | Texas Instruments Ltd |
| **ISBN** | 0 89512 035 6 |

THIS IS one of the Understanding Series of books developed at the Texas Instruments Learning Centre, Dallas, Texas, to provide easy-to-understand texts for all those wanting to learn quickly and effectively about modern electronic technology.

The volume is divided into ten sections, each with a learning quiz: plus a short but useful glossary. Although based on a "block-schematic" rather than a circuit-diagram approach, this book undoubtedly does what it sets out to do: provides an understandable in-depth introduction to the whole world of modern telecommunications including radio, television, telephone networks and computer data networks.

It is far from a "beginners only" book although the beginner will find in it the merits of a well-designed teaching course. Unfortunately for British readers it suffers from a serious handicap. Many of the systems and standards used in the UK differ from those found in the United States.

For example all television in this book is 525 line NTSC and it is Bell Telephone System rather than British Telecom that is mentioned in several sections. This is a serious disadvantage in an otherwise excellent and up-to-date book.

P.H.

### SOUND RECORDING FROM MICROPHONE TO MASTERTAPE

| | |
|---|---|
| **Author** | David Tombs |
| **Price** | £7·95 Hardback |
| **Size** | 220 × 145mm 222 pages |
| **Publisher** | David and Charles |
| **ISBN** | 0 7153 7954 2 |

HANDS UP who remembers the old reel to reel tape recorders that everyone used to enjoy making silly noises into. You may also remember that however hard you tried to make a professional-sounding recording, it always seemed to come out wrong.

Of course good equipment always helps but even with the most expensive rig in the world, it's still what you do with it that counts and that's where this new book scores.

The author, a professional sound engineer, has set out deliberately to inform and encourage the amateur to get the best out of his equipment, not by spending a fortune on sophisticated gadgetry but by greater understanding of all the aspects of sound recording.

Some of the techniques used for catching animal sounds are particularly interesting and these are both fascinating to read and practical to use. Other topics covered in detail include studio recording, tape editing, and an extensive section on microphones and the author gives many tricks of the trade for getting round problems quickly and effectively.

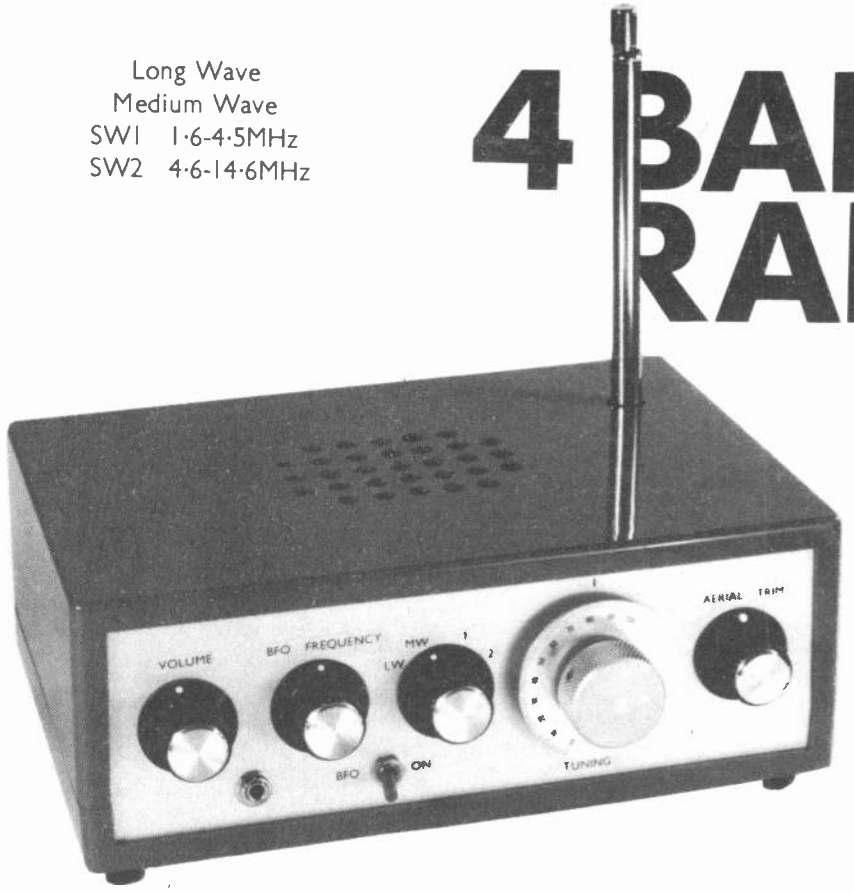
This hardback volume costs £7·95 which is about average for a book of this size but for anyone looking for an authoritative text on the subject, it is well worth it.

S.E.D.

Long Wave
Medium Wave
SWI 1·6-4·5MHz
SW2 4·6-14·6MHz

# 4 BAND RADIO

**By R.A.Penfold**




APART from covering the standard medium and long wavebands, this receiver additionally has two short wave ranges covering from about 1·6MHz to 4·5MHz, and 4·6MHz to 14·6MHz.

The set is primarily intended for the reception of ordinary a.m. broadcast stations, but it has a b.f.o. (beat frequency oscillator) which can be switched in for s.s.b. (single sideband) and c.w. (Morse) transmissions, enabling most amateur band transmissions to be resolved.

## SENSITIVITY

The circuit is of the superhetrodyne type, and is therefore quite sensitive and selective when compared with a simple t.r.f. (tuned radio frequency) set. It is also easier to operate. However, it is also far more complex and expensive to build than a simple t.r.f. set, and is likely to cost more than a comparable ready-made receiver! Nevertheless, it does make a very worthwhile and interesting constructional project that can provide many hours of entertainment when finished.

The circuit has been designed to eliminate the complicated alignment that is normally associated with superhet receivers, and the simple alignment that is required can be completed without the aid of any test equipment.

## SUPERHET

While it is not essential for constructors to understand the superheterodyne principle, it is very helpful to have such an understanding. The block diagram of Fig. 1 shows the stage line-up of the receiver, and helps to show the way in which it operates.

The aerial signal is applied to one input of a mixer, and the other input of the mixer is fed from an r.f. oscillator. The purpose of these two stages is to convert the incoming signal to another frequency, known as the intermediate frequency or i.f. In this case an i.f. of 455kHz is used, and whatever the received signal frequency may be, it is converted to 455kHz.

The point of doing this is that at the fixed and relatively low intermediate frequency it is easy to obtain high gain and a reasonably narrow bandwidth. This gives the set good sensitivity and selectivity (the latter being the degree to which the set can pick up just one transmission from a close group of stations).

The oscillator is tuned to a frequency which is 455kHz above the input signal frequency, and the heterodyne effect then produces a difference output frequency at the required i.f. For example, if the desired reception frequency is 900kHz, the oscillator would be tuned to 1·355MHz (1,355kHz), giving a difference frequency of 455kHz (1,355 −900=455).

## TUNED CIRCUIT

A tuned circuit at the input of the mixer is used to select signals at the desired reception frequency and attenuate other frequencies. This is necessary to limit the amount of signals fed to the mixer and prevent it from being overloaded. It also attenuates spurious responses which are a problem with any superhet.

One of these responses is called the "image response", and in the example given above it would occur at 1·81MHz (1,810kHz−1,355kHz=455kHz). Other responses occur due to breakthrough at the intermediate frequency and due to harmonics on the oscillator signal (signals at multiples of the oscillator frequency). At the frequencies involved here a single tuned circuit at the input is sufficient to adequately attenuate these unwanted responses.

## TWO STAGE I.F.

Two stages of i.f. amplification are employed in the receiver, and a ceramic filter is used to couple the two stages. The latter requires no alignment as it is accurately manufactured to operate at the correct frequency, and this helps to simplify the alignment of the set. The ceramic

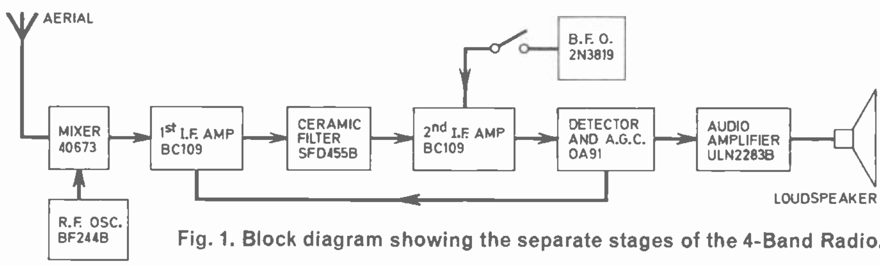



Fig. 1. Block diagram showing the separate stages of the 4-Band Radio.

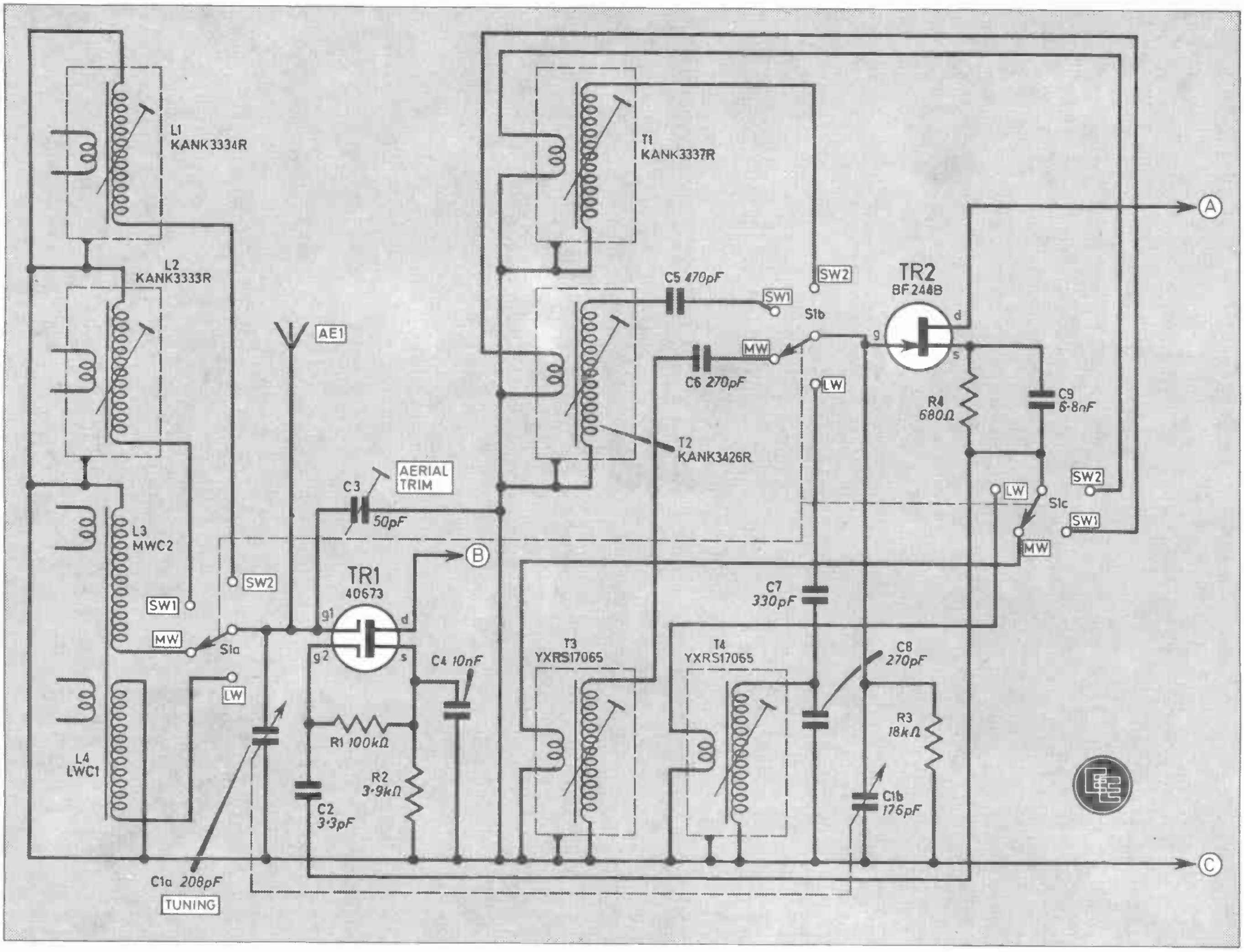



Fig. 2. The circuit diagram of the mixer and oscillator section of the 4-Band Radio.

filter provides most of the system selectivity.

The output from the second i.f. amplifier is fed to a detector which extracts the audio signal which is modulated onto the carrier wave. This is then fed to an audio power amplifier and to the loudspeaker.

In addition to the audio signal, the detector produces a d.c. potential which is proportional to the strength of the received carrier wave, and this is used to control the gain of the first i.f. amplifier. The circuit is arranged so that the stronger this d.c. signal, the lower the gain of the first i.f. stage. This is known as a.g.c. (automatic gain control) and has the effect of giving an almost constant audio output level from signals of greatly differing strengths. It also prevents very strong signals from overloading the set, and helps to counteract fading when receiving stations that are prone to this phenomenon.

A b.f.o. can be used to inject a signal into the second i.f. amplifier to permit the reception of s.s.b. and c.w. transmissions.

## MIXER AND OSCILLATOR

The circuit diagram of the mixer and oscillator stages of the receiver is shown in Fig. 2. This is really quite simple, although the waveband switching slightly complicates matters.

A dual gate m.o.s.f.e.t. (TR1) is used in the mixer stage. R2 is the source bias resistor and C4 is its bypass capacitor. The gate 2 terminal must be biased about 1 volt positive, and R1 couples a suitable bias voltage to this terminal from the source of TR1. The oscillator signal is coupled to the gate 2 terminal of TR1, and has the effect of varying the gain from the gate 1 terminal of TR1 to its drain terminal. The aerial signal is coupled to the gate 1 terminal, and is modulated by the oscillator signal to give the required heterodyne effect.

## COILS

There are four aerial coils, one for each waveband where L3 and L4 are the medium wave and long wave coils respectively, and are part of a ferrite rod aerial assembly.

Ferrite aerials are not very efficient at the higher frequencies involved in short wave reception, and so a telescopic aerial is used on the two short wave bands. In order to provide a good signal transfer this aerial is coupled direct into gate 1 of TR1. L1 and L2 are the two short wave aerial coils, and S1a is used to select the required aerial coil.

A m.o.s.f.e.t. has a very high input impedance, and the aerial coils can therefore be coupled direct to TR1, with the low impedance coupling winding on each coil being ignored. The coils are used to bias gate 1 of TR1 to the negative supply rail.

Tuning capacitor C1 is the tuning capacitor for the aerial coils, and C3 is the aerial trimmer control. The latter is used to keep the aerial tuned circuit peaked at the correct frequency, and eliminates the need for any complicated r.f. alignment.

Transistor TR2 is a j.u.g.f.e.t. device which is used as the basis of the oscillator. It is used in the source follower mode with the selected oscillator transformer being used to pro-

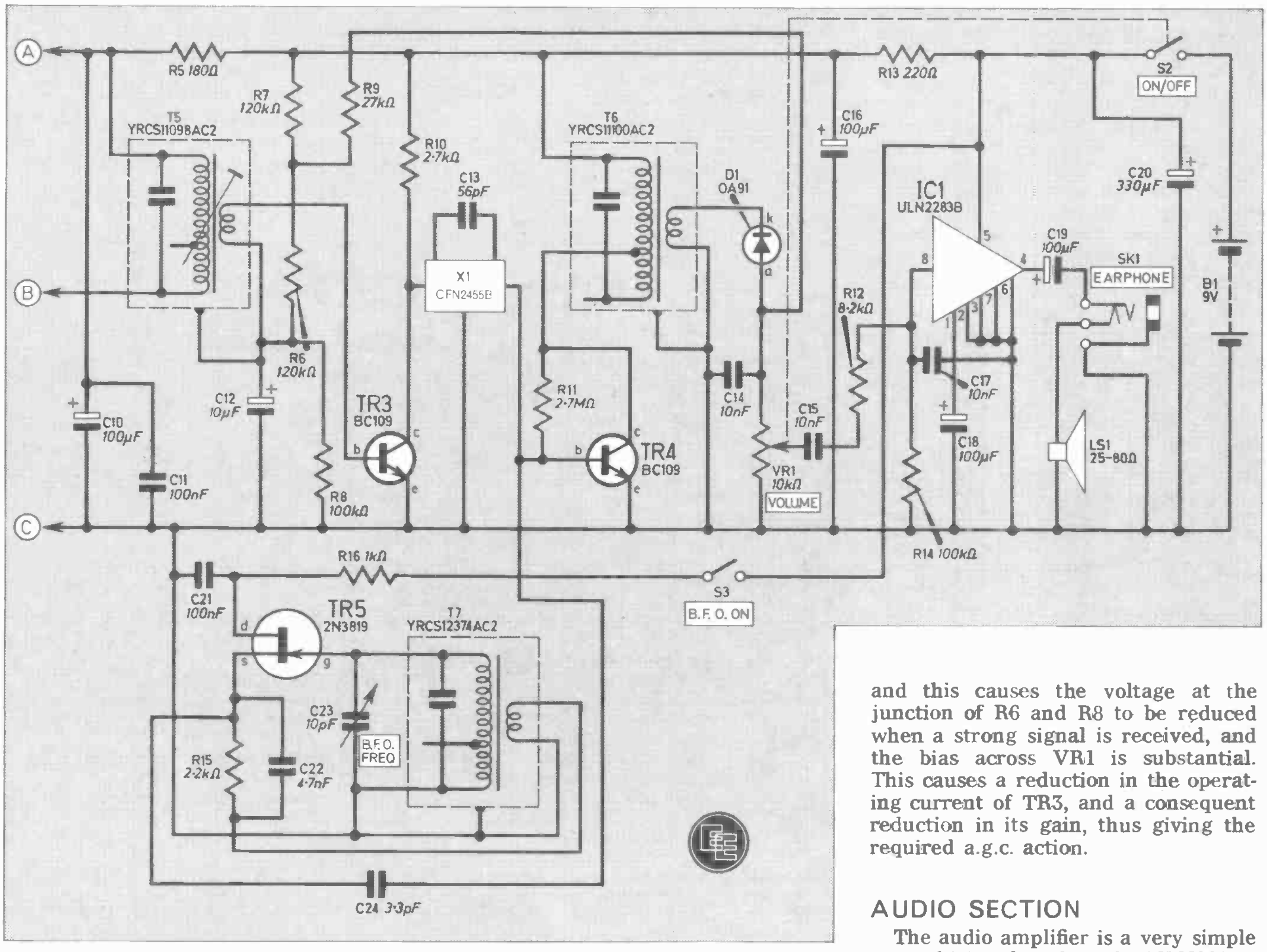



Fig. 3. The remainder of the circuit diagram containing the r.f. amplifier, detector, a.g.c., audio and b.f.o. stages of the 4-Band Radio.

vide positive feedback from the source circuit to the input at the gate.

Although the source follower has less than unity voltage gain, there is sufficient feedback to sustain oscillation due to the voltage step-up through each oscillator transformer. Components R4 and C9 are the source bias resistor and bypass capacitor, with R3 acting as the gate bias resistor.

The tuning capacitor for the oscillator is ganged with the "mixer" variable capacitor. S1b selects the tuned winding of the required oscillator coil and S1c selects the appropriate oscillator coil primary winding. On the medium, long, and short wave 1 ranges, C1b has a value which is slightly too high, and padder capacitors C5 to C7 are used in series with it to effectively reduce its value. Additionally, C8 is connected across the tuned winding of the longwave transformer in order to reduce its operating frequency range to the correct level.

The output from the oscillator is coupled to the mixer via C2. As TR2 is used in the source follower mode it has a fairly low output impedance, and gives reasonably good freedom from oscillator "pulling".

## I.F. AND AUDIO

The circuit diagram of the i.f. amplifier, detector, a.g.c., audio, and b.f.o. stages appears in Fig. 3.

Transformer T5 couples the output from the mixer to the input of the first i.f. amplifier transistor, TR3. The output from TR3 is coupled to the second i.f. stage by X1, a two stage ceramic filter, and C13 is used to couple the two stages. The second i.f. amplifier is a simple common emitter amplifier which is coupled by T6 to the detector. The latter is quite conventional, and consists of D1, C14 and VR1. TR3 is biased via R6 and the secondary winding of T5 from a potential divider formed by R6, R7 and R8. However, R9 and VR1 are shunted across R6, R8, and have an effect on the bias current of TR3. In fact, the smoothed r.f. half cycles across VR1 produce a negative bias, and this causes the voltage at the junction of R6 and R8 to be reduced when a strong signal is received, and the bias across VR1 is substantial. This causes a reduction in the operating current of TR3, and a consequent reduction in its gain, thus giving the required a.g.c. action.

## AUDIO SECTION

The audio amplifier is a very simple type which is based on the ULN2283B audio i.c. Its input is biased by R14, and C15 provides d.c. blocking at the input. An r.f. filter consisting of R12 and C17 is connected at the input of the amplifier to ensure that no significant r.f. signal breaks through to the i.c., as this would almost certainly result in instability. Capacitor C19 provides d.c. blocking at the output. The output connects to the speaker via a break contact on the earphone socket, and this automatically cuts out the internal speaker when the earphone is in use. The set can be used with any normal type or earphone or headphones (e.g. low impedance magnetic, crystal).

