PRACTICAL

# ELECTRONICS

MARCH 1972

20p

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# Now! From EMI precision speakers and enclosures in matched money-saving kits

EMI speakers are internationally recognised–used in the highest quality sound reproduction equipment. Because of this world-wide demand, EMI matched speaker kits are available to you at a really keen price.

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# The largest selection

## NEW LOW PRICE TESTED S.C.R.'s

| PIV | 1A TO-5 | 3A TO-66 | 7A TO-66 | 10A | 16A TO-48 | 30A TO-48 |
|---|---|---|---|---|---|---|
| | £p | £p | £p | £p | £p | £p |
| 50 | 0·23 | 0·25 | 0·47 | 0·50 | 0·53 | 1·15 |
| 100 | 0·25 | 0·33 | 0·53 | 0·58 | 0·63 | 1·40 |
| 200 | 0·35 | 0·37 | 0·57 | 0·61 | 0·75 | 1·60 |
| 400 | 0·43 | 0·47 | 0·67 | 0·75 | 0·93 | 1·75 |
| 600 | 0·53 | 0·57 | 0·77 | 0·97 | 1·25 | — |
| 800 | 0·63 | 0·70 | 0·90 | 1·20 | 1·50 | 4·00 |

## SIL. RECTS. TESTED

| PIV | 300mA | 750mA | 1A | 1·5A | 3A | 10A | 30A |
|---|---|---|---|---|---|---|---|
| | £p | £p | £p | £p | £p | £p | £p |
| 50 | 0·04 | 0·05 | 0·05 | 0·07 | 0·14 | 0·21 | 0·47 |
| 100 | 0·04 | 0·06 | 0·05 | 0·13 | 0·16 | 0·23 | 0·75 |
| 200 | 0·05 | 0·09 | 0·06 | 0·14 | 0·20 | 0·24 | 1·00 |
| 400 | 0·06 | 0·13 | 0·07 | 0·20 | 0·27 | 0·37 | 1·25 |
| 600 | 0·07 | 0·16 | 0·10 | 0·23 | 0·34 | 0·45 | 1·85 |
| 800 | 0·10 | 0·17 | 0·13 | 0·25 | 0·37 | 0·55 | 2·00 |
| 1000 | 0·11 | 0·25 | 0·15 | 0·30 | 0·46 | 0·63 | 2·50 |
| 1200 | — | 0·33 | — | 0·33 | 0·57 | 0·75 | — |

### TRIACS

| VBOM | 2A TO-1 | 6A TO-66 | 10A TO-88 |
|---|---|---|---|
| | £p | £p | £p |
| 100 | 0·50 | 0·63 | 1·00 |
| 200 | 0·70 | 0·90 | 1·25 |
| 400 | 0·90 | 1·00 | 1·60 |

### LUCAS SILICON RECTIFIERS

35 amp, 400 P.I.V. Stud type. £1·10 each.

### DIACS

FOR USE WITH TRIACS BR100 D32 ... 37p each

**2A POTTED BRIDGE RECTIFIERS 200V 50p**

### UNIJUNCTION

UT46. Eqvt. 2N2646, Eqvt. TIS43. BEN3000 27p each. 25-99 25p 100 UP 20p.

### NPN SILICON PLANAR

BC107/8/9. 10p each; 50-99, 8p; 100 up, 8p each; 1,000 off, 7p each. Fully tested and coded TO-18 case.

### FREE

One 50p Pak of your own choice free with orders valued £4 or over.

AF239 PNP GERM. SIEMENS VHF TRANSISTORS. RF MIXER & OSC. UP TO 900 MHZ. USE AS REPLACEMENT FOR AF139-AF186 & 100's OF OTHER USES IN VHF. OUR SPECIAL LOW PRICE: 1-24 37p each. 25-99 34p each 100+ 30p each.

### SPECIAL OFFER

2N2926 (Y) (O). 10 for 50p. 25 for £1. 10,000 TO CLEAR.

### CADMIUM CELLS

ORP12 43p
ORP60, ORP61 40p each

### PHOTO TRANS.

OCP71 Type. 43p

### SIL. G.P. DIODES

| | | £p |
|---|---|---|
| 300mW | 30 .. | 0·50 |
| 40PIV (Min.) | 100 .. | 1·50 |
| Sub-Min. | 500 .. | 5·00 |
| Full Tested | 1,000 .. | 9·00 |

Ideal for Organ Builders.

**D13D1 Silicon Unilateral switch 50p each.**
A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuits available on request.

## JUMBO COMPONENT PAKS

### MIXED ELECTRONIC COMPONENTS

***Exceptionally good value***

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P. £1·50 only

*Plus our satisfaction or money back guarantee.*

### FULL RANGE OF ZENER DIODES

VOLTAGE RANGE 2-33V. 400mW (DO-7 Case) 13p ea. 1½W (Top-Hat) 18p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

### BRAND NEW TEXAS GERM. TRANSISTORS

Coded and Guaranteed

| Pak No. | | | EQVT |
|---|---|---|---|
| T1 | 8 | 2G371B | OC71 |
| T2 | 8 | D1374 | OC75 |
| T3 | 8 | D1216 | OC81D |
| T4 | 8 | 2G381T | OC81 |
| T5 | 8 | 2G382T | OC82 |
| T6 | 8 | 2G344B | OC44 |
| T7 | 8 | 2G345B | OC45 |
| T8 | 8 | 2G378 | OC78 |
| T9 | 8 | 2G399A | 2N1302 |
| T10 | 8 | 2G417 | AF117 |

All 50p each pak

### 2N2060 NPN SIL. DUAL TRANS.

CODE D1699 TEXAS. Our price 25p each.

### 120 VCB NIXIE DRIVER TRANSISTOR.

Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND120. 1-24 17p each. TO-5 N.P.N. 25 up 15p each.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 5p each. Any Qty.

### EX-EQUIPMENT MULLARD

AF117 transistors. Large can 4 leads type. Leads cut short but still usable, real value at 15 for 50p.

## KING OF THE PAKS — SUPER PAKS

**Unequalled Value and Quality**

### NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

| Pak No. | | £p |
|---|---|---|
| U1 | 120 Glass sub-min. general purpose germanium diodes | 0·50 |
| U2 | 60 Mixed germanium transistors AF/RF | 0·50 |
| U3 | 75 Germanium gold bonded diodes sim. OA5, OA47 | 0·50 |
| U4 | 40 Germanium transistors like OC81, AC128 | 0·50 |
| U5 | 60 200mA sub-min. Sil. diodes | 0·50 |
| U6 | 30 Silicon planar transistors NPN sim. BSY95A, 2N706 | 0·50 |
| U7 | 16 Silicon rectifiers Top-Hat 750mA up to 1,000V | 0·50 |
| U8 | 50 Sil. planar diodes 250mA, OA/200/202 | 0·50 |
| U9 | 20 Mixed volts 1 watt Zener diodes | 0·50 |
| U11 | 30 PNP silicon planar transistors TO-5 sim. 2N1132 | 0·50 |
| U13 | 30 PNP-NPN sil. transistors OC200 & 28104 | 0·50 |
| U14 | 150 Mixed silicon and germanium diodes | 0·50 |
| U15 | 25 NPN Silicon planar transistors TO-5 sim. 2N697 | 0·50 |
| U16 | 10 3-Amp silicon rectifiers stud type up to 1000 PIV | 0·50 |
| U17 | 30 Germanium PNP AF transistors TO-5 like ACY 17-22 | 0·50 |
| U18 | 8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV | 0·50 |
| U19 | 25 Silicon NPN transistors like BC108 | 0·50 |
| U20 | 12 1·5-Amp silicon rectifiers Top-Hat up to 1,000 PIV | 0·50 |
| U21 | 30 A.F. germanium alloy transistors 2G300 series & OC71 | 0·50 |
| U23 | 30 Madt's like MAT series PNP transistors | 0·50 |
| U24 | 20 Germanium 1-Amp rectifiers GJM up to 300 PIV | 0·50 |
| U25 | 25 300Mc/s NPN silicon transistors 2N708, BSY27 | 0·50 |
| U26 | 30 Fast switching silicon diodes like IN914 micro-min | 0·50 |
| U29 | 10 1-Amp SCR's TO-5 can up to 600 PIV CRS1/25-600 | 1·00 |
| U31 | 20 Sil. Planar NPN trans. low noise amp 2N3707 | 0·50 |
| U32 | 25 Zener diodes 400mW D07 case mixed volts, 3-18 | 0·50 |
| U33 | 15 Plastic case 1 amp silicon rectifiers IN4000 series | 0·50 |
| U34 | 30 Sil. PNP alloy trans. TO-5 BCY26, 28302/4 | 0·50 |
| U35 | 25 Sil. planar trans. PNP TO-18 2N2906 | 0·50 |
| U36 | 25 Sil. planar NPN trans. TO-5 BFY50/51/52 | 0·50 |
| U37 | 30 Sil. alloy trans. SO-2 PNP, OC200 28322 | 0·50 |
| U38 | 20 Fast switching sil. trans. NPN, 400Mc/s 2N3011 | 0·50 |
| U39 | 30 RF germ. PNP trans. 2N1303/5 TO-5 | 0·50 |
| U40 | 10 Dual trans. 6 lead TO-5 2N2060 | 0·50 |
| U41 | 25 RF germ. trans. TO-1 OC45 NKT72 | 0·50 |
| U42 | 10 VHF germ. PNP trans. TO-1 NKT667 AF117 | 0·50 |
| U43 | 25 Sil. trans. plastic TO-18 A.F. BC113/114 | 0·50 |
| U44 | 20 Sil. trans. plastic TO-5 BC115/116 | 0·50 |
| U45 | 7 3A SCR's TO-66 up to 600 Piv | 1·00 |

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

## POWER TRANSISTOR BONANZA!

### GENERAL PURPOSE GERM. PNP POWER TRANSISTORS

Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACE:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. TI3027-3028, 2N250A, 2N456A-457A-458A. 2N511 A & B. 2G220-222. ETC. SPECIFICATION VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

| PRICE | 1-24 | 25-99 | 100 up |
|---|---|---|---|
| | 43p each | 40p each | 36p each |

**AD161** *NPN*
**AD162** *PNP*

OF GERM. POWER TRANSISTORS. OUR LOWEST PRICE OF 63p *PER PAIR*

**SILICON** High Voltage 250V NPN TO-3 case. G.P. Switching and Amplifier Applications. Brand new Coded R2400. VCBO250 / VCEO100 / IC 6A / 30W. HFE type 20/fT 5MHz

| OUR PRICE EACH | 1-24 | 25-99 | 100 up |
|---|---|---|---|
| | 50p | 45p | 40p |

### 2N3055

115 WATT SIL POWER NPN
Price 63p each.

**SILICON 50 WATTS MATCHED NPN/PNP.** BIP19 npn TO-3 plastic. BIP20 pnp. Brand new. VCBO 10/ VCEO 50/ IC 10A. HFE type 100/ft 3mHZ.

| OUR PRICE PER PAIR | 1-24 prs. | 25-99 prs. | 100 prs. |
|---|---|---|---|
| | 60p | 55p | 50p |

**GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8, BSY27/28/95A.** All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

| | | £p | | | |
|---|---|---|---|---|---|
| 20 | For | 0·50 | 100 | For | 1·75 |
| 50 | For | 1·00 | 500 | For | 7·50 |
| | | | 1000 | For | 13·00 |

**OUR STOCKS** of individual devices are now too numerous to mention in this Advertisement. Send S.A.E. for our listing of over 1,000 Semiconductors. All available **Ex-Stock** at very competitive prices.

### RTL MICROLOGIC CIRCUITS

| | 1-24 | 25-99 | 100 up |
|---|---|---|---|
| Epoxy TO-5 case | Price each | | |
| uL900 Buffer | 35p | 33p | 27p |
| uL914 Dual 2i/p gate | 35p | 33p | 27p |
| uL923 J-K flip-flop | 50p | 47p | 45p |

Data and Circuits Booklet for I.C's Price 7p.

## NEW QUALITY TESTED PAKS

| Pak | Description | Price £p |
|---|---|---|
| Q1 | 20 Red spot trans. PNP AF | 0·50 |
| Q2 | 16 White spot R.F. trans. PNP | 0·50 |
| Q3 | 4 OC77 type trans. | 0·50 |
| Q4 | 6 Matched trans. OC44/45/81/81D | 0·50 |
| Q5 | 4 OC75 transistors | 0·50 |
| Q6 | 4 OC72 transistors | 0·50 |
| Q7 | 4 AC128 trans. PNP high gain | 0·50 |
| Q8 | 4 AC126 trans. PNP | 0·50 |
| Q9 | 7 OC81 type trans. | 0·50 |
| Q10 | 7 OC71 type trans. | 0·50 |
| Q11 | 2 AC127/128 comp. pairs PNP/NPN | 0·50 |
| Q12 | 3 AF116 type trans. | 0·50 |
| Q13 | 3 AF117 type trans. | 0·50 |
| Q14 | 3 OC171 H.F. type trans. | 0·50 |
| Q15 | 5 2N2926 sil. epoxy trans. | 0·50 |
| Q16 | 2 GET880 low noise germ. trans. | 0·50 |
| Q17 | 3 NPN 1 ST141 & 2 ST140 | 0·50 |
| Q18 | 4 Madt's 2 MAT 100 & 2 MAT 120 | 0·50 |
| Q19 | 3 Madt's 2 MAT 101 & 1 MAT 121 | 0·50 |
| Q20 | 4 OC44 germ. trans. A.F. | 0·50 |
| Q21 | 3 AC127 NPN germ. trans. | 0·50 |
| Q22 | 20 NKT trans. A.F. R.F. coded | 0·50 |
| Q23 | 10 OA202 sil. diodes sub-min. | 0·50 |
| Q24 | 8 OA81 diodes | 0·50 |
| Q25 | 6 IN914 sil. diodes 75PIV 75mA | 0·50 |
| Q26 | 8 OA95 germ. diodes sub-min. 1N69 | 0·50 |
| Q27 | 2 10A 600PIV sil. rects. 1S45R | 0·50 |
| Q28 | 2 Sil. power rects. BYZ13 | 0·50 |
| Q29 | 4 Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698 | 0·50 |
| Q30 | 7 Sil. switch trans. 2N706 NPN | 0·50 |
| Q31 | 6 Sil. switch trans. 2N708 NPN | 0·50 |
| Q32 | 3 PNP sil. trans. 2 × 2N1131, 1 × 2N1132 | 0·50 |
| Q33 | 3 Sil. NPN trans. 2N1711 | 0·50 |
| Q34 | 7 Sil. NPN trans. 2N2369, 500MHZ. | 0·50 |
| Q35 | 3 Sil. PNP TO-5 2 × 2N2904 & 1 × 2905 | 0·50 |
| Q36 | 7 2N3646 TO-18 plastic 300MHZ NPN | 0·50 |
| Q37 | 3 2N3053 NPN sil. trans. | 0·50 |
| Q38 | 7 PNP trans. 4×2N3703, 3×2N3702 | 0·50 |
| Q39 | 7 NPN trans. 4×2N3704, 3×2N3705 | 0·50 |
| Q40 | 7 NPN amp. 4×2N3707, 3×3N3708. | 0·50 |
| Q41 | 3 Plastic NPN TO-18 2N3904 | 0·50 |
| Q42 | 6 NPN trans. 2N5172 | 0·50 |
| Q43 | 7 BC107 NPN trans. | 0·50 |
| Q44 | 7 NPN trans. 4×BC108, 3×BC109 | 0·50 |
| Q45 | 3 BC113 NPN TO-18 trans. | 0·50 |
| Q46 | 3 BC115 NPN TO-5 trans. | 0·50 |
| Q47 | 6 NPN high gain 3×BC167, 3×BC168 | 0·50 |
| Q48 | 4 BCY70 NPN trans. TO-18 | 0·50 |
| Q49 | 4 NPN trans. 2×BFY51, 2×BFY52 | 0·50 |
| Q50 | 7 BSY28 NPN switch TO-18 | 0·50 |
| Q51 | 7 BSY95A NPN trans. 300MHZ | 0·50 |
| Q52 | 8 BY100 type sil. rect. | 1·00 |
| Q53 | 25 Sil. & germ. trans. mixed all marked new | 1·50 |

### PRINTED CIRCUITS—EX-COMPUTER

Packed with semiconductors and components, 10 boards give a guaranteed 30 trans and 30 diodes. Our price 10 boards 50p. Plus 10p P. & P. 100 Boards £3, P. & P. 30p.

### *NEW EDITION 1971*

**TRANSISTOR EQUIVALENTS BOOK.** A complete cross reference and equivalents book for European, American and Japanese Transistors. Exclusive to BI-PAK 90p each.

### FET'S

| | | | |
|---|---|---|---|
| 2N3819 | 35p | 2N5458 | 50p |
| 2N3820 | 50p | 2N5459 | 40p |
| 2N3821 | 35p | BFW10 | 40p |
| 2N3823 | 30p | MPF105 | 40p |

### PHOTO TRANS.

OCP71 Type. 43p

### SILICON PHOTO TRANSISTOR.

TO-18 Lens end. NPN Sim. to BP × 25 and P21. BRAND NEW. Full data available. Fully guaranteed.

| Qty. | 1-24 | 25-99 | 100 up |
|---|---|---|---|
| Price each | 45p | 40p | 35p |

### Dual-in-Line Low Profile Sockets

14 and 16 Lead Sockets for use with Dual-in-Line Integrated Circuits

| Order No. | 1-24 | 25-99 | 100 up |
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| | Price each | | |
| TSO 14 pin type | 30p | 27p | 25p |
| TSO 16 pin type | 35p | 32p | 30p |

# - the lowest prices!

## 74 Series T.T.L. I.C's

### DOWN AGAIN IN PRICE

Check our 74 Series List before you by any I.C's. Our prices are the lowest possible. All devices ex-stock. Full spec. guaranteed.

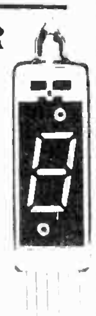
| BI-PAK Order No. | Price and qty. prices 1–24 £p | 25–99 £p | 100 up £p | BI-PAK Order No. | Price and qty. prices 1–24 £p | 25–99 £p | 100 up £p |
|---|---|---|---|---|---|---|---|
| BP00=SN7400 | 0·15 | 0·14 | 0·12 | BP86=SN7486 | 0·32 | 0·30 | 0·28 |
| BP01=SN7401 | [illegible] | 0·14 | 0·12 | BP90=SN7490 | 0·67 | 0·64 | 0·58 |
| BP02=SN7402 | 0·15 | 0·14 | 0·12 | BP91=SN7491AN | 0·87 | 0·84 | 0·78 |
| BP03=SN7403 | 0·15 | 0·14 | 0·12 | BP92=SN7492 | 0·67 | 0·64 | 0·58 |
| BP04=SN7404 | 0·15 | 0·14 | 0·12 | BP93=SN7493 | 0·67 | 0·64 | 0·58 |
| BP05=SN7405 | 0·15 | 0·14 | 0·12 | BP94=SN7494 | 0·77 | 0·74 | 0·68 |
| BP07=SN7407 | 0·18 | 0·17 | 0·16 | BP95=SN7495 | 0·77 | 0·74 | 0·68 |
| BP08=SN7408 | 0·18 | 0·17 | 0·16 | BP96=SN7496 | 0·77 | 0·74 | 0·68 |
| BP09=SN7409 | 0·18 | 0·17 | 0·16 | BP100=SN74100 | 1·75 | 1·65 | 1·55 |
| BP10=SN7410 | 0·15 | 0·14 | 0·12 | BP104=SN74104 | 0·97 | 0·94 | 0·88 |
| BP13=SN7413 | 0·29 | 0·26 | 0·24 | BP105=SN74105 | 0·97 | 0·94 | 0·88 |
| BP16=SN7416 | 0·43 | 0·40 | 0·38 | BP107=SN74107 | 0·40 | 0·38 | 0·36 |
| BP17=SN7417 | 0·43 | 0·40 | 0·38 | BP110=SN74110 | 0·55 | 0·53 | 0·50 |
| BP20=SN7420 | 0·15 | 0·14 | 0·12 | BP111=SN74111 | 1·25 | 1·15 | 1·00 |
| BP30=SN7430 | 0·15 | 0·14 | 0·12 | BP118=SN74118 | 1·00 | 0·95 | 0·90 |
| BP40=SN7440 | 0·15 | 0·14 | 0·12 | BP119=SN74119 | 1·35 | 1·25 | 1·10 |
| BP41=SN7441 | 0·67 | 0·64 | 0·58 | BP121=SN74121 | 0·67 | 0·64 | 0·58 |
| BP42=SN7442 | 0·67 | 0·64 | 0·58 | BP145=SN74145 | 1·50 | 1·40 | 1·30 |
| BP43=SN7443 | 1·95 | 1·85 | 1·75 | BP150=SN74150 | 1·80 | 1·70 | 1·60 |
| BP44=SN7444 | 1·95 | 1·85 | 1·75 | BP151=SN74151 | 1·00 | 0·95 | 0·90 |
| BP45=SN7445 | 1·95 | 1·85 | 1·75 | BP153=SN74153 | 1·20 | 1·10 | 0·95 |
| BP46=SN7446 | 0·97 | 0·94 | 0·88 | BP154=SN74154 | 1·80 | 1·70 | 1·60 |
| BP47=SN7447 | 0·97 | 0·94 | 0·88 | BP155=SN74155 | 1·40 | 1·30 | 1·20 |
| BP48=SN7448 | 0·97 | 0·94 | 0·88 | BP156=SN74156 | 1·40 | 1·30 | 1·20 |
| BP50=SN7450 | 0·15 | 0·14 | 0·12 | BP160=SN74160 | 1·80 | 1·70 | 1·60 |
| BP51=SN7451 | 0·15 | 0·14 | 0·12 | BP161=SN74161 | 1·80 | 1·70 | 1·60 |
| BP53=SN7453 | 0·15 | 0·14 | 0·12 | BP164=SN74164 | 2·00 | 1·90 | 1·80 |
| BP54=SN7454 | 0·15 | 0·14 | 0·12 | BP165=SN74165 | 2·00 | 1·90 | 1·80 |
| BP60=SN7460 | 0·15 | 0·14 | 0·12 | BP181=SN74181 | 2·75 | 2·60 | 2·40 |
| BP70=SN7470 | 0·29 | 0·26 | 0·24 | BP182=SN74182 | 0·97 | 0·94 | 0·88 |
| BP72=SN7472 | 0·29 | 0·26 | 0·24 | BP190=SN74190 | 3·50 | 3·25 | 3·00 |
| BP73=SN7473 | 0·37 | 0·35 | 0·32 | BP191=SN74191 | 3·50 | 3·25 | 3·00 |
| BP74=SN7474 | 0·37 | 0·35 | 0·32 | BP192=SN74192 | 2·10 | 1·95 | 1·75 |
| BP75=SN7475 | 0·47 | 0·45 | 0·42 | BP193=SN74193 | 2·10 | 1·95 | 1·75 |
| BP76=SN7476 | 0·43 | 0·40 | 0·38 | BP125=SN74195 | 1·10 | 1·05 | 0·95 |
| BP80=SN7480 | 0·67 | 0·64 | 0·58 | BP196=SN74196 | 1·80 | 1·70 | 1·60 |
| BP81=SN7481 | 0·97 | 0·94 | 0·88 | BP197=SN74197 | 1·80 | 1·70 | 1·60 |
| BP82=SN7482 | 0·97 | 0·94 | 0·88 | BP198=SN74198 | 5·50 | 5·00 | 4·00 |
| BP83=SN7483 | 1·10 | 1·05 | 0·95 | BP199=SN74199 | 5·50 | 5·00 | 4·00 |

**PRICE-MIX.** Devices may be mixed to qualify for quantity prices.

**PRICES** for quantities in excess of 500 pieces mixed, on application.

Owing to the ever increasing range of TTL 74 Series, please check with us for supplies of any devices not listed above, as it is probably now in stock. WARE 3442.

## NUMERICAL INDICATOR TUBE *Type* MG-17G



Cold Cathode gas-filled, side-viewing numerals (0–9) and Decimal Point.

**COLOUR:** Neon Red.

**DATA:** Anode supply voltage 180 min V d.c.
Cathode current: 0·35 Nom mA d.c.

Ideal for use in constructing Digital Clocks, Desk Calculators, etc., and many products described in this magazine. We recommend use of BP41 or BP141 to drive this tube.

*Full data available on request.*

**PRICE: 1-5, £1·55; 6-25, £1·40** ACTUAL SIZE

### BRAND NEW LINEAR I.C's—FULL SPEC.

| Type No. | Case | Leads | Description | Price 1–24 | 25–99 | 100 up |
|---|---|---|---|---|---|---|
| BP 201C—SL201C | TO-5 | 8 | G.P. Amp | 63p | 53p | 45p |
| BP 701C—SL701C | TO-5 | 8 | OP Amp | 63p | 50p | 45p |
| BP 702C—SL702C | TO-5 | 8 | OP Amp Direct OP | 63p | 50p | 45p |
| BP 702—72702 | D.I.L. | 14 | G.P. OP Amp (Wide Band) | 53p | 45p | 40p |
| BP 709 —72709 | D.I.L. | 14 | High OP Amp | 53p | 45p | 40p |
| BP 709P—µA709C | TO-5 | 8 | High Gain OP Amp | 53p | 45p | 40p |
| BP 710-72710 | D.I.L. | 14 | Differential comparator | 53p | 45p | 40p |
| BP 711—µA711 | TO-5 | 10 | Dual comparator | 58p | 50p | 45p |
| BP 741 —72741 | D.I.L. | 14 | High Gain OP Amp (Protected) | 75p | 60p | 50p |
| µA 703C—µA703C | TO-5 | 6 | R.F.-I.F. Amp | 43p | 35p | 27p |
| TAA 263— | TO-72 | 4 | A.F. Amp | 70p | 60p | 55p |
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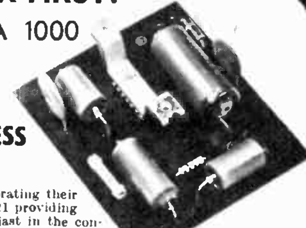

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| BP932 | Expandable dual 4-input NAND buffer | 13p | 12p | 11p |
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| BP935 | Expandable Hex Inverter | 13p | 12p | 11p |
| BP936 | Hex Inverter | 13p | 12p | 11p |
| BP944 | Dual 4-input NAND expandable buffer without pull-up | 13p | 12p | 11p |
| BP945 | Master-slave JK or RS | 25p | 24p | 22p |
| BP946 | Quad, 2-input NAND | 12p | 11p | 10p |
| BP948 | Master-slave JK or RS | 25p | 24p | 22p |
| BP951 | Monostable | 65p | 60p | 55p |
| BP962 | Triple 3-input NAND | 12p | 11p | 10p |
| BP9093 | Dual Master-slave JK with separate clock | 40p | 38p | 35p |
| BP9094 | Dual Master-slave JK with separate clock | 40p | 38p | 35p |
| BP9097 | Dual Master-slave JK with Common Clock | 40p | 38p | 35p |
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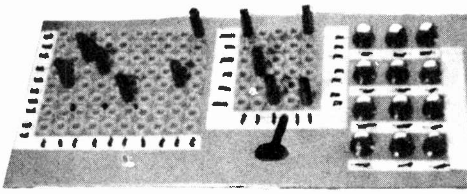

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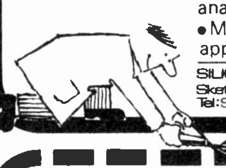

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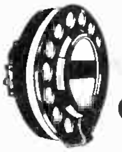

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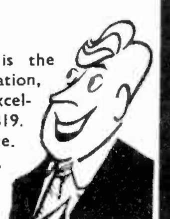

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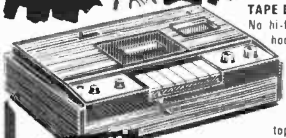

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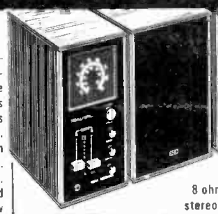

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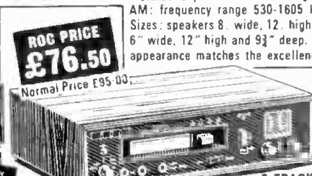
ROC PRICE £43.75 Normal Price £55·50



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The popular Lear-Jet type recording unit is the heart of the fantastic RP-1000ST, which has full record and playback facilities. Automatic track change with manual override. Press to start button. Stereo headphone and Left and Right Mic sockets on front panel. Dual recording level meter, and Left and Right volume controls. Built-in preamp. Tape speed 3¾ ips (9·5 cms). Frequency response: playback 30-10,000 Hz; recording/playback 30-8,000 Hz. Line output: fully variable 0-500mV. The RP-1000ST incorporates all the features you'd expect in a top quality Cartridge Tape Deck. Size 16" wide, 4" high, 9" deep. Cabinet in walnut. Including connecting leads

### OLSON RA-310 AM/FM/MPX STEREO TUNER

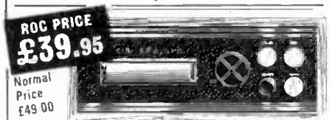
This ROC Tuner is especially designed to match the Olson AM-395 Stereo Amplifier. In price and value, as well as it's good looking design! But of course it's also ideal for use with any other amplifier. The RA-310 costs £10·00 less than the normal retail value, and yet it is a highly sophisticated unit, incorporating the latest solid state techniques. Operation is drift free for supreme station-holding capability. You can connect this Tuner to a stereo amplifier, to a tape deck or a tape recorder. And of course it covers all the stations in the AM and FM bands. FM: 87-108 MHz; AM: 525-1605 kHz. FM Sensitivities: FM, 3μV; AM, 250μV. Stereo separation 30dB at 1kHz, image rejection 60dB. Size: 11$\frac{7}{16}$" wide, 4" high, 7½" deep.