## B.F.O.

The b.f.o. uses the same configuration as the local oscillator, but uses an i.f. transformer so that it oscillates at 455kHz. C23 enables the operating frequency to be tuned slightly either side of 455kHz to permit the reception of upper and lower sideband signals. The b.f.o. signal is loosely coupled into the second i.f. stage by C24. Only a fairly low level of b.f.o. injection can be used as this signal would otherwise strongly operate the a.g.c. circuitry, and seriously reduce the sensitivity of the set. Switch S3 controls the positive supply line to the b.f.o, and acts as the b.f.o. on/off switch. The b.f.o. is still coupled to the second i.f. stage when it is switched off, but it has no significant effect on the i.f. amplifier due to the loose coupling used.

The quiescent current consumption of the set is about 15mA, but this can rise to over 50mA at high volume levels as the output stage of IC1 is a class B type.

# CONSTRUCTION starts here

## COMPONENT PANEL

With the exception of the controls, phones socket, telescopic aerial, and battery, all the components are mounted on a piece of plain 0·1 inch matrix s.r.b.p. panel, and wired together on the underside of the panel. Fig. 4 illustrates the component layout and the underside wiring of the panel. The board measures 149 x 114 mm and is arranged 58 x 42 holes. This is a standard size in which 0·1 inch matrix board is sold.

Commence construction of the board by drilling the three mounting holes. The coils and i.f. transformers are then fitted into place. Although these have bases designed to fit a 0·15 inch matrix layout, they will fit diagonally onto a 0·1 inch matrix board. It is necessary to slightly enlarge the holes that take the mounting lugs of these components, and a drill bit of about 2mm in diameter is needed to do this. The mounting lugs are bent flat against the underside of the panel in order to hold the coils firmly in position.

## FERRITE ROD

The ferrite rod aerial is mounted in a pair of purpose-made plastic clips, and the latter are mounted on the board using very short (about 6mm long) M3 or 6BA bolts and fixing nuts. Two holes in the board should be enlarged so that they will accept these mounting bolts.

Next the other components are gradually fitted on to the board, their leadout wires are bent flat against the underside of the panel, and they are wired together in the appropriate way. In most cases the leadout wires are long enough to complete this wiring, but in a few cases it will be necessary to use say, 22 s.w.g. tinned copper link wires. It is advisable to insulate the wiring with p.v.c. sleeving at places where it is congested, so as to avoid the possibility of accidental short circuits occurring.

It is the larger windings of L3 and L4 that are used, and a visual inspection of the medium wave coil will show which two tags connect to the main winding. The larger winding of the long wave coil connects to the two tags either side of a coloured spot marked on the coil former.

Although TR1 is a m.o.s.f.e.t. device, it has internal circuitry to protect it against static charges and therefore requires no special handling precautions.

## COMPONENTS

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 100kΩ | R9 | 27kΩ |
| R2 | 3·9kΩ | R10 | 2·7kΩ |
| R3 | 18kΩ | R11 | 2·7MΩ |
| R4 | 680Ω | R12 | 8·2kΩ |
| R5 | 180Ω | R13 | 220Ω |
| R6 | 120kΩ | R14 | 100kΩ |
| R7 | 120kΩ | R15 | 2·2kΩ |
| R8 | 100kΩ | R16 | 1kΩ |

All ¼Watt carbon ±5%, ±10% over 1MΩ.

**Capacitors**

| | | | |
|---|---|---|---|
| C1 | 208pF + 176pF ganged air spaced (Jackson type O) slow motion drive | C13 | 56pF ceramic plate |
| C2 | 3·3pF ceramic | C14 | 10nF polyester C280 |
| C3 | 50pF air spaced (Jackson type C804) | C15 | 10nF polyester type C280 |
| C4 | 10nF ceramic | C16 | 100μF 10V |
| C5 | 470pF ceramic plate | C17 | 10nF ceramic plate |
| C6 | 270pF ceramic plate | C18 | 100μF 10V |
| C7 | 330pF ceramic plate | C19 | 100μF 10V elect. |
| C8 | 270pF ceramic plate | C20 | 330μF 10V |
| C9 | 6·8nF ceramic plate | C21 | 100nF polyester type C280 |
| C10 | 100μF 10V elect. | C22 | 4·7nF ceramic plate |
| C11 | 100nF polyester type C280 | C23 | 10pF air spaced (Jackson type C804) |
| C12 | 10μF 10V elect. | C24 | 3·3pF ceramic |

**Semiconductors**

| | |
|---|---|
| IC1 | ULN2283B 875mW audio amplifier i.c. |
| TR1 | 40673 or MEM616 dual gate m.o.s.f.e.t. |
| TR2 | BF244B *n*-channel j.u.g.f.e.t. |
| TR3 | BC109 silicon *npn* |
| TR4 | BC109 silicon *npn* |
| TR5 | 2N3819 *n*-channel f.e.t. |
| D1 | OA91 silicon diode |

**COMPONENTS approximate cost £35**

**Inductors**

| | |
|---|---|
| L1 | KANK3334R 5·5μH shortwave coil |
| L2 | KANK3333R 45μH shortwave coil |
| L3 | MWC2 medium wave antenna coil |
| L4 | LWC1 longwave antenna coil |
| T1 | KANK3337R 5μH shortwave oscillator coils |
| T2 | KANK3426R 38μH shortwave oscillator coils |
| T3 | YXRS17065 180μH medium wave oscillator coils |
| T4 | YXRS17065 180μH medium wave oscillator coils |
| T5 | YRCS11098AC2 1st a.m. if. transformer |
| T6 | YRCS11100AC2 3rd a.m. if. transformer |
| T7 | YRCS12374AC2 2nd a.m. if. transformer |

See Shop Talk page 93

**Miscellaneous**

| | |
|---|---|
| S1 | 3-pole 4-way rotary |
| VR1/S2 | 10kΩ log. with ganged switch |
| S3 | miniature s.p.s.t. toggle |
| SK1 | 3·5mm jack socket with single break contact |
| LS1 | miniature loudspeaker having coil impedance 25 to 80 ohms |
| X1 | CFN2455B 455kHz a.m./i.f. ceramic filter |
| AE1 | telescopic aerial, 1 metre extended |
| B1 | 9V PP6 battery |

0·1in plain matrix board size 58 × 40 holes; Verocase type 75-1411D (205 × 140 × 75mm) or similar; 160mm long 9·5mm diameter ferrite rod; control knobs (4 off); mounting clips for the ferrite aerial, type FRPC (2 off); Jackson 44mm, 6 to 1 dial and drive (m.e.s.).

**NOTE**

If C1 is a component having integral trimmers, these should be fully unscrewed so as to provide minimum capacitance.

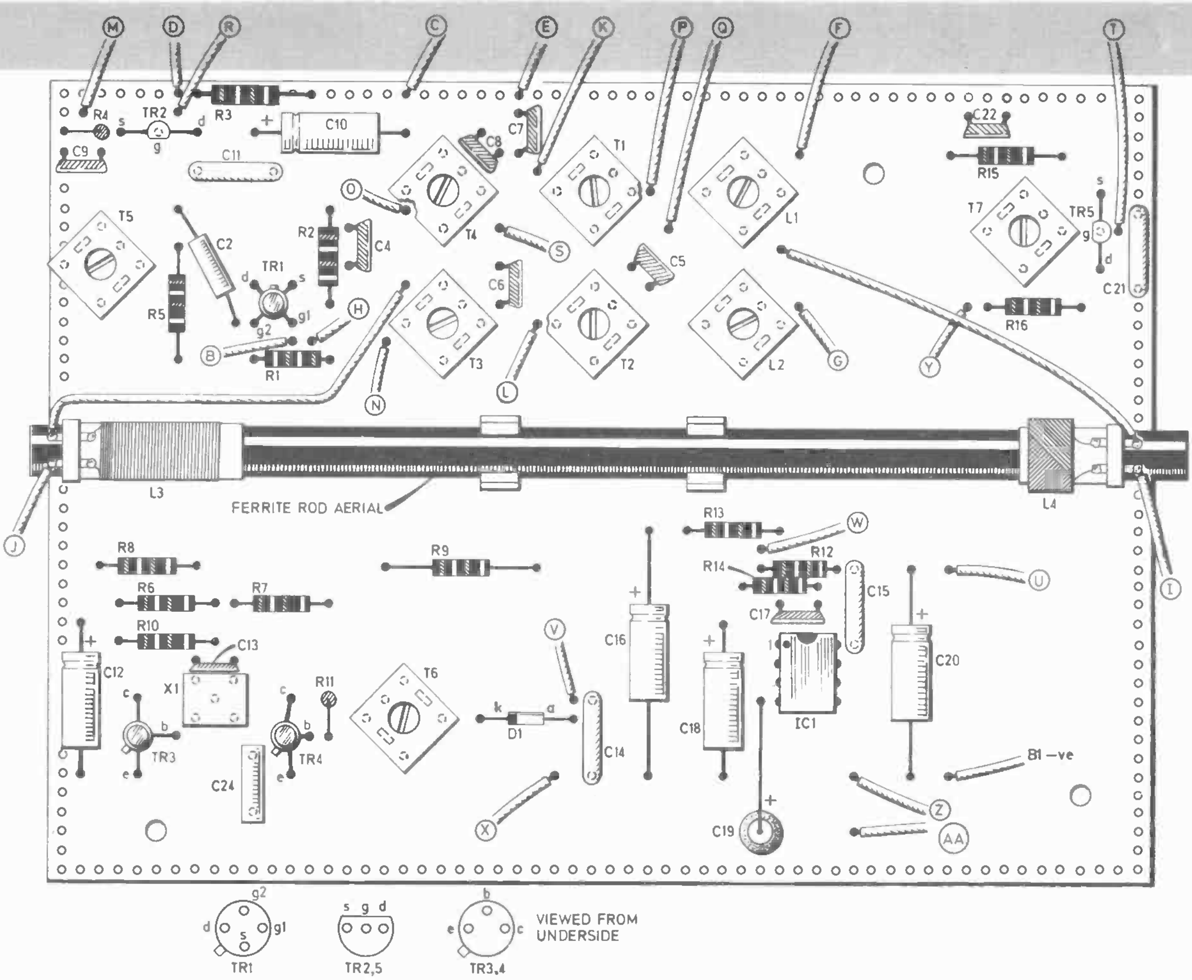
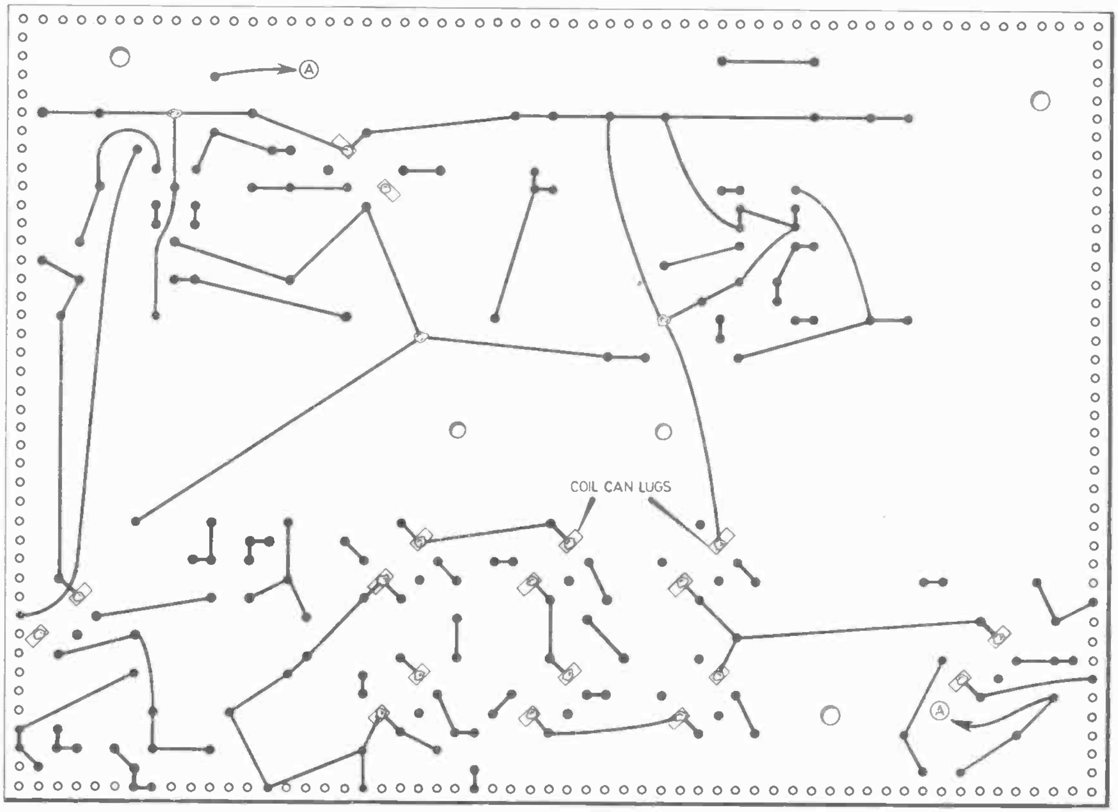



Fig. 4. The layout of the components on the topside of the circuit board and their interconnection (below) on the underside. Also shows flying leads to the case mounting components.



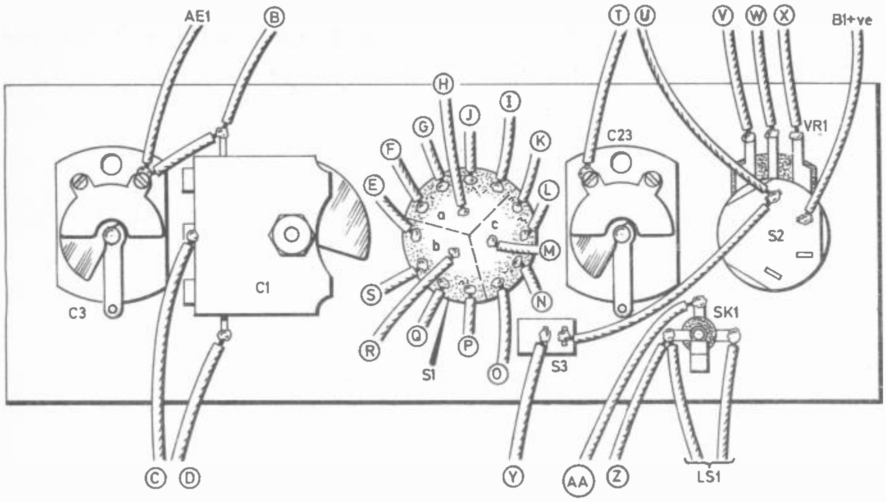


Fig. 5. The layout and interwiring of the front panel mounted components. See photograph and text for C3/C1 bracket fixing details.

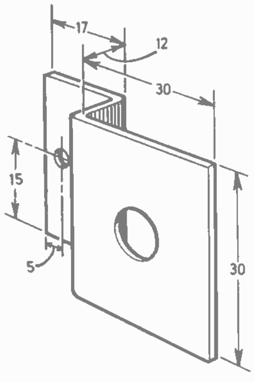


Fig. 6. Drilling and bending details of the tuning capacitor brackets.

## CASE

The prototype was housed in a Verobox which has approximate outside dimensions of 205 x 140 x 75mm. It is not essential to use the same case, and any box of a similar size and of non-metalic (or largely non-metalic) construction should be suitable. The set would probably work if housed in a metal case, but the ferrite aerial would be screened by the case, and performance on the medium and long wavebands would suffer since the set would have to operate using the telescopic aerial alone.

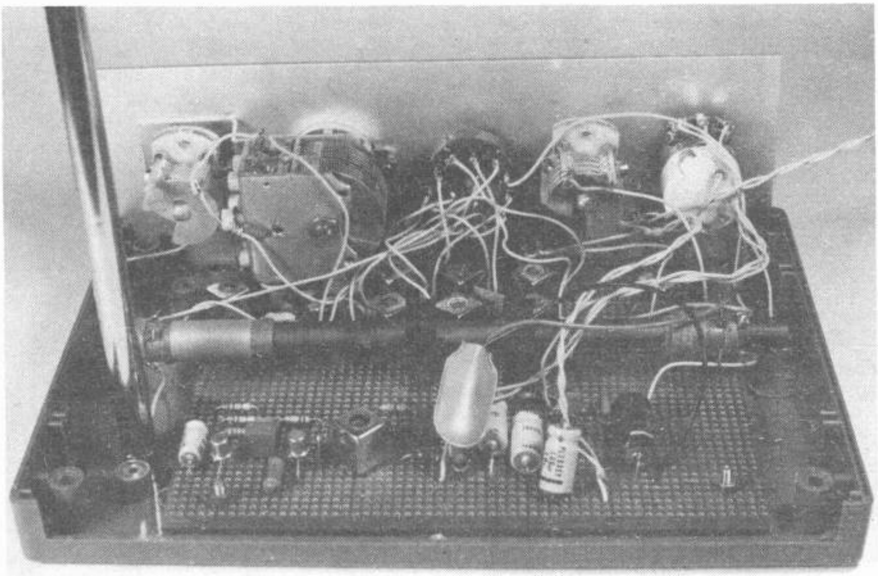
## FRONT PANEL LAYOUT

Reference to the accompanying photographs will show the front panel layout of the unit, and it is recommended that constructors should keep to this general layout. The rotary controls each require a standard 10mm diameter mounting hole, except for C1 which is fitted with a slow motion drive and dial. This requires a main 25mm diameter cut-out which can most easily be made using a chassis punch. An alternative is to drill a ring of small, closely spaced holes just inside the perimeter of the required cut-out. It should then be possible to punch out the piece of metal at the centre of the cut-out, and file the rugged hole to a neat finish using a large half round file.

The two smaller mounting holes can then be drilled in the panel, after using the drive as a template to help mark the positions of the holes. Short M3 or 6BA bolts (about 6mm long) and fixing nuts are used to fix the drive to the panel, with the mounting plate of the drive being positioned on the rear side of the panel.

If SK1 and S3 are standard components they will each require a 6·5-mm diameter mounting hole.

Mounting and wiring details on the front panel are shown in Fig. 5.



## TUNING CAPACITOR BRACKET

A small aluminium mounting bracket is required for the tuning capacitor, and this is detailed in Fig. 6. It can be constructed from thin (20 or 22 s.w.g.) aluminium as it is mainly required to prevent the whole of the tuning capacitor from rotating when the tuning drive is operated, rather than to give any support to the component.

The position of the mounting hole for C3 is found by fitting the bracket into place, and then marking through the mounting hole for C3 in the front panel. The bracket is fixed to C1 using a short 4BA screw which fits into a threaded hole in the front of the component. This must not be allowed to penetrate more than about 3 or 4mm into C1 as this could result in the capacitor becoming damaged. If necessary, use washers to reduce the penetration of the screw to an acceptable level.

The mounting bush and nut of C3 are used to effectively bolt the bracket to the front panel.

## AERIAL AND SPEAKER

The telescopic aerial is mounted on the base panel of the cabinet, towards the rear, right hand corner. Most types have provision for mounting by means of a 4BA screw which fits into a threaded hole in the base of the aerial. A hole for the aerial must also be made in the top panel of the case.

The loudspeaker is mounted on the top panel of the case, and a small matrix of holes about 6mm in diameter are drilled in the top panel to form a speaker grille. The speaker is then carefully glued in place beneath this using a good quality general purpose adhesive such as Bostik No. 1.

## WIRING

Next, the component panel is wired up to the other components. The complete wiring is shown in Figs. 4 and 5. Start by wiring the panel to the waveband switch, S1. This wiring must be kept as short as possible, and will probably be easier if S1 is temporarily dismounted from the front panel while this wiring is completed. The other wiring is all quite straight forward. The connection to the telescopic aerial is made via a 4BA solder tag fitted on the mounting bolt.

When the wiring has been completed, the component panel is mounted on the base of the cabinet. The specified case has mounting pillars moulded into its base section, but in this application these tend to get in the way. They can easily be drilled away using a drill of about 10mm in diameter. The component panel can then be used as a sort of template with which the positions of the three mounting holes in the case are located. The panel is mounted using M3 or 6BA bolts about 12·5mm long.

The PP6 battery fits into the space at the rear of the case, and an aluminium mounting bracket can be fabricated for it, and fixed to the rear panel.

## ADJUSTMENT

After giving the wiring a thorough check for errors, and correcting any that are found, the set is ready for testing and alignment. Start with the set switched to the medium waveband (MW), as it should be possible to locate a few stations on this band with little difficulty. L3 can be slid along the ferrite rod to peak received signals. Tune accurately to a station of consistent strength, and then adjust the core of T5 to peak this signal. It is easiest to accurately peak adjustments with the set tuned to a weak station as these will not be much affected by the a.g.c. action of the set. The tuning of T6 is very broad, and the setting of its core not very critical, although it should not be unscrewed too far as this could give a poor passband shape, and could even cause instability.

Now tune to a station with the vanes of C1 about half meshed, set C3 for about half capacitance, and slide L3 along the ferrite rod to the position that gives maximum signal strength. L3 should then be taped or glued in this position. There is no need to adjust the core of T3 unless there is an obvious lack of coverage at one or other end of the medium waveband. T3 core can then be adjusted to correct this, and L3 should be re-aligned. However, it is unlikely that T3 will need any adjustment.

Next switch S1 to the long waveband position (LW), adjust C1 for slightly less than half capacity, and adjust the core of T4 to tune-in BBC Radio 4, 200kHz long wave transmission. With C3 still at half capacitance, L4 is slid along the ferrite rod to peak this transmission, and is then glued or taped in this position.

With the telescopic aerial fully extended, switch S1 to the SW1 position, search for a station with C1 at about half capacity, and adjust the core of L2 to peak this station (with C3 still at half maximum capacitance). Switch S1 to the SW2 position and repeat this procedure with the core of L1. Note that a proper trimming tool must be used when adjusting the cores of L1 and L2.