ROC PRICE £39.95 Normal Price £50·00

ROC PRICE £33.20 Normal Price £42·00

### PALACE AM/FM/MPX STEREO TUNER AMPLIFIER SSA-16

This is one of the lowest priced stero tuner amplifiers on the market. It covers the full range of both AM and FM broadcast frequencies. And when you're switched to FM, an indicator lights up when a stereo signal is received – that's the time to switch to 'Stereo'! The SSA-16 has all the facilities you'd expect to find on tuners costing twice as much – separate volume, bass, treble, balance and tuning controls. Selector switch for tape, phono, AM, FM, stereo. Jack socket on front panel for stereo headphones. Frequency range: FM 88-108 MHz. AM 535-1605 kHz. Frequency response: 50-10,000 Hz ± 3dB. Power output: 4 watts total music power into two 8 ohm speakers. Size: 16" wide, 4¼" high, 8" deep.



ROC PRICE £39.95 Normal Price £49·00

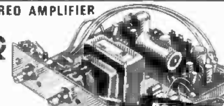
### 8-TRACK HOME STEREO CARTRIDGE PLAYER MODEL E1

With this unit, you can play any standard 8-track cartridge on the market – at a fraction of the normal retail value! It gives you a total of 5 watts of power, to feed into two 8-ohm speakers. The frequency response is 50 to 10,000 Hz, giving you a fine tonal quality that can't be bettered at anything near this price. The E1 has separate tone, balance and volume controls, giving you complete freedom to select the sound you want to hear. Tape speed is 3¾ ips, and wow and flutter are both less than 0·3%. Size: 11½" wide, 5" high, 11" deep.

### REALISTIC SA-100B 6-WATT STEREO AMPLIFIER

Here's fabulous, exciting value in miniature! This high quality stereo amplifier measures only 9" wide × 3" high × 5¾" deep. And yet it has separate ganged volume, balance and tone controls. Plus speaker in/out, mono/stereo, phono/tuner and power on/off slide switches. The ends are oiled walnut, with matching enamelled metal top. The front panel is satin aluminium and walnut-brown enamel. Frequency response is 50 to 10,000 Hz ± 3dB. Output 3 watts r.m.s. per channel into 8 ohms. Inputs are 100mV for both phono and tuner.

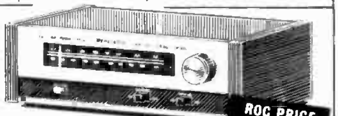
ROC PRICE £14.50 Normal Price £21·00



### ROC 7-WATT STEREO AMPLIFIER CHASSIS SK-317

This exclusive R O C Stereo Chassis is completely self-contained, and it costs £2·25 less than the normal retail value! The SK-317 is a really compact unit measuring only 5¼" wide, 1¾" high and 6⅜" deep. It contains its own mains power supply, and has a ganged volume control and separate treble controls for each channel. Specification: frequency response 40-17,000 Hz ± 3dB; output 3·5 watts music power per channel into 8 ohms; input, phono, 600mV; signal-to-noise ratio better than 45dB.

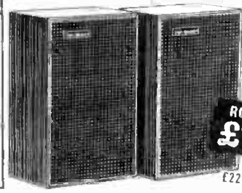
ROC PRICE £5.50 Normal Price £7·75



### REALISTIC TM-100 AM/FM/MPX STEREO TUNER

Here's another unit that gives you fabulous value in miniature! Designed specifically to match the Realistic SA-100B in both appearance, size and performance, the TM-100 is superb value-for-money. It gives you the full FM and AM ranges – FM, 88-108 MHz; AM, 535-1605 kHz. Sensitivities FM 5μV; AM 250μV. Image rejection 50dB.

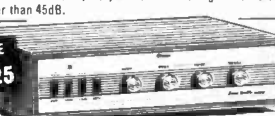
ROC PRICE £23.25 Normal Price £28·60



ROC PRICE £16.40 Normal Price £22·50 per pair.

### R.446 3-WAY MATCHED SPEAKERS

These will do justice to your amplifier – and to your pocket. At only £16·40 a pair, they are real value-for-money. Each cabinet is heavily lagged and teak finished. They handle 16 watts rms (8 watts rms each). Each loudspeaker contains a large dual cone base unit, plus a separate tweeter. Frequency range: 40 to 19,000 Hz. Size 14" high, 9" wide, 6¼" deep.



ROC PRICE £18.25 Normal Price £25·20

### OLSON AM-372 16-WATT STEREO AMPLIFIER

Here's a really good amplifier at a really down-to-earth price – nearly £7 less than the normal retail value! Just look at what the AM-372 will do for you – reproduce signals from ceramic or crystal cartridges, AM and FM tuners, and tape recorders. And it gives you outputs for two sets of speakers, headphones and tape recorders. Frequency response is 30 to 20,000 Hz ± 3dB. Output 8 watts r.m.s per channel music power into 8 ohm speakers. Phono input 200mV. Tuner input 200mV. Size: 12¾" wide, 3¼" high, 7½" deep.

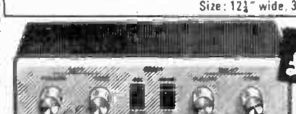
### OLSON AM-395 40-WATT STEREO AMPLIFIER

An ideal unit for your new stereo separate system. It is more than £10·00 below the normal retail price! Making the AM-395 one of Britain's best hi-fi buys. It takes in signals from magnetic or ceramic pick-ups, tuners (see Olson RA-310) and tape decks. And it's got outputs for taping and for headphones. There are separate bass and treble controls, separate Left and Right channel volume controls. And a loudness switch for boosting the bass and treble notes when listening at low output levels. Frequency response: 20-20,000 Hz ± 3dB. Output: 20 watts r.m.s. per channel into 8 ohms. Inputs: magnetic phono 3·0mV RIAA, crystal phono 100mV; tape 160mV; tuner 160mV. Size 11$\frac{7}{16}$" wide, 4" high, 7½" deep. The specification reads well – sounds even better!

ROC PRICE £29.00 Normal Price £39·60

### OLSON AM-357 4-WATT STEREO AMPLIFIER

Here's marvellous value for someone just starting to set themselves up in audio! At only £10·50, you get a fine amplifier in a scratch resistant metal cabinet, with a smart brushed aluminium front panel. It incorporates separate tone and volume controls for each channel. Inputs are provided for turntable (ceramic cartridge), tuner and tape deck or recorder. Frequency response: 70-20,000 Hz ± 3dB. Output: 2 watts r.m.s. per channel into 8 ohms. Inputs: phono 80mV; tuner/aux 80mV. Size 8" wide, 2⅞" high, 4½" wide.



ROC PRICE £10.50 Normal Price £14·70

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**Every item shown here is the best of its kind within its price range. Buy them separately or at the same time as the other top-value audio products listed.**

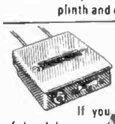
**R.328 STEREO HEADPHONE**
If you're starting in hi-fi, and you discover the need for a pair of really good stereo headphones. The R.328 is ideal, at a price you can afford. They have padded ear cushions, a 6-foot cord and jack plug. Frequency range 30-15,000 Hz. Impedance 8 ohms per channel.
**ROC PRICE £2·95**

**EAGLE SE-30 STEREO HEADPHONE**
This model is for the more discriminating listener. For a start the frequency range extends from 30 to 16,000 Hz. And you can adjust the volume of each earpiece independently. There's also a mono/stereo switch. For maximum comfort, the ear cushions are covered in soft leathers. **ROC PRICE £7·05**

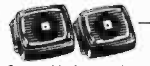
**EAGLE SE-80 STUDIO STEREO HEADPHONE**
Here's the ultimate in headphone design! Apart from its fantastic ability to reproduce all the frequencies from 20 to 20,000 Hz, the SE-80 has eliminated the discomfort and strain associated with traditional headphone design. Eagle have designed and produced a pair of headphones which breaks with all previous concepts. You hear all the sounds crisp and clear. In fact, the reproduction is so good, that it compares favourably with the most expensive hi-fi speaker systems. Separate slider volume control on each earpiece. Impedance: 8 ohm per channel.
**ROC PRICE £14·90**

**TEC HR-007 HEADPHONE RADIO**
When you want to listen to the radio all by yourself. Then this will solve the problem. Separate volume and tuning controls with easy-to-use knobs. Frequency range is 535 to 1605 kHz medium wave band. Maximum output is 300 mW.
Normal Price £9·45 **ROC PRICE £7·65**

**THORENS TD150AB/II**
Transcription Turntable. Complete with pick up arm, plinth and cover. £52·31



**R.186 STEREO HEADPHONE JUNCTION BOX**
If you want easy, fingertip control of headphones *and* loudspeakers, here's the ideal solution to the problem. All you do is connect it to your speakers and amplifier, plug in your headphones – and you're ready to take over! At the flick of a slide switch, you can have headphones alone, or speakers alone, or both together. Input: suitable for use with amplifiers rated up to 20 watts. Size: 2$\frac{11}{16}$" × 3$\frac{3}{32}$" × 1$\frac{7}{32}$".
**ROC PRICE £1·50**



**R.151 STEREO CAR SPEAKERS**
Smart black, tough, plastic cases, each containing a high flux 110mm diameter speaker unit. Just what you need to go with the CS.8 Cartridge Player or any other car stereo system. Fitted with over three yards of connecting cable. Dimensions: 6$\frac{11}{16}$" × 5$\frac{11}{16}$" × 3$\frac{3}{16}$". Impedance: 8 ohms per speaker. Rating: 5 watts max per speaker. **ROC PRICE £3·72**

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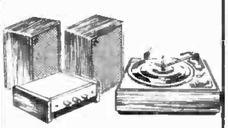
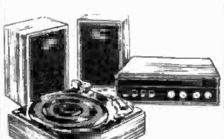
Now run your eye over the prices, select the System nearest to your budget – and you've hit on the best value that your money can buy! Supplied with all necessary leads and plugs, ready to use.



**REALISTIC SA-100B SYSTEM**
Realistic SA-100B Stereo Amplifier, Garrard 2025TC Autochanger with Stereo ceramic cartridge, plinth and cover and a pair of ROC R.446 Speakers. Matching TM-100 Stereo Tuner £23·25 extra if required.
Normal Price £63·98
**ROC PRICE £47·60**

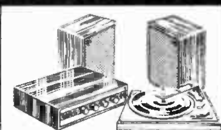


**OLSON AM-395 SYSTEM**
Olson AM-395 Stereo Amplifier, Garrard SP25 Mk III Record Player with Eagle LC07 Stereo Magnetic Cartridge, plinth and cover and a pair of Eagle DL.67 Speakers. Matching RA.310 Stereo Tuner £39·95 extra if required.
Normal Price £106·65
**ROC PRICE £92·60**

**OLSON AM-357 SYSTEM**
Olson AM-357 Stereo Amplifier, Garrard 2025 T/C Autochanger with Stereo ceramic cartridge, plinth and cover and a pair of ROC R.088 4 watt Speakers.
Normal Price £45·28
**ROC PRICE £36·70**

**PALACE SYSTEM**
Palace SSA-16 Stereo Tuner Amplifier, Garrard 2025 T/C autochanger with stereo ceramic cartridge, plinth and cover and a pair of ROC R.446 Speakers.
Normal Price £84·98
**ROC PRICE £66·30**

**REALISTIC SA-500 SYSTEM**
Realistic SA-500 Stereo Amplifier, Garrard SP25 Mk III Single Record Player with Eagle LC.07 Stereo Magnetic Cartridge, plinth and cover and a pair of Crysler CE-5b Speakers. Normal Price £157·95
**ROC PRICE £124·00**



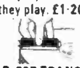
**OLSON AM-372 SYSTEM**
Olson AM-372 Stereo Amplifier, Garrard 2025 T/C Autochanger with Stereo ceramic cartridge, plinth and cover and a pair of ROC R.446 Speakers.
Normal Price £68·18
**ROC PRICE £51·53**

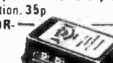
**REALISTIC 12-694 SYSTEM**
Realistic 12-694 Stereo Tuner Amplifier with matching speakers and Garrard SP25 Mk III with Eagle LC.07 Stereo Magnetic Cartridge and plinth and cover.
Normal Price £144·05
**ROC PRICE £124·50**

**ROC E1 SYSTEM**
ROC E1 8 track Stereo Cartridge Player complete with a pair of ROC R.088 4 watt Speakers.
Normal Price £59·10
**ROC PRICE £49·45**

**EAGLE 8-TRACK CAR STEREO PLAYER, CS.8**
Drive to the sound of music – with this fabulous 8-Track Cartridge Player. It gives you superb tone and power to fill the car with stereo sound. Ideal for use with R.151 or R.152 speakers. Complete with all mounting accessories. For negative earth electrical systems only. Output: 2·5 watts per channel. Frequency range: 70-10,000 Hz. Wow and flutter: less than 0·3%. Tape speed: 3·5 cm/sec. Channel selector: automatic with manual over-ride. Mounting dimensions: 5$\frac{13}{16}$" × 5$\frac{1}{4}$" × 2$\frac{11}{16}$". **ROC PRICE £27·20**

**"WATTS" RECORD CLEANERS**
The original "Dust Bug" Automatic Record Cleaner keeps your records clean as they play. £1·20 Watts Disc Preener. Keeps new records like new – for perfect record reproduction. 35p

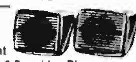




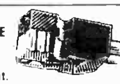
**R.307 TRANSISTORIZED STEREO PRE-AMPLIFIER**
Now your amplifier that could only reproduce ceramic or crystal pick-up cartridges, can accept signals from moving-magnet cartridges! The R.307 steps up signals from between 5-20mV to 200-800 mV. Input: 5-20mV. Equalisation: RIAA. Output: 200-800mV flat. Frequency range: 20-22,000 Hz. Dimensions: 3$\frac{1}{4}$" × 1$\frac{1}{2}$" × 2$\frac{3}{16}$". Supply: 240 VAC. **ROC PRICE £4·92**

**15-FOOT STEREO HEADPHONE EXTENSION CORD R.362**
Fitted with heavy duty 3-circuit stereo plug at one end and a matching stereo socket at the other. **ROC PRICE £1·30**

**STEREO HEADPHONE "Y" ADAPTOR**
R.361 Enables you to use two sets of stereo headphones from a single socket. Fitted with male plug and two female sockets. **ROC PRICE £1·30**

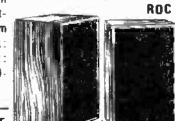


**R.152 STEREO CAR SPEAKERS**
These sloping front speakers match the CS.8 Cartridge Player or any other car stereo system. Fitted with high flux 110mm diameter speaker unit, and over three yards of connecting cable. Dimensions: 6$\frac{11}{16}$" × 6$\frac{11}{16}$" × 3$\frac{1}{4}$". Impedance: 8 ohms per speaker. Rating: 5 watts max. per speaker.
**ROC PRICE £4·96**

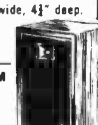


**EAGLE LC.05 STEREO MAGNETIC CARTRIDGE**
For fabulous reproduction at a very low price, you'll find it hard to beat. 0·7 mil diamond stylus. Output: 6mV per channel. Frequency range: 30-18,000 Hz. Channel balance: ± 1·5dB. Channel separation: 20dB. Recommended stylus pressure: 2-4 grams. Compliance: 9 × 10-6 cm/dyne. **ROC PRICE £4·75**

**EAGLE LC.07 STEREO MOVING-MAGNET CARTRIDGE**
Here's your opportunity to own a transcription cartridge for the price of a ceramic! Is specially designed to match top quality tone arms, and to get the very best from your hi-fi amplifier. 0·7 mil diamond stylus. Output: 7mV per channel. Frequency range: 20-21,000 Hz. Channel balance: ± 1dB. Channel separation: 28dB. Compliance: 12 × 10-6 cm/dyne.
**ROC PRICE £6·37**



**R.088 MATCHED STEREO LOUDSPEAKERS**
Here's real value in stereo speakers! Each unit comes complete with 10-foot lead and phono plug, and look really smart. Power handling per speaker: 4 watts rms, 8 watts peak. Frequency range: 40-16,000 Hz. Flux density: 8,500 gauss. Impedance: 8 ohms. Dimensions: 9" high, 5$\frac{1}{2}$" wide, 4$\frac{1}{2}$" deep. Finish: oiled walnut.
**ROC PRICE £9·50 pair**



**EAGLE DL.67 HIGH COMPLIANCE 3-WAY TEAK SPEAKER SYSTEM**
From a rich, deep, 35 Hz bass to above the limit of human hearing – this fantastic response comes from such a small size – only 10" × 6" × 6$\frac{1}{2}$"! The DL.67 is the end product of several years effort into the problems of full frequency response from small cabinets. The DL.67 has a dual cone high compliance bass mid range unit, and a horn tweeter. The speaker has a variable brilliance control to suit individual rooms – a feature normally only found on very expensive speaker systems. Power handling capacity: 10 watts rms, 20 watts peak. Frequency range: 35-20,000 Hz. Flux density: 11,000 gauss. Impedance: 8 ohms. Dimensions: 11$\frac{1}{4}$" high × 8" wide × 6$\frac{1}{4}$" deep. Finish: oiled teak. **ROC PRICE £18·80 each**

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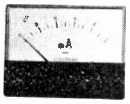
### CLEAR PLASTIC METERS

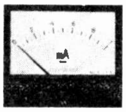
TYPE SW. 100
100 x 80 mm



| | | | |
|---|---|---|---|
| 50µA | £3·60 | 500µA | £3·35 |
| 50-0-50µA | £3·45 | 1mA | £3·10 |
| 100µA | £3·20 | 20V d.c. | £3·10 |
| 100-0-100µA | £3·45 | 50V d.c. | £3·10 |
| | | 300V d.c. | £3·10 |
| | | 1A d.c. | £3·10 |
| | | 5A d.c. | £3·10 |
| | | 300V a.c. | £3·10 |
| | | VU Meter | £3·75 |

### BAKELITE PANEL METERS

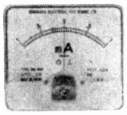
TYPE S-80
80 mm square fronts



| | | | |
|---|---|---|---|
| 50µA | £3·20 | 1A d.c. | £2·60 |
| 50-0-50µA | £3·10 | 5A d.c. | £2·60 |
| 100µA | £2·75 | 300V a.c. | £2·60 |
| 100-0-100µA | £3·10 | VU Meter | £3·37 |
| 500µA | £3·00 | | |
| 1mA | £2·60 | | |
| 20V d.c. | £2·60 | | |
| 50V d.c. | £2·60 | | |
| 300V d.c. | £2·60 | | |

## "SEW" CLEAR PLASTIC METERS

**Type MR.85P. 4¼in 4¼in fronts.**



| | | | |
|---|---|---|---|
| 50µA | £3·60 | 50mA | £2·80 |
| 50-0-50µA | £3·10 | 100mA | £2·80 |
| 100µA | £3·10 | 500mA | £2·80 |
| 100-0-100µA | £3·00 | 1A | £2·80 |
| 200µA | £3·00 | 5A | £2·80 |
| 500µA | £2·90 | 15A | £2·80 |
| 500-0-500µA | £2·80 | 30A | £2·90 |
| 1mA | £2·80 | 20V d.c. | £2·80 |
| 1-0-1mA | £2·80 | 50V d.c. | £2·80 |
| 5mA | £2·80 | 150V d.c. | £2·80 |
| 10mA | £2·80 | 300V d.c. | £2·80 |
| | | 15V a.c. | £2·80 |
| | | 300V a.c. | £2·80 |
| | | S Meter 1mA | £2·87 |
| | | VU Meter | £3·60 |
| | | 1A a.c.* | £2·80 |
| | | 5A a.c.* | £2·80 |
| | | 10A a.c.* | £2·80 |
| | | 20A a.c.* | £2·80 |
| | | 30A a.c.* | £2·80 |

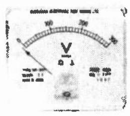
**Type MR.52P. 2½in square fronts.**

| | | | |
|---|---|---|---|
| 50µA | £3·10 | 20V d.c. | £2·00 |
| 50-0-50µA | £2·60 | 50V d.c. | £2·00 |
| 100µA | £2·60 | 300V d.c. | £2·00 |
| 100-0-100µA | £2·50 | 15V a.c. | £2·10 |
| 500µA | £2·30 | 300V a.c. | £2·10 |
| 1mA | £2·00 | S Meter 1mA | £2·10 |
| 5mA | £2·00 | VU Meter | £3·20 |
| 10mA | £2·00 | 1A a.c.* | £2·00 |
| 50mA | £2·00 | 5A a.c.* | £2·00 |
| 100mA | £2·00 | 10A a.c.* | £2·00 |
| 500mA | £2·00 | 20A a.c.* | £2·00 |
| 1A | £2·00 | 30A a.c.* | £2·00 |
| 5A | £2·00 | | |
| 10V d.c. | £2·00 | | |

**Type MR.65P. 3½in 3½in fronts.**

| | | | |
|---|---|---|---|
| 50µA | £3·37 | 20V d.c. | £2·20 |
| 50-0-50µA | £2·75 | 50V d.c. | £2·20 |
| 100µA | £2·75 | 150V d.c. | £2·20 |
| 100-0-100µA | £2·65 | 300V d.c. | £2·20 |
| 200µA | £2·65 | 15V a.c. | £2·30 |
| 500µA | £2·40 | 50V a.c. | £2·30 |
| 500-0-500µA | £2·20 | 150V a.c. | £2·30 |
| 1mA | £2·20 | 300V a.c. | £2·30 |
| 5mA | £2·20 | 500V a.c. | £2·30 |
| 10mA | £2·20 | S Meter 1mA | £2·37 |
| 50mA | £2·20 | VU meter | £3·37 |
| 100mA | £2·20 | 50mA a.c.* | £2·20 |
| 500mA | £2·20 | 100mA a.c.* | £2·20 |
| 1A | £2·20 | 200mA a.c.* | £2·20 |
| 5A | £2·20 | 500mA a.c.* | £2·20 |
| 10A | £2·20 | 1A a.c.* | £2·20 |
| 15A | £2·20 | 5A a.c.* | £2·20 |
| 20A | £2·20 | 10A a.c.* | £2·20 |
| 30A | £2·30 | 20A a.c.* | £2·20 |
| 50A | £2·50 | 30A a.c.* | £2·20 |
| 5V d.c. | £2·20 | | |
| 10V d.c. | £2·20 | | |

**Type MR.38P. 1 21/32in square fronts.**



| | | | |
|---|---|---|---|
| 50µA | £2·10 | 150mA | £1·60 |
| 50-0-50µA | £1·90 | 200mA | £1·60 |
| 100µA | £1·90 | 300mA | £1·60 |
| 100-0-100µA | £1·75 | 500mA | £1·60 |
| 200µA | £1·75 | 750mA | £1·60 |
| 500µA | £1·65 | 1A | £1·60 |
| 500-0-500µA | £1·60 | 2A | £1·60 |
| 1mA | £1·60 | 5A | £1·60 |
| 1-0-1mA | £1·60 | 10A | £1·60 |
| 2mA | £1·60 | 3V d.c. | £1·60 |
| 5mA | £1·60 | 10V d.c. | £1·60 |
| 10mA | £1·60 | 15V d.c. | £1·60 |
| 20mA | £1·60 | 20V d.c. | £1·60 |
| 50mA | £1·60 | 100V d.c. | £1·60 |
| 100mA | £1·60 | 150V d.c. | £1·60 |
| | | 300V d.c. | £1·60 |
| | | 500V d.c. | £1·60 |
| | | 750V d.c. | £1·60 |
| | | 15V a.c. | £1·70 |
| | | 50V a.c. | £1·70 |
| | | 150V a.c. | £1·70 |
| | | 300V a.c. | £1·70 |
| | | 500V a.c. | £1·70 |
| | | S Meter 1mA | £1·70 |
| | | VU meter | £2·10 |

**Type MR.45P. 2in square fronts.**

| | | | |
|---|---|---|---|
| 50µA | £2·25 | 10V d.c. | £1·50 |
| 50-0-50µA | £2·10 | 20V d.c. | £1·50 |
| 100µA | £2·10 | 50V d.c. | £1·50 |
| 100-0-100µA | £1·87 | 300V d.c. | £1·50 |
| 200µA | £1·87 | 15V a.c. | £1·80 |
| 500µA | £1·75 | 300V a.c. | £1·80 |
| 500-0-500µA | £1·70 | S Meter 1mA | £1·85 |
| 1mA | £1·70 | VU Meter | £2·25 |
| 5mA | £1·70 | 1A a.c.* | £1·70 |
| 10mA | £1·70 | 5A a.c.* | £1·70 |
| 50mA | £1·70 | 10A a.c.* | £1·70 |
| 100mA | £1·70 | 20A a.c.* | £1·70 |
| 500mA | £1·70 | 30A a.c.* | £1·70 |
| 1A | £1·70 | | |
| 5A | £1·70 | | |

## "SEW" BAKELITE PANEL METERS

**Type MR.65 3½in square fronts.**

| | | | |
|---|---|---|---|
| 25µA | £3·50 | 500mA | £1·90 |
| 50µA | £2·37 | 1A | £1·90 |
| 50-0-50µA | £2·35 | 5A | £1·90 |
| 100µA | £2·35 | 15A | £1·90 |
| 100-0-100µA | £2·25 | 30A | £1·90 |
| 500µA | £2·20 | 50A | £1·90 |
| 1mA | £1·90 | 3V d.c. | £1·90 |
| 1-0-1mA | £1·90 | 10V d.c. | £1·90 |
| 5mA | £1·90 | 20V d.c. | £1·90 |
| 10mA | £1·90 | 50V d.c. | £1·90 |
| 50mA | £1·90 | 150V d.c. | £1·90 |
| 100mA | £1·90 | 300V d.c. | £1·90 |
| | | 30V a.c.* | £1·95 |
| | | 50V a.c.* | £1·95 |
| | | 150V a.c.* | £1·95 |
| | | 300V a.c.* | £1·95 |
| | | 500mA a.c.* | £1·95 |
| | | 1A a.c.* | £1·95 |
| | | 5A a.c.* | £1·95 |
| | | 10A a.c.* | £1·95 |
| | | 20A a.c.* | £1·95 |
| | | 30A a.c.* | £1·95 |
| | | 50A a.c.* | £1·95 |
| | | VU meter | £3·10 |

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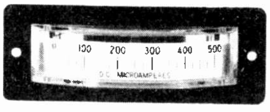
## "SEW" EDUCATIONAL METERS

**Type ED.107. Size overall 100mm × 90mm × 108mm.** A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:

| | | | |
|---|---|---|---|
| 50µA | £5·00 | 20V d.c. | £4·40 |
| 100µA | £4·65 | 50V d.c. | £4·40 |
| 1mA | £4·40 | 300V d.c. | £4·40 |
| 50-0-50µA | £4·65 | Dual range | |
| 1-0-1mA | £4·40 | 500mA/5A d.c. | £4·65 |
| 1A d.c. | £4·40 | 5V/50V d.c. | £4·65 |
| 5A d.c. | £4·40 | | |
| 10V d.c. | £4·40 | | |

## EDGEWISE METERS



**PE.70 3 17/32in 1 15/32in 2¼in deep.**

| | | | |
|---|---|---|---|
| 50µA | £3·10 | 500µA | £2·75 |
| 50-0-50µA | £3·00 | 1mA | £3·45 |
| 100µA | £3·00 | 300V a.c. | £3·45 |
| 100-0-100µA | £2·90 | VU meter | £3·40 |
| 200µA | £2·90 | | |

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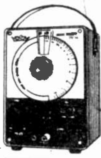

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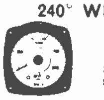

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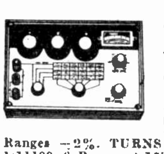

A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω–11·1 megΩ 6 Ranges ±1%. L.1 µH – 111 HENRYS 6 Ranges ±2%. C. 10pF – 1110mFd. 6 Ranges ±2%. TURNS RATIO 1:1/1000–1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100µA. Meter indication. Attractive 2 tone metal case. Size 7¼ × 5 × 2in. **£20.** P. & P. 25p.

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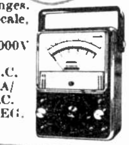
**HT100B4 MULTIMETER**



Features A.C. current ranges. 100,000 o.p.v. Mirror Scale. Overload protection. 0/·5/2·5/10/50/250/500/1000V D.C. 0/2·5/10/50/250/1000V A.C. 0/10/250µA/2·5/25/250MA/10 Amp D.C. 10Amp A.C. 0/20K/200K/2MEG/20MEG. −20 +62db. **£12·50.** P. & P. 25p.

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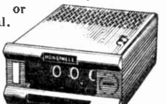

Can be panel or bench mounted. Basic meter measures 1 volt d.c. but can be used to measure a wide range of a.c. and d.c. volt, current and ohms with optional plug-in cards. Specification:—Accuracy: ± 0·2, ± 1 digit. Resolution: 1mV. No. of digits: 3 plus fourth overrange digit. Overrange: 100% (up to 1·999). Input impedance: 1000 Meg ohm. Measuring cycle: 1 per second. Adjustment: Automatic Zeroing, full scale adjustment against an internal reference voltage. Overload: to 100V d.c. Input: Fully floating (3 poles). Input power: 110-230V a.c. 50/60 cycles. Overall size: 5⅝in. × 2 13/16in. × 8 3/16in. AVAILABLE BRAND NEW AND FULLY GUARANTEED AT APPROX. HALF PRICE. **£49·97½** Carr. 50p

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| 2N404 | 20p |
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| 2N697 | 15p |
| 2N698 | 25p |
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| 2N708 | 12p |
| 2N709 | 45p |
| 2N718 | 25p |
| 2N718A | 30p |
| 2N726 | 25p |
| 2N727 | 25p |
| 2N914 | 17p |
| 2N916 | 17p |
| 2N918 | 30p |
| 2N929 | 22p |
| 2N930 | 20p |
| 2N937 | 52p |
| 2N1090 | 22p |
| 2N1091 | 22p |
| 2N1131 | 25p |
| 2N1132 | 25p |
| 2N1302 | 17p |
| 2N1303 | 17p |
| 2N1304 | 22p |
| 2N1305 | 22p |
| 2N1306 | 25p |
| 2N1307 | 25p |
| 2N1308 | 25p |
| 2N1309 | 25p |
| 2N1507 | 17p |
| 2N1613 | 20p |
| 2N1631 | 35p |
| 2N1632 | 30p |
| 2N1637 | 30p |
| 2N1638 | 27p |
| 2N1639 | 27p |
| 2N1701 | 162p |
| 2N1711 | 24p |
| 2N1889 | 32p |
| 2N1893 | 37p |
| 2N2147 | 72p |
| 2N2160 | 57p |
| 2N2193 | 40p |
| 2N2193A | 42p |
| 2N2194 | 27p |
| 2N2194A | 30p |
| 2N2217 | 25p |
| 2N2218 | 20p |
| 2N2219 | 20p |
| 2N2220 | 25p |
| 2N2221 | 25p |
| 2N2222 | 20p |
| 2N2222A | 25p |
| 2N2297 | 30p |
| 2N2368 | 15p |
| 2N2369 | 15p |
| 2N2369A | 15p |
| 2N2410 | 42p |
| 2N2483 | 27p |
| 2N2484 | 32p |
| 2N2539 | 22p |
| 2N2540 | 22p |
| 2N2613 | 35p |
| 2N2614 | 30p |
| 2N2646 | 47p |
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| 2N2712 | 25p |
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| 2N2714 | 30p |
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| 2N2926O | 12p |
| 2N2926Y | 12p |
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| 2N3014 | 25p |
| 2N3053 | 20p |
| 2N3054 | 49p |
| 2N3055 | 72p |
| 2N3133 | 25p |
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| 2N3391A | 30p |
| 2N3392 | 17p |
| 2N3393 | 15p |
| 2N3394 | 15p |
| 2N3402 | 22p |
| 2N3403 | 22p |
| 2N3404 | 32p |
| 2N3405 | 45p |
| 2N3414 | 22p |
| 2N3415 | 22p |
| 2N3416 | 27p |
| 2N3417 | 37p |
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| 2N3440 | 97p |
| 2N3564 | 17p |
| 2N3565 | 15p |
| 2N3566 | 22p |
| 2N3568 | 25p |
| 2N3569 | 25p |
| 2N3570 | 125p |
| 2N3572 | 97p |
| 2N3605 | 27p |
| 2N3606 | 27p |
| 2N3607 | 22p |
| 2N3638 | 18p |
| 2N3638A | 20p |
| 2N3641 | 18p |
| 2N3642 | 18p |
| 2N3643 | 20p |
| 2N3644 | 25p |
| 2N3645 | 25p |
| 2N3691 | 15p |
| 2N3692 | 18p |
| 2N3693 | 18p |
| 2N3694 | 18p |
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| 2N3703 | 10p |
| 2N3704 | 12p |
| 2N3705 | 10p |
| 2N3706 | 10p |
| 2N3707 | 12p |
| 2N3708 | 10p |
| 2N3709 | 10p |
| 2N3710 | 10p |
| 2N3711 | 10p |
| 2N3713 | 187p |
| 2N3714 | 200p |
| 2N3715 | 220p |
| 2N3716 | 285p |
| 2N3773 | 240p |
| 2N3791 | 275p |
| 2N3819 | 34p |
| 2N3820 | 55p |
| 2N3823 | 30p |
| 2N3854 | 27p |
| 2N3854A | 27p |
| 2N3855 | 27p |
| 2N3855A | 30p |
| 2N3856 | 30p |
| 2N3856A | 35p |
| 2N3858 | 25p |
| 2N3858A | 30p |
| 2N3859 | 27p |
| 2N3859A | 32p |
| 2N3860 | 30p |
| 2N3866 | 150p |
| 2N3877 | 40p |
| 2N3877A | 40p |
| 2N3900 | 37p |
| 2N3900A | 40p |
| 2N3901 | 97p |
| 2N3903 | 20p |
| 2N3904 | 25p |
| 2N3905 | 30p |
| 2N3906 | 25p |
| 2N4058 | 12p |
| 2N4059 | 10p |
| 2N4060 | 12p |
| 2N4061 | 12p |
| 2N4062 | 12p |
| 2N4244 | 47p |
| 2N4248 | 15p |
| 2N4249 | 15p |
| 2N4250 | 18p |
| 2N4254 | 42p |
| 2N4255 | 42p |
| 2N4284 | 17p |
| 2N4285 | 17p |
| 2N4286 | 17p |
| 2N4287 | 17p |
| 2N4288 | 15p |
| 2N4289 | 12p |
| 2N4290 | 15p |
| 2N4291 | 15p |
| 2N4292 | 15p |
| 2N4294 | 17p |
| 2N4303 | 47p |
| 2N4964 | 15p |
| 2N4965 | 18p |
| 2N5027 | 52p |
| 2N5028 | 57p |
| 2N5029 | 47p |
| 2N5030 | 42p |
| 2N5172 | 12p |
| 2N5174 | 52p |
| 2N5175 | 52p |
| 2N5176 | 45p |
| 2N5232A | 30p |
| 2N5245 | 45p |
| 2N5246 | 42p |
| 2N5249 | 67p |
| 2N5265 | 325p |
| 2N5305 | 37p |
| 2N5306 | 40p |
| 2N5307 | 37p |
| 2N5308 | 37p |
| 2N5309 | 62p |
| 2N5310 | 42p |
| 2N5354 | 27p |
| 2N5355 | 27p |
| 2N5356 | 32p |
| 2N5365 | 47p |
| 2N5366 | 22p |
| 2N5367 | 57p |
| 2N5457 | 30p |
| 2N5458 | 35p |
| 2N5459 | 40p |
| 2S102 | 25p |
| 2S103 | 25p |
| 2S104 | 25p |
| 2S301 | 30p |
| 2S302 | 50p |
| 2S303 | 60p |
| 2S304 | 75p |
| 2S501 | 32p |
| 2S502 | 35p |
| 2S503 | 27p |
| 3N83 | 40p |
| 3N128 | 70p |
| 3N140 | 77p |
| 3N141 | 72p |
| 3N142 | 55p |
| 3N143 | 67p |
| 3N152 | 87p |
| 40050 | 55p |
| 40250 | 50p |
| 40251 | 32p |
| 40309 | 32p |
| 40310 | 45p |
| 40311 | 35p |
| 40312 | 47p |
| 40314 | 37p |
| 40315 | 37p |
| 40316 | 47p |
| 40317 | 37p |
| 40319 | 55p |
| 40320 | 47p |
| 40323 | 40p |
| 40324 | 47p |
| 40326 | 37p |
| 40329 | 30p |
| 40344 | 27p |
| 40347 | 57p |
| 40348 | 52p |
| 40360 | 40p |
| 40361 | 40p |
| 40362 | 50p |
| 40370 | 32p |
| 40406 | 57p |
| 40407 | 40p |
| 40408 | 52p |
| 40409 | 55p |
| 40410 | 62p |
| 40412 | 50p |
| 40467A | 57p |
| 40468A | 35p |
| 40528 | 72p |
| 40600 | 57p |
| 40603 | 57p |
| AC107 | 30p |
| AC126 | 20p |
| AC127 | 24p |
| AC128 | 20p |
| AC151 | 20p |
| AC152 | 22p |
| AC154 | 20p |
| AC176 | 20p |
| AC187 | 25p |
| AC188 | 25p |
| ACY17 | 27p |
| ACY18 | 24p |
| ACY19 | 24p |
| ACY20 | 20p |
| ACY21 | 20p |
| ACY22 | 12p |
| ACY28 | 17p |
| ACY39 | 47p |
| ACY40 | 14p |
| ACY41 | 15p |
| ACY44 | 25p |
| AD140 | 47p |
| AD149 | 47p |
| AD150 | 62p |
| AD161 | 35p |
| AD162 | 35p |
| AF109 | 25p |
| AF114 | 25p |
| AF115 | 25p |
| AF116 | 25p |
| AF117 | 20p |
| AF118 | 44p |
| AF121 | 25p |
| AF124 | 22p |
| AF125 | 19p |
| AF126 | 16p |
| AF127 | 16p |
| AF139 | 28p |
| AF178 | 42p |
| AF179 | 45p |
| AF180 | 50p |
| AF181 | 45p |
| AF186 | 30p |
| AF239 | 30p |
| AF279 | 47p |
| AF280 | 47p |
| AFZ11 | 32p |
| ASY26 | 25p |
| ASY27 | 30p |
| ASY28 | 24p |
| ASY29 | 27p |
| ASY50 | 15p |
| ASY51 | 25p |
| ASY54 | 25p |
| ASY67 | 45p |
| ASY86 | 32p |
| ASZ21 | 51p |
| AUY10 | 150p |
| BC107 | 10p |
| BC108 | 10p |
| BC109 | 10p |
| BC113 | 10p |
| BC114 | 15p |
| BC115 | 15p |
| BC116 | 15p |
| BC118 | 15p |
| BC119 | 30p |
| BC121 | 20p |
| BC122 | 15p |
| BC125 | 15p |
| BC126 | 25p |
| BC134 | 12p |
| BC135 | 12p |
| BC136 | 15p |
| BC137 | 15p |
| BC138 | 20p |
| BC140 | 35p |
| BC141 | 35p |
| BC147 | 10p |
| BC148 | 10p |
| BC149 | 12p |
| BC152 | 17p |
| BC153 | 20p |
| BC154 | 20p |
| BC157 | 15p |
| BC158 | 11p |
| BC159 | 12p |
| BC160 | 35p |
| BC167 | 11p |
| BC168B | 12p |
| BC168C | 15p |
| BC169B | 14p |
| BC169C | 12p |
| BC170 | 12p |
| BC171 | 15p |
| BC172 | 15p |
| BC175 | 22p |
| BC177 | 20p |
| BC178 | 20p |
| BC179 | 20p |
| BC182 | 12p |
| BC182L | 10p |
| BC183 | 9p |
| BC183L | 10p |
| BC184 | 12p |
| BC184L | 11p |
| BC186 | 25p |
| BC187 | 27p |
| BC212L | 15p |
| BC213L | 12p |
| BC214L | 15p |
| BCY10 | 27p |
| BCY30 | 30p |
| BCY31 | 40p |
| BCY32 | 60p |
| BCY33 | 30p |
| BCY34 | 35p |
| BCY38 | 45p |
| BCY39 | 60p |
| BCY40 | 50p |
| BCY41 | 15p |
| BCY42 | 15p |
| BCY43 | 15p |
| BCY54 | 32p |
| BCY58 | 20p |
| BCY59 | 22p |
| BCY60 | 97p |
| BCY70 | 15p |
| BCY71 | 20p |
| BCY72 | 15p |
| BCY78 | 30p |
| BCY79 | 30p |
| BCZ10 | 27p |
| BCZ11 | 42p |
| BD112 | 50p |
| BD116 | 112p |
| BD121 | 65p |
| BD123 | 80p |
| BD124 | 62p |
| BD131 | 75p |
| BD132 | 80p |
| BDY10 | 125p |
| BDY20 | 105p |
| BDY61 | 125p |
| BDY62 | 100p |
| BF115 | 25p |
| BF117 | 47p |
| BF152 | 28p |
| BF154 | 20p |
| BF158 | 15p |
| BF159 | 35p |
| BF163 | 35p |
| BF167 | 25p |
| BF170 | 33p |
| BF173 | 30p |
| BF177 | 30p |
| BF178 | 25p |
| BF179 | 30p |
| BF180 | 35p |
| BF181 | 35p |
| BF182 | 30p |
| BF184 | 20p |
| BF185 | 20p |
| BF194 | 15p |
| BF195 | 15p |
| BF196 | 15p |
| BF197 | 15p |
| BF198 | 15p |
| BF200 | 35p |
| BF224 | 14p |
| BF225 | 19p |
| BF237 | 22p |
| BF238 | 22p |
| BF244 | 17p |
| BFW61 | 47p |
| BFW87 | 25p |
| BFW88 | 23p |
| BFW89 | 20p |
| BFW90 | 22p |
| BFW91 | 20p |
| BFX12 | 22p |
| BFX13 | 22p |
| BFX29 | 25p |
| BFX30 | 25p |
| BFX37 | 30p |
| BFX44 | 37p |
| BFX68 | 67p |
| BFX84 | 25p |
| BFX85 | 30p |
| BFX86 | 25p |
| BFX87 | 25p |
| BFX88 | 20p |
| BFX89 | 62p |
| BFX93A | 70p |
| BFY11 | 42p |
| BFY18 | 25p |
| BFY19 | 25p |
| BFY21 | 42p |
| BFY24 | 45p |
| BFY29 | 40p |
| BFY30 | 40p |
| BFY41 | 50p |
| BFY43 | 62p |
| BFY50 | 20p |
| BFY51 | 20p |
| BFY52 | 20p |
| BFY53 | 15p |
| BFY56A | 57p |
| BFY76 | 45p |
| BFY77 | 57p |
| BFY90 | 65p |
| BSX19 | 17p |
| BSX20 | 15p |
| BSX21 | 20p |
| BSX26 | 45p |
| BSX27 | 47p |
| BSX28 | 32p |
| BSX60 | 82p |
| BSX61 | 62p |
| BSX76 | 15p |
| BSX77 | 20p |
| BSX78 | 25p |
| BSY24 | 15p |
| BSY25 | 15p |
| BSY26 | 17p |
| BSY27 | 15p |
| BSY28 | 17p |
| BSY29 | 25p |
| BSY32 | 25p |
| BSY36 | 25p |
| BSY37 | 25p |
| BSY38 | 20p |
| BSY39 | 22p |
| BSY43 | 50p |
| BSY51 | 32p |
| BSY52 | 35p |
| BSY53 | 37p |
| BSY54 | 40p |
| BSY56 | 90p |
| BSY79 | 45p |
| BSY90 | 57p |
| BSY95A | 12p |
| C424 | 15p |
| C450 | 15p |
| GET102 | 35p |
| GET113 | 25p |
| GET114 | 20p |
| GET118 | 20p |
| GET120 | 25p |
| GET873 | 15p |
| GET880 | 45p |
| GET887 | 15p |
| GET889 | 22p |
| GET890 | 22p |
| GET896 | 22p |
| GET897 | 22p |
| GET898 | 22p |
| MAT100 | 25p |
| MAT101 | 25p |
| MAT120 | 25p |
| MAT121 | 25p |
| MJ400 | 107p |
| MJ420 | 80p |
| MJ421 | 80p |
| MJ430 | 102p |
| MJ440 | 95p |
| MJ480 | 97p |
| MJ481 | 125p |
| MJ490 | 100p |
| MJ491 | 137p |
| MJE340 | 50p |
| MJE370 | 80p |
| MJE371 | 80p |
| MJE520 | 75p |
| MJE521 | 70p |
| MPF102 | 42p |
| MPF103 | 37p |
| MPF104 | 37p |
| MPF105 | 37p |
| MPS3638 | 32p |
| NKT124 | 42p |
| NKT125 | 27p |
| NKT126 | 27p |
| NKT128 | 27p |
| NKT135 | 27p |
| NKT137 | 32p |
| NKT210 | 30p |
| NKT211 | 30p |
| NKT212 | 30p |
| NKT213 | 30p |
| NKT214 | 20p |
| NKT215 | 22p |
| NKT216 | 35p |
| NKT217 | 40p |
| NKT219 | 30p |
| NKT223 | 27p |
| NKT224 | 22p |
| NKT225 | 22p |
| NKT229 | 30p |
| NKT237 | 35p |
| NKT238 | 25p |
| NKT240 | 27p |
| NKT241 | 27p |
| NKT242 | 20p |
| NKT243 | 62p |
| NKT244 | 17p |
| NKT245 | 20p |
| NKT261 | 20p |
| NKT262 | 30p |
| NKT264 | 20p |
| NKT271 | 20p |
| NKT262 | 20p |
| NKT274 | 20p |
| NKT275 | 20p |
| NKT278 | 25p |
| NKT281 | 27p |
| NKT401 | 87p |
| NKT402 | 90p |
| MKT403 | 75p |
| NKT404 | 55p |
| NKT405 | 75p |
| NKT406 | 62p |
| NKT451 | 62p |
| NKT452 | 62p |
| NKT453 | 47p |
| NKT713 | 20p |
| NKT717 | 42p |
| NKT734 | 27p |
| NKT736 | 35p |
| NKT773 | 25p |
| NKT781 | 30p |
| OC16 | 50p |
| OC19 | 37p |
| OC20 | 85p |
| OC22 | 50p |
| OC23 | 60p |
| OC24 | 60p |
| OC25 | 40p |
| OC26 | 25p |
| OC28 | 60p |
| OC29 | 60p |
| OC35 | 50p |
| OC36 | 60p |
| OC41 | 22p |
| OC42 | 40p |
| OC44 | 15p |
| OC45 | 12p |
| OC46 | 15p |
| OC70 | 12p |
| OC71 | 12p |
| OC72 | 12p |
| OC73 | 30p |
| OC74 | [illegible] |
| OC75 | 25p |
| OC76 | 25p |
| OC77 | 40p |
| OC78 | 20p |
| OC81 | 20p |
| OC81D | 20p |
| OC82 | 25p |
| OC82D | 15p |
| OC83 | 25p |
| OC84 | 25p |
| OC139 | 25p |
| OC140 | 40p |
| OC170 | 25p |
| OC171 | 30p |
| OC200 | 40p |
| OC201 | 75p |
| OC202 | 80p |
| OC203 | 40p |
| OC204 | 40p |
| OC205 | 75p |
| OC206 | 95p |
| OC207 | 75p |
| OCP71 | 42p |
| ORP12 | 50p |
| ORP60 | 40p |
| ORP61 | 42p |
| P346A | 22p |
| ST140 | 15p |
| ST141 | 20p |
| TIS34 | 62p |
| TIS43 | 40p |
| TIS44 | 12p |
| TIS45 | 12p |
| TIS46 | 12p |
| TIS47 | 12p |
| TIS48 | 12p |
| TIS49 | 12p |
| TIS50 | 12p |
| TIS51 | 10p |
| TIS52 | 11p |
| TIS53 | 22p |
| XB112 | 12p |
| XC141 | 35p |
| ZTX107 | 15p |
| ZTX108 | 12p |
| ZTX109 | 15p |
| ZTX300 | 12p |
| ZTX301 | 15p |
| ZTX302 | 20p |
| ZTX303 | 20p |
| ZTX304 | 25p |
| ZTX500 | 15p |
| ZTX501 | 15p |
| ZTX502 | 20p |
| ZTX503 | 17p |
| ZTX504 | 40p |
| ZTX531 | 25p |

### Integrated Circuits

| | |
|---|---|
| CA3000 | 180p |
| CA3005 | 117p |
| CA3007 | 262p |
| CA3011 | 75p |
| CA3012 | 88p |
| CA3013 | 105p |
| CA3014 | 124p |
| CA3018 | 84p |
| CA3018A | 110p |
| CA3019 | 84p |
| CA3020 | 126p |
| CA3020A | 160p |
| CA3021 | 156p |
| CA3022 | 130p |
| CA3023 | 126p |
| CA3026 | 100p |
| CA3028A | 74p |
| CA3028B | 105p |
| CA3029 | 87p |
| CA3029A | 165p |
| CA3030 | 137p |
| CA3035 | 122p |
| CA3036 | 72p |
| CA3039 | 82p |
| CA3041 | 109p |
| CA3042 | 109p |
| CA3043 | 137p |
| CA3044 | 120p |
| CA3045 | 122p |
| CA3046 | 81p |
| CA3047 | 137p |
| CA3048 | 204p |
| CA3049 | 160p |
| CA3050 | 185p |
| CA3051 | 134p |
| CA3052 | 165p |
| CA3053 | 46p |
| CA3054 | 109p |
| CA3055 | 240p |
| CA3059 | 165p |
| CA3064 | 120p |
| FCH101 | 85p |
| FCH111 | 105p |
| FCH121 | 105p |
| FCH131 | 50p |
| FCH141 | 105p |
| FCH151 | 105p |
| FCH161 | 50p |
| FCH171 | 105p |
| FCH181 | 105p |
| FCH191 | 105p |
| FCH201 | 130p |
| FCH211 | 130p |
| FCH221 | 130p |
| FCH231 | 150p |
| FCJ101 | 160p |
| FCJ111 | 150p |
| FCJ121 | 275p |
| FCJ131 | 275p |
| FCJ141 | 525p |
| FCJ201 | 100p |
| FCJ211 | 275p |
| FCK101 | 430p |
| FCL101 | 230p |
| FCY101 | 102p |
| FJH101 | 25p |
| FJH111 | 70p |
| FJH121 | 25p |
| FJH131 | 25p |
| FJH141 | 25p |
| FJH151 | 25p |
| FJH161 | 70p |
| FJH171 | 25p |
| FJH181 | 25p |
| FJH221 | 25p |
| FJH231 | 25p |
| FJH241 | 25p |
| FJH251 | 25p |
| FJJ101 | 50p |
| FJJ111 | 50p |
| FJJ121 | 60p |
| FJJ131 | 60p |
| FJJ141 | 125p |
| FJJ181 | 75p |
| FJJ191 | 65p |
| FJJ211 | 125p |
| FJJ251 | 125p |
| FJL101 | 125p |
| FJY101 | 25p |
| IC10 | 250p |
| IC12 | 250p |
| L900 | 40p |
| L914 | 40p |
| L923 | 40p |
| MC724P | 60p |
| MC780P | 247p |
| MC788P | 146p |
| MC790P | 124p |
| MC792P | 66p |
| MC799P | 66p |
| MC1303L | 100p |
| MC1304P | 225p |
| MC1305P | 386p |
| MC838P | 549p |
| MC1435P | 345p |
| MC1552G | 461p |
| MC1709CG | 94p |
| MFC4000P | 75p |
| PA222 | 260p |
| PA230 | 140p |
| PA234 | 92p |
| PA237 | 210p |
| PA246 | 160p |
| PA424 | 235p |
| PA264 | 190p |
| PA265 | 200p |
| SN7400 | 20p |
| SN7401 | 20p |
| SN7402 | 20p |
| SN7403 | 20p |
| SN7404 | 20p |
| SN7405 | 20p |
| SN7406 | 80p |
| SN7408 | 20p |
| SN7409 | 20p |
| SN7410 | 20p |
| SN7411 | 23p |
| SN7413 | 30p |
| SN7420 | 20p |
| SN7430 | 20p |
| SN7440 | 20p |
| SN7441AN | 75p |
| SN7442 | 75p |
| SN7446 | 100p |
| SN7447 | 135p |
| SN7448 | 125p |
| SN7450 | 20p |
| SN7451 | 20p |
| SN7453 | 20p |
| SN7454 | 20p |
| SN7460 | 20p |
| SN7472 | 30p |
| SN7473 | 40p |
| SN7474 | 40p |
| SN7475 | 45p |
| SN7476 | 45p |
| SN7483 | 87p |
| SN7486 | 33p |
| SN7490 | 87p |
| SN7492 | 87p |
| SN7493 | 87p |
| SN7495 | 87p |
| SN7496 | 87p |
| SN74107 | 52p |
| SN74153 | 140p |
| SN74154 | 220p |
| SN74160 | 180p |
| SN74161 | 260p |
| SN74164 | 220p |
| SN74165 | 225p |
| SN74192 | 175p |
| SN74193 | 175p |
| TAA241 | 162p |
| TAA242 | 425p |
| TAA243 | 150p |
| TAA263 | 75p |
| TAA293 | 97p |
| TAA300 | 175p |
| TAA310 | 125p |
| TAA320 | 72p |
| TAA350 | 175p |
| TAA435 | 147p |
| TAA521 | 132p |
| TAA522 | 360p |
| TAA530 | 495p |
| TAA811 | 445p |
| TAB101 | 97p |
| TAD100 | 150p |
| TAD110 | 150p |
| SL403D | 150p |
| SL702C | 147p |
| UA702A | 280p |
| UA702C | 77p |
| UA703C | 187p |
| UA709C | 125p |
| UA710C | 125p |
| UA716 | 187p |
| UA723C | 162p |
| UA730C | 160p |
| UA741C | 87p |