Finally, the b.f.o. is aligned. Tune accurately to any a.m. broadcast station and switch on the b.f.o. using S3. By adjusting the core of T7 it should be possible to produce an audio tone from the speaker that varies in pitch as the core is adjusted. With C23 set at half maximum capacitance, adjust the core of T7 for the lowest possible audio output note.

## USING THE SET

The tuning, wavechange, volume, and on/off controls of the unit are quite conventional. The aerial trimmer control (C3) is merely adjusted to peak received signals. The b.f.o. is switched in for the reception of s.s.b. and c.w. signals, and in the case of the latter the setting of the b.f.o. tuning control (C23) is of little importance. For the reception of s.s.b. the b.f.o. tuning must be offset from a central position. Lower sideband is almost exclusively used on the three low frequency amateur bands (160, 80 and 40 metres), and this mode requires the vanes of C23 to be adjusted so that they are virtually fully meshed.

Table 1. Received frequency as a function of dial position for the two short-wave bands in the prototype.

| Dial Reading | Received frequency (MHz) Range SW1 | Received frequency (MHz) Range SW2 |
|---|---|---|
| 0 | 1·66 | 4·6 |
| 10 | 1·79 | 4·95 |
| 20 | 1·9 | 5·35 |
| 30 | 2·01 | 5·75 |
| 40 | 2·15 | 6·2 |
| 50 | 2·3 | 6·8 |
| 60 | 2·55 | 7·6 |
| 70 | 2·9 | 8·7 |
| 80 | 3·5 | 10·5 |
| 90 | 4·25 | 13·1 |
| 100 | 4·5 | 14·6 |

The 20 metre amateur band lies at the high frequency end of the sw2 range (vanes of C1 almost unmeshed), and upper sideband is the form of s.s.b. mainly used on this band. Upper sideband reception needs C23 to be offset in the other direction, with its vanes largely unmeshed.

For c.w. reception, the tuning control is adjusted to give an audio tone of the desired pitch. The tuning is much more critical than for s.s.b. reception, and the tuning control must be carefully adjusted to give an audio output of the correct pitch. Strong s.s.b. signals will swamp the b.f.o. signal, giving a very distorted audio output. This can be avoided by keeping the volume control well advanced, and detuning C3 to keep the volume down to a reasonable level.

When using the set on the short wavebands the telescopic aerial should be fully extended, and it is advisable to use a fairly long aerial (about 1 metre or more). It is not essential to extend the aerial for medium and long wave reception, although performance on these bands will be improved by doing so.

## EARTH AND AERIAL

Performance can be improved by using an earth connection, and this merely connects to the negative supply rail. There is plenty of space on the rear panel to accommodate an earth socket. The earth itself can consist of a metal pipe buried in the ground and connected to the receiver by a lead which should be as short as possible.

An external longwire aerial can be coupled to the telescopic aerial, and again, a suitable socket can be added to the rear panel of the set. An external aerial will be of most use on the SW1 range during daylight hours (when signal strengths are normally low), but can also be of benefit on any band when conditions are poor and signal strengths are low. An external aerial should not be used if the telescopic aerial is capable of providing good signal strengths, as the mixer could become overloaded with a consequent reduction in performance.

## DIAL CALIBRATION

To assist users in tuning, the author has provided the data in Table 1 from measurements taken on the prototype unit. The dial marker is sited centrally above the dial. The Table allows the operator to see at a glance which frequency is being tuned in by noting the dial reading and the band selector switch position. A copy of this Table glued to the top of the case should prove very useful.


# BREADBOARD 80

## SHOW REPORT

RECESSION—What recession? So one exhibitor summed up the response amongst visitors to this year's Breadboard 80 Exhibition held at the Royal Horticultural Halls in London recently.

Attendances were 60 per cent up on last years figures and at £1·50 a time there can't have been many casual observers.

### EXHIBITORS

From the exhibitors point of view this could only have meant more business and improved public relations although it was surprising how few new products were on show.

Still product consolidation isn't such a bad thing and as Tina Knight, Managing Director of Continental Specialities Corporation put it:

"We can offer last year's models slightly cheaper which helps us and the customers as well. We get a chance to meet people and get our latest catalogues out."

In fact CSC have just introduced an extension to their Experimenter Solderless Breadboard System which consists of free leaflets called "Three for Free". These contain full circuit and assembly details for three simple projects. CSC hope to keep adding to the range.

Other new products include two new frequency counters and a new "idea box" which has gone down very well in the United States.

Meanwhile that other stalwart of the electronics market, Vero, were relying chiefly on their Verobloc solderless breadboard and Verokit hobby kits to provide interest—and with some success.

Mike Humphries, Retail Sales Manager said: "Sales have been incredible. Over 2,000 catalogues have gone at 40p each and we've handed out over 5,000 leaflets on the Verokits."

However, Vero were also showing off their new wire wrapping kit. Priced at around £38 it contains a power wrap tool with rechargeable batteries, battery charger, stripping tool, cutters and wire, and is all British.

### COMPONENT SUPPLIERS

Overall most of the major component suppliers had a stand of some sort although several of our regular advertisers were conspicuous by their absence. Again Maplin Electronics had the largest stand and their main attractions were the new "Matinee" organ and the 5600 synthesiser, both of which were demonstrated frequently. However, the new catalogue was by far the biggest selling point.

The promised CB contingent was in fact quite small, really only confined to part of two stalls. Perhaps this was due to the rather ambiguous legal position surrounding the whole subject.

### THE PRESS

Magazines play a big part in encouraging electronics as an interest and a hobby and all the major titles were represented. It gave each magazine a chance to show off their projects and meet their readers.

The fact that it was getting near to Christmas time hadn't eluded the staff at EVERYDAY ELECTRONICS and the major part of the stand was given over to electronic games. These certainly attracted the public, especially the children, including four year old Clare Birkby from Wargrave near Reading.

Her father, Mr Roy Birkby, told us how Clare and her seven year old sister Jane became interested in electronics.

Getting younger every year! Four year old Clare Birkby tries her hand at the Live Wire Game.

He said: "I bought a computer kit recently and the two girls became interested in all the bits and pieces whilst I was building it up. They wanted to know what everything was and now Jane can read the circuit diagrams."

Of course many people of all ages have taken up electronics but its a sign of our times that when one fellow explained why he would have more time for his hobby, he said: "I'm being made redundant tomorrow."

# NEXT MONTH'S ATTRACTIONS

## BENCH POWER SUPPLY UNIT

A comprehensive unit to meet the requirements of the serious constructor.

D.C. Voltage
Variable 1·25V to 25V d.c. Current limiting.

A.C. Outlets
Six fixed voltages, ranging from 3 to 30V; also 12–0–12 and 15–0–15V.

## TREBLE BOOST

Gives that "lift" desired by guitarists and vocalists in pop groups. Floor standing unit, operated by footswitch.

## SIMPLE TRANSISTOR/ DIODE TESTERS

Inexpensive and easy to build test instruments. Two versions are described: one is intended to be used with a multimeter, the other is self-contained and uses an l.e.d. as indicator.

## MODEL RAILWAY POINT CONTROLLER

A simple capacitive-discharge unit that eliminates risk of damage to the points actuator through excessive currents as is likely with conventional remote control systems.

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**Everyday ELECTRONICS**

**MARCH 1981**
**ISSUE ON SALE FRIDAY, FEBRUARY 20**

# Everyday News

## APPRENTICE OF THE YEAR

Andrew Easdown a 21 year old former apprentice at Chatham Naval Base has been named the M.o.D. Apprentice of the Year.

He was presented with his award by the Countess Mountbatten of Burma in a ceremony at the Ministry of Defence, Whitehall early in December.

Andrew, son of an Army cook, was one of 2,000 final year apprentices eligible for the award and his trophy took the form of a gold plated contemporary column on an oak plinth. He finished his apprenticeship in August and is now a professional and technical officer working on Chatham Naval Base development.

In the run up to the final award each of the four areas of M.o.D. responsibility nominated their own Apprentice of the Year and Andrew won the Dockyard section. The other areas were Royal Ordnance Factories, Services Support and Procurement Executive.

At the same ceremony the Countess unveiled two clocks made by apprentices at RAE Farnborough in memory of her father, Earl Mountbatten of Burma.

One of these clocks, a reproduction 1710 English design, was made from brass and stainless steel and enclosed in an oak case. The timber was salvaged from the HMS *Victory* during restoration work.

The other was an ultra-modern electronic design with both analogue and digital time display controlled by a pulse signal from the Post Office transmitter in Rugby.

Both have been installed in the Concourse Hall of the Ministry of Defence Building and will be a permanent tribute to Earl Mounbatten who, in the early days of his naval career, was a signals officer.

## INDUSTRIAL REVOLUTION

*One would be blind not to see the ever growing importance of all kinds of information, not only for vital business decisions but for personal choices in our everyday life, for consumer products and services.*

*We have traditionally relied on paper and print for most of such information. Now, progress in electronics and the availability of computing capacity at low cost by integrated circuits is making it possible to collect, process and distribute much more information much more quickly to many more users in many more ways.*

*The effect of information technology may indeed amount to a new industrial revolution; and just as we in Europe led the world in the transition from agricultural economies to industrialised societies, so we need to be in the forefront of this new change.*

The above is an extract from a speech given by the Minister of State for Industry, Mr. Adam Butler, M.P., at a symposium on Viewdata Systems in The Hague recently.

Mr. Butler, who has special responsibility for information technology, forecast that the effects of information technology may amount to a new industrial revolution in which Europe must lead the world.

### Just the Ticket

A contract from British Rail for 200 electronic ticket issuing machines worth in the region of £1 million has been awarded to Westinghouse Revenue Controls, the ticket machine branch of Westinghouse Brake and Signal Co Ltd.

These intermediate ticket machines are an improved version of the small station microprocessor-based machine, sixty of which are being delivered for use in the Clyde rail area of the Scottish Region of British Rail. They have a full tally-roll printout and record data in a magnetic cartridge for subsequent analysis.

**British Telecom, the fourth largest telecommunications system in the world, now has 26·7 million telephones on line through 6,310 exchanges. Despite the doubling in size over the last ten years the number of staff at 240,000 is substantially the same as before.**

## M.P.s on Trial

In their response to the Home Office discussion document "Open Channel" the Citizens Band Association have drafted a 24-point response in which they are highly critical of their proposals, particularly with regards to expense and efficiency of such a service. They do, of course, offer alternative suggestions.

In a separate letter to M.P.s the association have also offered to loan a Citizens Band Receiver so that they may make their own evaluations on the merits of such a service. They regret that they are unable to loan transmitters, as their possession and operation is illegal.

### On The Air

*In the first nine months of 1980 only 331 people were charged with illegal use of 27MHz CB radios. Six were acquitted and 325 convicted. This is a tiny fraction of an estimated 200,000 illegal users.*

*Legal licensed "hams" are increasing fast. Membership of the Royal Society of Great Britain topped 25,000 last year with the enrolment of a record 4,215 new members.*

### TEACHING MICROS

Twenty-nine projects to the value of £1·2 million have been approved by the British Government in the first phase of a four-year programme to encourage the development of microelectronics in education. The total programme, including items like teacher-training and software, has been budgeted at £9 million up to 1984.

## ANALYSIS

### GIMMICKS GALORE

A prominent and essential feature of our Twentieth Century consumer society, particularly marked in consumer electronics, is the endless search for and promotion of new ideas translated into saleable products, at least different but ostensibly also better than "last year's model".

There was no problem in selling radio in the 1920s and 1930s. The rapid spread of sound broadcasting did the trick. The pattern was repeated with television in the 1950s and momentum was maintained up to saturation point. Slump was averted by a switch to 625-line monochrome followed by colour TV.

Sound radio also experienced new booms with the transistor portable and later the cassette radio and clock radio. Audio had its booms, too, with the L.P. record, (first mono, then stereo), reel-to-reel recorders, cassette recorders and the music centre.

The new wave of promotion, now that saturation has set in for colour TV with almost every household having one, is concentration on VTRs and, soon, video disc, plus an urge to equip with teletext, to expand our repetoire of TV games and even to add on home computing equipment with the TV as a VDU.

We are by no means nearing the end of the road. Even old-fashioned steam radio is scheduled to have a new generation of micro-processor-controlled domestic receiver capable of being programmed in advance for a whole week of listening. It will not only switch itself on and off at the right times but will automatically tune itself to the correct channel and if alternative channels are available, that for best reception. Programming will just be a simple matter of stroking a light-pen across a bar-code adjacent to the programme details in the Radio Times. The MPU does the rest.

**Brian G. Peck**

This year's Leeds Electronics Exhibition will be held from June 30 to July 2 in association with the organisers of the All Electronics/E.C.I.F. Show.

### Safety at Sea

A new type of radio navigation beacon designed to be easily used by small boats, including pleasure craft, is on trial at a number of locations round the coast of Britain. Developed by Standard Telecommunications Laboratories, the beacon transmits on v.h.f. and can be received on any v.h.f. radio, even on a domestic portable.

A yachtsman can fix his bearing by timing with a stop watch for maximum or minimum audio signal or, alternatively, by counting tone cycles. Range is typically 20 nautical miles if the beacon is well-sited above sea level as is the trial installation at North Foreland.

### First Computer Language Standards

*Computing in the UK enters a new phase with the publication by British Standards Institution of the first British Standards to deal with general purpose programming languages.*

*The standards involved are BS 5904 and BS 5905 which specify the semantics and syntax for two different computer programming languages (RTL/2 and CORAL 66) already in common use for the control of industrial processing and general applications in real-time computer systems.*

**The 12th annual Scottish Electronics Exhibition and Convention, *"Scotelex '81,"* will be held during the period June 2 to 4, 1981, at the Royal Highland Exhibition Hall, Ingliston, Edinburgh EH28 8NF. Admission is free via tickets available from Exhibitors or the Organisers, the Institution of Electronics.**

## Chips for Maggie

The millionth integrated circuit microprocessor, otherwise known as "the chip," to be produced by the Mullard UK factory was presented to the Prime Minister Margaret Thatcher in the House of Commons recently.

### Buzby meets Tintti

*The chatty British Telecom bird, Buzby, is making his first real flight abroad to Finland.*

*The National Association of Telephone Companies in Finland has just signed a contract with British Telecom for the exclusive rights in Finland to the Buzby character for all forms of advertising, excluding merchandising.*

*In Finland, Buzby will be known as "Tintti", and will appear in four of his original British TV advertising campaigns: Happy Birthday, The Hospital, Laughing Buzby and The Girlfriend.*

### ON SHOW

Projects from the *Young Engineer for Britain* competition (see last month's issue), are among exhibits being displayed at the Brighton and Hove Engineerium in an exhibition jointly organised by the Industry/Education Unit, Department of Industry and Industrial Contintuum Ltd.

The exhibition is open until February 28 and includes the overall winners of the 1979 and 1980 competitions. Although the exhibition is free, there is a charge of 30p for children, OAPs, and 60p for adults to the Engineerium.

**The Home Secretary has appointed the Rt. Hon. Lord Thomson of Monifieth to be Chairman of the Independent Broadcasting Authority in succession to Lady Plowden, D.B.E.**

**Appointed to be Deputy Chairman of the I.B.A. is Sir John Riddell, Bt.**

## THINK BIG—SAYS TEXAS

Equipment designers attending *Interface 80* at London's Talk of the Town were urged to think big where memory chips are concerned. According to speakers at this year's Texas Instruments seminar it will be wise to design new computing equipment around 64K devices even though the entire capacity may not be utilised initially. The cost of memories is steadily falling, and it will prove economical in the coming months to use the larger devices.

A wide range of micro-products were introduced to the large audience on each of the four days of the seminar. Memories, speech synthesis i.c., microprocessors and support circuits, bubble memories; linear devices, advanced low power Schottky logic devices; switching mode power supplies; and solid state sensors, a particularly interesting area of current development.

New devices for sensing temperature position, flow, pressure, level, acceleration were described. Many of these seem destined to find employment in the automative field, as part of comprehensive indicating and controlling systems that could eventually become standard equipment in motor cars.

Of particular note is the pinning arrangements for the Texas memory chip family. These have been arranged so that ROMS and RAMS are pin-for-pin allowing interchangeably between the two types. Further to this, higher density chips (more bytes per package) have been designed in a new 28-pin package which are virtually pin-for-pin with the 24-pin chips requiring only a couple of link wires for the change to be effected. Designers can now layout for a 28-pin system (larger memory) and use 24-pin packages initially, and readily increase memory capability on the same board by merely plugging in.

# RADIO WORLD

**By Pat Hawker, G3VA**

## Station identification made easy

Recently, for an Irish broadcaster's journal, I attempted to indicate some of the technical developments and improvements that I would like to see in sound radio receivers. After surveying such possibilities as better balance between speech and music, microprocessor-controlled frequency-synthesis tuning, and reception of programmes direct from satellites and rather reluctantly coming to the conclusion that most of these were still some way off, I finally produced a short list of more modest requirements.

These included simpler tuning and "granny-proof" station identification and low-cost "touch-button" rather than knob tuning of a memorised list of stations as already general practice for television.

My wish (shared by very many listeners) for easier tuning and station identification is, of course, already occupying the attention of many professional engineers in industry and broadcasting. For example many different organisations, including the BBC and Philips of Eindhoven, have developed very cunning digital data systems that can be inserted onto a v.h.f. radio signal in much the same way as the Oracle and Ceefax teletext data are carried on television transmissions.

By means of simple, low-cost matrix displays these systems can show the listener the station and programme to which the set is tuned, can help accurate tuning, and carry other information such as time or short messages relating to the programme.

A lot of work has already been put into developing such systems and there have been field trials in a number of countries. One recent international trial, carried out in Switzerland under the aegis of the European Broadcasting Union, included tests of five different systems, one each from France, Finland, the Netherlands, Sweden and the UK. Three of the systems, including that submitted by the BBC, are designed to carry the data on subcarriers at about 57kHz. Two use a 19kHz subcarrier.

The tests were carried out in an area known to be subject to multipath reflections, since it is now well recognised that data signals can be very vulnerable to echoes or "ghosts". While the trials are reported to have left the engineers reasonably optimistic that a reliable data and station identification system will be feasible, it was, unfortunately, concluded that none of the five systems tested can be regarded as sufficiently reliable when operating in difficult conditions. The engineers concerned are now considering whether some modified form of coding the data will need to be incorporated to provide better protection against errors.

But at least it looks as though station and programme identification will prove to be one of the first of my list of requirements likely to become available.

## Red faces after RAE

Talking recently to would-be radio amateurs who had sat the Radio Amateurs' Examination on December 1, 1980, it became clear that there are still criticisms of some of the questions being asked—although it is recognised that since the introduction of the multiple choice form of paper in May 1979, the percentage of candidates who successfully pass the examination has risen significantly. In multiple choice, four possible answers are provided to each question and the candidate then has to indicate which one he feels is correct.

The trouble appears to be that candidates consider that in some cases the more you know about the subject the less sure you become that only one of the answers is "correct" and that the other three are positively "wrong".

There is also a feeling, possibly mistaken, that the examination includes a few "trick" questions. This type of unease was intensified last December when a number of the more knowledgeable candidates realised that none of the answers given to one of the questions could possibly be correct.

The City and Guilds Institute have since admitted that indeed this was the case and have announced that they will omit Question 37 in Part 2 of the paper from their marking. Fair enough, but I wonder whether this takes into account the psychological stress that the unanswerable question may have placed on those suffering from examination nerves.

## Transatlantic on 70 MHz

Although the present sunspot cycle reached its peak in November 1979, some very high frequencies were once again being reflected by the ionosphere during November 1980. Indeed for the first time ever, a British amateur, Gordon Pheasant, G4BPY of Walsall, had the thrill of knowing that his 70MHz signals were spanning the Atlantic and enabling him to conduct a cross-band 70/50MHz two-way contact with Canadian station VE1ASG in St John, New Brunswick.

Cross-band working was necessary since North American stations cannot use 70MHz and similarly the 50MHz band is not available to British amateurs. The contact was made on November 17 when the Canadian station copied weak morse signals from the British amateur at a time when his own signals, 20MHz lower in frequency, were being strongly received in Europe.

Gordon Pheasant, ten days later, also became the first British amateur to "work all continents" by means of crossband 28/50MHz contacts.

High energy particles constantly bombarding the upper atmosphere include cosmic rays. For more than 50 years astro-physicists have been arguing whether they originate in our own galaxy or whether they are of extragalactic origin. The answer is still in doubt but an East-West controversy is evident, with Russian scientists favouring the galaxy; British astronomers suggesting extragalactic sources.

## Take care

In the days before the risk of causing television interference forced us all to shield our transmitters, many amateurs favoured breadboard or open rack-and-panel construction. These had their merits but also their dangers.

As I discovered several times, inadvertent touching of wires carrying 350V, 500V or more was not something to be quickly forgotten and indeed not all amateurs lived to tell the tale. Today the danger of shock, except perhaps during injudicious servicing of equipment, have virtually been eliminated.

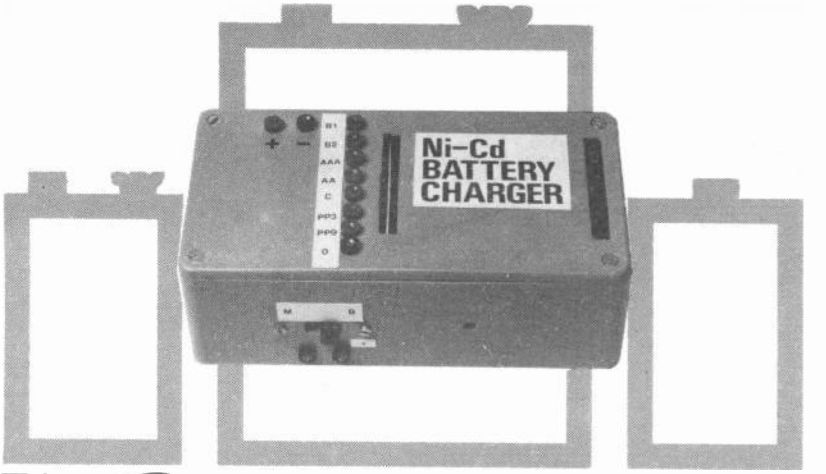
However, even today one should never take too casual an attitude towards any equipment or appliance connected to the mains. I was reminded of this by hearing about an amateur who lost all his equipment and suffered other household damage from a fire caused by his going out leaving a soldering-iron switched on.