### BRIDGE RECTIFIERS PLASTIC ENCAPSULATED

| | |
|---|---|
| 600 PIV 1A | 50p |
| 50 PIV 2A | 55p |
| 100 PIV 2A | 60p |
| 200 PIV 2A | 65p |
| 400 PIV 2A | 75p |
| 50 PIV 4A | 60p |
| 100 PIV 4A | 70p |
| 200 PIV 4A | 70p |
| 400 PIV 4A | [illegible] |
| 50 PIV 6A | 62p |
| 100 PIV 6A | [illegible] |
| 200 PIV 6A | 75p |
| 400 PIV 6A | 100p |

### SILICON RECTIFIERS MINIATURE WIRE ENDED PLASTIC

| | IN SERIES 1 AMP | PL SERIES 1·5 AMP | CL SERIES 3 AMP |
|---|---|---|---|
| 4001 50PIV | 7p | 8p | 19p |
| 4002 100PIV | 7p | 9p | 20p |
| 4003 200PIV | 8p | 10p | 22p |
| 4004 400PIV | 8p | 10p | 25p |
| 4005 600PIV | 10p | 12p | 26p |
| 4006 800PIV | 12p | 15p | 27p |
| 4007 1000PIV | 15p | 16p | 30p |

50 + less 15% 100 + less 20%

### SILICON RECTIFIERS STUD MOUNTING

| | 6A | 10A | 17·5A | 35A |
|---|---|---|---|---|
| 100PIV | — | 45p | 50p | £1·22 |
| 200PIV | 25p | [illegible] | 55p | £1·42 |
| 400PIV | 30p | 55p | 62p | £1·77 |
| 600PIV | 32p | 60p | 72p | £2·12 |
| 800PIV | 35p | 75p | 87p | £2·47 |
| 1000PIV | 40p | 85p | £1·05 | £2·77 |

50 + less 15% 100 + less 20%

### ZENER DIODES

| 400MW | 1·5 WATT | 10 WATT |
|---|---|---|
| 3·3-33 V | 2·4—100 | 3·9—100V |
| 10p each | 25p each | 40p each |

25 + less 15% 100 + less 20%

**TRANSISTOR DISCOUNTS**:- 12 + 10%; 25 + 15%; 100 + 20% any one type. Postage on all Semi Conductors 7p extra.

**S A E FOR FULL LISTS**

### VALVES

| | |
|---|---|
| OA2 | 38p |
| OB2 | 45p |
| OZ4 | 30p |
| 1L4 | 20p |
| 1R5 | 40p |
| 1S5 | 30p |
| 1T4 | 25p |
| 1U4 | 30p |
| 1U5 | 60p |
| 2D21 | 35p |
| 3Q4 | 50p |
| 3S4 | 35p |
| 3V4 | 48p |
| 5R4 | 75p |
| 5U4 | 35p |
| 5V4 | 45p |
| 5Y3 | 40p |
| 5Z4G | 40p |
| 6/30L2 | 80p |
| 6AC7 | 40p |
| 6AG7 | 40p |
| 6AK5 | 35p |
| 6AK6 | 60p |
| 6AL5 | 20p |
| 6AM6 | 30p |
| 6AQ5 | 38p |
| 6AS6 | 40p |
| 6AT6 | 35p |
| 6AU6 | 25p |
| 6AV6 | 30p |
| 6BA6 | 25p |
| 6BE6 | 30p |
| 6BH6 | 75p |
| 6BJ6 | 50p |
| 6BQ7A | 40p |
| 6BR7 | 90p |
| 6BR8 | 70p |
| 6BW6 | 85p |
| 6BW7 | 80p |
| 6BZ6 | 40p |
| 6C4 | 33p |
| 6CD6 | 125p |
| 6CL6 | 50p |
| 6CW4 | 65p |
| 6F1 | 62p |
| 6F6G | 35p |
| 6F13 | 45p |
| 6F14 | 70p |
| 6F15 | 65p |
| 6F18 | 50p |
| 6F23 | 85p |
| 6H6 | 17p |
| 6J4 | 50p |
| 6J5 | 25p |
| 6J5GT | 30p |
| 6J6 | 20p |
| 6J7 | 45p |
| 6K8G | 40p |
| 6L6GT | 45p |
| 6LD20 | 50p |
| 6Q7 | 40p |
| 6SA7 | 40p |
| 6SG7 | 40p |
| 6SJ7 | 40p |
| 6SK7 | 40p |
| 6SL7 | 35p |
| 6SN7 | 35p |
| 6SQ7 | 40p |
| 6U4 | 65p |
| 6V6G | 25p |
| 6V6GT | 32p |
| 6X4 | 35p |
| 6X5G | 30p |
| 6X5GT | 40p |
| 10C2 | 50p |
| 10F1 | 75p |
| 10P13 | 60p |
| 10P14 | £1·10 |
| 12AT6 | 30p |
| 12AT7 | 30p |
| 12AU7 | 30p |
| 12AX7 | 30p |
| 12AV6 | 40p |
| 12BA6 | 40p |
| 12BE6 | 40p |
| 12BH7 | 45p |
| 19AQ5 | 45p |
| 20D1 | 50p |
| 20F2 | 65p |
| 20L1 | £1·10 |
| 20P1 | 50p |
| 20P3 | 60p |
| 20P4 | £1·10 |
| 20P5 | £1·20 |
| 25L6 | 50p |
| 25Z4 | 30p |
| 25Z5 | 42p |
| 25Z6 | 65p |
| 30C15 | 80p |
| 30C17 | 90p |
| 30C18 | 80p |
| 30F5 | 85p |
| 30FL1 | 75p |
| 30FL12 | 120p |
| 30FL14 | 95p |
| 30L15 | 85p |
| 30L17 | 80p |
| 30P12 | 80p |
| 30P19 | 85p |
| 30PL1 | 75p |
| 30PL13 | 93p |
| 30PL14 | 90p |
| 35L6 | 50p |
| 35W4 | 35p |
| 35Z4 | 35p |
| 35Z5 | 50p |
| 50B5 | 50p |
| 50C5 | 50p |
| 80 | 55p |
| 85A2 | 50p |
| 807 | 50p |
| 1625 | 50p |
| 5763 | 70p |
| 6146 | 160 |
| AZ31 | 55p |
| CY31 | 35p |
| DAF91 | 30p |
| DAF96 | 45p |
| DF91 | 22p |
| DF96 | 45p |
| DK91 | 40p |
| DK92 | 55p |
| DK96 | 50p |
| DL92 | 35p |
| DL94 | 48p |
| DL96 | 45p |
| DM70 | 40p |
| DY86 | 32p |
| DY87 | 33p |
| E88CC | 100p |
| E180F | 100p |
| EABC80 | 35p |
| EAF42 | 35p |
| EB91 | 20p |
| EBC41 | 55p |
| EBC81 | 30p |
| EBF80 | 40p |
| EBF83 | 40p |
| EBF89 | 32p |
| EBL21 | 60p |
| EC86 | 60p |
| EC88 | 60p |
| ECC40 | 65p |
| ECC84 | 30p |
| ECC85 | 40p |
| ECC88 | 40p |
| ECF80 | 35p |
| ECF82 | 35p |
| ECF86 | 65p |
| ECH21 | 57p |
| ECH35 | 100p |
| ECH42 | 75p |
| ECH81 | 30p |
| ECH83 | 45p |
| ECL80 | 45p |
| ECL82 | 35p |
| ECL83 | 70p |
| ECL86 | 40p |
| EF37A | 120p |
| EF39 | 50p |
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| EF86 | 30p |
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| EM81 | 60p |
| EM84 | 35p |
| EM85 | £1·00 |
| EM87 | 70p |
| EY51 | 40p |
| EY86 | 40p |
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| EZ40 | 55p |
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| EZ80 | 27p |
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| MU14 | 75p |
| PABC80 | 40p |
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| PCC189 | 55p |
| PCF80 | 30p |
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| PCF84 | 60p |
| PCF86 | 60p |
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| PCF801 | 50p |
| PCF802 | 50p |
| PCF805 | 80p |
| PCF806 | 70p |
| PCF808 | 75p |
| PCL82 | 35p |
| PCL83 | 65p |
| PCL84 | 45p |
| PCL85 | 40p |
| PCL86 | 45p |
| PFL200 | 65p |
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| PL83 | 45p |
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| PY33 | 63p |
| PY80 | 40p |
| PY81 | 30p |
| PY82 | 35p |
| PY83 | 38p |
| PY88 | 40p |
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| PY801 | 50p |
| U25 | 80p |
| U26 | 80p |
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| U52 | 35p |
| U191 | 75p |
| U281 | 40p |
| U282 | 40p |
| U301 | 40p |
| U801 | £1·80 |
| UABC80 | 40p |
| UAF42 | 55p |
| UBC41 | 50p |
| UBC81 | 40p |
| UBF80 | 40p |
| UBF89 | 35p |
| UCC84 | 49p |
| UCC85 | 40p |
| UCF80 | 55p |
| UCH21 | 60p |
| UCH42 | 70p |
| UCH81 | 40p |
| UCL82 | 35p |
| UCL83 | 60p |
| UF41 | 60p |
| UF80 | 35p |
| UF85 | 40p |
| UF89 | 40p |
| UL41 | 65p |
| UL84 | 40p |
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### DIODES & RECTIFIERS

| | |
|---|---|
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| 1N914 | 7p |
| 1N916 | 10p |
| AA119 | [illegible] |
| AA129 | 10p |
| AAZ13 | 10p |
| AAZ15 | 10p |
| BA100 | 15p |
| BA102 | 30p |
| BA110 | 25p |
| BA111 | 27p |
| BA112 | 70p |
| BA115 | 7p |
| BA141 | 32p |
| BA142 | 32p |
| BA144 | 12p |
| BA145 | 20p |
| BA154 | 12p |
| BAX13 | 12p |
| BAX16 | 7p |
| BAY31 | 7p |
| BAY38 | 15p |
| BY100 | 15p |
| BY103 | 22p |
| BY122 | 37p |
| BY124 | 15p |
| BY126 | 12p |
| BY127 | 15p |
| BY164 | 57p |
| BY210 | 35p |
| BYZ11 | 30p |
| BYZ12 | 30p |
| BYZ13 | 25p |
| BYZ16 | 40p |
| GJ7M | 37p |
| OA5 | 25p |
| OA6 | 12p |
| OA10 | 25p |
| OA9 | [illegible] |
| OA47 | 10p |
| OA70 | 10p |
| OA73 | 10p |
| OA79 | 10p |
| OA81 | 8p |
| OA85 | 7p |
| OA90 | 8p |
| OA91 | [illegible] |
| OA95 | 7p |
| OA200 | 7p |
| OA202 | 10p |
| OA210 | 17p |

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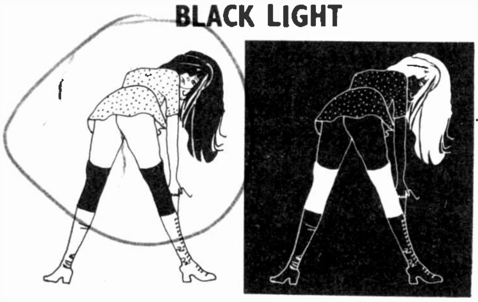

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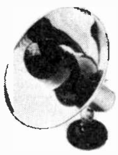

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Construction of the unit can easily be completed in an evening and installation should take no longer than half an hour.
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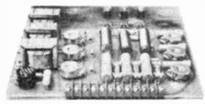

This unit represents a natural progression from our phenomenally successful Mk. 1 and 2 Units. As before the drive voltage is derived directly from the amplifier output or across the speakers. The unit converts the audio frequency signals into a three-coloured light display; the colour depending on the frequency of the signal and the intensity on the loudness of the audio source.
The unit is constructed on professional fibre-glass printed-circuit board material and uses latest full-wave triac circuitry. There is a master-level control, together with independent sensitivity controls for each channel. The original minimum ambient light level controls have been redesigned permitting their use as faders; allowing dimming from max. to zero at the turn of a knob. R.F.I. suppression is now incorporated as standard as well as provision for D.J. "Pulse-Flash" controls. The choice of two inputs enables operation from both high and low power amplifiers. Max. power 1·5kW per channel at 240V a.c.
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**PRICES** SYSTEM 1

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| Viscount III R101 amplifier | £22 + 90p | P.&P. |
| 2 × Duo Type II speakers | £14 + £2 | P.&P. |
| Garrard SP25 Mk. III with MAG. cartridge, plinth and cover | £23 + £1·50 | P.&P. |
| Total | £59 | |

**Available complete for only £52 + £3·50 P.&P.**

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| | | |
|---|---|---|
| Viscount III R101 amplifier | £22 + 90p | P.&P. |
| 2 × Duo Type III speakers | £32 + £3 | P.&P. |
| Garrard SP25 Mk. III with MAG. cartridge, plinth and cover | £23 + £1·50 | P.&P. |
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| | | |
|---|---|---|
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| 2 × Duo Type II speakers | £14 + £2 | P.&P. |
| Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover | £21 + £1·50 | P.&P. |
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**SPEAKERS** Duo Type II
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VOL. 8 No. 3
March 1972

# PRACTICAL ELECTRONICS

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## IN CHARACTER

THE requirement for direct readout of data at high operating speeds from a variety of equipments ranging from large computers to pocket size calculators, and from process counters to digital voltmeters, has provoked intense development work into opto-electronic devices. This month we commence an important new series dealing with alpha and numeric displays intended for such purposes..

The present day range of such devices is particularly interesting in that it includes representative examples based on all three traditional electronic processes: the glow discharge in a gas filled tube, the incandescent filament in a vacuum tube, and now the semiconductor light emitting diode. (An interesting parallel to the course of development of those fundamental active devices, the valve and semiconductor.) As for the future, this holds promise of further advancement in the form of plasma panels and liquid crystals. What has become known as optoelectronics is now perhaps the most important new frontier of advancing electronic technology.

Regarding character representation, it seems there often has to be a compromise between style and technical possibility. This is especially true in the case of the latest kind of display devices designed to operate from low voltage lines and to be driven directly from an i.c. Some ingenious arrangements have been devised in order to provide easily recognisable characters which are sufficiently bright for viewing under normal lighting conditions. But in the process, technical limitations have wrought some havoc with the graceful curved roman characters which have been long in general literary use. The resulting severely angular characters are less pleasing in an aesthetic sense, but as more and more digital instruments come into everyday use their general acceptance seems assured.

Maybe the ousting of the elegant cursive letter is somehow appropriate, in view of the reduced part now played by varying-amplitude sinusoidal waveforms. Sharp bursts of current are the prime movers in today's high speed circuits; and pulses are well typified by those partially dismembered characters built up from discrete spots or bars of light.

Sad but true, cursive copperplate writing, however beautiful to look at, belongs to the leisurely past; austere functional characters are the handwriting of this vigorous (some might say vicious) data acquiring and consuming age. If an artist had been commissioned to envoke the visual significance of digital techniques he could hardly have bettered this character style brought about through technical expedience and necessity. F.E.B.

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### GENERAL FEATURES



### NEWS AND COMMENT



### SPECIAL SUPPLEMENT



***Our April issue will be published on Friday, March 10.***


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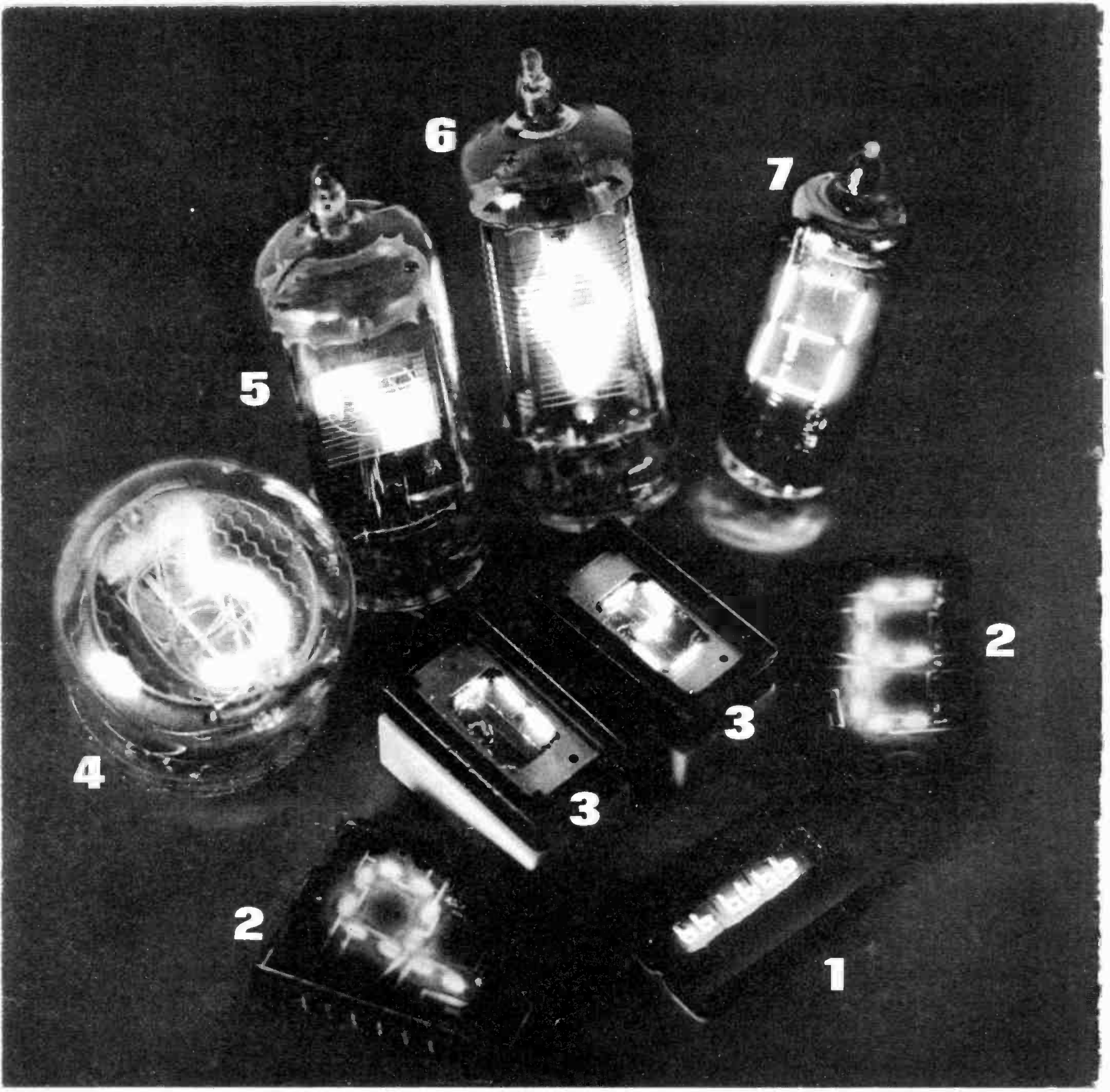



# ALPHA NUMERIC DISPLAYS

By R.W. Coles

## Part ① Data display formats and cold cathode tubes

THE growth explosion in the electronic handling of numerical data has brought with it a great demand for simple systems to display the processed data in a readily understandable form for human interpretation. Electronic data handling in this context is a loose term which covers a wide variety of equipment from the mighty computer to the humble batch counter or digital clock, all of which have need of a means of interfacing their data with people.

Amateur enthusiasts will have little need of the print-out facilities of the larger computers, some of which can print the results of their deliberations at the rate of several pages per second, but there is an increasing amateur application area for simple "Nixie" type displays for use in counters, measuring instruments, and, of course, clocks and calculators.

Alpha-numeric display devices available, or potentially available, to the amateur market are appearing in bewildering profusion, and now seems a good time to review the operation and application of the most useful types, along with some ideas on how to use them in complete display systems.

**1** Six figure, seven segment L.E.D. display. Ferranti

**2** Seven segment, L.E.D. display. Litronix (Guest International Ltd.)

**3** Seven segment, filament indicator. Minitron, type 3015F (A. Marshall & Son)

**4** Cold cathode, neon filled numerical indicator Mullard, type ZM1020

**5** Cold cathode, neon filled character indicator. Mullard, type ZM1263

**6** Cold cathode, neon filled character indicator. Mullard

**7** Seven segment, luminescent filament indicator. Atron (West Hyde Developments Ltd.)

(U.K. suppliers are shown in brackets)

## DATA FORMATS

There are quite a large number of technologies employed to form the heart of display devices: cold cathode tubes, incandescent filaments, fluorescent phosphors, gallium arsenide light emitting diodes (L.E.D.s), being but a few examples. Before looking into the operation of these various displays it is as well to look at the data formats available, as these are common to all device technologies.

Every type of readout is based on one of three basic data formats, the particular form employed being governed mainly by the variety of data to be displayed, the simpler types handling only the numerals, and generally costing less in consequence.

## DISCRETE CHARACTERS

The simplest format available, and the one which potentially gives the most pleasing and easy to interpret display, employs a separate character for each display option. The character set to be displayed is "stored" in the device during manufacture, and may take the form of a set of shaped wire cathodes in a "Nixie" tube, or a set of tiny photographic transparencies to be projected onto a screen by an incandescent lamp in another type of indicator. In either case, a separate character is used for each symbol. The word symbol is used because with this system a device can be produced to display any type of alphabetic, numeric, or symbolic character, in any type of style, limited only by the designer's imagination.

While the flexibility and readability of this format are both excellent, in a practical device vocabulary is rather limited due to the space required to store the separate symbols, and for this reason this format is used only when a comparatively small repertoire is required, 0 to 9, plus and minus or kHz/MHz for example.

## DOT MATRIX

By constructing a display device from a matrix of dots, which may be individually illuminated if required, a very versatile indicator is formed which does not have a limited repertoire like the discrete character type.

A dot matrix can be built from separate filament lamps, light emitting diodes, gas discharges, and others, and though the readability is perhaps slightly worse than the discrete types, the wide variety of characters which can be handled by each device more than compensates.

Fig. 1.1 shows 36 characters of the A.S.C.I.I. (American Standard Code for Information Interface) code, which can be displayed on a group of 35 dots arranged as a 7×5 matrix. A single plane readout with such an impressive character capability can be used to handle even the most sophisticated display tasks but the crunch comes with the decoding and driving electronics required to handle the matrix.

Taking the A.S.C.I.I. code as an example, each character is defined by a six bit binary word, and it is necessary to decode this information to a form which is suitable for driving the matrix directly, for example, telling the display to light up all of rows 3 and 5 to form an equals sign. In a nutshell, the decoder has to decode the binary code to its one-of-sixty-four decimal equivalent, which is then used to determine the state of each of 35 dots. In these days of M.O.S. large scale integrated circuits this is not such a difficult or expensive task as it may appear at first sight.

## BAR MATRIX

The two formats discussed so far represent opposite extremes of display versatility, and for some applications it is handy to have a system which bridges the gap between the two. This compromise is available in the form of bar matrix displays, which are obtainable with varying degrees of complexity, and hence a wide range of repertoires.