Attention to good practice in such matters, and also in the use of suitable plugs, multi-way adaptors, correct fuses and periodical examination of all flexible leads is very much to be recommended. Some of us, and I plead guilty, fall into bad habits such as using matchsticks to insert wires into sockets or failing to ensure good all-round ventilation of equipment. Toxic smoke and fumes from some modern furnishing materials can make any fire deadly dangerous.

A few years ago the manufacturing members of the British Radio Equipment Manufacturers Association agreed a series of recommendations that deserve to be widely known. For example, do see that all electrical equipment which does not have to remain operational is switched off at the mains outlet if you are going away for an extended period. Do not continue to operate equipment if you are in any doubt about it working normally, or if it is damaged in any way.

Do not remove any fixed cover unless you are qualified to do so—and even then withdraw the mains plug before you start. Do not leave equipment switched on when it is unattended. Check that it is switched off at night and when you go out.

Make sure other members of the family know how to switch it off. Do not obstruct the necessary all-round ventilation (of a TV set) and especially do not stand it close to curtains or on soft furnishings such as carpets (unless legs are fitted). Overheating can cause unnecessary damage and shortens the life of equipment.




# Ni-Cd BATTERY CHARGER

By T. R. de Vaux Balbirnie B.Sc.

PORTABLE electronic equipment usually relies on "dry" batteries for a power supply. For occasional use these are ideal in providing a compact, efficient and safe source of energy.

Their chief disadvantage is the cost as regular users of battery operated radios will testify. Alkaline batteries give much better performance but cost more than the regular type.

There are two alternatives. Either a mains unit may be used (but only where a suitable supply exists) or rechargeable batteries employed. Of the various kinds of rechargeable batteries, the nickel cadmium is the most useful for general applications.

These are robust and will withstand all sorts of misuse such as being left discharged for long periods. They will be damaged, however, by overcharging, that is, charging them by a current which is substantially greater than that recommended.

In practice, this means that a constant current charging circuit is needed and this is the subject of the present article.

## POPULAR BATTERIES

Table 1 lists most of the popular batteries, some of the popular applications and the appropriate charging rate for the nickel cadmium versions. It is not harmful to charge nickel cadmium batteries at a *lower* rate, of course, but it takes longer.

One particular case is the "D" battery (HP2/U2 size). No provision has been made for this as the recommended charging rate is 500mA which is too much for the present circuit. If "D" cells have to be charged, then the 250mA output appropriate for the smaller "C" cell will be used and double the time given.

The rates given in the table are the *maximum continuous* charge rates. They will fully charge a battery in 12 hours. No harm will result if they are left charging for longer than this.

The PP3 battery, charged at 9mA, will be fully charged in 14 hours and it should not be left for longer than that.

## CHARGE RATES

The present circuit allows for seven charge rates to suit all batteries listed including two button cells. After setting the correct rate for a given battery, the circuit will deliver this current irrespective of operating conditions.

Any number of individual cells may be connected in series to be charged as long as their total does not exceed 9 volts. Similarly, a single 6 volt or 9 volt battery may be used.

One point about nickel cadmium batteries is that their output voltage is nominally 1·2 volts rather than the 1·5 volts of dry batteries.

Table 1. Charge currents for different Ni-Cd battery sizes.

| Size | Typical Applications | Charge Current (mA) |
|---|---|---|
| AAA | calculators, photoflash | 20 |
| AA | calculators, shavers, torches | 60 |
| C | torches, tape recorders | 250 |
| PP3 | calculators, radios, general electronic equipment | 9 |
| PP9 | radios, electronic equipment | 100 |
| B1 | photoflash, watches | 1·5 |
| B2 | cameras, various | 3 |

However, in practice, nickel cadmium cells and their dry cell counterparts behave in a very similar manner in most circuits because of their lower internal resistance.

In a 9 volt battery (PP3 or PP9) there are six separate cells internally connected in series in the regular version. In the nickel cadmium type there are seven (7×1·2=8·4 volts). Again, these will behave in much the same way when used in a circuit.

## CAR BATTERY

A special feature of the present design is its ability to charge nickel cadmium cells by means of a car battery as well as from the mains. This was originally intended for use on camping holidays to charge the batteries in an electric shaver.

Some constructors may find it such an attractive idea that they will miss out the mains section altogether and use it just this way.

## CIRCUIT

The full circuit diagram is shown in Fig. 1. With S1 set to position shown, that is for mains operation, current flows from the secondary of the mains transformer to the bridge rectifier consisting of four separate diodes D1-D4. The rectified current is now smoothed by the electrolytic capacitor C1.

If S1 is set to other position for battery operation, d.c. current enters at this point. In either case there will be a 12 volt supply across C1. The current now flows through R1 and the two diodes connected in series D5 and D6.

As these are *silicon* diodes, they will have approximately 0·6 volts across their terminals. There will therefore be about 1·2 volts across the pair. This voltage appears at the base of TR1.

The value of R1 is chosen to allow sufficient base current to flow in TR1 under all working conditions. TR1 will be biased "on" with about 0·6 volts across the base/emitter junction (as this behaves as a silicon diode as well). This leaves the other 0·6 volts to appear across the emitter resistor.

## EMITTER RESISTOR

The emitter resistor is really any one of a set of fixed resistors R2 to R10 which may be selected by a plug and socket system. A specific current will flow through the emitter resistor as predicted by Ohm's Law.

Now, for a transistor, $I_e = I_c + I_b$ and as the base current, $I_b$, is small compared with the collector, $I_c$ (the transistor has a high $h_{fe}$) $I_c$ and $I_e$ will be almost the same. It will be seen that $I_c$, which charges the batteries, only depends on the value of R2-R10.

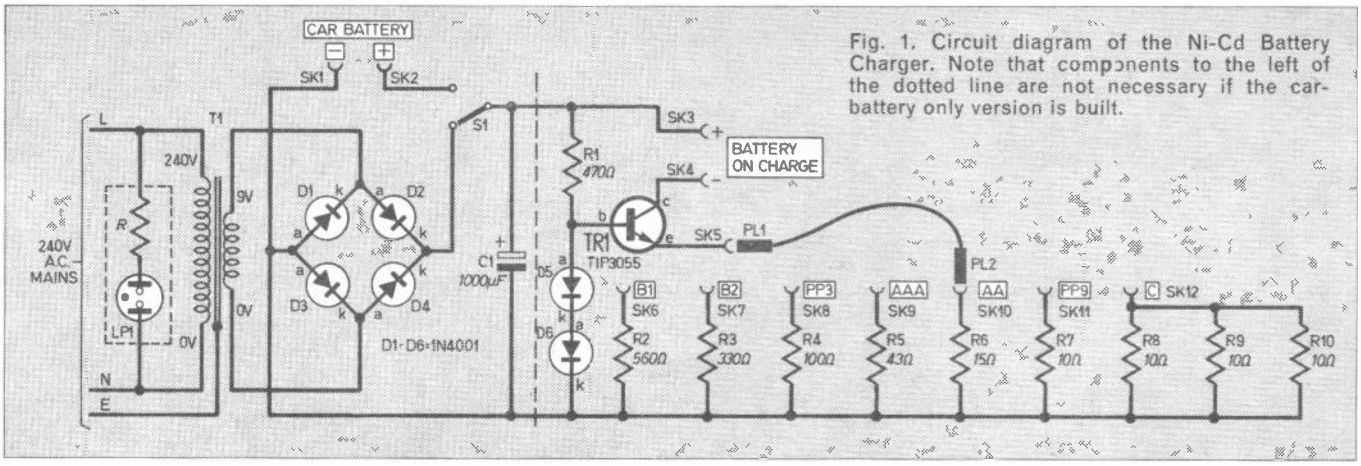



Fig. 1. Circuit diagram of the Ni-Cd Battery Charger. Note that components to the left of the dotted line are not necessary if the car-battery only version is built.

For quite a wide variation in operating conditions, therefore, the charging current will be fairly constant. This state will be maintained so long as no more than approximately 9 volts of batteries are connected to the output.

There will be at least one volt across the transistor collector/emitter and there would soon be insufficient voltage left out of the 12 volt supply to operate the circuit. Where a small number of batteries are connected for charging, the bulk of the supply voltage will be "dropped" across the transistor.

If the circuit is set to a high charge rate then a considerable amount of heat will be generated in the transistor.

## WORST CONDITIONS

Under the "worst" conditions, there will be about 10 volts across the transistor with 250mA flowing. Using Watts = Amps × Volts, power dissipated = 10 × 0·25 = 2·5 watts. If an efficient heat sink were not used for the transistor it would lead to overheating.

If the user is only going to charge 9 volt batteries where most of the voltage will appear across the battery and relatively little across the transistor, there will be far less heat produced. Furthermore, if only small charging currents are to be used, a smaller transistor without a heat sink might serve.

For the prototype, it was considered that the most versatile circuit was best especially in view of the small difference in constructional costs.

## COMPONENTS approximate cost £11

## CONSTRUCTION starts here

## CIRCUIT BOARD

The circuit panel was built on a piece of 0·1 inch stripboard (14 strips by 29 holes). Breaks should be made in the tracks in the places indicated and care must be taken to make good soldered joints with no bridging between the copper tracks.

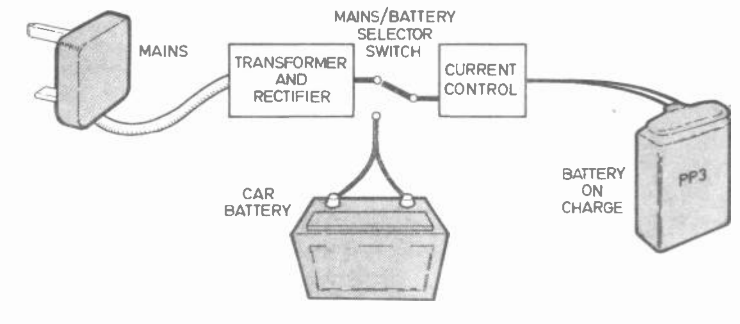
In the prototype R2 to R10 are selected by a system of miniature sockets. A flying lead with a plug on each end is plugged into the socket SK5 and the appropriate one for the battery being charged. An alternative would be to use a rotary switch.

The values of R2 to R10 are chosen from the preferred values and the currents will probably err on the low side. A little extra charging time may be allowed for this. The value of 3·3 ohms for the "C" type battery was obtained by connecting three 10 ohm resistors in parallel in the manner shown.

## TRANSFORMER

One corner is cut off the transformer panel to allow the connections to the secondary to pass to the circuit panel. The raw edge is protected with a piece of insulation stripped from a scrap of thick wire. The mains connections to the transformer primary should be made with three core wire.

The earth wire is connected to a solder tag and secured under the nut of a transformer fixing bolt. A hole is drilled in the case just large enough to allow the mains lead to pass out. Some slack should be allowed and a cable retainer fitted to the wire so




## HOW IT WORKS

Nickel cadmium cells can be damaged if charged at an unsuitably high current.

Mains voltage is transformed, rectified and smoothed to approximately 12 volts. This passes to a current controller which will allow regulated currents to flow into the cell being charged according to a selector plug.

The mains derived low voltage can be replaced by a battery if necessary.

# Ni-Cd BATTERY CHARGER

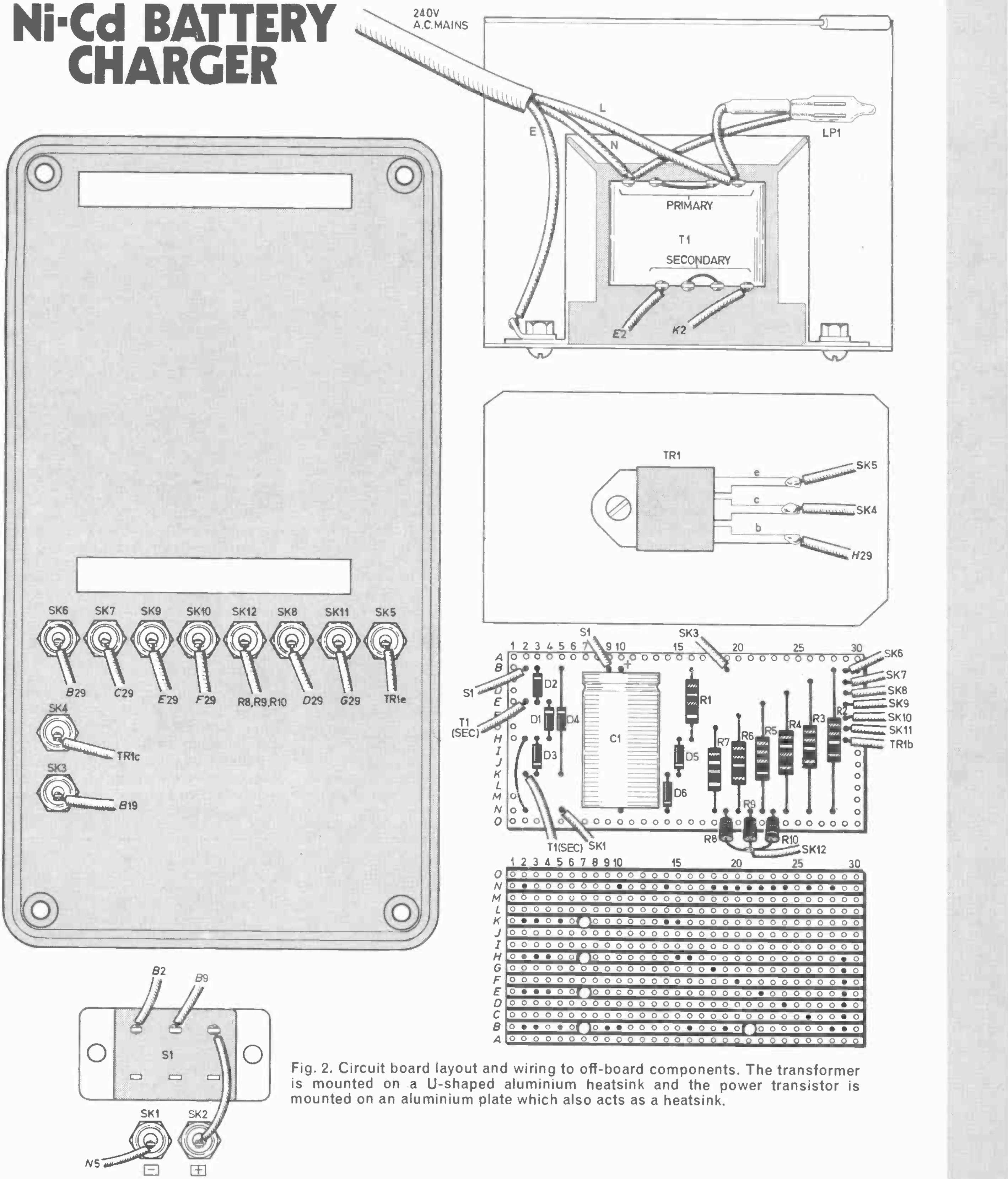



Fig. 2. Circuit board layout and wiring to off-board components. The transformer is mounted on a U-shaped aluminium heatsink and the power transistor is mounted on an aluminium plate which also acts as a heatsink.

## COMPONENTS

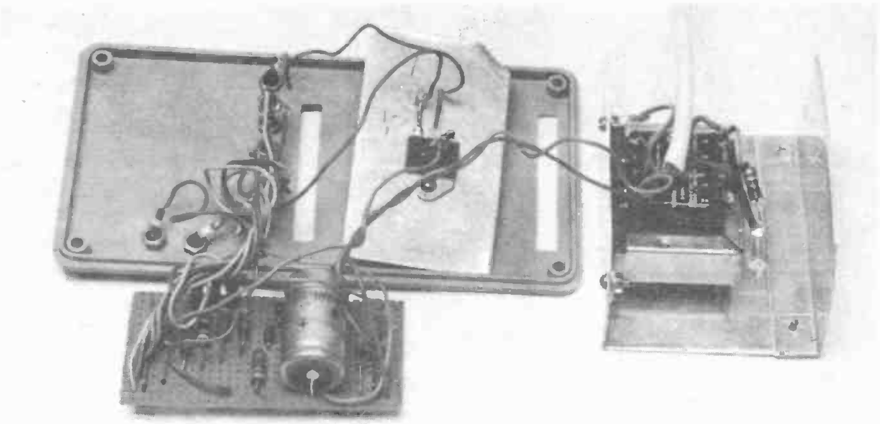
See Shop Talk page 93

**Resistors**
- R1 470Ω
- R2 560Ω
- R3 330Ω
- R4 100Ω
- R5 43Ω
- R6 15Ω
- R7-R10 10Ω (4 off)
- All ½W carbon ± 5%

**Capacitor**
- C1 1000μF 25V elect.

**Semiconductors**
- TR1 TIP3055 *npn* silicon plastic power package
- D1-D6 1N4001 1A 50V silicon rectifier diode (6 off)

**Miscellaneous**
- T1 mains primary/9V 600mA secondary
- S1 s.p.d.t. toggle or slide switch
- LP1 mains panel mounting neon indicator.
- SK1-SK12 1mm sockets (9 off red, 3 off black)
- PL1, 2 1mm plug, black (2 off)
- Plastics box 150 × 80 × 50mm, Bimbox 2005/15 or similar; 0·1 inch matrix stripboard, 14 strips × 29 holes; sheet aluminium for transformer and transistor heat-sinks; interconnecting wire; three-core, 3A mains cable.



Exploded view of interior components of the battery charger. The transformer mounted on its heat sink can be seen on the right with the transistor laying on top of the front panel in the centre of the picture. The circuit board is lying below the front panel.

that accidental strain will not pull the connections loose. A mains switch was not thought necessary.

### HEAT SINK

It was found that the small mains transformer specified produced rather a lot of heat. It was therefore necessary to take special precautions in the mounting of this component using aluminium panels (see photographs and Fig. 2) to avoid overheating.

There was a strong temptation to use a metal case for the project to reduce problems due to this heat. Unfortunately, good-looking metal boxes are expensive and demand greater care with mains connections.

It was therefore decided to use an ABS plastic box and no overheating was experienced with the layout given. Constructors are strongly advised to follow the original plans for this reason. In particular, the two slots cut into the top of the box are necessary to promote an airflow.

These should not be covered up during use. In a final test on the prototype, it was left switched on delivering 250mA with short-circuited output terminals. After 36 hours, the case was just slightly warm to the touch.

Under car battery use there will be far less heat produced as the mains transformer is not used. Although a more substantial mains transformer would be more efficient and keep cooler it would increase the size of the finished project.

The neon indicator in the prototype is optional. A ready made mains neon is used here. In the prototype a small hole was drilled in the case so that the neon could be plainly seen through it. Where there is any danger of bare wires touching an aluminium panel, they should be sleeved with scraps of insulation.

### SETTING UP

After fitting a 1 amp fuse to the mains plug, the unit may be checked on its various settings in the following way. A milliameter should be connected straight across the terminals to which the battery under charge will be connected. The values of current should be equal to, or rather less than, those given in Table 1. A check may be done with a car battery and, of course, in this case the unit is not plugged in to the mains. A long period under full load should confirm that it remains cool. ⌑

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## in My Class

by
T.R.de Vaux-Balbirnie

I HAD set the class an exercise. They were asked to check diodes using multitesters.

They were to set their meters to "ohms" then to check that they read zero when the leads were touched together. Then they connected the diode to the leads, first one way round then the other.

A good diode would show low resistance one way and high resistance the other. A low or a high reading on both occasions would indicate a faulty component.

When everyone has succeeded in separating the good diodes from the bad John came up with a question—was it right that the *negative* end of the diode was marked? I confirmed that our diodes had a white band indicating the negative or cathode end. He was puzzled because, in every case, a good diode showed low resistance when the marked end was connected to the *positive* lead of the meter.

It told him that his mistake was in supposing that the lead marked "positive" is connected to the positive terminal of the internal battery. This is not so, at least not with most multimeters. The polarity marked on the meter refers to its use as a voltmeter or an ammeter—the positive lead must be connected to the positive terminal of the supply.

When the meter is switched to "ohms" an internal battery is connected and it turns out that the polarity of the leads is opposite to what is expected—the lead marked "positive" is connected to the negative of the battery. I drew a diagram to illustrate this point.

When simply checking for good and bad diodes this is unimportant but where the cathode of a diode needs to be identified, some diodes are not marked, then this fact needs to be remembered.

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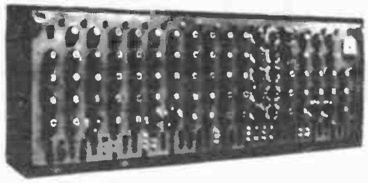

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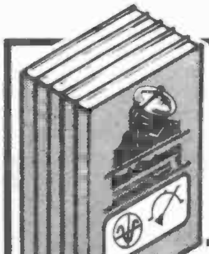

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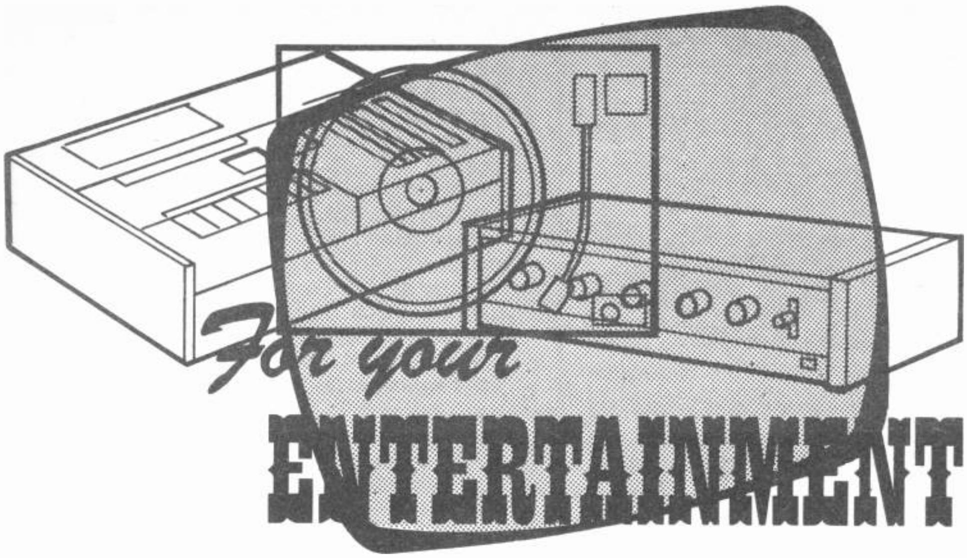


# For your ENTERTAINMENT

**By BARRY FOX**

## Time Out

Like something out science fiction, the occupants of a block of North London houses woke up recently and went about their daily business exactly one hour late.

In the early hours of the morning the London Electricity Board had shut off their mains supply for an hour while working on an emergency repair. As a result every mains-powered analogue electric clock and alarm was effectively set back by an hour.

Because it all happened while they were asleep, residents only found out if they had a digital clock which re-set to a warning 8888 display. Others found out only when they were berated by angry employers for turning up to work an hour late.

"Have you thought through what this could mean, for example, to someone who misses a non-refundable airline flight", I asked the LEB. "We can hardly go round knocking on doors in the middle of the night to warn people that they are going to wake up an hour late the next day" was the reply.

"But you could drop duplicated notes through their doors warning them to check their clocks when they wake up" we persisted. "We never thought of that" admitted the LEB.

So will the simple warning scheme be implemented? Only time and readers' experience will tell us.

## Classic Hoax

It becomes increasingly difficult to feel any sympathy for the record companies and their current financial strife. It seems they don't even listen to their own records and they don't read the magazines that report on them.

In a classic hoax the managers of an Edinburgh record shop sent "demo" tapes of famous pop and jazz artists to the talent spotters of their own record companies. The tapes were labelled only with pseudonyms and, yes, you've guessed it, the record companies unanimously rejected them.

The same week Decca, the record company which once rejected a demo tape made for them by the then-unknown Beatles, staged an impressive trade and press demonstration of its digital recording equipment at the elegant Arts Club in Warwick Square. But only a handful of the old-established music reviewing magazines were invited. The new hi-fi magazines, which have been enthusing in print over Decca's digital work for the last 18 months, only found out by chance or not at all.

To cap the same memorable week, Malcolm McLaren (the man who sold EMI the Sex Pistols) claimed to have collected £55,000 from EMI for a group called Bow Wow. Their first record was entitled C30, C60, C90 and yes, again, you've guessed it, the lyrics seemed to encourage listeners to tape records rather than buy them.

Commenting on the record, EMI say they have released the record "to bring the whole business of home taping out into the open". Others in the industry were less charitable. But the Bow Wow disc soon climbed the sales charts and became a hit!

## Power Packs

Some time ago I suggested that readers try scavenging the flat batteries from used Polaroid SX-70 instant-film packs. Even after all ten picture shots have been used up these batteries usually hold a useful reserve of 6 volt power. The only difficulty in using the batteries is securing the leads to the metal terminal tags, because these will not take solder.

Polaroid is however now selling flat batteries on their own, complete with a holder with external fly leads. The only snag now is the price.

The "Polapulse design kit', which should by now be available in the UK will cost around £15. For that you get five flat carbon-zinc 6 volt Polapulse batteries and a moulded plastic holder into which the battery inserts as a push fit. The external fly leads on the battery holder go through the case to internal pressure contacts which bear hard against the battery terminals to provide a secure electrical connection.

Although the batteries have a shelf life of three years, are leak proof and will deliver up to 26A for instantaneous discharge and 1A for nearly six minutes, the £15 price tag seems very high. Polaroid say this is because the kits are only being offered in limited quantities for designers who are looking at the possibility of using flat Polapulse batteries to power electronic toys, recorders, radios and remote control devices.

Readers will doubtless immediately hit on the idea of buying a single kit and then "feeding" the battery holder with more batteries scavenged from old SX-70 packs. Unfortunately this isn't feasible. Polaroid have (deliberately?) designed the Polapulse battery holder so that it will not accept old XS-70 batteries.

You can, in fact, get the size right by stripping an SX-70 battery from its outer protective wrapper but the terminals are still in the wrong position. However, it shouldn't be too difficult to build a battery holder, for instance from Perspex, with pressure terminals in just the right place to accept an SX-70 battery.

## Life of a Bulb

Have you ever timed the working life of a light bulb? For that matter have you ever met anyone who has ever timed the working life of a light bulb? Perhaps now is the time to start.

The companies who make and sell electric light bulbs are very touchy over the question of guaranteed life and the possibility of otherwise of making light bulbs last longer than they currently do. It's obviously a tricky commercial problem for them. A short-life bulb only sells more until the public realises it offers short life. A long-lasting light bulb can be sold for more money but by definition fewer of them will be sold.

At least one manufacturer discharges a high voltage from a capacitor through every light bulb coming off the production line to limit its working life. This is not as malicious as you might expect. The aim is to create stresses in the filament which make it fail suddenly, rather than run on with decreasing light output and efficiency. And if a light bulb fails before its guaranteed life a purchaser shouldn't have too much problem claiming a free replacement.

But now we are back to that original question. Who actually times the working life of their light bulbs?.

## No Guarantee

Recently I noticed a disturbing trend which raises more questions. Woolworths are starting to sell light bulbs without any mention of guaranteed life.

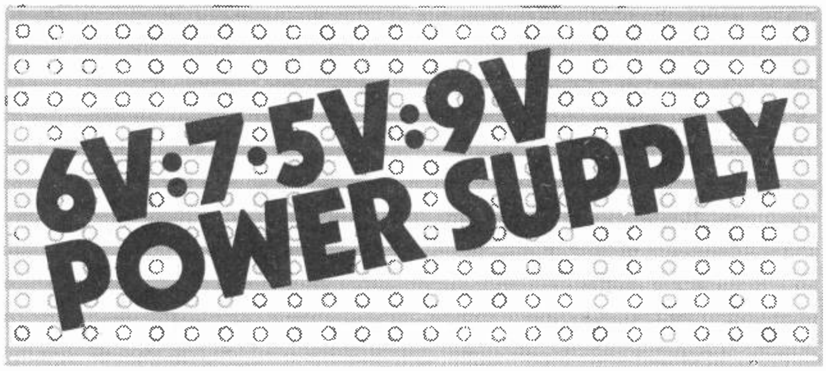
I asked the company for comments. After a little vacillation they came up with the reassurance that they guarantee "most of our bulbs for 1,000 hours and our stores will always change a bulb which fails to last the guaranteed time". This inevitably raises the question of how purchasers are to know which Woolworths (Winfield brand) fall under the "most of" category and which don't.

Is this perhaps advance warning of an alarming new trend—an end even to guarantees of 1,000 hours? And are bulbs now being sold without a guarantee of 1,000 hours regularly failing after shorter periods?

If any reader has carried out any serious tests on lamp bulb life, or feels inclined to do so, I would be pleased to receive them, collate the results, put them to manufacturers where appropriate and publish any useful findings. Any such tests should confirm voltage rating for the bulb, nominal mains voltage, rated life (if stated), actual life measured and, of course, brand name of bulb under test.

# I.C. UNIBOARDS

## SIMPLE INTEGRATED CIRCUIT DESIGNS



# 6V:7·5V:9V POWER SUPPLY

No. 3

BY A. R. WINSTANLEY

THIS MONTH'S design is a Mini Power Unit designed for general-purpose applications. From a mains input it will supply 6V, 7·5V or 9V d.c. The maximum recommended load is about 300mA, although in some applications (where noise is not important) this can rise to 500mA maximum.

The Mini Power Unit, although useful for powering radios, cassette recorders, calculators from the mains could also be used as a simple bench power unit, where it has proved ideal for simple experiments and testing.

## CIRCUIT

The full circuit can be seen in Fig. 1. Mains voltage is applied through S1 (the on/off switch) and FS1 to the primary of T1, a step-down transformer. This reduces the mains to 12V a.c. and this is rectified by D1-D4 and smoothed by C2 to produce a d.c. output of roughly 17V, no load. The capacitor C1 removes noise which may arise in the bridge rectifier diodes and D5 is a standard l.e.d. with current-limiting resistor R1. This provides a "power on" indication.

In its present form the 17V d.c. is of course not variable. Furthermore, being unregulated, it will tend to reduce somewhat as the load current increases.

## VOLTAGE REGULATOR

The most important part of the circuit is IC1, a LM317H three-terminal variable voltage regulator. The 17V d.c. is passed through R2 and R3 to the input of the regulator. These two resistors, which are wirewound, assist in diverting power dissipation away from IC1, allowing it to run more efficiently.

The integrated circuit itself is fully protected. Included on the chip are both thermal overload protection and current-limiting circuits. This means that the i.c. will shut down if overheating due to insufficient heatsinking occurs.

Current limiting prevents the current passing through the device from exceeding 750mA as actually measured on the prototype.

This means that the Mini Power Unit will not suffer any damage if the output is temporarily shorted, although prolonged short-circuits are not recommended.

## OUTPUT

A reference voltage is supplied via R10 and 240 ohms is the value used in most applications. The output of the regulator depends on the resistance between the Pin 3 of IC1, and 0V. The formula is:

$$\text{Output voltage} = \frac{1{\cdot}2\,(240+R)}{240}\ \text{Volts}$$

where $R$ is the resistance (in ohms) between Pin 3 and ground.

The various resistor values are selected by S2 so that by altering this switch, various output voltages are obtainable. Fixed resistors (as opposed to presets) are used as shown so that 6, 7·5 or 9 volts are obtainable at the touch of a switch. Also, no test equipment is needed in setting up readers' models.

Capacitors C3, C4 and C5 in the circuit help to improve the performance of the unit by reducing noise around the i.c. and on the voltage rails.

## MULTIPLUG LEAD

This design is intended for use with a "multiplug" power lead. On one end this has a 2·5mm and 3·5mm jack plug, together with a 2·1mm and 2·5mm d.c. power plug. The other end requires a 3·5mm jack plug.

The sockets SK1 and SK2 are two insulated 3·5mm jacks. Depending on which socket the multi-plug power lead is inserted into, the tips of the

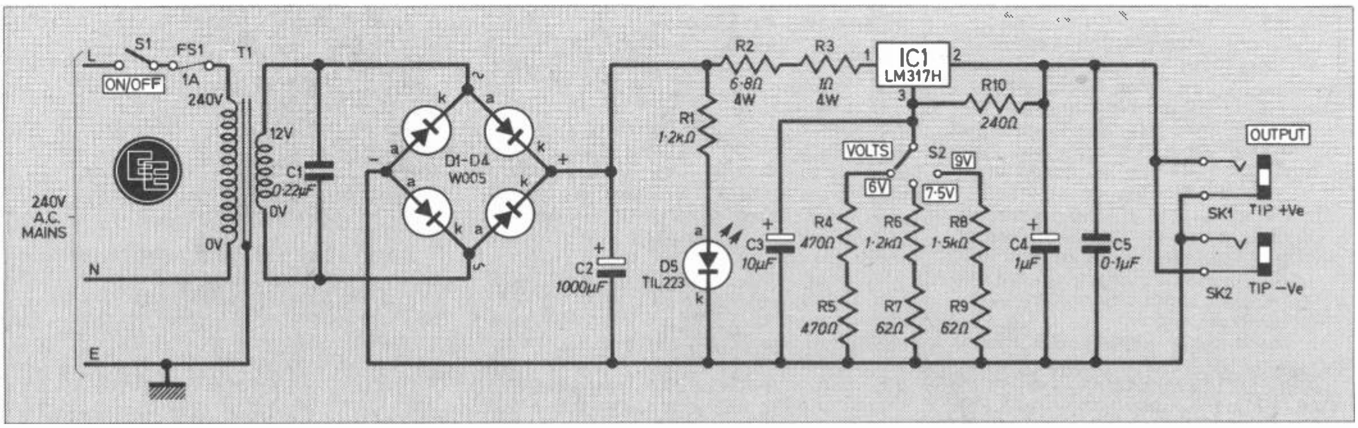
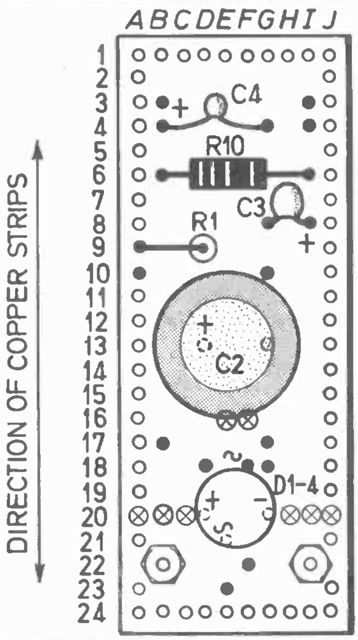



Fig. 1. Full circuit diagram of the Uniboard Power Supply.



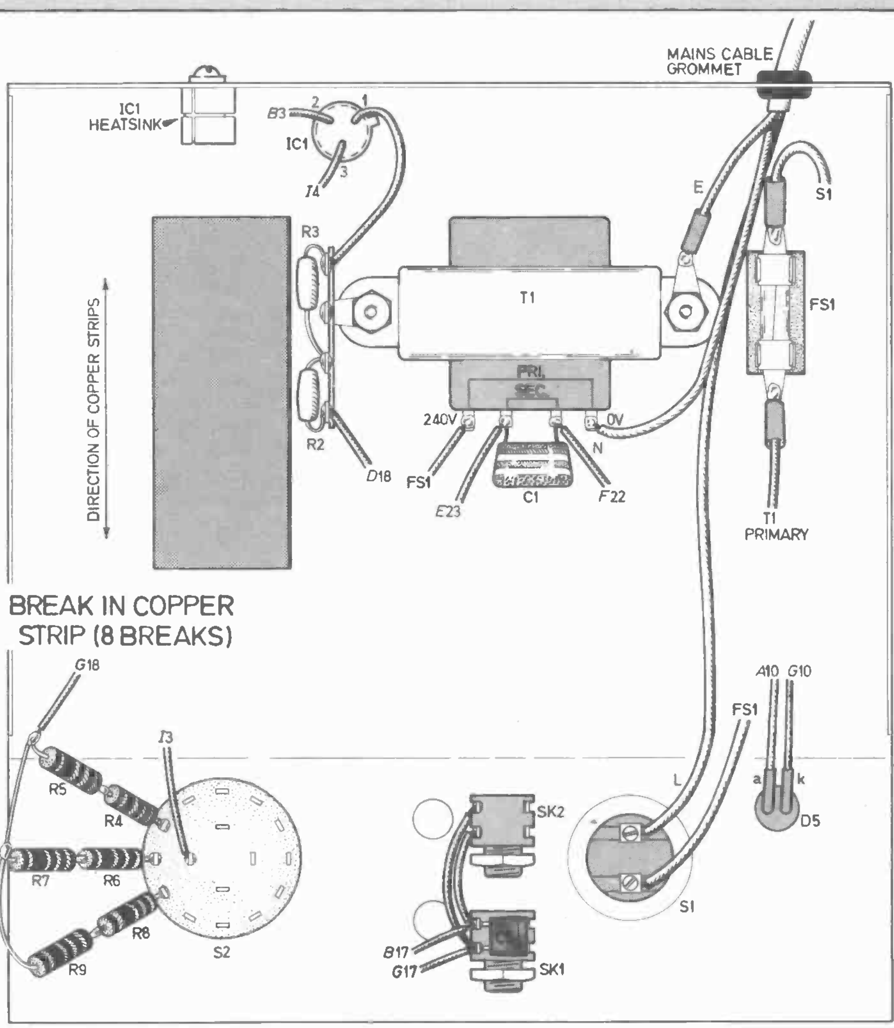




Fig. 2. Circuit board layout and interconnection diagram. The heatsink for IC1 must be insulated from the metal chassis.

## COMPONENTS

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 1·2kΩ | R6 | 1·2kΩ |
| *R2 | 6·8Ω 4W | R7 | 62Ω |
| *R3 | 1Ω 4W | R8 | 1·5kΩ |
| R4 | 470Ω | R9 | 62Ω |
| R5 | 470Ω | R10 | 240Ω |

All ¼W carbon ± 5%, except R2, R3.
*Wire-wound

**Capacitors**

C1 0·22μF polyester C280
C2 1000μF 25V elect.
C3 10μF 35V tantalum bead
C4 1μF 35V tantalum bead
C5 0·1μF ceramic plate

**Semiconductors**

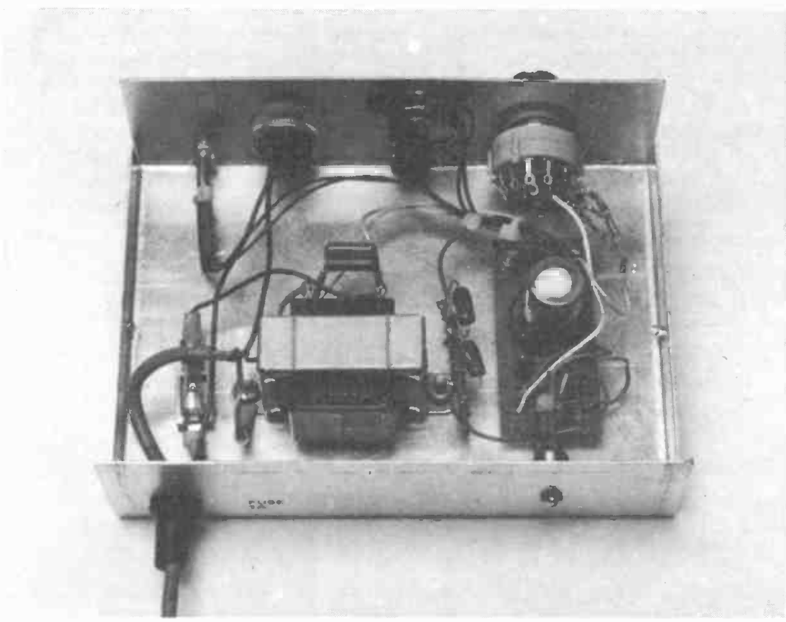
IC1 LM317H variable voltage regulator, TO-5 can
D1-D4 W005 50V, 1·5A bridge rectifier
D5 TIL223 0·2 inch yellow l.e.d.

**Miscellaneous**

T1 Mains primary/12V 500mA secondary
S1 s.p.s.t. mains rocker switch
S2 one-pole, three-way rotary switch (see text)
SK1, 2 3·5mm mono jack, fully insulated type (2 off)
FS1 20mm 1A fuse with chassis mounting holder

Case, 150 × 125 × 50mm, type TP2, or similar; 0·1 inch matrix stripboard, 10 strips × 24 holes; panel mounting TO-5 type heat-sink; four-way tagstrip; solder tag; lens clip for D5; knob; multi-plug power lead; adhesive rubber feet; mounting hardware; cable grommet and retainer; three core mains cable; interconnecting wire.

**Guidance only Approx cost** **£12·50** complete
See page 93



Interior view of the unit from the rear. The wiring to the front panel mounted controls can be clearly seen.


Exterior view of the completed power supply showing front panel controls and labelling.

multi-plug will be positive (SK1) or negative (SK2). Therefore an output of either polarity is obtainable, making the Mini Power Unit compatible with many types of apparatus.

## TRANSFORMER

It would be wise to obtain the transformer first, and then choose a housing of suitable height to encase the unit. The prototype was built in an aluminium/steel box measuring 150 x 125 x 50mm.

Some components are accommodated on a piece of 0·1 inch matrix stripboard of the usual Uniboard dimensions, 10 strips x 24 holes. The board layout is shown in Fig. 2 along with the off-board component interwiring. The stripboard requires two 6BA clearance holes so that it can be bolted down with nuts, bolts and spacers.

The rotary switch S2 is mounted on the front panel, and resistors R4 to R9 are soldered to its terminals as shown. A four-pole three-way switch can be employed, of which only one section is used, so that a one-pole three-way switch is achieved.

For SK1 and SK2 fully insulated sockets *must* be used. The standard metal open sockets will short out the output and are not suitable here. Fig. 2 shows how these two sockets are wired. Note that C5 is also soldered across SK1.

**TABLE 1**

| Output Voltage | Actual Voltage (*no load*) | Actual Voltage (*with load*) |
|---|---|---|
| 6V | 6·2V | 6·1V at 200mA |
| 7·5V | 7·8V | 7·8V at 250mA |
| 9V | 9·3V | 9·2V at 300mA |

## HEAT SINK

The i.c. is fixed down with a TO-5 panel-mounting heatsink to help in heat dissipation. The three wires to the i.c. should be soldered on and then the TO-5 case should be pushed into the heatsink, which is then bolted to the back panel with a steel 6BA bolt passing through an insulating bush.