The simplest bar matrix display format is the "seven segment" type, which handles all the numerals, nine letters, and one or two symbols. This type of readout is competitive with the discrete

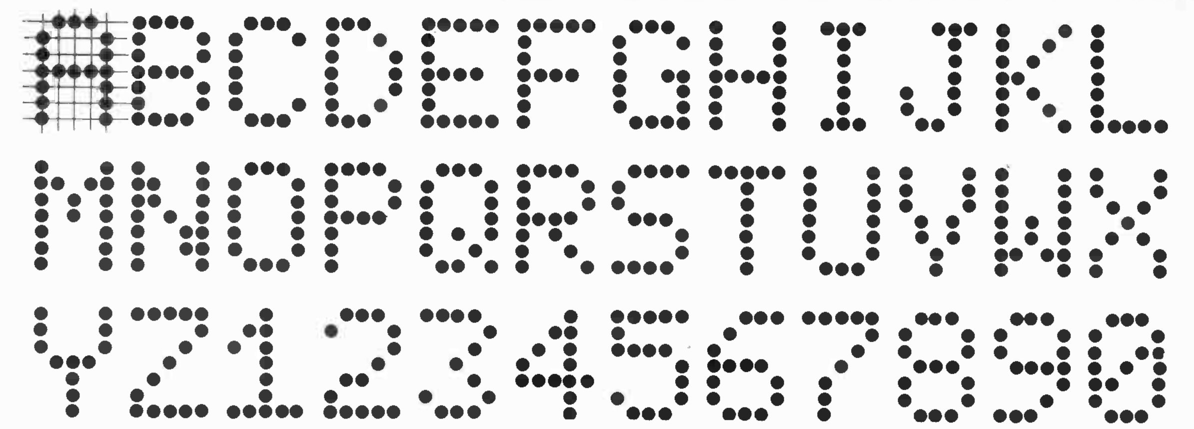
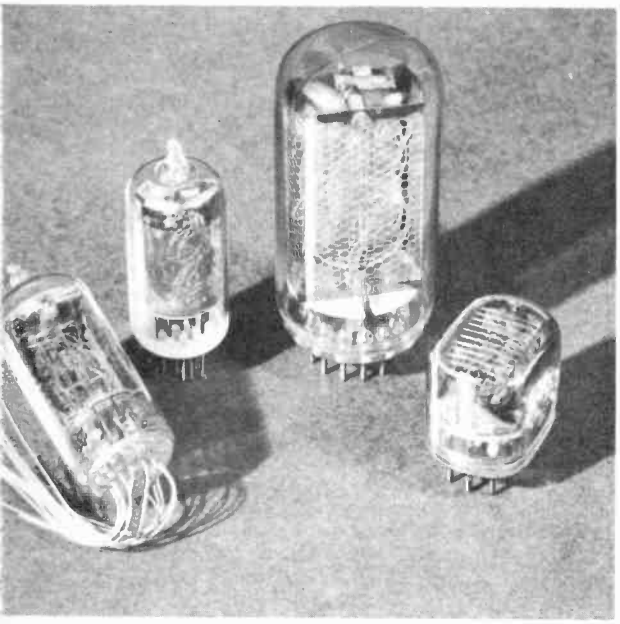


Fig. 1.1. The alphabetic and numeric characters available in the A.S.C.I.I. code from a 7 × 5 dot matrix



Some of the shapes and sizes of commercially available cold cathode tubes

character type, and is likely to prove more popular in the long run. Already seven segment displays are obtainable in incandescent, fluorescent, and L.E.D. technologies, and decoding/driving i.c.s are becoming very cheap, a definite area to watch for practical amateur requirements of the future.

Fig. 1.2 shows the "seven segment" format, and as can be seen, it is based on a stylised figure of eight made from seven individually illuminated bars. The character set available is quite extensive considering the simplicity of the format, though in general these devices are used only for numeric data, decoders being available for this task. The most obvious drawback of this system is that the characters are highly stylised, and not as we would normally write them, a problem which can be eased to some extent by using zero suppression to enhance readability of multi-digit arrays. We will be looking at the way zero suppression is achieved later on.

To overcome readability problems of the basic seven segment indicator, a version using a different bar format has been developed, and this type is shown in Fig. 1.3. To achieve this some of the versatility of the simple version is lost, and some may consider the numerals a bit "wonky" but in use this version gives a very easy to read display whilst retaining the simplicity of the parallel bar type, decoding being of the same nature.

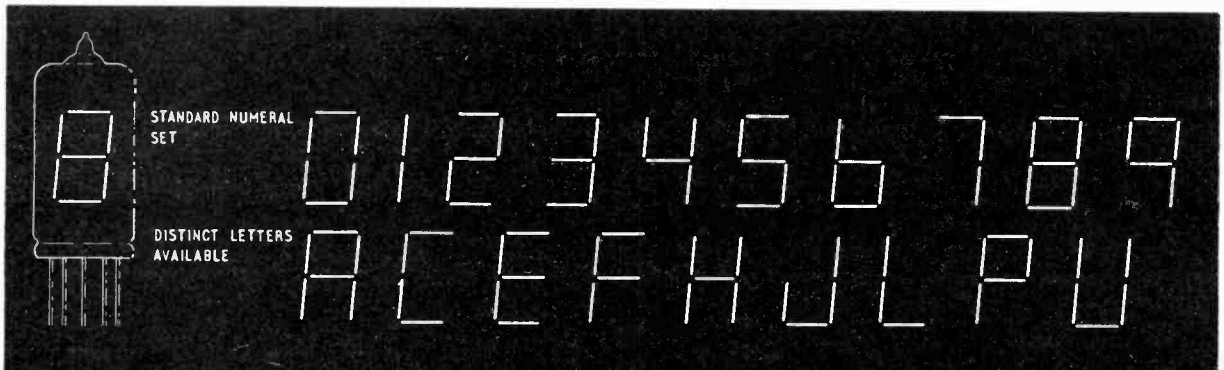



Fig. 1.2. The normal seven segment format and the alphabetic and numeric characters available

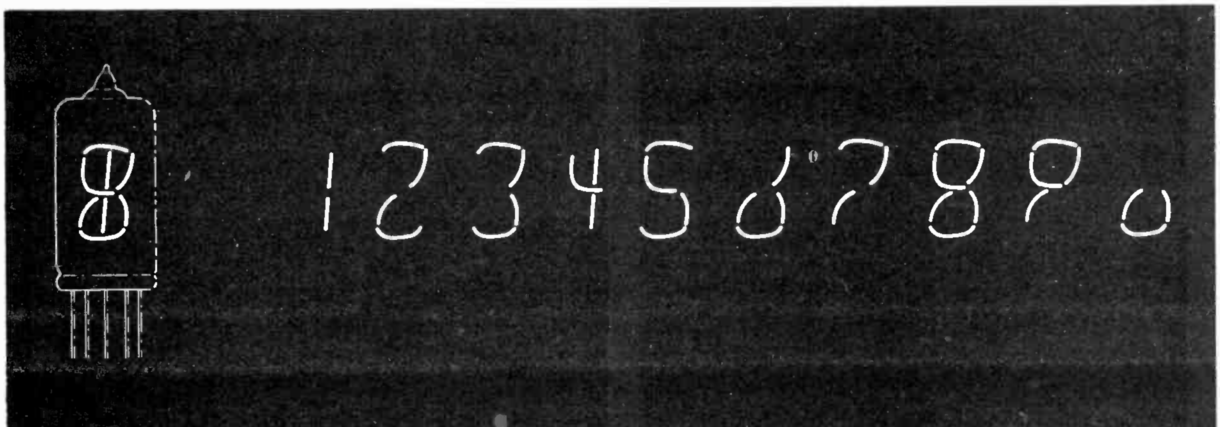
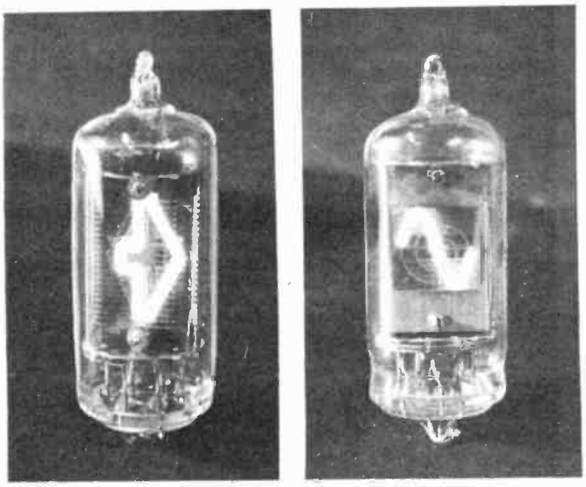


Fig. 1.3. A modified seven segment display giving greater readability but no alphabetic characters

By increasing the number of bars used it is possible to build a device which will handle all the alphabet characters as well as the numerals, and in Fig. 1.4 a possible format using 14 separate bars is shown with its character set (several types of symbol or punctuation mark are also possible). With so many bars as this, the decoding/driving problem again rears its ugly head, resort being made to either M.O.S. arrays or to complex discrete gate decoders.

As we have seen, formats are available to readout manufacturers to enable them to produce a device at the right price and complexity to suit every application. Most of the technologies used can be incorporated into several of the formats, a situation which leads to the present (and very desirable) state where there are literally hundreds of devices to choose from.



Two cold cathode character indicator tubes

## COLD CATHODE DISPLAYS

Perhaps the most well-known type of alphanumeric display and one which has been featured in


Fig. 1.4. Multi-segment display showing how numeric and all alphabetic characters can be generated

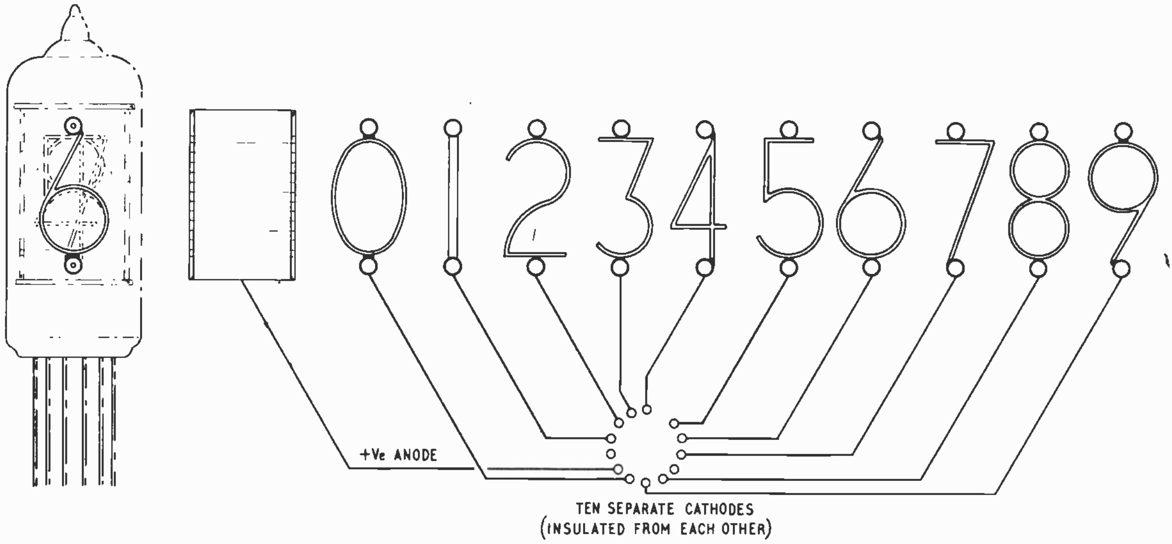
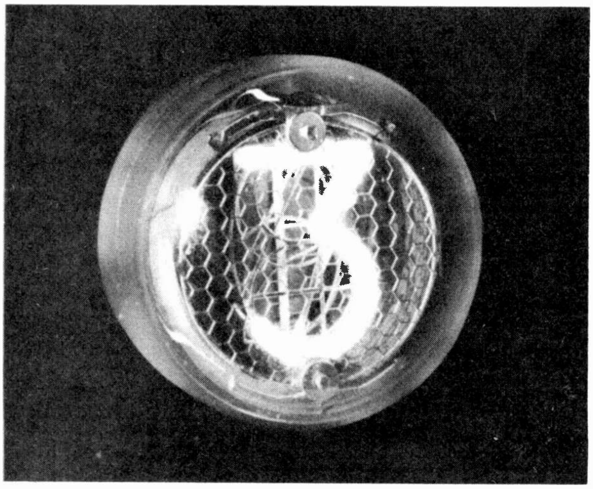



Fig. 1.5. Internal construction of a side-viewing cold-cathode numeric indicator tube



A top-viewing cold cathode tube

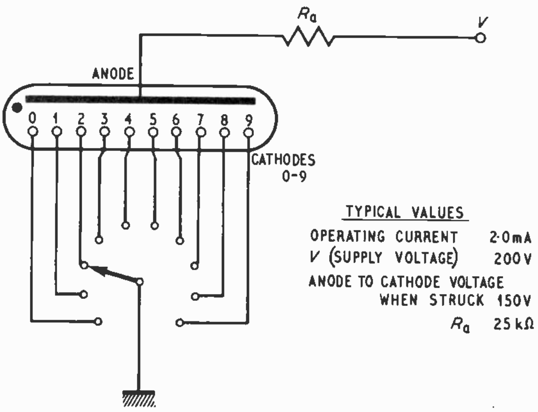



Fig. 1.6. Calculation of the limiting resistor and power supply

several articles in this magazine in the past, is the cold cathode numerical indicator tube called variously "Nixies", "Numicators" and "Numbertrons". These tubes use the same principle of operation as standard neon indicator lamps, that is the ionisation of neon gas by the application of a suitable voltage across them.

The standard type consist of a number of discrete character shaped cathodes, mounted one behind the other, viewed through a metal grid which forms the anode, all contained in a neon filled glass envelope similar to that used for valves. (Fig. 1.5). The cathodes are insulated from one another and spaced as closely as possible to make a compact assembly with a reasonable field of view.

In operation the anode is connected to a high positive voltage through a current limiting resistor, and the required cathode is grounded by the driving circuitry (which may consist of relays, valves, transistors or an i.c.). The voltage developed across the anode-cathode system causes the neon gas to ionise, and with careful physical design a uniform glow is produced round the cathode selected.

The glow colour is a mixture of blue and orange, and if the tube is used without a colour filter reflections from the other cathodes and the anode produce a rather indistinct blurred display. With a red filter positioned in front of the tube, either as an envelope lacquer or a window material common to several digits, background glow can be cut out completely, producing a very pleasing readout. The anode voltage required is not critical, in fact the higher the better, but there is a lower limit set at about 180 to 200V below which some tubes will be very slow to ionise, and more difficult to control.

## DRIVING CIRCUITRY

To consider the operation of these tubes in a simple circuit see Fig. 1.6. When the selected cathode is grounded by means of the switch the tube will strike, illuminating the required character. When the neon gas is ionised a current flows through it, limited by the resistor $R_a$ and the voltage across the tube necessary to maintain conduction. If the anode voltage could fall below the maintaining value then conduction would cease, reducing the voltage drop across $R_a$ and causing the tube to strike again, in a sort of feedback action.

The operating conditions of the tube are thus set by the resistor $R_a$, and the value required can either be calculated precisely from manufacturers' data sheets, or in the absence of such information a very rough rule of thumb which suffices for the large majority of applications, can be employed. A good average value of operating current for these devices is 2mA, this is the first assumption necessary to use the rule of thumb, and modifications to this figure can be made if desired on the grounds that a big tube will work better with a larger value, and a small one with less.

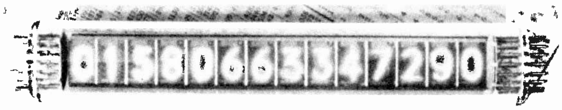
The next assumption needed concerns the anode to cathode maintaining voltage which will be present across the tube when it is struck, and a useful guess here is 150V. Using these two figures and the known value of the H.T. voltage ($V$) to be used, the resistor value can be calculated thus:

$$R_a = \frac{\text{H.T. voltage} - \text{maintaining voltage}}{\text{cathode current}}$$

Using the values mentioned above this works out as

$$R_a = \frac{200 - 150}{2} \text{ kilohms,}$$

giving a value of 25 kilohms for $R_a$, and this is likely to be adequate for most medium sized tubes, and is within a few kilohms of the values worked out from extensive calculations dealing with particular, coded tubes. It should be stressed here that if data is available it is far better to perform the calculations which take into account manufacturing spreads, tube individualities, and the bias on other cathodes, but if data is not available (as so often is the amateur's lot) the rule of thumb will get those tubes burning regardless.



A Mullard "Pandicon" fourteen numeral cold cathode tube

## OTHER COLD CATHODE FORMATS

The standard Nixie is not the only format used with the cold cathode technology, and both bar and dot matrix versions are available. The bar types have cathodes which form the segments of the format, and operate in a similar fashion to the standard neon tube, identical supply voltages and drivers being required.

The dot type display uses a somewhat different physical construction, each dot in the matrix operates as an individual glow discharge light source, and the required dots are selected by an X/Y addressing array of transparent, thin film, metal lines (Fig. 1.7). Note that the address lines do not come into direct contact with the gas in the recesses, the ionising potential being applied capacitively as a.c. pulses. This type of display is a recent innovation, and promises to be a very useful technique for displaying several lines of data at a time when it will be cheaper than using separate tubes.

Despite these other formats availability, they are not yet an economical choice for the amateur, and in the notes on decoding and driving for cold cathode tubes, we will deal specifically with the discrete character type.

**Next month: Driving and decoding circuits for cold cathode tubes**

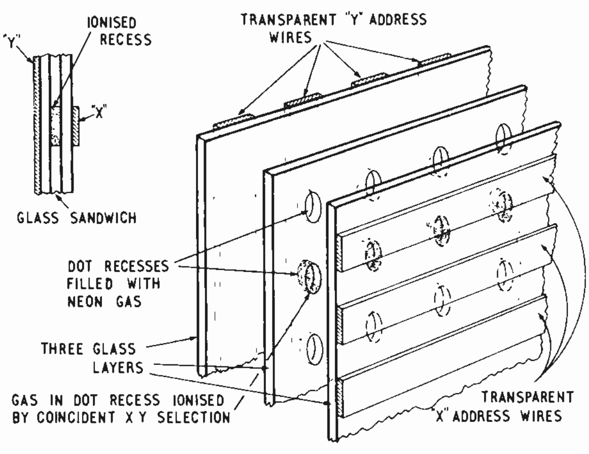
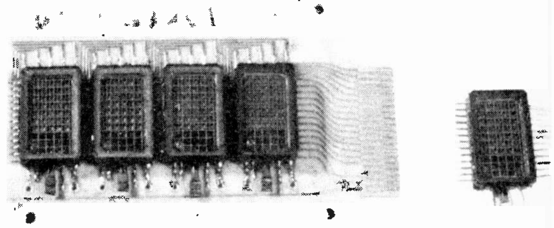
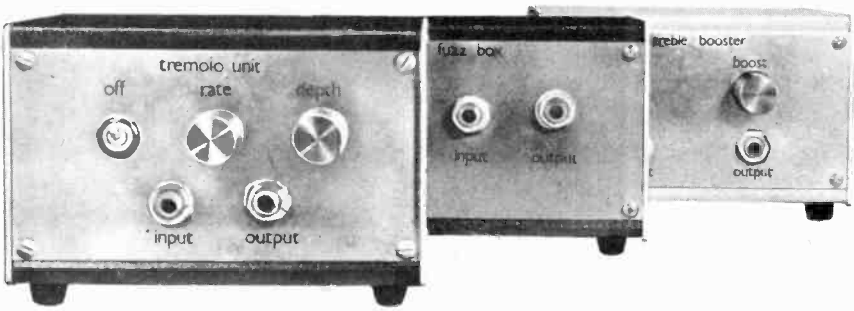



Fig. 1.7. Construction of a dot matrix neon-filled cold cathode tube



A cold cathode dot matrix display. In this type each dot can be individually illuminated (Mullard)




# TREMOLO UNIT

The first of three guitar effects units which will add new dimensions to the sounds produced. By A. Russell

MANY electric guitar players will have noted the high cost of commercially available sound effects units. The tremolo unit described here was designed around cheap, easily available components. It is simple to build and economical with battery power and it will provide a potent tremulant effect for a guitar input with controls available for both tremolo rate and depth of sound produced.

## HOW IT WORKS

In the circuit diagram of Fig. 1, the multivibrator circuit comprising TR1, TR2, switches at a rate made variable by VR1, between 1Hz and 10Hz.

As the collector of TR2 rises and falls between 0V and 8V the capacitor C3 will charge at a rate determined by the CR product of R5 and C3. As the voltage of C3 rises exponentially there comes a point when TR3 switches on. If a guitar is connected to JK1 the output to JK2 which is normally developed across VR2 and TR3 is suddenly very much reduced when TR3 does conduct. With the transistor switched off the guitar signal passes through the unit unchanged. As TR3 is being switched at a regular rate the output level will vary in depth to produce a tremolo effect.

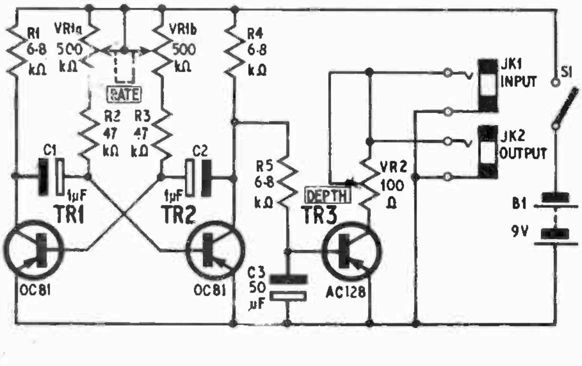



Fig. 1. Circuit diagram of Tremolo Unit

## COMPONENTS . . .

**Resistors**
- R1 6·8kΩ
- R2, R3 47kΩ (2 off)
- R4, R5 6·8kΩ (2 off)
- All ½ watt, 10% carbon

**Capacitors**
- C1, C2 1µF elect. 12V (2 off)
- C3 50µF elect. 12V

**Transistors**
- TR1, TR2 OC81 (2 off)
- TR3 AC128

**Potentiometers**
- VR1 500kΩ dual gang carbon linear
- VR2 100Ω carbon linear

**Switch**
- S1 on/off toggle

**Miscellaneous**
- SK1, SK2 Standard jack sockets (2 off)
- BY1—PP3 9V
- Battery connectors
- Veroboard 0·15 matrix 2in × 2½in
- Plastic angle (see text)
- Instrument case 6½in × 4in × 4in (G. W. Smith)
- Control knobs (2 off)

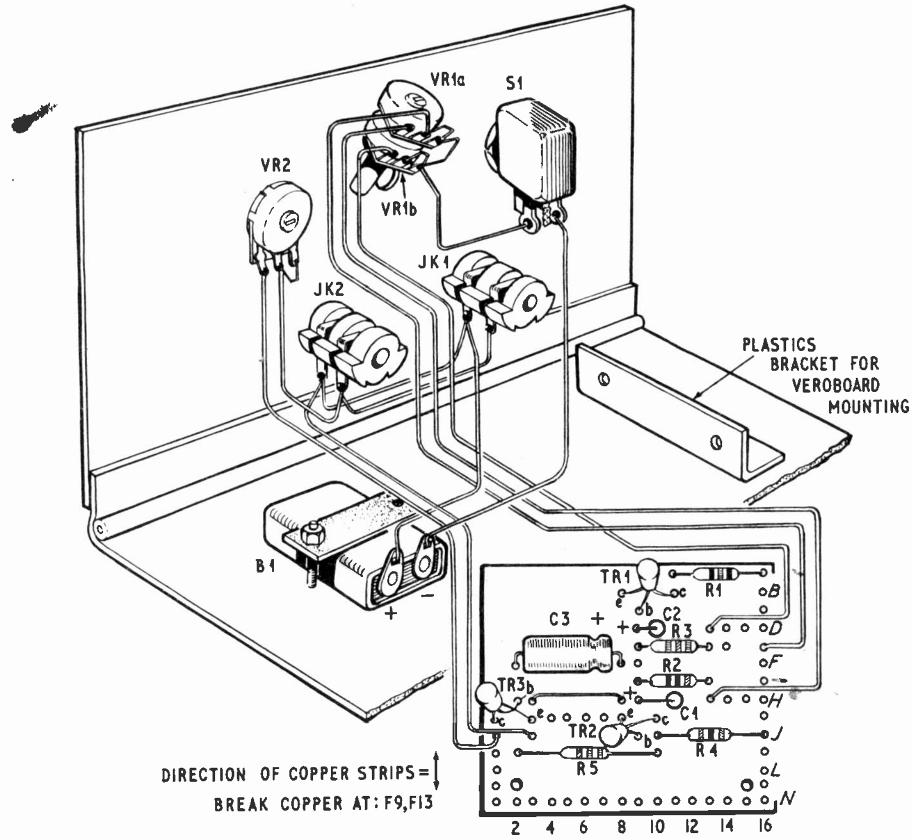
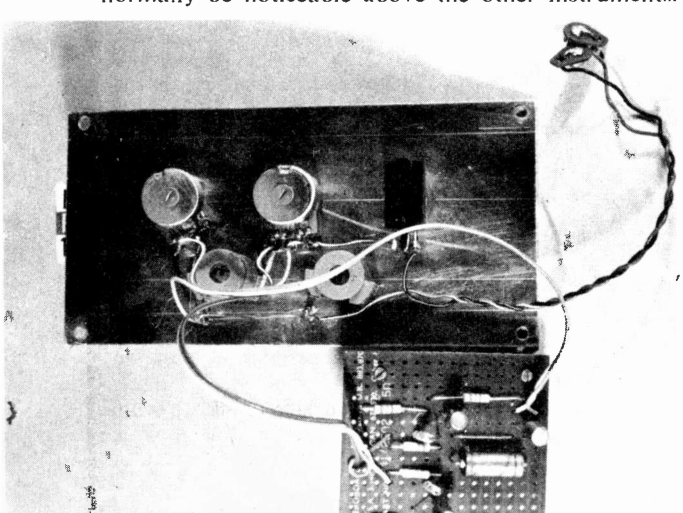



Fig. 2. Component board layout and interwiring details

With VR2 a variable resistor the depth of effect can be altered but there is a point when multivibrator breakthrough is slightly apparent as a ticking noise. While this is not objectionable the unit can be switched off when the guitar is not being played, although if used in a group the ticking would not normally be noticeable above the other instruments.



Increasing the value of C3 may damp this a little, but there will be a maximum above which the tremolo effect will not be satisfactory.

## CONSTRUCTION

The majority of components are assembled on a 2in × 2½in piece of Veroboard as in Fig. 2. Also shown are the connections of this to the control panel.

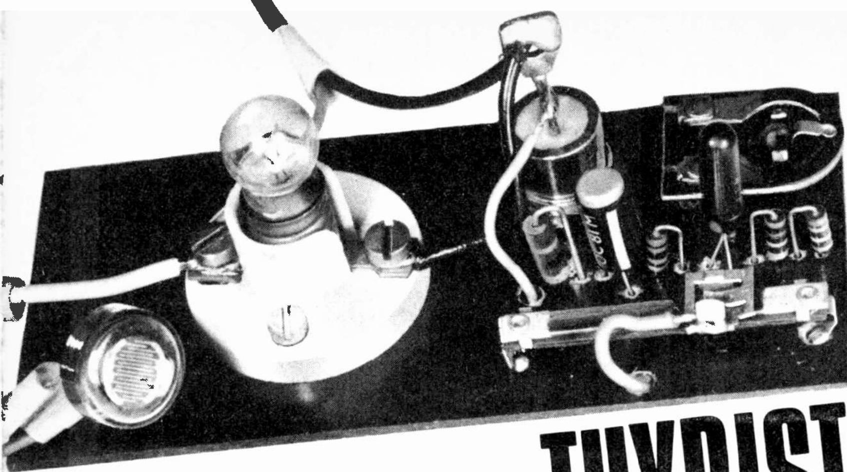
A piece of ½in plastics angle was Araldited to the board and drilled for screw mounting to the case. For ease of operation S1 can be replaced by a foot-switch connected by way of a socket at the front panel.

## TESTING

When the unit is completed the wiring should be checked ensuring that the electrolytic capacitors in the multivibrator are the right way round. Should the polarity of these be reversed the multivibrator will probably operate but at the wrong frequency.

Connect the unit to the amplifier and guitar and switch on. Check the operation of the rate and depth controls. If all is satisfactory the case panels can be assembled so completing the construction.

Some loss of signal should be expected when the tremolo unit is connected and if the gain of the amplifier is not sufficient to compensate for this a preamplifier may be necessary. If so, it should be connected between the unit and the amplifier. ★



# PHOTOCELL THYRISTOR SWITCH

By L.H.Olsen & D.A.Reeves

THE following circuit is for an automatic, light-operated switch which offers reliability and high sensitivity to light variation but low sensitivity to component changes.

The electronic experimentalist constructing a light-operated switch generally must contend with a variety of electronic and mechanical problems. This circuit is an all solid-state design employing a thyristor as the load current switch. Simplicity and economy are apparent with the design. The unit is either self-latching, remaining on after initial activation, or an on-off switch following light variations. The choice depends on whether the power supply is smoothed or simply half-wave rectified a.c., respectively. Load currents approaching 5 or 10 amps are allowed with a relatively inexpensive range of thyristors. In the off state, only a very low leakage current in the order of a few microamps is drawn.

## SIGNAL INPUT

The cadmium sulphide photoresistive cell, PCC1, in Fig. 1 acts as a voltage divider in conjunction with the series pair of resistors R1 and VR1. In bright light conditions, the photoresistor has a nominal resistance of approximately 500 ohms.

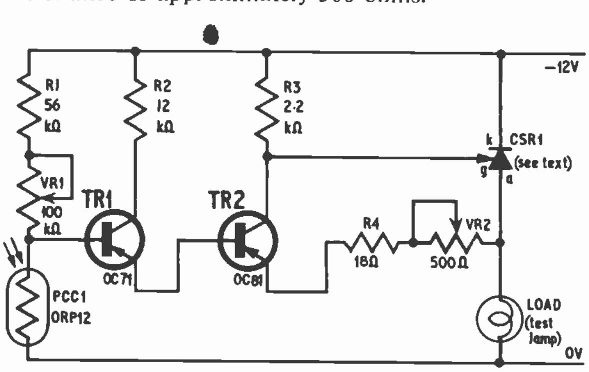



Fig. 1. Circuit diagram of the photocell thyristor switch

This value will hold the base bias on transistor TR1 near zero volts which corresponds to the off or non-conducting state. In low light conditions, the base bias increases (negatively) as PCC1 resistance increases in the voltage divider. TR1 becomes forward biased with emitter current increasing to some maximum value.

## TRANSISTOR STAGES

The high gain transistor pair TR1 and TR2 act as both voltage follower and current amplifier with respect to the photocell.

When TR1 is biased off, the relative base-emitter bias of TR2 is zero. Thus negligible current will flow in the emitter-collector circuit of TR2. The direct connection between the emitter of TR1 and base of TR2 gives a high degree of current sensitivity at the collector of TR2 to variations in photocell resistance changes. Current through the voltage divider and in TR1 are in the order of microamps, whatever the state of the circuit.

As TR2 is biased on by conduction through the emitter of TR1, large current flow is possible through the circuit formed by the load, R4 and VR2 in TR2 emitter lead, and the thyristor gate-cathode junction in TR2 collector lead. Switching the thyristor on requires moderate current for approximately 50 microseconds after which the thyristor gate serves no purpose in maintaining anode to cathode conduction.

To prevent possibly destructive power dissipation in TR2, a self-biasing feature links TR2 and the thyristor.

## THYRISTOR OPERATION

The device has a *pnpn* construction as shown in Fig. 2a. The *p* and *n* material of the terminal regions are the anode and cathode, respectively. A lead from the internal *p*-type semiconductor material serves as the gate for switching the thyristor from the off state to conduction. The gate requires a current of roughly 25 milliamps to trigger the device on.

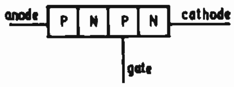
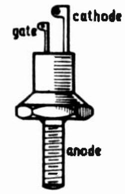



Fig. 2a. Internal construction of the thyristor (left)

Fig. 2b. A typical external view of a power thyristor (right)




It is recommended that the gate-cathode junction never be reverse biased, i.e. the gate should not be allowed to become more negative than the cathode.

Thyristors act as diodes when supplied with an a.c. power supply. Note here that the gate should be protected by a series diode when supplied with a.c. voltage. Thyristors are self-latching to the on state after the gate signal has been applied, but when the supply voltage falls to zero as with an a.c. supply, the thyristor switches off and remains off unless a gate signal occurs during the next cycle.

Physically, high power thyristors are encased for mounting on a heat sink. The threaded stud on one end is the anode (leading to the positive end of a power supply for conduction). The opposite end contains two tags, the larger being the cathode and the smaller being the gate, see Fig. 2b.

## SELF-BIASING ACTION

Looking at the transients as the thyristor is switched on reveals an interesting circuit characteristic. As TR2 begins to conduct, current flows through the gate of the thyristor. So long as the current is insufficient to switch the thyristor on, the emitter of TR2 remains near zero volts. When the thyristor switches on, the full supply voltage rapidly appears across the load rather than the thyristor.

In the switching process, the emitter of TR2 swings to full negative potential while TR1 holds the base of TR2 at a positive voltage with respect to the negative rail. Thus TR2 is switched off by this reverse biasing process.

The sensitivity of TR1 and TR2 means that conduction to the thyristor gate occurs rapidly as the light level crosses a threshold set by VR1. The variable resistor VR2 assists by holding small conduction currents below the gate threshold level. Once conduction begins at the thyristor, the otherwise wasted current in TR2 is limited to a duration of a few microseconds.

## CONSTRUCTION

Due to the simplicity of this circuit, wiring details can be arranged to suit the reader's own requirements. A suggested layout is shown in Fig. 3. Obviously miniaturisation can easily be achieved. R1, VR1, R2 and R3 dissipate less than $\frac{1}{8}$ watt of power. Due to the short duration of power dissipation in R4 and VR2, these resistors can be $\frac{1}{4}$ watt.

Throughout the circuit, fixed resistance values are not critical so that any reasonably close resistor should be sufficient. R1 and R4 are included as safety resistors to protect the circuit from accidental zeroing of VR1 or VR2 during the setting up procedure. They should not be omitted during construction.

The selection and mounting of a thyristor should be done with the care usually given to semiconductor components.

## SETTING UP

After constructing and checking connections in the circuit, turn VR1 and VR2 to their maximum resistance setting. Set the photocell in the required light conditions for switching on, remembering that in bright light the circuit should be off. With the power on, bring the value of VR2 down until the circuit switches on. Next, adjust VR2 back to a

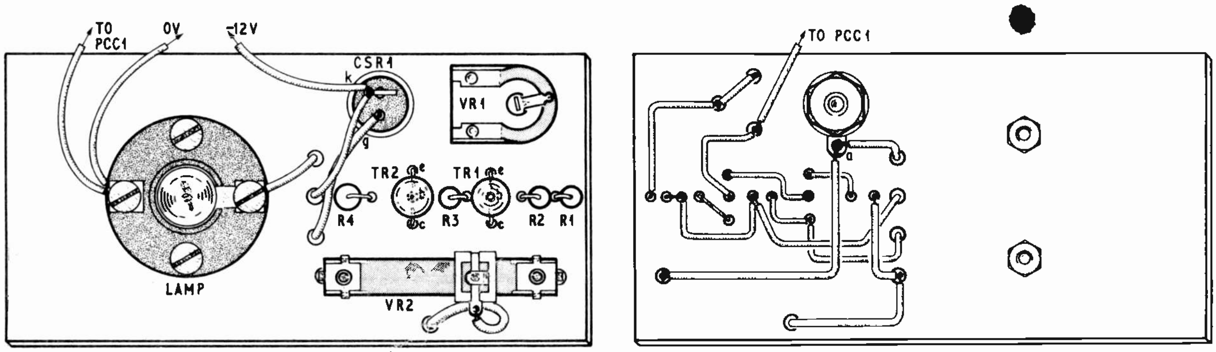



Fig. 3. Wiring details of the prototype

higher resistance so as to hold a test lamp off. The lead to the test lamp must be broken and re-made to switch the thyristor off (or the power supply switched off).

VR2 is a rougher control than VR1 for switching in relative darkness. They reverse their function in this respect when set to switch in brighter lighting.

Resistor R1 may be increased toward 100kΩ or 150kΩ if more sensitivity in dark conditions is needed, i.e. if the circuit is to differentiate between very dim lighting levels. These settings are moderately sensitive to a shift in the supply voltage although the circuit was found to function readily over a ±30% change from the stated 12V supply voltage.

## MODIFICATIONS

In its present state the circuit can actuate parking lights or various detection systems. The speed of switching is controlled by the slowest element in the circuit. In this case, the photocell is the slow link for the detection of a rapid variation between lighting shades. The response time is somewhere around 50 milliseconds.

If an external voltage pulse or photodiode is used at the base of TR1, the switching time drops to roughly 50 microseconds. This is better than a relay reaction time. The transistors, even if not those suggested in the circuit diagram, generally switch in a range of fractions of a microsecond to a few microseconds, which is a negligible time.

Other signal sources may be a photo-transistor, a piezoelectric crystal giving a pressure sensing switch, or capacitive or inductive reactance giving a frequency sensitive switch.

## SUGGESTED APPLICATIONS

Applications of this simple circuit are closely related to the power rating of the thyristor selected by the constructor. The authors used in the prototype an unmarked thyristor of approximately 30 volts p.i.v. in a 5 amp case, as may be purchased from many electronics shops.

A 5 amp thyristor used with the test lamp at 2 watts was sufficient in the authors' application to switch on automobile lights which draw about 30 watts. This still represents only half the current rating of the thyristor.

The other rating to bear in mind is the peak inverse voltage which may be regarded as being roughly a measure of the forward voltage hold-off rating.

The maximum voltage is restricted to the maximum voltage allowed by the transistors.

With some imagination a voltage dropping resistor and Zener diode may be added to allow increased voltage on the thyristor, whilst the transistors are protected to below their limit values.

Besides finding convenient use of the switch for parking lights, the authors also found the circuit was ample to operate a small mechanical cycle counter, for which the input was generated by a rotating disc with a segment cut out, permitting light to fall onto the photocell. On this application full wave rectified voltage was supplied to the circuit, again referring to the thyristor, the part of each voltage cycle which dropped to zero ensured that the thyristor turned off as opposed to latching on as it is designed to do when constant d.c. voltage is the power source.

# COMPONENTS...

**Resistors**

R1 56kΩ
R2 12kΩ
R3 2·2kΩ
R4 18Ω ¼ watt
All resistors ±10%, ⅛W unless otherwise stated

**Potentiometers**

VR1 100kΩ carbon skeleton preset
VR2 500Ω wirewound linear slider

**Transistors**

TR1 OC71 or equivalent
TR2 OC81 or equivalent

**Thyristor**

CSR1 5RC5 (International Rectifier Co.)
5A 50V p.i.v. (Gate triggers at 2 volts, 15mA)

**Light Dependent Resistor**

PCC1 ORP12

**Miscellaneous**

Paxolin sheet or Veroboard 3in × 2in × 1/16in
M.E.S. lamp and holder (see text)

A counter and parking light application have been mentioned. The thyristor load may also be a burglar alarm set off by interrupting a light source.

The idea in each application is to replace the test lamp load with a working load. Then a thyristor is inserted which has the correct rating in terms of a sufficient value for the maximum current and voltage applied. Remember that the transistors are giving a high gain so that there appears to be a fair disparity betweeen the current drawn by the thyristor and by the rest of the circuit; a large thyristor current—say 10 amps—can be expected.

## THYRISTOR SELECTION

Either latching or non-latching action is possible and a range of load voltages and currents are possible according to the type power source, whether d.c. or rectified a.c. respectively, and the selected value of the thyristor.

If a constant d.c. power source is used then the device will be latched on without regard to the photocell until the power source is removed.

To find the correct thyristor current rating either

(a) take the value of current given for your load, or
(b) divide rated wattage by the applied volts, or
(c) divide applied voltage by the rated load resistance.

Then select the next largest thyristor so that there is a factor of safety.

Further suggestions for the load which may be developed quickly are a d.c. solenoid coil, a relay coil—the relay poles doing multiple switching or H.T. switching—or a simple resistive load such as a light. If the photoresistor were sensitive to the light from a flame, the switch could be used for flame detection.

Other suggestions are left to the reader. ★

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## TRANSISTORS

**A SELECTION FROM OUR LIST**

| | |
|---|---|
| AAY30 | 10p |
| AAY42 | 15p |
| AAZ13 | 10p |
| AAZ15 | 10p |
| AAZ17 | 10p |
| AC107 | 35p |
| AC126 | 30p |
| AC127 | 25p |
| AC127Z | 50p |
| AC128 | 20p |
| AC176 | 20p |
| AC187 | 35p |
| AC188 | 35p |
| ACY17 | 30p |
| ACY18 | 25p |
| ACY19 | 25p |
| ACY20 | 20p |
| ACY21 | 20p |
| ACY22 | 10p |
| ACY39 | 55p |
| ACY40 | 20p |
| ACY41 | 15p |
| ACY44 | 25p |
| AD140 | 50p |
| AD149 | 50p |
| AD161 | 35p |
| AD162 | 35p |
| AF114 | 25p |
| AF115 | 25p |
| AF116 | 25p |
| AF117 | 20p |
| AF118 | 60p |
| AF124 | 25p |
| AF125 | 20p |
| AF126 | 20p |
| AF127 | 20p |
| AF139 | 30p |
| AF180 | 50p |
| AF181 | 45p |
| AF185 | 50p |
| AF186 | 40p |
| AF239 | 40p |
| ASY26 | 25p |
| ASY27 | 30p |
| ASY28 | 25p |
| ASY29 | 30p |
| ASZ21 | 55p |
| BA100 | 15p |
| BA102 | 30p |
| BA110 | 25p |
| BA115 | 7p |
| BAX13 | 5p |
| BAX16 | 7p |
| BAY31 | 7p |
| BAY38 | 15p |
| BC107 | 10p |
| BC108 | 10p |
| BC109 | 10p |
| BC109C | 12p |
| BC113 | 10p |
| BC114 | 20p |
| BC115 | 20p |
| BC116 | 20p |
| BC116A | 25p |
| BC117 | 20p |
| BC118 | 20p |
| BC119 | 30p |
| BC134 | 20p |
| BC135 | 15p |
| BC136 | 20p |
| BC137 | 20p |
| BC138 | 20p |
| BC147 | 12p |
| BC148 | 10p |
| BC149 | 12p |
| BC153 | 20p |
| BC154 | 20p |
| BC167 | 15p |
| BC169 | 12p |
| BC169C | 15p |
| BC177 | 25p |
| BC178 | 20p |
| BC179 | 20p |
| BC182L | 10p |
| BC183L | 10p |
| BC184L | 12p |
| BC212L | 12p |
| BC213L | 12p |
| BC214L | 15p |
| BCY30 | 35p |
| BCY31 | 40p |
| BCY32 | 65p |
| BCY33 | 30p |
| BCY34 | 35p |
| BCY38 | 45p |
| BCY39 | £1·00 |
| BCY40 | 50p |
| BCY70 | 15p |
| BCY71 | 20p |
| BCY72 | 15p |

| | |
|---|---|
| BD115 | 75p |
| BD123 | 85p |
| BD124 | 80p |
| BD131 | 75p |
| BD132 | 80p |
| BDY11 | £1·50 |
| BDY17 | £1·50 |
| BDY38 | 65p |
| BDY60 | £1·00 |
| BF115 | 25p |
| BF154 | 20p |
| BF158 | 15p |
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| BF180 | 35p |
| BF194 | 15p |
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| BF197 | 15p |
| BFX13 | 35p |
| BFX29 | 35p |
| BFX30 | 25p |
| BFX84 | 25p |
| BFX85 | 30p |
| BFX86 | 25p |
| BFX87 | 25p |
| BFX88 | 20p |
| BFY18 | 25p |
| BFY50 | 20p |
| BFY51 | 20p |
| BFY52 | 20p |
| BFY53 | 15p |
| BFY90 | 65p |
| BSX20 | 15p |
| BSX21 | 20p |
| BSY27 | 15p |
| BST95A | 12p |
| BSY95 | 12p |
| BU105 | £2·25 |
| BY100 | 15p |
| BY126 | 12p |
| BY124 | 15p |
| BY182 | 90p |
| BYZ10 | 35p |
| BYZ11 | 30p |
| BYZ12 | 30p |
| BYZ13 | 25p |
| BZY78 | £1·00 |
| GET102 | 35p |
| GET103 | 25p |
| GET111 | 45p |
| GET113 | 25p |
| GET114 | 20p |
| GET115 | 50p |
| GET116 | 55p |
| GET880 | 45p |
| GET882 | 30p |
| GEX66 | £1·50 |
| GM378A | 55p |
| MAT101 | 25p |
| MAT121 | 25p |
| MC724P | 60p |
| MJ420 | 80p |
| MJ421 | 80p |
| MJ2801 | £1·10 |
| MJ2901 | £1·50 |
| MJE340 | 50p |
| MJE370 | 20p |
| MJE371 | 80p |
| MJE520 | 75p |
| MJE521 | 70p |
| MJE2955 | £1·10 |
| MJE3055 | 75p |
| MPSA06 | 35p |
| MPSA56 | 20p |
| MPSA70 | 15p |
| MPSU06 | 50p |
| MPSU56 | 55p |
| NKT214 | 20p |
| NKT216 | 35p |
| NKT403 | 75p |
| NKT404 | 55p |
| OA5 | 25p |
| OA10 | 25p |
| OA47 | 10p |
| OA70 | 10p |
| OA79 | 10p |
| OA81 | 8p |
| OA90 | 8p |
| OA91 | 8p |
| OA95 | 8p |
| OA200 | 8p |
| OA202 | 10p |

| | |
|---|---|
| OC16 | 50p |
| OC20 | 85p |
| OC22 | 50p |
| OC23 | 60p |
| OC24 | 60p |
| OC25 | 40p |
| OC26 | 35p |
| OC28 | 60p |
| OC29 | 60p |
| OC35 | 50p |
| OC36 | 60p |
| OC42 | 40p |
| OC43 | 50p |
| OC44 | 15p |
| OC45 | 12p |
| OC70 | 12p |
| OC71 | 12p |
| OC72 | 25p |
| OC75 | 25p |
| OC76 | 15p |
| OC77 | 40p |
| OC81 | 20p |
| OC81D | 20p |
| OC81Z | 40p |
| OC83 | 25p |
| OC84 | 25p |
| OC139 | 25p |
| OC140 | 40p |
| OC141 | 60p |
| OC170 | 25p |
| OC171 | 30p |
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| WO1 | 30p |
| WO6 | 45p |
| ZTX107 | 15p |
| ZTX108 | 12p |
| ZTX109 | 15p |
| ZTX300 | 12p |
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| ZTX302 | 20p |
| ZTX303 | 20p |
| ZTX304 | 25p |
| ZTX500 | 15p |
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| ZTX502 | 20p |
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| 2G303 | 35p |
| 2N404 | 20p |
| 2N696 | 15p |
| 2N697 | 15p |
| 2N698 | 30p |
| 2N706 | 10p |
| 2N706A | 12p |
| 2N708 | 15p |
| 2N930 | 20p |
| 2N987 | 40p |
| 2N1131 | 25p |
| 2N1132 | 25p |
| 2N1302 | 18p |

| | |
|---|---|
| 2N1303 | 18p |
| 2N1304 | 22p |
| 2N1305 | 22p |
| 2N1306 | 25p |
| 2N1307 | 25p |
| 2N1308 | 25p |
| 2N1309 | 35p |
| 2N1613 | 20p |
| 2N2147 | 75p |
| 2N2160 | 60p |
| 2N2217 | 25p |
| 2N2218 | 20p |
| 2N2218A | 25p |
| 2N2219 | 20p |
| 2N2219A | 25p |
| 2N2220 | 25p |
| 2N2221 | 20p |
| 2N2221A | 25p |
| 2N2222 | 20p |
| 2N2222A | 25p |
| 2N2369 | 15p |
| 2N2369A | 15p |
| 2N2646 | 40p |
| 2N2904 | 20p |
| 2N2904A | 25p |
| 2N2905 | 25p |
| 2N2905A | 25p |
| 2N2906 | 20p |
| 2N2906A | 25p |
| 2N2907 | 23p |
| 2N2907A | 25p |
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| 2N4290 | 12p |
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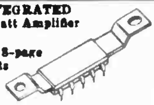

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## HIGH POWER IN THE IONOSPHERE

There are a number of areas where man attempts to modify his environment to suit his needs and the latest of these would appear to have a possible future effect on communication systems.

The new experiments in this direction have been made using a radio telescope, with a 1,000 feet diameter dish, located at Arecibo. The very high powers that have been used with this radio telescope dish have resulted in the heating of the *F*-layer of the ionosphere.

The idea that this might be possible has been talked about for a number of years. The writer was engaged in some of this work when the ITA television system was inaugurated. It was noticed then that when a high powered station was opened the transmissions appeared to become reduced in intensity after about three months.

Although a few people accepted that this was due to ionospheric modification the work was not pursued for lack of support. Now in the intense beam that is obtained with this giant dish, it is possible to follow up early ideas, particularly those put forward in 1970 by a team at Boulder, Colorado, using a very large aerial array.

The Arecibo dish has already established itself as a pioneer instrument. It confirmed beyond doubt the rotation period of Venus and also proved the correct rotation period of Mercury.

Since it is the largest dish in the world there have been many calls on its use by radio astronomers and the ionospheric teams have felt that they have been rather overshadowed by the astronomers. However, the dish may for a time at least revert to its original planned purpose which was the study of the ionosphere.

The ... r W. E. Gordon, ... ed a preliminary report of what has been accomplished with the 100kW transmitter, which operates in the 5 to 10MHz band. The actual frequency of the experiments was 5·62MHz. It is possible to use the radar equipment at the same time as the "heater" transmitter. It is, therefore, possible to observe the effects of the high power on the ionosphere.

When the transmitter is switched on the temperature of the *F*-layer increases and airglow appears together with infra-red activity. The variation in heating is measured at 430MHz and a contour map plotted for changes of temperature. It is clear from these maps that plasma forms like a bubble some 100km in length and 50km across. Aligned with the magnetic field this rather cigar-shaped plasma shows a temperature rise of some 300°C over the normal temperature of the region which is of the order of 1,000°C.

Naturally such an area has a direct effect on communications since the reflecting property is affected. It may become a useful tool in the propagation conditioning of the ionosphere.

## MARTIAN MOONS

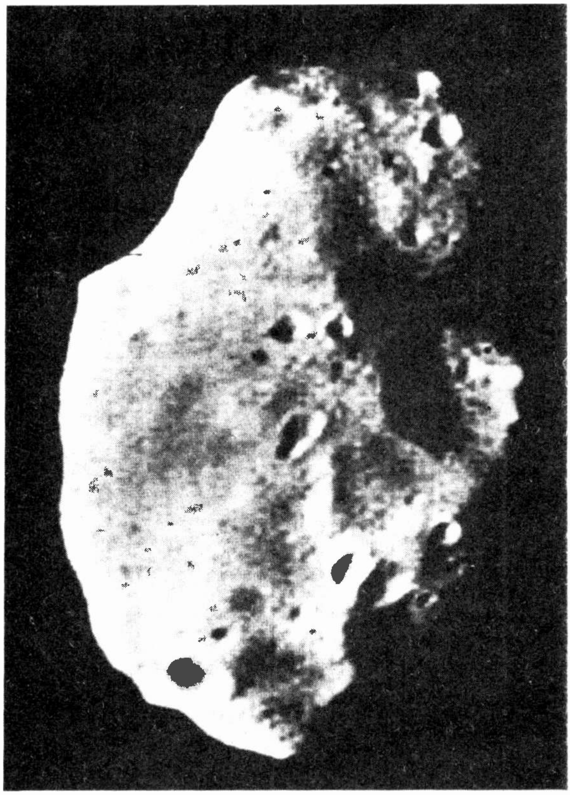
Much speculation has been made about the inner Martian moonlet Phobos in the past, including a suggestion that it was hollow or an artificial body, because of the low density that it appeared to have.

Since *Mariner 9* went into orbit around Mars on November 13 a raging dust storm had obscured the surface features of the planet. So scientists directed its television cameras towards one, then the other of the two martian moons. Some scientists regard Phobos and is sister moon Deimos as even more attractive research targets than Mars.

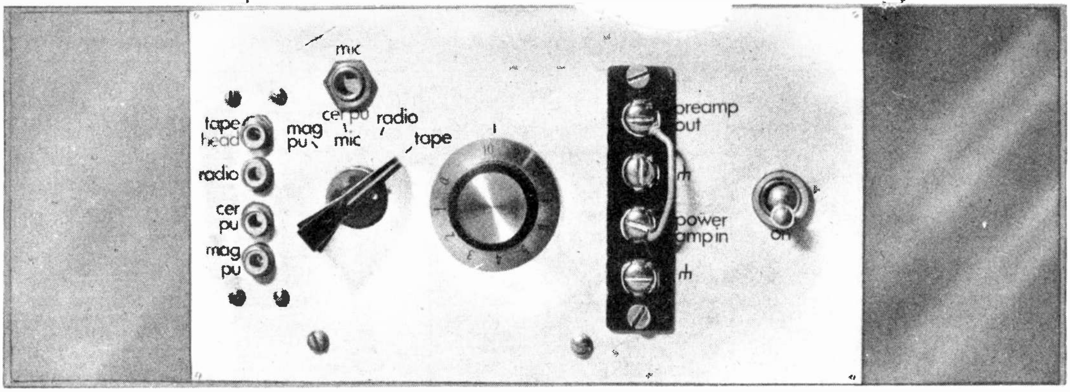
Of all the moons in the solar system, Phobos is the only one moving around its planet faster than the rotation of its parent body and no one has yet suggested a reasonable explanation for this unique behaviour, reminiscent of man-made satellites.

Both the satellites of Mars have now been photographed and the pictures of Phobos show it to be a rather miserable irregular chunk of rock. It is crater marked, with at least one huge crater, and its size is approximately 15 miles by 13 miles. The natural conclusion must follow that it is a captured asteroid.

During the journey towards Mars the probe photographed Deimos from a distance of 5,300 miles. It was described in the preliminary reports as being potato shaped, about 8 miles across and have groove like markings. The irregular shape is compatible with its small size.



Rugged surface features of the irregularly shaped Martian moonlet Phobos are visible in this computer enhanced photo. The photograph was taken by *Mariner 9* during the 34th orbit of Mars.




# GENERAL PURPOSE AMPLIFIER

*An experimenter's amplifier with input sensitivities to suit most bench requirements* **By F. C. JUDD**

THE general purpose amplifier described in this article has inputs suitable for a wide variety of audio signal sources including those requiring special frequency correction such as magnetic pick-up cartridges and tape heads. The amplifier can be split into two sections and operated (a) as a signal pre-amplifier and (b) as a small power amplifier, each being independently usable.

There are five input sockets and these can be used for the following signal sources:

(SK4) For all magnetic pick-up cartridges. Provides RIAA frequency response correction and has a nominal input sensitivity of 6mV at 56 kilohms.

(SK3) For ceramic or crystal pick-up cartridges of high impedance and output signal. The high input impedance provides the necessary equalisation for record replay.

(JK1) Input sensitivity is approximately 2mV. Suitable for microphones from 200 ohms impedance and upward.

(SK2) Suitable for radio tuners and/or tape record/replay units with linear output or any linear signal source of between 100mV and 500mV.