Also the aluminium-oxide washer (provided with the heatsink) is sandwiched between the chassis and the heatsink, thereby preventing electrical contact.

The two power resistors can be soldered onto a piece of insulated tag strip which can be retained by one of the transformer mounting bolts. The other bolt on the transformer holds a solder tag in place, to which the earth input should be connected. This earths the metal case.

The mains cable passes through a hole in the chassis rear panel. This hole must be fitted with a rubber grommet to prevent chafing and also a cable retainer to hold the mains lead firmly in position. Miniature 3A three-core cable can be used for the mains input. Elsewhere employ standard hook-up wire. Plastic sleeving (2mm diameter) should be used as necessary on the l.e.d. and i.c. leads to prevent short-circuiting.

## FINISHING OFF

The l.e.d. should be fitted with a lens-clip to keep it in place and to improve appearance. If you wish to letter the front panel do this before fitting the panel mounted components and use rub-down lettering as required. A couple of coats of lacquer will help protect the transfers.

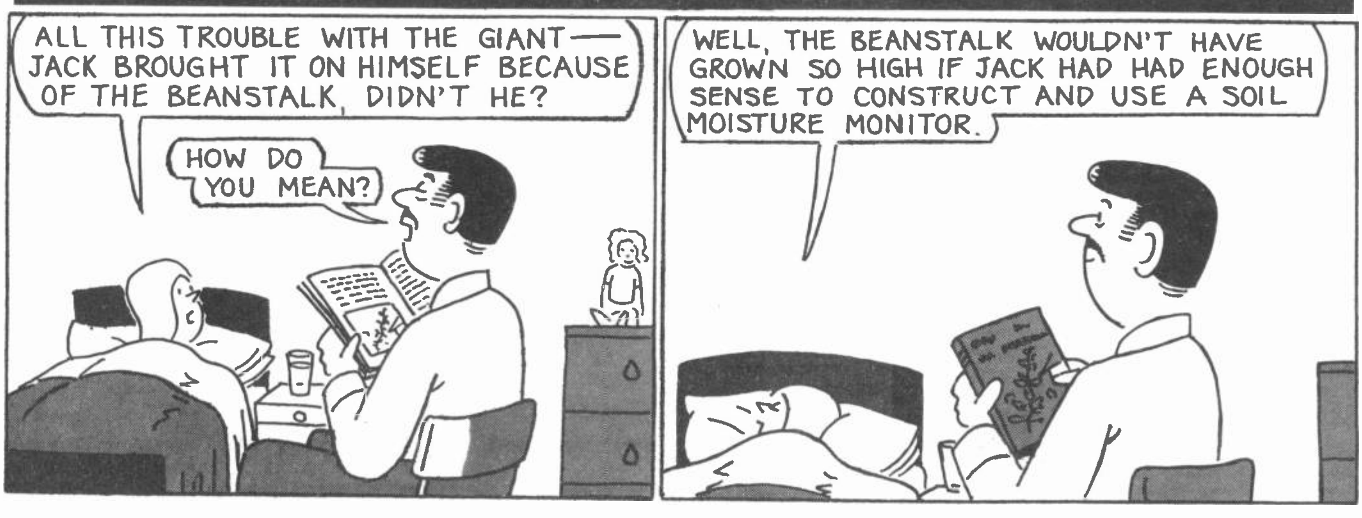
Solder a 3·5mm jack plug to the bare end of the multi-way power lead. The tips of the multiplug are connected to the wire with the tracer marking. Stick four adhesive feet onto the bottom of the case.

With construction complete, check all interwiring carefully, especially that going to IC1, and then switch on the mains to the unit. If a voltmeter is available then test to see that roughly the correct output voltages are generated (of the correct polarity) when S2 is operated.

The unit is then finished and ready for use. Table One gives a brief summary of readings taken on the author's prototype. ⌑

## JACK PLUG & FAMILY...

BY DOUG BAKER



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Two silver oxide batteries give approximately 1000 hours continuous use with power-saving automatic cut-off, with data and memory protection.
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Supplied with leathette wallet.

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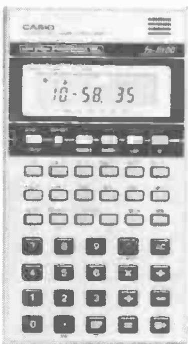

46 scientific functions, clock, calendar, alarm, countdown alarm, interval alarm timer, 1/100 second stop watch with lap timing.
**Clock.** Hours, minutes, seconds, am/pm.
**Calendar.** Pre-programmed to 1999. Day, date, month and year.
**Alarm.** 24 hour alarm with hourly chimes.
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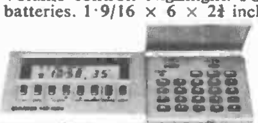
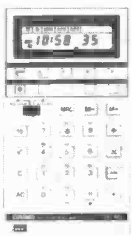
MQ-1200 (below). Desk or bedside. Built in speaker. Volume control. Nightlight. Powered by three AA batteries. 1·9/16 × 6 × 2 3/4 inches.



**£19·95** (£22.95)



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**Digital.** Hours, minutes, seconds, day and date.
**Stopwatch.** 1/100 second to 12 hours. Net, lap and 1st and 2nd place. Start/stop and 10 minute signals.
**Alarm.** For 30 seconds with carousel display.
**Countdown Alarm.** Normal and net times to 1 hour with amazing "Star Burst" flashing display.
**Time signal.** Half hourly and hourly chimes. Tone control. Lithium battery. Light, Water Resist case. 8·65mm thick. Mineral glass.
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**AA81G Gold plated £49.95**
**AA82 Stainless steel £39.95**

**12 MELODY ALARM CRONOGRAPHS**
**Countdown alarm. Date memories.**
Hours, minutes, seconds, am-pm, 12 or 24 hour. Day, date and month auto calendar.
**Alarm.** 7 melodies, one for each day of the week.
**Hourly time signals.** With "Big Ben" type tune.
**Date memory.** Select either "Wedding March" or "Trinklied" to be played.
**Birthday and Christmas Memory.**
**Countdown alarm.** From 1 second to 1 hour. After zero, count continues positively.
**Stopwatch.** 1/10 second to 1 hour. Net, lap etc. Picturesque moving display of notes played. Light, Lithium, Glass, Water Resist cases.
M-12 resin, s/s trim.
M-1200 all s/s 9·0mm thick.

**£24·95** **£29·95**
For around 40 functions.

CASIO

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**Alarm Chronographs with countdown**
Amazing 5 year lithium battery life. Hours, minutes, seconds, am/pm, day, date and month. 12 or 14 hour. Time is always visible regardless of display mode.
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**Alarm.** Sounds for 30 seconds.
**Countdown Alarm.** Normal and net times to 12 hours. Start/stop and 10 minute signals.
**Time signal.** Half hourly and hourly chimes.
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## SEIKO Alarm chronos from £37·50

JET 010. Duo display (far right)
Independent analogue time. Digital time Calendar, alarm, hourly chimes, 1/100 second stopwatch. Stainless steel.
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# SQUARE one FOR BEGINNERS

ONCE THE electrical connections are complete the would-be constructor is often tempted to think that the major part of the job is done and little thought need be given to the rather less glamorous subject of hardware.

However it is very often true to say that the reason for electrical equipment failure is mechanical rather than electrical and can be traced back to flimsy or inadequate component mountings.

## NUTS AND BOLTS

Perhaps the most basic mounting device is the nut and bolt. These can be used to fasten virtually anything to anything but with such a large range of sizes, styles and materials, obviously certain types will be more suitable for certain applications than others.

The first distinction is metal or plastic. The latter should always be used to mount items which may become live or are fragile.

Metal types are rather more diverse but basically they can be classified in terms of size or head design.

Screw sizes are either classified in terms of diameter (6mm, 3mm, etc) or according to the BA range (2BA, 6BA, etc). It is more usual for E.E. to use the latter system and the largest size bolt is 0BA running to the smallest, 8BA.

## SCREW HEAD

The design of the screw head generally falls into two categories: counter-sunk, where the head is tapered underneath and allows the screw to lie flush with the panel surface; and non counter-sunk where the head may be domed, bevelled or flat (cheese head). The choice of design here is usually left to the taste of the constructor.

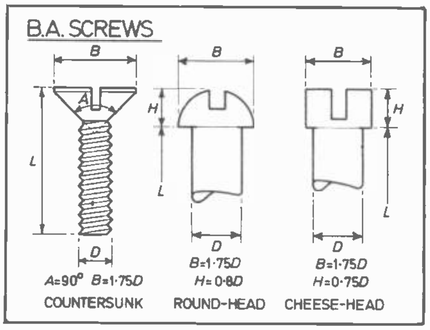



Table 1: Size and drilling data for BA nuts and bolts.

| Number | Diameter (mm) | Diameter (inches) | Tapping drill size | Clearance drill size |
|---|---|---|---|---|
| 8 | 2·2 | 0·087 | No. 50 | No. 43 |
| 6 | 2·8 | 0·110 | No. 43 | No. 33 |
| 4 | 3·6 | 0·142 | No. 32 | No. 27 |
| 2 | 4·7 | 0·185 | No. 24 | No. 12 |
| 0 | 6·0 | 0·236 | No. 10 | Letter B |

A third type of screw is the self-tapper. As its name implies it can be inserted into a hole of suitable size and will distort the hole slightly so as to form a screw thread which it can then grip. This type of screw is very useful when it is inconvenient to locate a nut behind the hole you are using.

Of course all the above metal nuts and bolts can be obtained in a variety of finishes, including chrome plate and brass.

## CIRCUIT BOARDS

When it comes to locating circuit boards, there are a variety of methods. The commonest is to use a spacing collar with a long nut and bolt. These collars can even be made from empty ball pen shells.

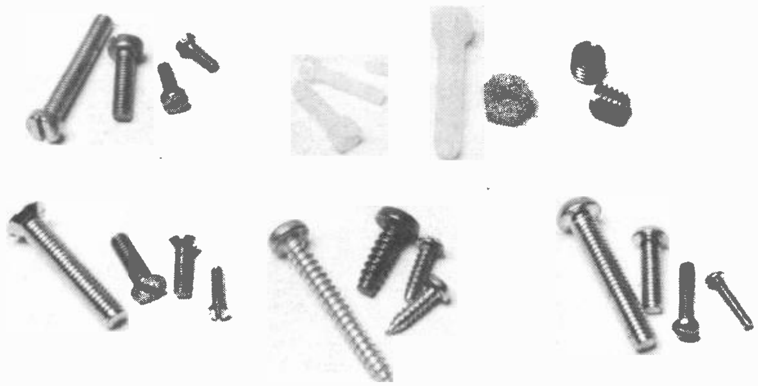
A variation on this is to use threaded collars which require a small bolt at each end.

Probably the easiest way of securing the board is by using self adhesive circuit board guide. This consists of a preformed plastic section attached to which is a length of self adhesive material. The guide can be cut to length, slipped on the board, and then the whole stuck down firmly in the case. It can be obtained for vertical or horizontal board mounting.

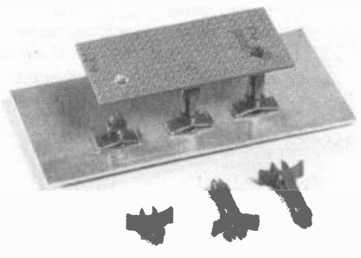
Another method of mounting is really a variation on the bolt and collar detailed above. This is a specially designed plastic support pillar which can be clipped onto the board and also the case through holes of an appropriate size. Some designs allow the boards to be stacked. However this arrangement is only really suitable for light duty, low power equipment.

## SPECIAL CASES

If the constructor is willing to restrict his choice of board size and case then he may well want to use one of the cases available with preformed slots on the interior walls. These are available in both metal and plastic and allow certain sizes of circuit board to be simply slotted into position without further mounting problems.



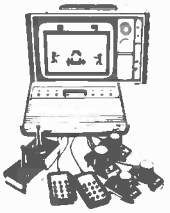
Top row (left to right): cheese head bolts; nylon bolts; grubscrews.
Bottom row: counter-sunk bolts; self-tapping screws; dome-head bolts.



Plastic board mounting pillars.

# ELECTRONIC GAMES

## ATARI



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## INTELLIVISION MATTEL

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This is the most advanced TV game in the world. Expandable next year into a full microcomputer.
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## CHESS COMPUTERS

NEW RANGE AVAILABLE AUGUST 1980
We specialise in computer chess machines & stock over 13 different models from £20 to £300

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## TELETEXT

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Add on Adaptor
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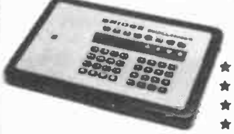
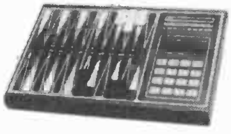
## BRIDGE COMPUTER



* Plays 1/2/3 or 4 Hands
* Problem Mode
* Audio Feedback
* Instant Response
* Auto scorekeeping

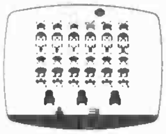
## BACKGAMMON COMPUTERS



OMAR 1
OMAR 2
CHALLENGER
GAMMONMASTER

From £38 to £108. Send for further details.

## SPACE INVADERS



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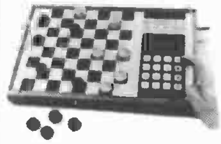

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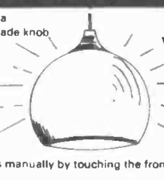
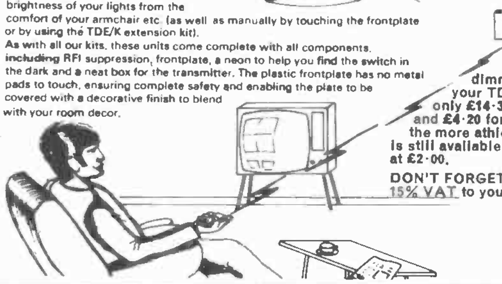
## AND NOW A DIMMER THAT MAKES TOUCH DIMMERS OBSOLETE

Two years ago TK Electronics launched a touchdimmer kit, the TD300K, which made knob controlled dimmers obsolete. This was such a great success that many magazines and more retailers soon produced similar designs. SO THAT OTHERS MAY FOLLOW, TK have designed a touch dimmer kit with an Infra Red Remote Control, enabling you to switch and control the brightness of your lights from the comfort of your armchair etc. (as well as manually by touching the frontplate or by using the TDE/K extension kit).



We have designed the light dimmer unit to fit a standard wall box, the transmitter to fit your hand and the price to fit your pocket.

As with all our kits, these units come complete with all components, including RFI suppression, frontplate, a neon to help you find the switch in the dark and a neat box for the transmitter. The plastic frontplate has no metal pads to touch, ensuring complete safety and enabling the plate to be covered with a decorative finish to blend with your room decor.



In two years' time everyone will be selling remote control dimmers but you can have your TDRK300K kit NOW for only £14·30 for the dimmer unit and £4·20 for the transmitter. For the more athletic of you, the TD300K is still available at £6·50 and the TDE/K at £2·00.

DON'T FORGET to add 40p P&P and 15% VAT to your total purchase.

## NEW REMOTE CONTROL KITS

MK6 — Simple Infra Red Transmitter—A pulsed infra red source which comes complete with a hand held plastic box. Requires a 9V battery. £4.20

MK 7 — Infra Red Receiver—Single channel, range approximately 20ft. Mains powered with a triac output to switch loads up to 500W at 240V ac, can be modified for use with 5-15V dc supplies and transistor or relay outputs. £9.00

*Special Price* MK6 and MK7 together. Order as RC500K £12.50

MK8 — Coded Infra Red Transmitter—Based on the SL490, the kit includes two IR LEDs, measures only 6 × 2 × 1·3 cms. Requires a 9V (PP3) battery. £5.90

MK9 — 4 Way Keyboard—for use with the MK8 kit, to make a 4-channel remote control transmitter. £1.90

MK10 — 16 Way Keyboard—for use with the MK8 kit, to generate 16 different codes for decoding by the ML926 or ML928 receiver (MK12 kit). £5.40

MK12 — 16 Channel IR Receiver—for use with the MK8 kit with 16 on/off outputs which with further interface circuitry, such as relays or triacs, will switch up to 16 items of equipment on or off remotely. Outputs may be latched or momentary depending on whether the ML926 or ML928 is specified. Includes its own mains supply. Size 9 × 4 × 2 cms, excluding transformer. £11·95

ALL COMPONENTS ARE BRAND NEW AND TO SPECIFICATION. ADD VAT AT CURRENT RATE TO ABOVE PRICES. 40p P&P MAIL ORDER – CALLERS WELCOME BY APPOINTMENT. *Send SAE with all enquiries.

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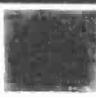
## 24 HOUR CLOCK/APPLIANCE TIMER KIT

Switches any appliance up to 1KW on and off at present times once per day. Kit contains: AY-5-1230 IC, 0·5" LED display, mains supply, display drivers, switches, LEDs, triac, PCBs & full instructions.

| | |
|---|---|
| CT1000K Basic Kit | £14.90 |
| CT1000KB with white box (56/131 × 71mm) | £17.40 |
| Ready Built | £22.50 |

## D.V.M. THERMOMETER KIT



Based on the ICL 7106. This kit contains a PCB, resistors, presets, capacitors, diodes, IC and 0.5" liquid crystal display. Components are also included to enable the basic DVM kit to be modified to a Digital Thermometer using a single diode as the sensor. Requires a 3mA 9V supply (PP3 battery). £19.50

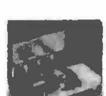
## DISCO LIGHTING KITS

Each unit has 4 channels (rated at 1KW at 240V per channel) which switch lamps to provide sequencing effects, controlled manually or by an optional opto-isolated audio input.

**DL1000K**

This kit features a bi-directional sequence, speed of sequence and frequency of direction change being variable by means of potentiometers. Incorporates master dimming control. £14.60

**DLZ1000K**



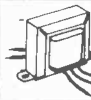
A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a preset pot. Outputs switched only at mains zero crossing points to reduce radio interference to minimum. £8.00

Optional Opto Input DLA1 60p

## LEDs

| | |
|---|---|
| 0·1" Red or 0·2" | 9p |
| 0·1" Green or 0·2" | 12p |
| 0·1" Yellow | 12p |
| 0·2" Yellow | 12p |
| 0·2" clips | 3p |
| Rectangular Red | 18p |
| Rectangular Green | 20p |
| Rectangular Yellow | 21p |

## MINI TRANSFORMERS



Standard mains primaries 240V a.c. 100mA secondaries

| | |
|---|---|
| 6-0-6V | 80p |
| 9-0-9V | 85p |
| 12-0-12V | 90p |

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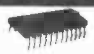
## CMOS

| | | | | | |
|---|---|---|---|---|---|
| 4000 | ·17 | 4019 | ·42 | 4069 | ·19 |
| 4001 | ·18 | 4023 | ·22 | 4070 | ·19 |
| 4002 | ·18 | 4025 | ·21 | 4071 | ·18 |
| 4007 | ·17 | 4026 | 1·30 | 4077 | ·26 |
| 4011 | ·19 | 4027 | ·40 | 4081 | ·20 |
| 4012 | ·17 | 4028 | ·50 | 4093 | ·54 |
| 4013 | ·38 | 4040 | ·80 | 4501 | ·24 |
| 4015 | ·75 | 4049 | ·38 | 4511 | ·90 |
| 4016 | ·35 | 4050 | ·40 | 4514 | 1·80 |
| 4017 | ·70 | 4060 | 1·80 | 4516 | 1·80 |

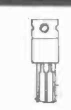
## INTEGRATED CIRCUITS



| | |
|---|---|
| 555 Timer | 21p |
| 741 Op. Amp. | 19p |
| AY-5-1224 Clock | £2·60 |
| AY-5-1230/2 Clock/timer | £4·50 |
| AY-3-1270 Thermometer | £8·20 |
| ICL7106 DVM (LCD drive) | £7·00 |
| LM377 Dual 2W Amp. | £1·45 |
| LM379S Dual 6W Amp. | £3·50 |
| LM380 2W Audio Amp. | 80p |
| LM382 Dual low noise Preamp. | £1·00 |
| LM386 250mW low voltage Amp. | 75p |
| LM1830 Fluid Level Detector | £1·50 |
| LM2917 f-v Converter (14 pin) | £1·60 |
| LM3909 LED Flasher/Oscillator | 60p |
| LM3911 Thermometer | £1·20 |
| LM3914 Dot/Bar Driver | £2·10 |
| MM74C911 4 digit display controller | £6·50 |
| MM74C915 7 segment-BCD converter | 96p |
| MM74C926 4 digit counter with 7 seg. o/p | £4·50 |
| S566B Touchdimmer | £2·50 |
| SL440 AC Power phase control | £1·75 |
| SN76477 Complex Sound Generator | £2·52 |
| TBA800 5W Audio Amp. | 68p |
| TBA810AS 7W Audio Amp. | £1·00 |
| TDA1024 Zero Voltage Switch | £1·20 |
| TDA2020 20W Audio Amp. | £2·85 |
| ZN1034E Timer | £1·80 |

All ICs supplied with data sheets.
Data Sheets only. 10p each device.