(SK1) Input sensitivity 5mV. Suitable for direct connection from medium impedance tape heads and provides a compromise CCIR/NAB replay characteristic.

The sixth possible input is direct to the output amplifier via the volume control. This will permit connection of linear signal sources in excess of about 500mV which would otherwise overload the pre-amplifier.

The power amplifier will deliver 3 watts r.m.s. power to any small loudspeaker of between 5 and 15 ohms and its input sensitivity via the direct input link to the volume control is 80mV for 3 watts output. The pre-amplifier will deliver 80mV from its link output terminal for the following input ratings:

Magnetic pick-up (SK4) 6mV 56 kilohms

Ceramic pick-up (SK3) 100mV 820 kilohms

Microphone (JK1) 2mV 100 kilohms

Radio (SK2) 100mV 120 kilohms

Tape head (SK1) 5mV 100 kilohms

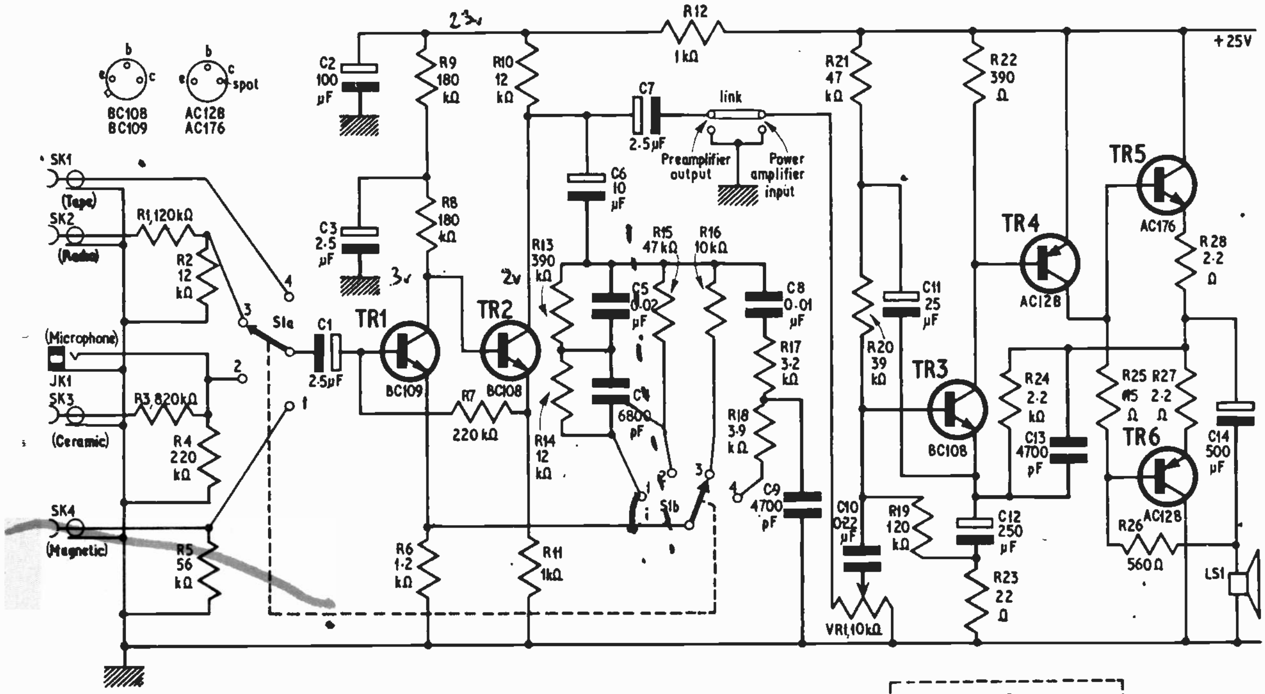
## THE CIRCUIT

The circuit is shown in Fig. 1. The inputs are selected by S1a and where necessary taken through suitable attenuation networks to TR1 which, with TR2, forms a direct coupled pre-amplifier. Negative feedback is used to control gain and/or equalisation and is taken from TR2 collector via the networks and S1b to the emitter of TR1.

The pre-amplifier output is taken to the link terminal strip and then by VR1 (volume control) to the output amplifier. When the link is uncoupled the pre-amplifier output can be used to drive any other external amplifier. Alternatively, signals may be taken directly to the output amplifier by way of VR1.

The output amplifier itself is a fairly simple driver and complementary pair output arrangement and providing the specified components are used and the heatsinks are to the dimensions given, it requires no special adjustment or protection against thermal runaway.

The power supply employs a transformer with a centre tapped secondary delivering 13V either side. Note that only 13V are applied to the rectifier, that



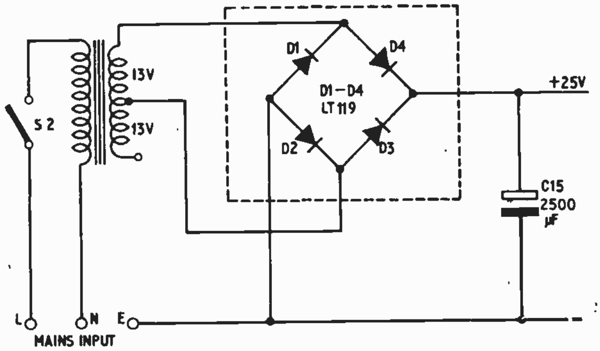




Fig. 1. Circuit diagram of amplifier and power supply

# COMPONENTS . . .

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 120kΩ | R15 | 47kΩ |
| R2 | 12kΩ | R16 | 10kΩ |
| R3 | 820kΩ | R17 | 3·2kΩ |
| R4 | 220kΩ | R18 | 3·9kΩ |
| R5 | 56kΩ | R19 | 120kΩ |
| R6 | 1·2kΩ | R20 | 39kΩ |
| R7 | 220kΩ | R21 | 47kΩ |
| R8 | 180kΩ | R22 | 390Ω |
| R9 | 180kΩ | R23 | 22Ω |
| R10 | 12kΩ | R24 | 2·2kΩ |
| R11 | 1kΩ | R25 | 15Ω |
| R12 | 1kΩ | R26 | 560Ω |
| R13 | 390kΩ | R27 | 2·2Ω 2·5W |
| R14 | 12kΩ | R28 | 2·2Ω 2·5W |

All ¼W, 10% carbon except where otherwise stated

**Capacitors**

| | | | |
|---|---|---|---|
| C1 | 2·5µF elect. 16V | C8 | 0·01µF |
| C2 | 100µF elect. 40V | C9 | 4,700pF |
| C3 | 2·5µF elect. 16V | C10 | 0·22µF |
| C4 | 6,800pF | C11 | 25µF elect. 25V |
| C5 | 0·02µF | C12 | 250µF elect. 25V |
| C6 | 10µF elect. 25V | C13 | 4,700pF |
| C7 | 2·5µF elect. 16V | C14 | 500µF elect. 25V |
| | | C15 | 2,500 elect. 40V |

**Transistors**

TR1 BC109
TR2 BC108
TR3 BC108
TR4 AC128
TR5 AC176
TR6 AC128

**Potentiometers**

VR1 10kΩ carbon logarithimc

**Switches**

S1 Double pole 4-way switch
S2 Mains on/off toggle switch

**Transformer**

T1 Mains transformer, 13–0–13V secondaries type TS2/13 (Henry's Radio)

**Sockets**

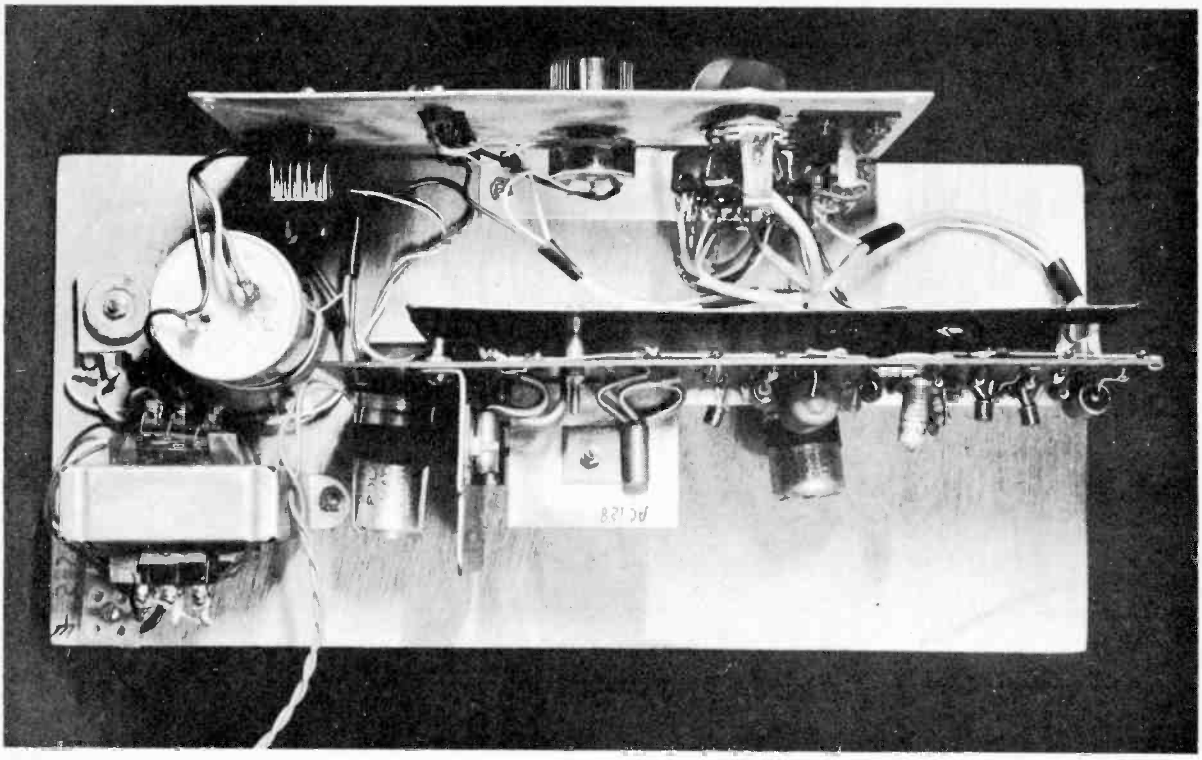
SK1–SK4 Phono sockets (4 off)
JK1 Standard jack socket

**Rectifier**

D1–D4 Rectifier type LT119 (Henry's Radio)

**Miscellaneous**

Link terminals—4-way strip type TS64 (Henry's Radio), 0·15in matrix plain Veroboard 3⅜in × 8in, heatsinks and copper transistor clips (3 off), 8in × ⅜in aluminium angle. Plywood for base board and cabinet.



Baseboard assembly of amplifier control panel, component board and power supply. Note the use of aluminium heat sinks for mounting the output stage transistors and aluminium screening for the underside of the components board

is, only one half of the winding is used. This provides 25V d.c. to the amplifier which falls to approximately 22V when the power stage is delivering its full output.

## CONSTRUCTION

The entire pre-amplifier and output stage can be assembled on a single circuit board as shown in Fig. 3. The input sockets, the selector switch S1, the link terminal strip and volume control, etc. are mounted on the control panel as in Fig. 2.

The transistors TR4, TR5 and TR6 are mounted on aluminium heatsinks with copper transistor clips. Do not cut the transistor leads and place a piece of sleeving over each to prevent short circuits. The circuit board is plain s.r.b.p. (0·15in matrix) which is mounted on an aluminium screen by means of stand-off spacers and 6B.A. bolts. The complete assembly is attached to the base board on a length of aluminium angle. The control panel is also mounted on the baseboard by similar means.

The lead from the common of S1a to C1 must be screened with the screen grounded at the component board.

## PERFORMANCE AND TESTING

Before connecting check the output pair and driver transistor circuitry in particular as both *npn* and *pnp* transistors are used and it is quite easy to connect them wrongly with obvious results. It is also worth checking the power supply before connecting the positive line to the amplifier and make sure that 25V only are available.

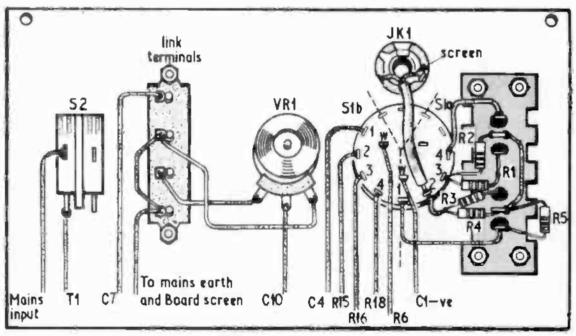



Fig. 2. Component layout and wiring of amplifier control panel. Apart from S2 all flying leads should be routed to the component board

The quiescent current of the amplifier with no signal input should be approximately 22mA. At maximum r.m.s. power output the current will rise to about 200mA and the rail volts will fall to about 22V. The amplifier is quite safe with the speaker disconnected but do not short circuit the speaker terminals whilst power is being developed.

## AMPLIFIER CIRCUIT BOARD

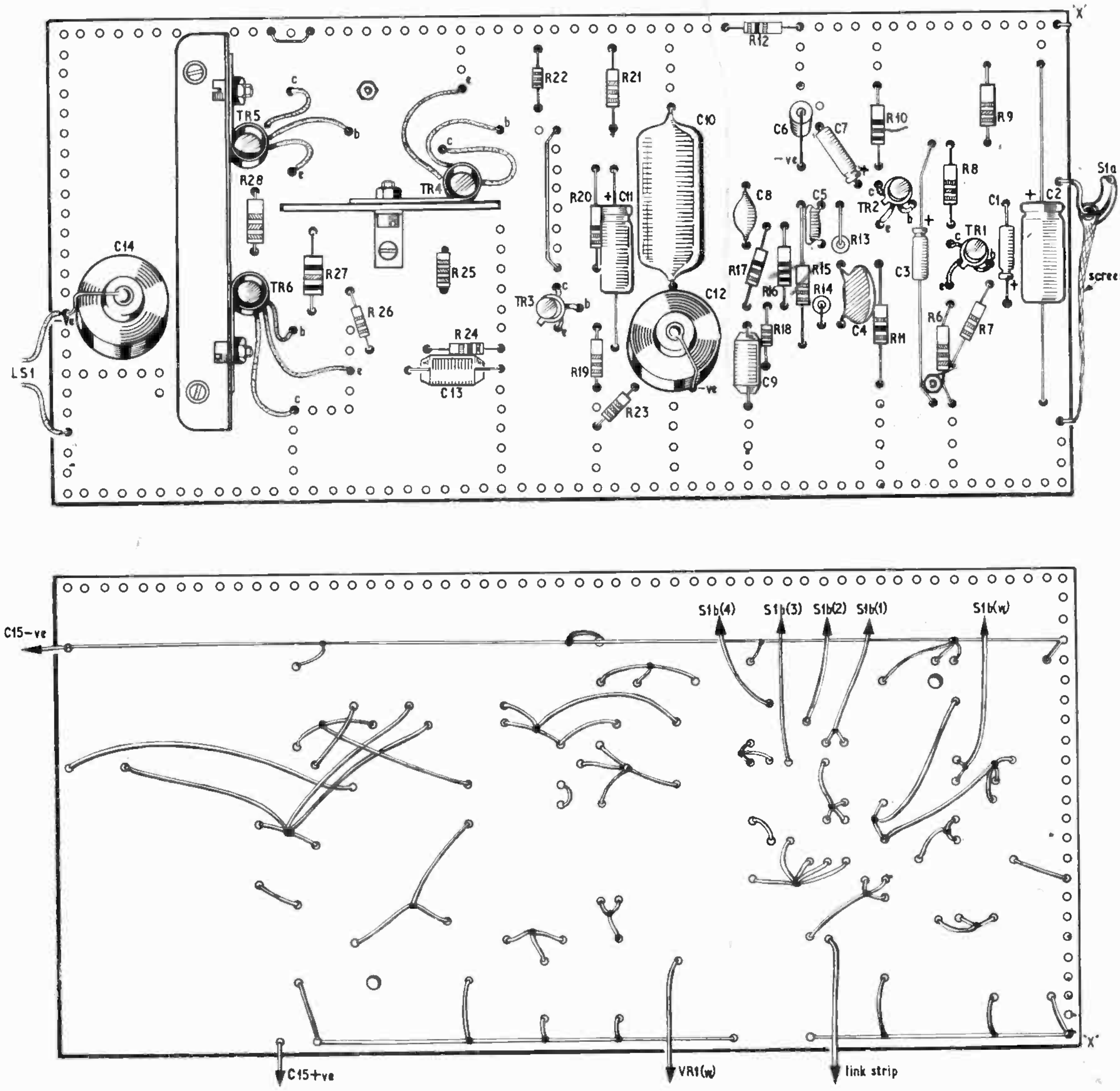
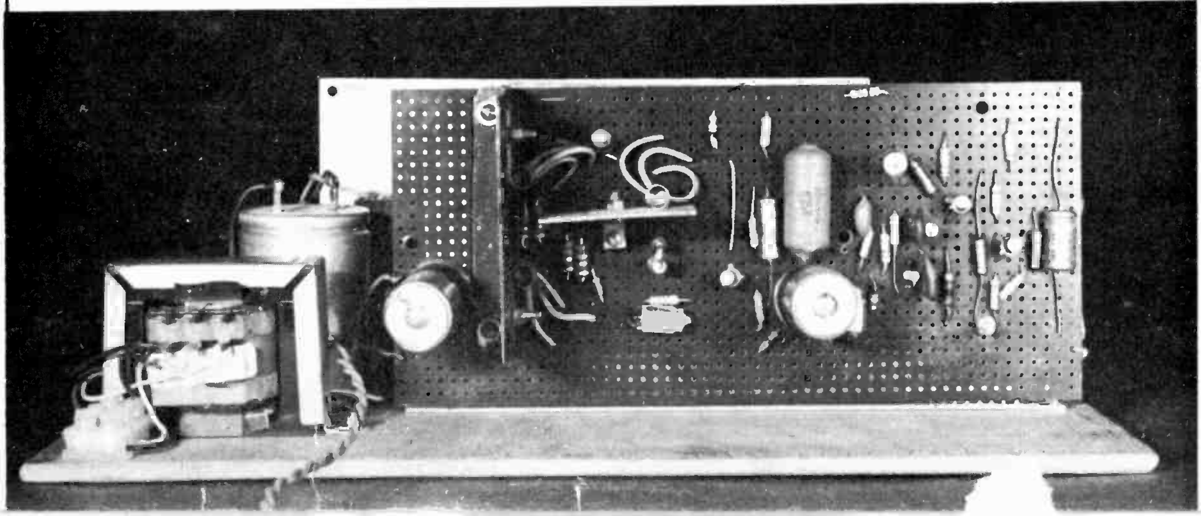



Fig. 3. Board layout and wiring of pre-amplifier and output stage



The amplifier being used to check a record deck. One of the many bench applications of the unit

If possible the signal input sensitivities should be checked but providing the circuit has been correctly wired these should comply with the figures given.

The frequency response of the power stage is given in Fig. 4 but can be extended a little at the low frequency end by doubling the value of the output coupling capacitor C14, that is, making this 1,000μF. The same graph shows the response from

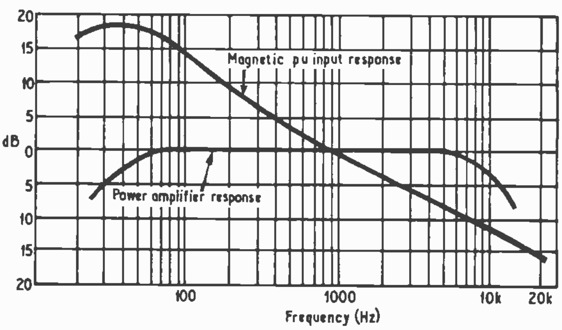



Fig. 4. Graphs of magnetic pick-up and frequency responses

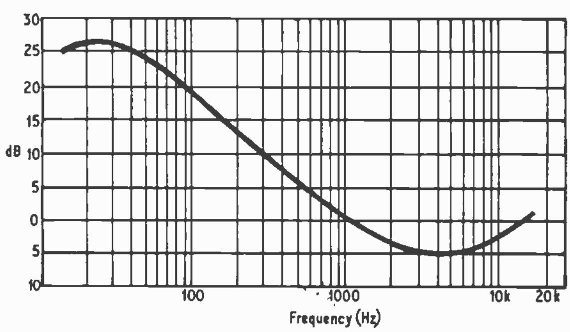



Fig. 5. Tape head input frequency response

the magnetic pick-up input which is to RIAA characteristic. The response from the tape head input (Fig. 5) is between CCIR and NAB characteristics and provides a replay response more in line with that used on modern domestic tape recorders. It is suitable for tape speeds of $7\frac{1}{2}$ and $3\frac{3}{4}$ inches per second.

The combined response of the pre-amplifier and power amplifier for radio or microphone input is as shown in Fig. 4 although the response of the pre-amplifier by itself is considerably wider and extends down to 20Hz and to well above 25,000Hz. The hum and noise level for the complete amplifier is better than −60dB for all inputs.

## A SUITABLE CABINET

The cabinet size or shape is not critical and it need be only large enough to accommodate the amplifier and a loudspeaker which may be any round or eliptical type capable of handling 3 to 4 watts of audio.

## APPLICATIONS

The amplifier has many applications as a bench testing instrument for audio signal sources of all kinds and could be duplicated for stereo reproduction with the second channel run from the spare 13V mains transformer secondary with an extra rectifier and smoothing capacitor. The circuit could also be used for a small record player in which case the switching and components for unwanted inputs need not be included. For example, for a mono record player with a ceramic or crystal pick-up the switch S1 is omitted, the collector of TR2 coupled back to the emitter of TR1 via C6 and R15 and the input taken via R3 straight to C1 with R4 connected from R3 to earth as shown. The link terminals would not be necessary so C7 would be connected straight to the top of VR1.

One final point. It may be found worthwhile to place a screen (thin tinplate or aluminium) underneath the baseboard and connect this to common earth to prevent hum pick up particularly from bench mains wiring. ★

# POINTS ARISING

**I.C. DIGITAL DICE** *(December 1971)*
There should not be a connection between gate output G6 and common, that is *P14* and *P15* on the Veroboard layout.

**P.E. SCORPIO IGNITION SYSTEM** *(November, December 1971)*
See letter on *Readout* page 248

**PHOTOPRINT PROCESS CONTROL** *(January 1972)*
Components List page 26. TR5 should be type 2N2926G.
Fig. 2 page 24. R16 is 3·3 ohms or 6·8 ohms as in the Components List.
FS1 could be a 1A anti-surge fuse for better protection.

# pick ups.....

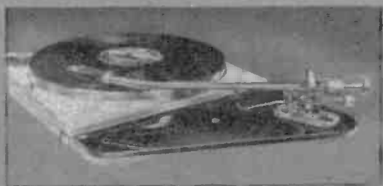
# & turntables

***Whether you are a hi fi fanatic with an ultimate desire to reproduce recorded sound at its very best, or just an average person who likes music around the house without being too particular about the techniques or finesse of the result, this supplement has been devised to explain some of the more important points about pickups and turntable units that most users may meet.***

***That equipment used to rotate a recorded disc and detect the recorded signal is sometimes called (a) a record deck; (b) a transcription unit; (c) an autochanger; (d) turntable and pickup. A record deck is the general term applied without any implications of quality. A transcription unit has by convention implied high quality often with the finest performance currently available. An autochanger is a record deck with extra mechanisms to change the disc at the end of replay and operate the pickup on and off the disc.***

***Whatever class of equipment interests you, it is fairly certain that manufacturers' literature will offer you some or all of the important technical features that you will wish to know to assess the value-for-money factor of your intended purchase.***

***Philips GA308 record deck***



***Transcription turntable Thorens TD124 Series II and SME 3009 Series II pickup arm with rest, side thrust correction weight, counterbalance weight at the rear and tracking weight on the side***

***Garrard autochanger AT60 Mk II***

BEFORE going into characteristics individually let us first consider the equipment as a whole. The sensitive element, which translates information stored in the disc groove, is a transducer—frequently called a cartridge. Its function is to generate electrical signals from vibrations of a stylus caused by varying patterns of modulation in the groove wall. The principles are the same for mono (single channel) or stereo (dual channel) recordings. The significant difference is the direction in which the stylus is vibrated and the relationship between the signals derived as will be explained later.

The cartridge is fitted to the underside of the pickup head, which may or may not be detachable from the pick-up arm. A modern cartridge usually carries two holes or slots in its mounting with a "standard" pitch of 0·5in for securing to the head shell.

The motive power to rotate the disc is provided by a synchronous motor driven turntable operated from an a.c. mains supply.

The translation of the recorded information into an electrical signal is loaded with mechanical and electrical problems, although current engineering practice has enabled the designer to master them. Extremely high quality reproduction from disc is now possible in two and four channels.

## HOW THE STEREO PICKUP WORKS

As is well known, sound signals recorded monophonically or from a centre-stage sound source causes the replay stylus to vibrate laterally. See Fig. 1a.

In the case of two-channel stereo records, the two walls of a V-shaped groove are modulated independently (Fig. 1b). The wall nearest the centre of the disc carries the left channel information; the other carries the right channel information.

Depending on the phasing between the left and right signals, the replay stylus vibrates laterally when there is only mono or centre-of-stage - stereo information (Fig. 2d), indicating in-phase conditions; and towards the vertical when the stereo information is at a maximum (Fig. 2c), indicating anti-phase conditions. Intermediate phase conditions result in different angles of vibration (Figs. 2a and 2b).

Some of the latest "four channel" or quadraphonic discs carry hall ambience effects in one or two rear channels by the phasing interplay between the front left and right channels, with the rear channels being derived from anti-phase information. The four channels are matrixed into the two channels of the disc, so that when four-channel replay is required a corresponding decoding matrix is adopted, the disc replaying in normal two-channel stereo.

Another scheme is based on the front two channels being recorded almost normally, with the two rear channels introduced by frequency modulated signals with sidebands extending to some 50kHz. This is called the "discrete" system because the four channels are handled in isolation throughout.

At the time of writing there is no quadrophonic disc standard, but ideas on both methods exist, with variations of the former.

Compatibility is one key note, which refers to the ability of the four channel system to replay in stereo or, indeed, in mono with minimal loss.

Correctly balanced mono replay from stereo discs is achieved by using a mono cartridge or a stereo type with the two channels correctly phased in parallel or series into the single replay channel. However, the stylus assembly must be endowed with adequate vertical compliance to avoid the inertia of the whole pickup from trying to follow the vertical vibrations of the stylus!

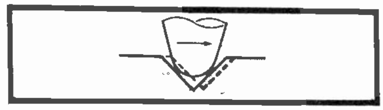


*Fig. 1a. Stylus tip in a mono recording groove; first half-cycle*

*Fig. 1b. Stylus tip in a mono recording groove; second half-cycle*

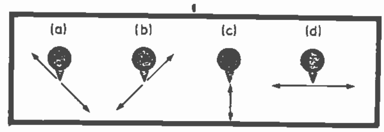



*Fig. 2. Modes of stylus vibration. (a) left channel, (b) right channel, (c) equal left and right in anti-phase, (d) equal left and right in-phase*

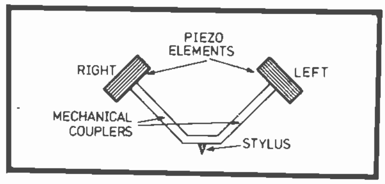



*Fig. 3. Elementary features of a piezoelectric stereo cartridge*

## PIEZOELECTRIC PICKUPS

The pickup transducer is most frequently an electromagnetic or piezoelectric generator, the latter using Rochelle salt or ceramic elements. Fig. 3 shows the essential features.