## TRIACS



400V Plastic Case (Texas)

| | | | |
|---|---|---|---|
| 3A | 49p | | |
| 8A | 58p | 16A | 95p |
| 12A | 85p | | |
| 6A with trigger | 80p | | |
| 8A isolated tab | 65p | | |
| Diac | 18p | | |

# CIRCUIT EXCHANGE

## ELECTRONIC VOLTMETER

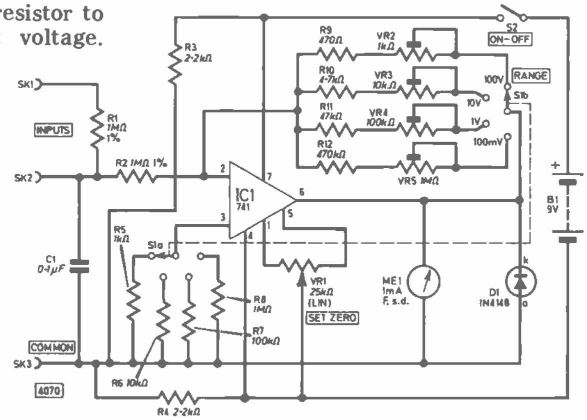
Here is the circuit diagram for an Electronic Voltmeter which I have built. The input impedance is nominally 1 megohm on all ranges (SK3 and SK2) and the ranges are: 100mV, 1V, 10V, 100V.

The design requires no expensive 1 per cent resistors or hard-to-obtain large-value resistors. S1b selects the appropriate feedback resistor which determines the range of the meter and calibration is achieved by adjusting the presets in series with the fixed resistors.

S1a selects the necessary resistor to minimise the output offset voltage. The 25 kilohm linear potentiometer is for zeroing purposes.

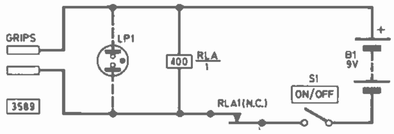
SK1 and its associated 1 megohm resistor is optional and provides voltage ranges of 200mV, 2V, and 200V. If this facility is included the two 1 megohm resistors must be 1 per cent tolerance.

D. J. Edwards,
St Ann's,
Nottingham




## ELECTRIC SHOCK MACHINE

The "Electric Shock Machine", or induction coil as it is called, is a popular novelty

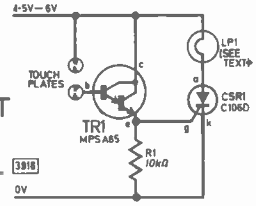



The circuit I put forward needs only a relay (300-400 ohms) with at least one normally-closed contact, a s.p.s.t. switch and a PP3 battery.

The circuit works on the back e.m.f. from the relay coil (which is usually a nuisance) produced every time the relay turns off. The voltage produced is sufficient to make a neon lamp glow, or to give a "jolt".

Nicholas Ray,
Buntingford, Herts

## TOUCH-ON PILOT LIGHT



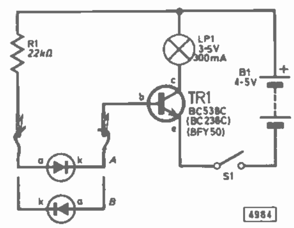

I have devised a Touch-On Pilot Light that might interest other readers.

The design uses the very minimum of components and has no on/off switch so that it is always in the standby mode without using any current. This is because the lamp used (a Japanese bi-metal flashing lamp) switches itself off after a certain period and then "waits" for the thyristor to switch it on again. I have found that, in practice, just one transistor is usually not sufficient to supply the current for even a sensitive gate thyristor, so that I have resorted to using an *npn* Darlington transistor as the touch sensitive element with very high input impedance.

R. L. A. Trost,
Soest,
Holland

## DIODE POLARITY TESTER

Here is my own idea for a Diode Polarity Tester which will also ascertain if a diode is working or not. The circuit is quite simple.




With the diode connected at position *A* the bulb will light. If it is reversed as at position *B*, the bulb will not light. By a process of elimination alternating the diode between *A* and *B* the polarity of the diode (and whether or not it is working) can be ascertained.

Mark Danielson (aged 14),
Chelmsford,
Essex

## ULTRA-SONIC TRANSMITTER-RECEIVER

This circuit can be used as a switch as well as an alarm. It comprises a transmitter with a basic oscillator circuit tuned to 30kHz and a matching receiver.

*Transmitter*—TR1 and TR2 are emitter coupled via the transducer X1 so the circuit oscillates at the frequency of the transducer and generates an ultrasonic signal.

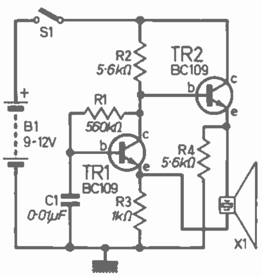
*Receiver*—The circuit C2, L1 is tuned to the required frequency. Values for C2 and L1 can be worked out by trial and error or using a fixed value for L1 and varying the capacitor for best possible results where $f = 2\pi\sqrt{L1 \times C2}$.

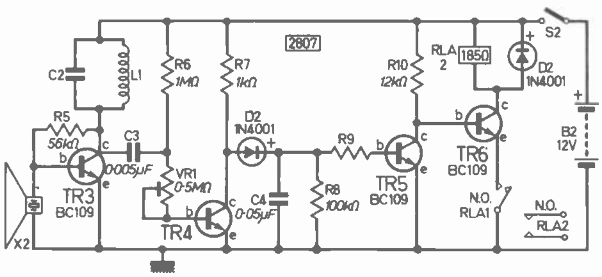
If used as an alarm VR1 can be adjusted so TR4 bias is at about 1·8 volt (i.e. saturated). If the beam is broken TR4 is then driven out of saturation and switches TR5 so switching the relay on, since this is self-latching, the alarm will stay on until it is switched off.

The transmitter and receiver must be positioned some yards apart and face to face before any adjustments are made.

If used as a switch, similar circuitry is used except that TR4 is replaced by a *pnp* type transistor.

K. K. Gandaa,
London SW9



# LETTERS

## Great Stimulant—But . . .

For the past couple of years I have been reading your magazine with a great deal of interest and have built many of your projects. And I feel I must write to you on a subject I am sure many other readers have had their say on.

The subject? Well it is simple, why do you not print the circuits in p.c.b. fashion?

I personally loath working on matrix boards and prefer the easier p.c.b.s. I have even gone to the length of designing my own p.c.b.s (when I have the time to do so) from your circuit diagrams which I must admit I do enjoy doing immensely, as it is a great mental stimulant. But there are times, that due to work pressure I am either forced to use the matrix or shelve a project for some months.

I would also like to take this opportunity to ask any of your readers if they would like to correspond with me, and exchange any ideas we may have, and to help solve problems that we both encounter in any projects.

E. Shearer,
Canley Vale, Australia

## Why no p.c.b.s?

Every month I read with great interest E.E. and make up a lot of projects.

In August issue *Auto Lighting-up Warning* I find you include a printed circuit board diagram, this is a nice change. I wonder why you nearly always specify Veroboard or matrix board. I find these difficult to get on with compared to printed circuits which are very simple to make for anything but complex circuits. I find matrix untidy and Veroboard, well it's very hard not to miss an occasional hole.

Is there any possibility of including both printed circuit diagrams as well as one of the others, giving your readers an alternative. I realise I am asking a lot, but all the USA and Australian circuits are all p.c.b.s.

As far as E.E. goes it's Tops as I have told you before and my best wishes for its continued success.

Ron Lockerbie,
Merimbula, Australia

## A Matter of Cost

May I draw your attention to the October issue 1980—project *Bicycle Alarm*. The cost was approximated as £8·00, but on checking with Tandy's catalogue it would cost £13·00.

Another incident where the quoted approximate cost is shown as £4·50, is the *Reaction Timer*, issue November 1980. Having bought a number of the parts, my nephew now finds the final total will be £10·50, an enormous excess for a schoolboy enthusiast, which has now to be shelved until he has more funds to carry on with this project.

Your comments would be appreciated.

C. J. Jones (Mrs),
Kidderminster

*We have now carried out a further and detailed costing of the two projects you mention. Referring to the catalogues of two different suppliers, we arrived at the following figures:*

*1. Bicycle Alarm*

| | |
|---|---|
| *Magenta Electronics* | *£10·30* |
| *Watford Electronics* | *£7·74* |

*Another advertiser in this magazine is now offering a complete kit for this project for an inclusive price of £9·25.*

*2. Reaction Tester*

| | |
|---|---|
| *Magenta Electronics* | *£8·12* |
| *Watford Electronics* | *£6·84** |

** P.C.B. and facia board NOT included.*

*From these figures it would appear that our published cost of £8·00 in respect of item (1) is not far off the mark. With regard to item (2) however, we appear to be adrift by a fairly considerable amount with our suggestion of £4·50. However, Tandy's prices which you quote are considerably higher than any of those we have now arrived at.*

*I think it is a fair comment to make that Tandy's prices are, in general, 25-50 per cent above most other component suppliers. Although again here one must be cautious, since there are some instances where Tandy do quote a lower price than others for identical parts.*

*A possible explanation could be in the fact that certain small components are available from Tandy in packs only. Maybe you have included the pack price for resistors and capacitors, rather than the unit cost. This would of course help inflate the total cost arrived at.*

*I hope the above information will illustrate what a difficult problem it is in trying to establish a realistic cost for any project. We never claim that the price published is in any way an exact figure. We give these prices purely as a general indication as to the order of cost, and quite obviously the actual price will vary from supplier to supplier.*

*Where we do err on the low side this is perhaps to the advantage of the reader, since advertisers will endeavour to match the quoted price as closely as they can. Should we attempt to play safe and quote "high", apart from discouraging the reader, there is a danger that some suppliers might rise to the occasion!*

*It is advisable to acquire a number of catalogues from different suppliers, then one can make one's own costings from the items listed, and then decide which supplier to order the parts from.*

*I hope this experience has not been too discouraging to your nephew. Considering today's prices in general, I am sure he will find that the hobby of electronics is a very economical one when considering the amount of enjoyment and also the useful pieces of equipment that can be built from one's own efforts.—Ed.*

## The Best

I have been a reader of E.E. since issue No. 1 and have all the copies published since. I have always found the magazine most interesting and enjoyable.

I have made quite a number of projects which have appeared over the years. The best of these was undoubtedly the *EE 2020 Tuner Amplifier*.

It may be of interest to you to know that since making the 2020 this has had quite a lot of use and has given no problems at all. A really splendid project.

I. B. Morris,
Liverpool

## Radio Control System

With regard to the Everyday Electronics *Radio Control System* (November '79 to April '80) there are certain problems I have yet to overcome.

A switch S1 is shown in the circuit diagram of the transmitter to operate the seventh channel on the receiver but there is no on/off type switched control. Also I have not been able to locate the ZN458T 2·45V reference, the MC14051 and MC14024 CMOS Motorola integrated circuits. In the receiver I could not obtain any of the Toko i.f. transformers (types 4827, L238 and 4828).

Apart from these few setbacks I have found the project an interesting and challenging one. Before I read your project I had no feelings of becoming a Radio Control Enthusiast, now I am a full-hearted one.

Andrew Lord,
Malvern College, Malvern

*The On/Off switch (channel 7) can be used for various control functions, for example: Aircraft—Undercarriage Up/Down; Gliders—Air brakes; Boats—Water Jet (on fire tender).*

*We understand that all components for this project are available from Cheadle Model Supplies Ltd., 55 Cheadle Road, Cheadle Hulme, Cheshire.*

*We are very glad to learn that through this magazine you have acquired another absorbing interest.*

## Oldest Reader?

I am 80 years old and probably one of your oldest readers. Believe it or not, my radio experience goes back to 1913, when a cadet in our school O.T.C. unit, and our signal section constructed a wireless transmitter and receiver and established 2-way communication over a distance of 15 miles! The basis of the transmitter was a home made induction coil which gave a 1 inch spark when the key was depressed.

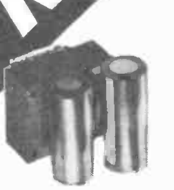
Truly we were gay young "sparks" in those early days, but I am a bit out of touch now with all these I.C.s, T.T.L.s, CMOS etc.

F. W. Blakeley,
Wrexham, Clwyd

**'A computer made him redundant—it showed how much he'd been embezzling".**

NEW

# PRACTICAL ELECTRONICS PROJECT 125 WATT POWER AMP KIT



**SPECIFICATIONS**

| | |
|---|---|
| Max. Output power | 125 watt RMS |
| Operating voltage (DC) | 50-80 Max. |
| Loads | 4-16 ohms |
| Frequency response Measured at 100 watts | 25Hz-20kHz |
| Sensitivity for 100 watts | 400mV @ 47K |
| Typical T.H.D. @ 50 watts 4 ohms load | 0.1 % |
| Dimensions | 205 x 90 and 190 x 36 mm |

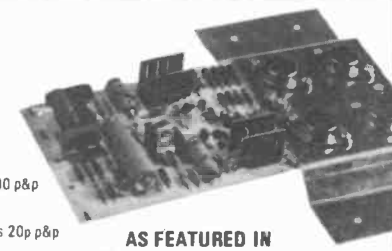
The P.E. power amp kit is a module for high power applications—disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, the output stage uses four 115 watt transistors normally only two would be used, result, a high powered rugged unit. The PC Board is backprinted, etched and ready to drill for ease of construction, and the aluminium chassis is preformed and ready to use. supplied with all parts and circuit diagrams.

125 watt power amp kit **£9.50** plus £1.00 p&p

**ACCESSORIES**

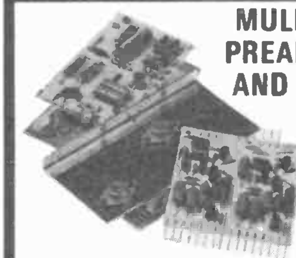
Suitable L.S. coupling electrolytic **£1.00** plus 20p p&p

Suitable Mains Power Supply Unit sufficient for one power amp **£7.50** plus £2.75 p&p



**AS FEATURED IN PRACTICAL ELECTRONICS OCTOBER ISSUE**

# DIY STEREO BARGAIN PACKS FEATURING FAMOUS BUILT MULLARD PREAMP MODULES



## MULLARD STEREO PREAMP MODULES AND TWO 12 WATT POWER AMP KITS.

In easy to build form P.C.B.s backprinted, etched and drilled ready to use.

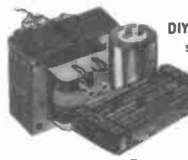
## BUILD A 12 WATTS PER CHANNEL STEREO AMPLIFIER £6.00

**ACCESSORIES AND L.S. KIT EXTRA** *(not available separately)*

**DIY PACK 1** 2 x power amp kits LP1182/ preamp module, suitable for ceramic and auxiliary inputs. **£6.00** plus £1.10 p&p

**DIY PACK 2** 2 x power amp kits LP1184 preamp module suitable for magnetic ceramic and auxiliary inputs. **£8.50** plus £1.15 p&p

**DIY SPEAKER KIT** Two 8" x 5" approx. 4 ohm bass. **£3.50** plus £1.70 p&p



**DIY ACCESSORIES** Mains transformer smoothing capacitor rectifier 4 x slider controls, for base, treble and volume. **£3.00** plus £1.60 p&p

**ACCESSORIES: Available only at time of purchase of Bargain Packs**

## 12 + 12 WATT AMPLIFIER KIT

*NOTE:* for use with 4 to 8 ohms speakers.

With up-to-the-minute features. To complete you just supply screws, connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs—tape, speakers and headphones. By the press of a button it transforms into a 24 watt mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus 2 power amplifier assembly kits and mains power supply. Also featured 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia panel with matching knobs. Easy to assemble teak simulate cabinet and ready made metal work. For further information instructions are available price 50p. Free with kit.
Size 9¼" x 8¾" x 4" approx.

*NOTE:*
for use with 4 to 8 ohms speakers.

**£13.95** plus £2.55 p&p

**BSR** chassis record deck with manual set down and return, complete with stereo ceramic cartridge **£8.50** plus £2.75 p&p when purchased with amplifier. Available separately **£10.50** plus £2.75 p&p.

**8" SPEAKER KIT.** 2 Phillips 8" approx. speakers. **£4.75** per stereo pair plus £1.50 p&p when purchased with amplifier. Available separately **£6.75** plus £1.50 p&p.

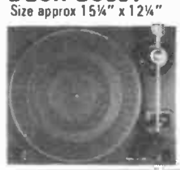
**STEREO MAGNETIC PRE-AMP CONVERSION KIT** all components including P.C.B. to convert your ceramic input on the 12 + 12 amp to magnetic. **£2.00** when purchased with kit featured above. **£4.00** separately inc p&p.

**BSR** Manual single play record deck with auto return and cueing lever. Fitted with stereo ceramic cartridge 2 speeds with 45 rpm spindle adaptor ideally suited for home or disco use.

**£12.25** OUR PRICE plus £2.75 p&p Size approx 13" x 11"

## PHILLIPS RECORD PLAYER DECK GC037

Size approx 15¼" x 12¼"



Hi Fi record player deck, 2 speed, damped cueing, auto shut-off, belt drive with floating sub chassis to minimise acoustic feedback. Complete with GP401 stereo magnetic cartridge—*LIMITED STOCK.* **UNBEATABLE OFFER AT**

**£27.50** complete plus £2.75 p&p

***OFFER!*** SAVE MONEY by purchasing 12 + 12 amp kit, BSR record deck and speaker kit together for only **£25.50** p&p £4.50.

## PRACTICAL ELECTRONICS CAR RADIO KIT £10.50

**(Constructors pack 7)** plus £1.75 p&p

**2 WAVE BAND MW LW**

- Easy to build • 5 push button tuning
- Modern styling design • All new unused components
- 6 watt output • Ready etched & punched P.C.B.
- Incorporates suppression circuits • Now with tape input socket

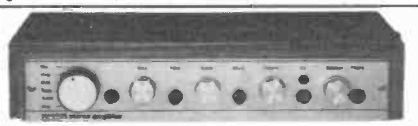
All the electronic components to build the radio, you supply only the wire and solder as featured in the Practical Electronics March issue. Features: Pre-set tuning with five push button options, black illuminated tuning scale, with matching rotary control knobs, one, combining on/off volume and tone-control, the other for manual tuning, each set on wood simulated fascia.
The P.E. Traveller has a 6 watts output, neg ground and incorporates an integrated circuit output stage, a Mullard IF module LP1181 ceramic filter type, pre-aligned and assembled and a Bird pre-aligned push button tuning unit. The radio fits easily in or under dashboards.
Complete with instructions.

**CONSTRUCTORS PACK 7A**

Suitable stainless steel fully retractable locking aerial and speaker (approx. 6" x 4") is available as a kit complete **£1.95** per pack p&p £1.00
Pack 7A may only be purchased at the same time as Pack 7.

NOTE: Constructor's pack 7A sold complete with radio kit **£15.20** including p&p.

*FEATURED PROJECT IN PRACTICAL ELECTRONICS.*



## 30 + 30 WATT STEREO AMPLIFIER BUILT AND TESTED

Viscount IV unit in teak simulate cabinet silver finished rotary controls and pushbuttons with matching fascia, red mains indicator and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape and auxiliary. Rear panel features fuse holder. DIN speaker and input socket 30 + 30 watts. RMS 60 + 60 watts peak for use with 4 to 8 ohm speakers. Size 14¾" x 10" approx.

**READY TO PLAY £32.90** plus £3.30 p&p

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For further information send for instructions 20p plus stamped addressed envelope.

NOTE:
Persons under 16 years not served without parent's authorisation.

***BARGAIN OFFER!!***

## ARISTON PICK UP

Ariston pick-up arm manufactured in Japan. Complete with headshell. Listed price over £30.00 OUR PRICE **£11.95** plus £2.50 p&p

## 100 WATT MONO DISCO AMPLIFIER

Brushed aluminium fascia and rotary controls. Size approx 14" x 4" x 10¼. Five vertical slide controls, master volume, tape leverl, mic level, deck level, PLUS INTER DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre fade level controls (PRL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.

**£76.00** plus £4.00 p&p

## 50 WATT MONO DISCO AMPLIFIER

Size appox 13⅜" x 5¼" x 6¾". 50 watts rms. 100 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

**£30.60** plus £3.20 p&p

Personal Shoppers EDGWARE ROAD LONDON W2 Tel: 01-723 8432. 9.30am-5.30pm. Closed all day Thursday ACTON: Mail Order only. No callers GOODS DESPATCHED TO MAINLAND AND N. IRELAND ONLY

# I Can't Do Maths!

BY GEORGE HYLTON

### *DON'T DESPAIR.* THIS FOUR-PART SERIES PROVIDES A GUIDE TO BASIC CONCEPTS

## 4 - BITS AND PIECES

VULGAR FRACTIONS. The phrase has a suggestion of snobbery about it, as if halves, quarters, fifths and so on were too insignificant for a person of refinement to bother about.

But they have their uses, and a knowledge of how to handle them leads straight on to the handling of fractions in algebraic form, which crop up in electronics.

Know how to manipulate the ordinary vulgar fractions and you are half way to coping with the algebraic ones.

Vulgar fractions are often not easy to add. It is all very well when they are all the same kind; two-fifths plus one-fifth obviously makes three-fifths. But what happens when they are different? What is $\frac{3}{8}+\frac{5}{9}+\frac{1}{12}$?

The answer is certainly not obvious. In these days of the pocket calculator it is possible to sidestep the problem, by turning each vulgar fraction into its equivalent decimal fraction.

However, this trick of turning vulgar fractions into decimal fractions is no help when you come to algebra. There is no decimal equivalent of xy/ab. To handle that sort of expression you need to master the traditional methods of handling vulgar fractions.

So let's look at them. Like all maths they are just common sense plus a bit of low cunning. Here is a typical problem:

$$\frac{5}{8}+\frac{3}{5}=?$$

Not being a mathematician myself but a journalist I find that a knowledge of the meanings of words helps, in maths as in other things.

"Fraction" is connected with "fracture". To fracture is to break, and a fraction is what is produced by breaking: "fraction" means "broken-off piece".

The number which gets broken is generally the number 1. As everybody who has broken one plate knows, it is always possible to take one of the pieces and break it into still smaller pieces. The same applies to fractions.

A half can be broken into (for instance) two quarters, or three sixths, or four eighths, and so on. A half can also be broken into bits of assorted size.

It is obvious, I think, that bits of the same size can easily be added. Halves to halves, quarters to quarters, and so on. Thus one sixth plus two sixths makes three sixths.

In numbers:

$$\frac{1}{6}+\frac{2}{6}=\frac{3}{6}$$

But what if the bits are of assorted sizes? The last example contains the vital clue. You may have noticed that $\frac{2}{6}=\frac{1}{3}$, so the sum could have been written, $\frac{1}{6}+\frac{1}{3}=?$

Evidently the trick is to break the larger fractions (here, $\frac{1}{3}$) into smaller ones so that they can be added to the rest of the smaller ones in the sum.

In the present case, thirds conveniently break into sixths so the process is quite easy. But in many cases the sizes are less conveniently assorted. For example, $\frac{1}{2}+\frac{1}{3}=?$ Halves can't be broken into thirds. But both halves and thirds can be turned into sixths:

$$\frac{1}{2}+\frac{1}{3}=\frac{3}{6}+\frac{2}{6}=\frac{5}{6}.$$

Before going on to more interesting vulgar fractions there is just one thing to be said about the forms in which fractions are written down.

To make life easier for himself the typist and in his steps the printer usually adopts the style of writing 1/4 instead of $\frac{1}{4}$, and so on.

This makes it easy to type or typeset a fraction like 7/16, because it now comes all on one line instead of one bit below the rest. The snag is that it is no longer sensible to talk about the "top" or "bottom" of a fraction.

Instead you have to use the mathematician's long words, "numerator" and "denominator". The "denominator" (at the bottom) tells you what kind of "—ths" you are dealing with. In sixteenths the denominator is the 16 at the bottom.

The "numerator" tells you how many of them there are. Thus in seven sixteenths the numerator is 7.

To get back to practical cases, we've seen that:

$$\frac{1}{2}+\frac{1}{3}=\frac{5}{6}.$$

Note that if you multiply together the two denominators (bottom numbers) in the problem you get the denominator of the answer, in this case 6. It always works. If the sum is $\frac{1}{5}+\frac{1}{8}=?$, then the "numbers at the bottom" tell you that the answer can be obained by turning both fractions into fortieths, since $5\times8=40$:

$$\frac{1}{5}+\frac{1}{8}=\frac{8}{40}+\frac{5}{40}=\frac{13}{40}.$$

Sometimes this trick leads you to use smaller "—ths" than are strictly necessary, but it always works. Here's a more difficult case:

$$\frac{5}{8}+\frac{3}{5}=\frac{25}{40}+\frac{24}{40}=\frac{49}{40}.$$

which raises another point. Expressions like $\frac{49}{40}$, where the numerator (top) is bigger than the denominator (bottom) are called Improper Fractions. Despite their name (more snobbery?) improper fractions can be more useful than proper ones.

The number, Pi, which keeps cropping up in calculations, is roughly three and one-seventh. But in using it you'll find that it's generally more convenient to turn it into the improper fraction, $\frac{22}{7}$.

Vulgar fractions can be used to solve a series-capacitance problem. The textbooks say that the three capacitances add up to one single equivalent capacitance, *C* whose value is found by the formula:

$$1/C=1/C_1+1/C_2+1/C_3$$

Don't be put off by the fact that this gives 1/*C*, not *C*. Putting in actual values gives:

$$\frac{1}{C}=\frac{1}{2}+\frac{1}{3}+\frac{1}{5}=\frac{15}{30}+\frac{10}{30}+\frac{6}{30}=\frac{31}{30}.$$

To turn 1/*C* back into *C* the fraction is "turned upside down", that is the numerator and the denominator are made to change places.

So when $1/C=\frac{31}{30}$, $C=\frac{30}{31}$. The three capacitances in series are the same as one of $\frac{30}{31}\mu$F or a little less than $1\mu$F.

In this article I've had space only to deal with adding fractions. Subtracting them follows commonsense lines:

$$\frac{3}{5}-\frac{1}{6}=\frac{18}{30}-\frac{5}{30}=\frac{13}{30}.$$

# WORKSHOP MATTERS

**By Harry T. Kitchen**

## Component Buying

Long experience has convinced me that the only way to buy components is in bulk. Why? Well, components in tens are usually slightly cheaper than in one's, and these days every little helps. More importantly, it increases your chances of commencing almost any project without first having to order the components for it.

Sitting here thinking about it, the only hinderance that I can foresee for myself is something special; a transformer perhaps, or a special i.c. or transistor. Very little else. So what is my buying philosophy?

## Resistors

Unless it is something very special or very expensive, I invariably buy in tens. Lets take resistors and capacitors for example. Mostly, ¼ Watt or ½ Watt resistors will be adequate, whilst the general tolerance of 5 per cent will also generally suffice.

Using the universal E12 range we should have everything between 10 ohms and 10 meghoms in stock, or more precisely 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 75, 91 ohms and their decades. A lot of resistors indeed, but they will fulfil most of your requirements. To these we should add others, as funds allow.

It is too much to advocate, neither have I done it myself, to buy wire wound resistors on the same scale, but a random selection, on a as-and-when basis can be adopted by buying an extra resistor each time. The same philisophy can be adopted towards potentiometers, or more accurately variable resistors.

Whilst I have never bought surplus, or seconds, or unmarked semi-conductors, I have bought jobs lots of ex-computer, but unused, resistors and have found them to be of the very highest quality. A great deal depends where you buy them, and if the source is not known to you I would suggest that you do as I do; buy a few to check and, if they are satisfactory, buy a lot.

Stipulate that they must be of the same quality, and if they are not the firm concerned must accept them back and refund your money. This philosophy should apply with any unknown components.

## Capacitors

I have adopted a modified approach to the purchase of capacitors, and this is necessary since capacitors have specific maximum working voltages, and to stock them all is quite impossible; and quite unnecessary. You have to make two basic decisions: the working voltage, and the mounting; radial or axial. This is particularly important with circuit boards.

In my own case, I found that I very rarely required a working voltage in excess of some 15 volts, and so I standardised on the 16 volt Seimens range, though other reputable makes are just as good. Most of my capacitors are axial ended, though a few are radial ended. I settled for a capacitance range that spanned 4·7µF to 1,000µF, based on experience.

So far we have been looking purely at electrolytic capacitors, hence the need to consider working voltages. Let us look at some of the others available; polystyrene, polyester, silvered mica, tantalum, and ceramic.

All have their uses, but as a general purpose capacitor, within its capacitance range, the polyester is probably the most suitable. For my own work I have standardised on the Mullard C280 series with radial leads. This has a working voltage of 250V, with a capacitance range spanning 0·01µF to 2·2µF.

## Semiconductors

You may expect to keep a large variety of semiconductors in stock, but with care a handful will suffice.

Let's look at diodes. Three or four basic types will do all that you require.

For low level work the 1N914 makes an excellent choice with a p.i.v. (peak inverse voltage) of 100 and a current rating of 75mA maximum. For medium power work the 1N4007 is excellent, with a p.i.v. of 1,000 at 1A. Higher still the 1N5407 will accept 800 p.i.v. at 3A. You can get lower p.i.v. in these two families, but the saving is small, and you can use them for all mains rectification purposes.

All the preceding diodes are silicon. Amongst the germanium diodes the OA90 makes a useful r.f. rectifier, and the OA91 and OA95 are useful general purpose diodes with p.i.v. ratings of 115 volts and a current rating of 50mA.

## Transistors

Similarly a small handful of transistors will suffice for most normal work. The BC109 is the low power low noise transistor par excellence. Higher up the 2N3053 or BFY50 will cope well, and still higher the 2N3055 and its plastic coated relatives, the MJE3055 and TIP3055 excell.

General purpose f.e.t.s are exemplified by the 2N3819, and the 2N2646 fills a similar position amongst the unijunction breed.

Amongst op-amps the 741 is an excellent choice as it is free from vice, as is the timer i.c. the NE555 and its dual version the NE556. Digital i.c.s proliferate, and here probably the best bet is to buy as you require.

From the foregoing you will see that, unless you are into exotic circuits, you will cope very well with a small selection of components, though their numbers may be many. By judicious purchase you can build your collection into an extensive one, as I have, even though it will take you time to do so, as it did me.

## Records

Earlier I write of the necessity of keeping records of work done. So too should records be kept of components in stock so that as the quantities drop they can be replaced, either directly or with something better.

The more components you have, the more constructional work you do, the greater the need for keeping records. It requires a certain amount of self-discipline but the effort is well worth while.

I myself use an *A5* notebook divided up into sections: resistors, capacitors, transistors, diodes and miscellaneous. The smaller the component the more need to document it as it is more easily over looked. Well kept records, like a well kept diary, are useful pointers about your progress, and sometime in the future you will almost certainly be glad that you made the effort.

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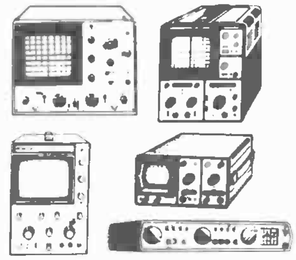

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### SINGLE TRACE (UK c/p etc £2·50)

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|---|---|
| Hm 307-3 10mHZ, 5mV, 6 × 7cm display plus component Test | £158·78 |
| C01303D 5mHZ, 10mHZ, 7 × 7cm display | £109·25 |
| SC110 10mHZ Battery portable, 10mV, 3·2 × 2·6cm display (Optional case £8·80, Nicads £7·95, Mains unit £4·00) | £149·95 |
| LB0512A 10mHZ, 10mV, 5" display | £195·50 |
| CS1559A 10mHZ, 10mV, 5" display | £198·50 |
| V151 15mHZ 1mV 5" display | £241·50 |

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| CS1566A 20mHZ, 5mV, 5" display | £323·15 |
| LBO3085 70mHZ, 2mV, 5 × 6·3cm display, Battery/Mains portable, built in Nicads | £482·00 |
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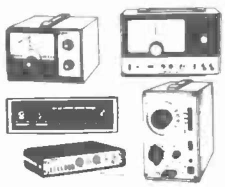

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| SG402 100KHZ-30mHZ with AM modulation | £64·40 |
| LSG16 100KHZ-100mHZ (300mHZ on Harmonics) | £56·50 |
| SG2030 250KHZ-100mHZ low cost range | £46·95 |
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| LAG26 20HZ-200KHZ | £69·00 |
| AG203 10HZ-1mHZ Sine/Square | £120·75 |
| LAG120A 10HZ-1mHZ | £137·00 |

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| LM1 Logic monitor | £33·00 |
| LDP 50 mHZ Logic probe with case | £51·00 |

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| M1200 100K/Volt 30 range plus AC/DC 15 amp | £67·00 |
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| M1500 20K/Volt 42 range plus AC/DC 10 amp | £53·50 |
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| K200 38 range FET 10m ohm input 20Hz to 30MHz | £95·00 |
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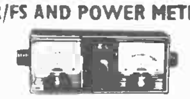
### SWR/FS AND POWER METERS



Range in stock covering up to 150mHZ and up to 1K watt power. PL259 sockets. 250UHZ Grid Dip.

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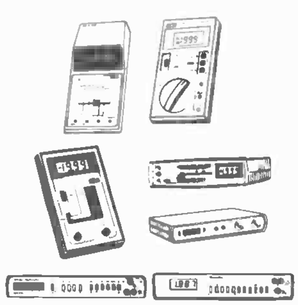

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(UK post etc 85p)

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| TM352 3½ Digit LCD plus 10ADC and Hfe checker | £54·95 |
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| DM350 3½ Digit LED 34 ranges, AC/DC 10A | £78·50 |
| TM353 3½ Digit LCD AC/DC 2 amp | £86·50 |
| TM351 3½ Digit LCD AC/DC 10 amp | £107·95 |
| LM100 3½ Digit LCD AC/DC 2 amp | £86·50 |
| DM450 4½ Digit LED 34 ranges, AC/DC 10 amp | £107·95 |
| 1503 4½ Digit LCD 28 ranges, AC/DC 10 amp include Mains adaptor | £159·85 |

(DM series options: Carry case £8·80, Nicads £7·95, Mains adaptor £4·00.)

## MULTIMETERS

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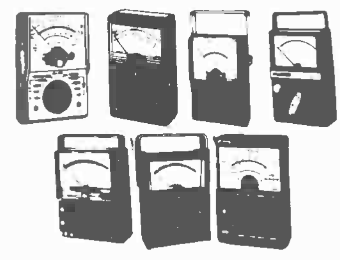

| | |
|---|---|
| KRT101 1K/Volt 10 range pocket | £4·50 |
| ATM1/LT1 1K/Volt 12 range pocket | £5·95 |
| NH55 2K/Volt 10 range pocket | £6·95 |
| AT1 2K/Volt 12 range pocket de luxe | £7·95 |
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| YN360TR 20K/Volt 19 range pocket plus hfe test | £13·95 |
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| AT2050 50K/Volt 18 range de luxe plus hfe test | £28·50 |
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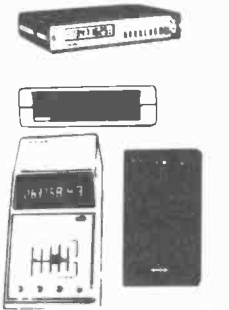
| 360TR 100K/Volt 23 range plus hfe checker and AC/DC 10 amps | £34·95 |

## FREQUENCY COUNTERS



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| MAX550 30KHZ to 550mHZ 6 Digit LED | £106·00 |

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| 7010A 9 Digit LED 10HZ to 600mHZ | £169·00 |
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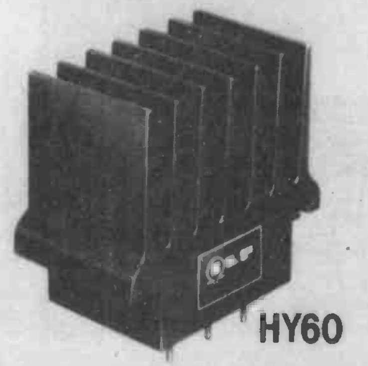

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| HY120 | 60W into 4-8Ω | 0.01% | 15V/μs | 5μs | 100dB | £17.48 + £2.62 |
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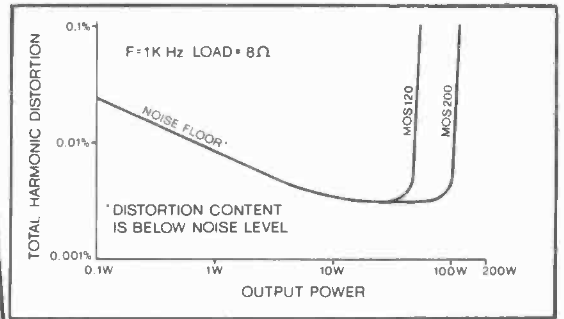
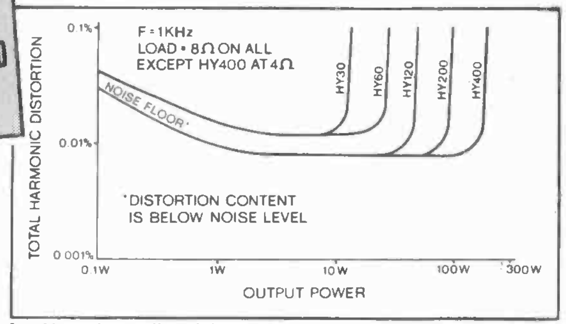
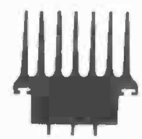



Load impedance both models 4Ω - ∞ Input sensitivity both models 500mV
Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB




Load impedance all models 4Ω - ∞ Input sensitivity all models 500mV
Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



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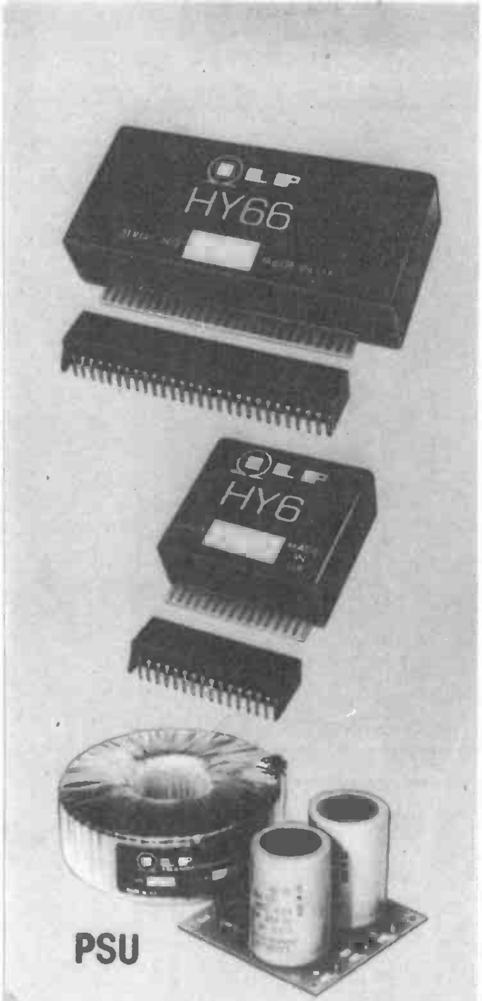


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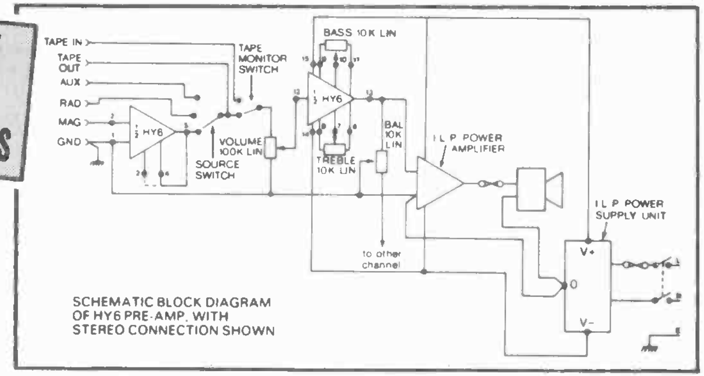


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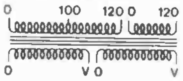


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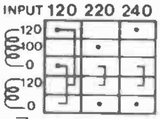


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| REF | AMPS | PRICE | P/P |
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| TTP 452 | 8·33•2 | 5·68 | 130 |

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| TTP 464 | 1·38•2 | 2·99 | 90 |
| TTP 465 | 2·77•2 | 4·57 | 125 |
| TTP 466 | 5·55•2 | 5·68 | 130 |

0v-12v 0v-12v

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|---|---|---|---|
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| TTP 472 | 2·08×2 | 4·57 | 125 |
| TTP 473 | 4·16•2 | 5·68 | 130 |

0-15v 0-15v

| REF | AMPS | PRICE | P/P |
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| TTP 477 | 0·4·2 | 2·36 | 70 |
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| TTP 480 | 3·33·2 | 5·68 | 130 |

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| TTC 451 | 4·18•2 | 4·70 | 125 |
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0v-9v 0v-9v

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|---|---|---|---|
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| TTC 461 | 0·50•2 | 2·20 | 60 |
| TTC 463 | 0·60•2 | 2·45 | 70 |
| TTC 464 | 1·38•2 | 3·10 | 90 |
| TTC 465 | 2·77•2 | 4·70 | 125 |
| TTF 466 | 5·55•2 | 5·85 | 130 |

0v-12v 0v-12v

| REF | AMPS | PRICE | P/P |
|---|---|---|---|
| TTC 467 | 0·25•2 | 1·85 | 50 |
| TTC 468 | 0·38•2 | 2·20 | 60 |
| TTC 470 | 0·50•2 | 2·45 | 70 |
| TTC 471 | 1·04•2 | 3·10 | 90 |
| TTC 472 | 2·08•2 | 4·70 | 125 |
| TTF 473 | 4·16•2 | 5·85 | 130 |

0v-15v 0v-15v

| REF | AMPS | PRICE | P/P |
|---|---|---|---|
| TTC 474 | 0·20•2 | 1·85 | 50 |
| TTC 475 | 0·30•2 | 2·20 | 60 |
| TTC 477 | 0·40•2 | 2·45 | 70 |
| TTC 478 | 0·83•2 | 3·10 | 90 |
| TTC 479 | 1·66•2 | 4·70 | 125 |
| TTF 480 | 3·33•2 | 5·85 | 130 |

0v-24v 0v-24v

| REF | AMPS | PRICE | P/P |
|---|---|---|---|
| TTC 495 | 0·13•2 | 1·85 | 50 |
| TTC 496 | 0·19•2 | 2·20 | 60 |
| TTC 498 | 0·25•2 | 2·45 | 70 |
| TTC 499 | 0·52•2 | 3·10 | 90 |
| TTC 500 | 1·04•2 | 4·70 | 125 |
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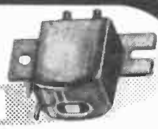

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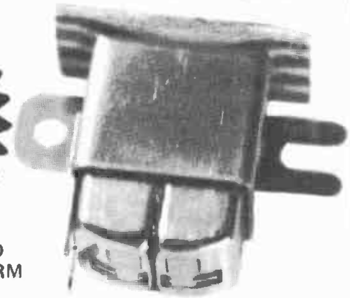

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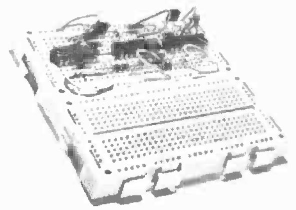

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| K171 | 25 | 11V do |
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