Rochelle salt crystal has the advantage of providing high output, having a high dielectric constant and hence high capacitance and relatively high compliance. Unfortunately it suffers the disadvantages of distortions due to moisture and temperature sensitivity.

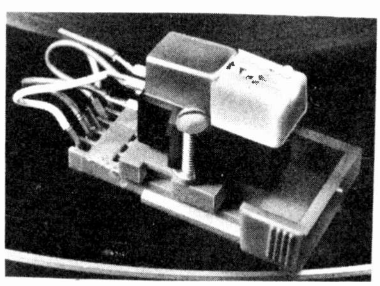
Ceramic, on the other hand, is impervious to atmospheric conditions, is capable of a better frequency response than Rochelle salt, but has a smaller output.

Rochelle salt crystal pickups have now been largely superseded by ceramic types and are employed mostly in the mass market type of equipment. The high output, sometimes 1V or more, can cut amplification costs, and in some low priced equipment the power amplifier stage is driven direct from the crystal pickup.

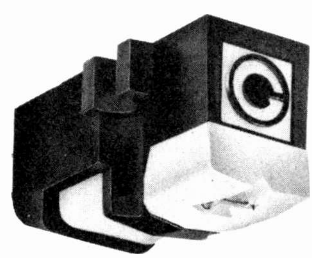
Typical ceramic pickup output is 50 to 100mV, and was used extensively at one time in budget price systems, but now that the better performance of magnetic pickups can be obtained for little more than the price of some ceramic types, the latter are tending to lose favour.

Since the output of a piezoelectric pickup is roughly proportional to the amplitude of modulation, it can be used when correctly loaded without equalisation, which can reduce the cost of the amplifier.


*Acos Crystal cartridge GP91-1SC for single channel (mono) replay of stereo or mono recordings*



*Audio-Technica AT-55 cartridge fitted into a headshell. Notice the mounting screw on the near side*



*The Goldring G800 induced field cartridge. Also uses the variable reluctance principle*

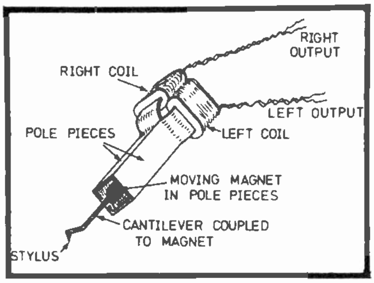



***Fig. 4. Moving magnet cartridge showing the stylus coupling***

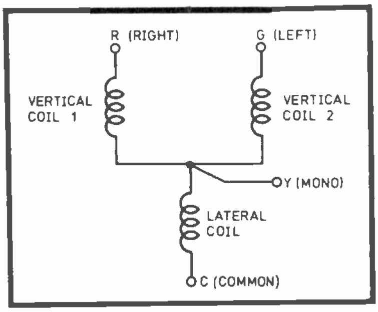



***Fig. 5. Coil system of the Decca sum-and-difference pickup***

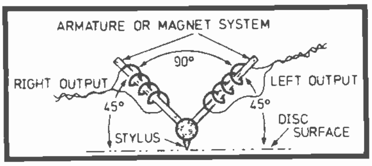



***Fig. 6. Showing how the left and right generators are independently operated by the 45/45 stereo cut***

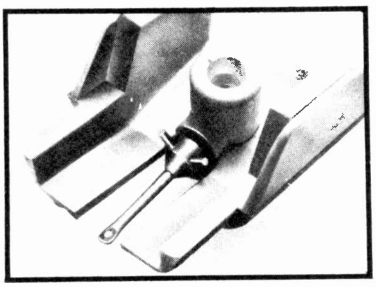
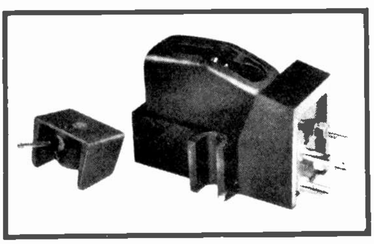


***Fig. 7. The V magnet system on the end of the cantilever corresponds to the 45/45 stereo cut. This is from the AT35 Audio-Technica cartridge***



***Most magnetic cartridges are designed so that the stylus assembly can be removed from the main body for cleaning or replacement. This is the Audio Technica AT35***

## MAGNETIC PICKUPS

Magnetic pickups come in a diversity of types, although all of them exploit the basic electro-magnetic principle (Fig. 4). Most common types are moving coil, moving magnet and variable reluctance, where a ferrous armature vibrates between "magnet" pole-pieces. Induced current can be excited in either a field coil (moving magnet) or armature coil (moving coil) by stylus vibrations.

When the field is provided by a magnet which is not in contact with the pole-pieces, the term "induced magnet" is sometimes adopted, as the field is coupled to the micro-mass armature.

Magnetic pickups produce an output proportional to the velocity of the modulation. Since this modulation is recorded on a rising characteristic (i.e. bass cut and treble boost), corresponding approximately to constant amplitude characteristics, equalisation is required at the amplifier. This should be designed to correct the frequency response of the reproduced sound signal. Typical output is a little over 1mV per cm s velocity.

## SUM-AND-DIFFERENCE PICKUP

One type of magnetic pickup is based on the variable reluctance principle, but employs a set of three coils from which the two stereo signals are obtained. The coils of the Decca sum-and-difference pickup are shown in Fig. 5.

Signal e.m.f. in the three coils is the same when there is modulation in one channel, but the phasing of the coils is such that the sum of the signals in right vertical coil 1 and the lateral coil appears across terminals C and R when the right channel is modulated. There is theoretically zero output from the left channel, between C and G, because the signal in vertical coil 2 is in phase opposition with that in the lateral coil, thus giving the difference function. In practice, however, a very small signal is obtained due to the crosstalk factor through leakage from other coils.

When the other wall is modulated, the right channel is quiet and the signal in coil 1 is in phase opposition to that in the lateral coil. When both left and right are modulated together, the two stereo signals are delivered with minimal interaction between them. The Y terminal allows the lateral coil only to be used for mono replay. (Codings R, G, and Y usually refer to colours of the connecting lead, i.e. red, green, yellow. Common C is the screen.)

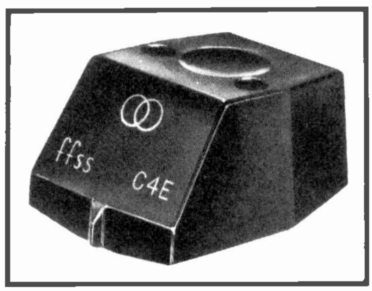
Other cartridges employ a pair of generators with their motional axes in V formation to correspond to the 45 45 stereo cut, where each channel is recorded 45 degrees to the surface of the disc and at right-angles to each other (Fig. 6). Sometimes the moving magnet is arranged in V formation, as shown in Fig. 7.

## OTHER PICKUPS

Other pickups include one based on the photoelectric principle, where a small lamp is focused on photoelectric diodes and the stylus vibration is caused to modulate the light on the diodes. Another is based on the strain gauge principle, where d.c. is modulated by the vibrating stylus.

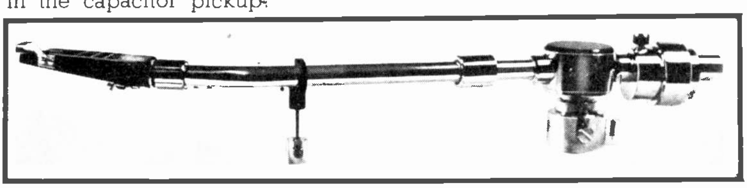
One uses ribbon instead of a moving coil, as in a ribbon microphone. This, as with the moving coil type, requires a booster amplifier or step-up transformer.

Other transducer principles have been adopted, and there would appear to be an increasing interest in the electrostatic principle, resulting in the capacitor pickup.




***Pickup head by Decca. This is based on the sum-and-difference principle***

***Audio Technica AT 1005/II pickup arm***



# PICKUP CHARACTERISTICS

## LOW FREQUENCY RESONANCE

One problem of arm/transducer matching is low frequency resonance (i.e. the natural tendency for vibration to be excited at a particular frequency related to the characteristics of the component). This results from the dynamic mass of the arm resonating with the compliance of the stylus assembly.

The electrical analogues of mass and compliance are inductance and capacitance, so not unnaturally the resonance frequency ($f_0$) is equal to $1/(2\pi\sqrt{MC})$, where $M$ is the mass and $C$ the compliance. Thus the greater is $M$ or $C$ the lower will be $f_0$.

At resonance the vibrations tend to magnify, as also does the pickup output, while below $f_0$ a high-pass filter effect occurs, in which the bass response tends to roll-off (Fig. 8).

Thus if the $MC$ combination results in $f_0$ being too high the bass response suffers, while a too low $f_0$ encourages unstable tracking, the stylus tending to leave the groove when the resonance is excited by external vibration, such as someone walking across the room.

Moreover, if $f_0$ corresponds to the resonance of another connected component, such as a loudspeaker in a room, acoustic feedback can lead to howl build-up as the amplifier's volume control is advanced. If $f_0$ falls near the slip frequency of the drive motor (22·5Hz), turntable rumble could be aggravated. Thus it is seen that not all heads or cartridges will work with all arms without some problems arising.

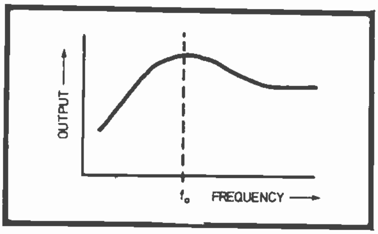



***Fig. 8. Below bass resonance the output rolls off, an effect which is sometimes exploited for attenuating rumble***

Fortunately, hi fi cartridges and arms are to some extent designed for each other. Arm mass is being made as low as practicable, while stylus compliance is being made as high as practicable. However, by going too far in these directions, other problems arise, such as inability to track properly; a proper balance between these two factors is very important.

It is known that at least one manufacturer reduced the compliance of a popular cartridge so that it could be used with budget auto-changers and decks. Consequently, high and low compliance models may be available to cater for high quality adjustable arms and medium class mass produced pickups.

In some cases l.f. resonances are tamed by arm decoupling (compliant couplings) and sometimes by viscous damping.

An $f_0$ between 8 and 20Hz is fairly safe, but calculation is not easy before purchase because the manufacturer's published specification rarely includes the effective mass. Mass is not the same as weight which is counterbalanced, with just sufficient turned on to the head end for tracking the groove. Nevertheless, the majority of hi fi arms will partner the best cartridges without trouble.

## FREQUENCY RESPONSE

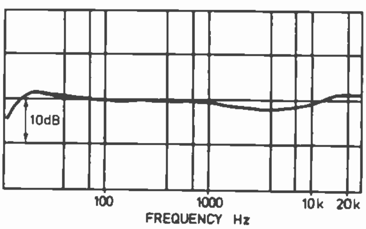



***Fig. 9. Frequency response of top-flight magnetic cartridge. The mild 5-6kHz droop is normal with magnetic types***

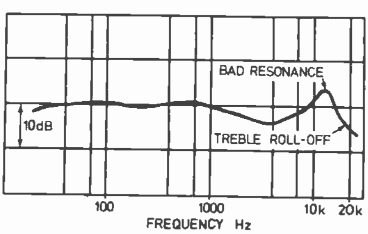



***Fig. 10. Cartridge with bad h.f. resonance, possibly due to the mass at the cantilever end removed from the tip resonating with the cantilever compliance***

Specifications which merely give a frequency range without reference to a nominal power level deviation of undistorted signal should be treated with suspicion. Correct frequency response relates output to frequency over the audio spectrum and usually extends beyond aural sensitivity (Fig. 9). Both channels should match very closely at all frequencies for good stereo listening quality. A good cartridge should be free from violent peaks in its characteristic which could signify undesirable resonances, particularly at the treble end.

One treble resonance is caused by the effective tip mass resonating with the compliance of the disc material (rather like a violin bow on a string), which has a value around $3 \times 10^{-8}$cm/dyne. The lower the tip mass, therefore, the higher the resonant frequency.

A low tip mass is essential for good tracking of high acceleration modulation, and a mass of 1mg or less would put the resonance outside the audio passband. However, the resonant frequency can be lower due to the mass at the end of the cantilever remote from the stylus tip and the compliance of the stylus lever arm.

High frequency resonances yield significant energy which can damage the groove walls and hence the modulation; moreover, h.f. resonance also results in acute treble roll-off (Fig. 10). This characteristic is typical of the cheaper crystal pickups at one time common on mass produced equipment.

H.F. resonances also show up on the separation curves at close or corresponding frequencies. Internal damping reduces the mechanical $Q$ factor and hence diminishes the peaks, thereby resulting in a "smoother" frequency response, but the intrinsic faults remain.

Many magnetic cartridges, especially those of current variable reluctance and moving magnet design, exhibit the droop around 5 to 6kHz (Figs. 9 and 10). The effect is not significant and can be tolerated since it is gradual and not a violent resonance.

Piezoelectric cartridges in general have less smooth frequency responses than magnetic cartridges.

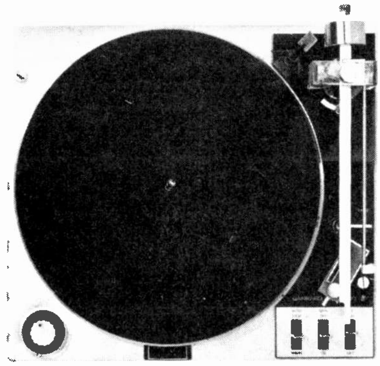
# AND PERFORMANCE

## MEAN OUTPUT VOLTAGE

The output is related to velocity of modulation, usually at 1 or 5cm/s at 1kHz. Each channel should yield the same output within 1dB (even closer in top quality pickups). An average moving iron magnetic cartridge would be expected to produce about 6mV from 5cm/s, both r.m.s. values.

Moving coils and ribbon types will generate a mere 100μV, which is why a booster or step-up transformer is required. Due to this lower sensitivity and the limitations in the frequency response of small transformers, these latter types tend to lose favour.

Crystal cartridges can generate as much as 1V r.m.s. from average modulation, but better class ceramic types settle for about 20 to 50mV, with a smoother frequency response characteristic over the whole audio range.



***An example of the parallel arm type of pickup, the Garrard Zero 100. The head is pivoted to both arms to maintain tangential tracking***

## STEREO SEPARATION

A stereo cartridge specification should give the channel separation at 1kHz or at two other frequencies. Good magnetic types often have a ratio as high as 25dB at mid-spectrum, falling possibly to 15 or 20dB at 100Hz and 10kHz.

Maximum stereo impact occurs at mid-spectrum, so the separation here must be as high as possible, but lack of stereo image stability can result if the separation ratio changes too violently in the upper treble regions.

The separation curve of a good magnetic cartridge is given in Fig. 11, where the mid-spectrum separation is better than 25dB. Notice the mild "ripples" at the top treble end which signify well damped resonances.

It is difficult to check cartridges with separation better than 30dB owing to the disc replay noise in the "non-speaking" channel approaching the level of the break-through signal.

Piezoelectric cartridges have less exacting separation characteristics than most magnetic cartridges.

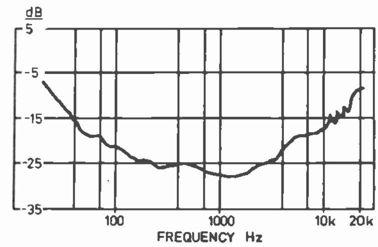



***Fig. 11. Separation characteristics of a good magnetic cartridge. The mild ripples at the treble end signify well controlled resonances.***

## LOADING

Correct cartridge loading is important for the best frequency response, and the optimum load is generally given in the specification. Most magnetic cartridges work best into about 47 kilohms, the treble lifting if the load impedance is too high and drooping if it is too low (Fig. 12).

Piezoelectric cartridges, on the other hand, are load sensitive at the bass end. This is because they are capacitive in source, a high pass filter effect thus occurring when the load is too low (Fig. 13).

Good ceramic types usually demand a load impedance of at least two megohms for extended bass response; to secure a reasonable overall frequency response from the RIAA recording characteristic inbuilt equalisation is often incorporated. The full-line curve in Fig. 14 approximates the RIAA recording characteristic, which is projected to the amplitude modulation characteristic in Fig. 15, this clearly revealing the need for piezoelectric type of equalisation.

A piezoelectric cartridge can be made to approximate velocity characteristics by loading with a low value resistor (about 33 kilohms), the output then being similar to that of a magnetic cartridge, allowing the normal magnetic equalisation to be used.

Care is necessary, though, to avoid the relatively high output from overloading the RIAA equalised preamplifiers and causing bad distortion on signal peaks. This is not the best way of using ceramics.

Capacitance in shunt with the load has virtually no affect on piezo cartridges, but it can affect the treble response of magnetic types, especially when the coil inductance (another parameter that might be specified) is high, and incite electrical resonance with the coils within the passband.

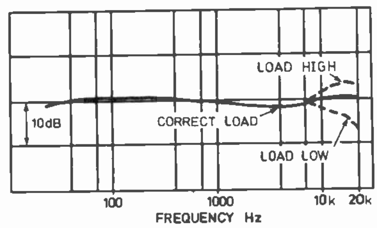



***Fig. 12. Effects of incorrect loading of a magnetic cartridge***

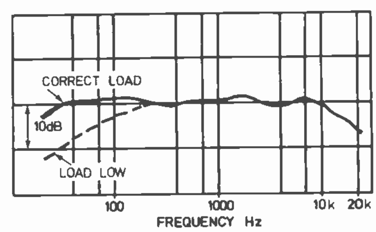
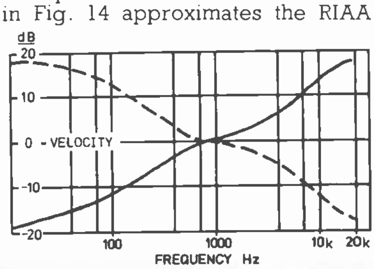



***Fig. 13. Effect of incorrect loading of peizoelectric cartridge***



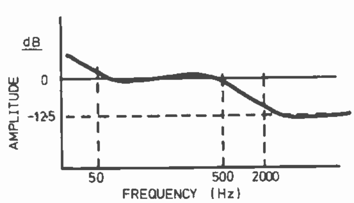
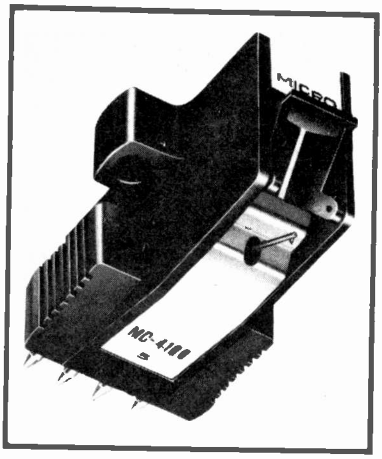
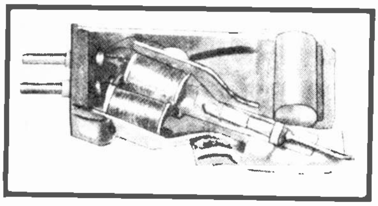




***Fig. 14 (far left). RIAA recording characteristic in full-line. The broken-line curve shows the equalisation required in the amplifier***

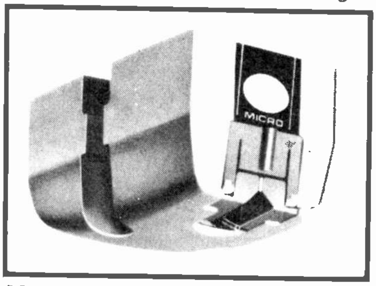
***Fig. 15 (left). The RIAA velocity recording characteristic projected in terms of amplitude. This shows the need for inbuilt equalisation of a piezoelectric cartridge.***




*Micro-Seiki MC 4100/5 cartridge with 0·5 thou radius diamond stylus*



*Artist's sectional view of the Audio and Design induced field cartridge*




*Magnetic cartridge which has a removable stylus assembly*

## BEARING FRICTION

The lower the vertical and lateral bearing frictions the better, and to reap the full advantage from a low tracking weight cartridge they should not exceed much more than the equivalent of 50 dynes force at the stylus tip, a value which is met by most hi fi arms.

## EFFECTIVE ARM MASS

This is effectively the inertia reflected at the stylus after the weight of the arm and cartridge have been counterbalanced and the required tracking weight turned on; total value must include the cartridge and headshell.

When the arm is to be used with high compliance cartridges the total value should be as small as possible to avoid a too low a low frequency resonance (see under this heading).

## COMPLIANCE

Most specifications give a figure for compliance which is expressed in terms of the distance in $10^{-6}$cm the stylus is displaced by a 1 dyne force (roughly equivalent to a weight of 1mg on Earth). Modern magnetic cartridges boast up to $20\times10^{-6}$cm dyne or more.

Static compliance is higher than the dynamic compliance, and confusion can thus arise in resonance calculations. Low frequency tracking is governed by the compliance and, since maximum recorded amplitudes are limited to about 0·005cm, from the tracking point alone there is no need for the compliance to exceed $5\times10^{-6}$cm dyne at a tracking force of 1 gramme. However, there are other factors, including mechanical damping and tip mass, that are related to compliance as explained earlier under Resonance.

Obviously the compliance cannot be increased to the extent where there is inadequate restoring force for the stylus assembly. Vertical and lateral compliances often differ, so there could be two main low frequency resonance factors.

## EFFECTIVE TIP MASS

The stylus is mechanically coupled to the transducer so the inertia of the mechanical assembly including the cantilever is reflected at the stylus tip, and is taken into account in determining the tip mass $M_t$. For adequate high frequency response and hence high acceleration tracking, $M_t$ has to be very small.

It is a difficult parameter to measure, which is why it is rarely found in published specifications. However, an approximation of performance can be found by calculating mass $M_t \simeq F/(2\pi fV)$ where $V$ is the velocity in cm s, $f$ the frequency in Hz and $F$ is the tracking weight at the stylus for a condition of "just tracking properly". The modulus of acceleration is $2\pi fV$.

A good frequency for estimating $M_t$ is 10kHz, and if 10cm s velocity puts the tracking threshold at, say, 1·5 grammes, then $M_t$ would equal approximately 2·3mgm.

The better cartridges tracking down to one or two grammes would have tip masses around 1mg. A treble resonance well within the passband indicates a relatively high tip mass.

## MECHANICAL RESISTANCE

In any electro-mechanical device some mechanical resistance to movement is inevitable, but in pickups it is deliberately employed in conjunction with compliance and tip mass to even the tracking and to damp resonances over the audio spectrum. It takes effect more over the middle part of the spectrum, while compliance is important at the low end and tip mass at the high end.

Again it is not a parameter that is specified, nor easily measured, but if natural resonance occurs over mid-range, it is likely that the mechanical assembly of stylus and cantilever is at fault.

## TRACKING PERFORMANCE

Few specifications carry meaningful information on the tracking performance, although Shure do give a parameter in terms of "trackability", which indicates the ability of a cartridge to track recorded waveforms of high amplitude, velocity and acceleration at minimum tracking weights.

The information given under compliance and effective tip mass implies that given sufficient tracking weight any cartridge would track a given modulation. This is untrue, of course, because the groove wall would collapse. Tracking performance thus relates to tracking weight.

Modern discs carry amplitude variations up to 0·005cm, velocities up to 25cm/s (sometimes more on heavily recorded "pop" discs) and accelerations sometimes exceeding 2,000g. Thus to track these at, say, 1 or even 2 grammes tracking weight, both the cartridge and the arm must be of high quality.

In a more advanced specification the tracking performance might be given as a curve showing the mechanical impedance of the stylus tip over the spectrum in terms of $F/V$, where $F$ is the threshold tracking force in milligrammes and $V$ the recorded velocity.

It is then possible to project a curve of maximum recorded velocities over the spectrum on to this curve as shown in Fig. 16. From these curves the tracking weight required at any frequency can be determined. At 3kHz, for example, the impedance is 50 mg/cm/s, while the maximum peak velocity is about 27cm/s, which means that a tracking weight of a little under 1·4 grammes is required.

Very few impedance curves are as smooth as this illustration, and it is only the best cartridges which can boast a tip impedance of less than 50 ohms at 2kHz.

## TRACKING WEIGHT

All specifications should give a tracking weight or maximum/minimum limits. The maximum merely indicates the force that the stylus assembly can handle before running into mechanical non-linearity effects (or bottoming) while the minimum is usually a very optimistic value having no relationship to real tracking performance.

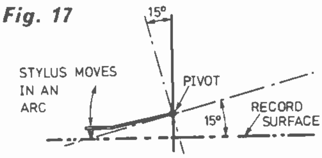
Tracking force of a specific amount is demanded, of course, to counter the reaction of the stylus in the modulated groove (see under Tracking Performance), but even running at the maximum is no indication that the pickup will track maximum velocities accurately unless the weight refers to given levels of modulation over the spectrum (see Fig. 16).

The arm and side-thrust correction are tied in with this problem, and one way that the user can determine the approximate tracking performance of his pickup at a given tracking weight is by testing with a special record. Bands are provided on the HF69 test record for this purpose and for optimising the side-thrust correction.

## VERTICAL TRACKING ANGLE

Discs are now being cut with a 15 degree vertical tracking angle, this value being given in the specification. If the angle deviates from 15 degrees there is a rise in harmonic distortion. The angle is defined in Fig. 17.

*Fig. 17*




## LATERAL TRACKING ERROR

When a disc is cut, the cutter head follows a line of true radius of the disc, tracking along a radial rotating lathe screw. On replay the stylus follows an arc because the arm is pivoted at one point. Tracking error results because of the departure from exact tangential alignment of the replay stylus with the groove over the whole groove length.

As high harmonic distortion and disc and stylus wear result from this error, steps are taken in the arm design to correct it or at least significantly to reduce it. They consist of offsetting the axis of the cartridge from that of the arm and arranging for the stylus tip to overhang the turntable pivot at centre swing.

In Fig. 18, $\phi_2$ is the offset angle and $d_3$—$d_2$ the overhang. The tracking error is thus equal to 90 minus $(\phi_1+\phi_2)$, or is zero when $\phi_1+\phi_2=90$ degrees.

The following expression is useful for calculating the offset angle for zero error with overhang and effective arm length ($d_3$) as parameters.

$$\cos x=\frac{d_1{}^2-(d_3-d_2)^2+2d_3(d_3-d_2)}{2d_3d_1}$$

whence $\phi_2$ for zero tracking error is $90-x$ degrees.

Clearly, many combinations of offset angle and overhang are possible for zero error, and it is the job of the designer to select that which yields minimum error at all arm positions relative to the effective length of the arm.

The overhang is commonly adjusted by the user with an alignment protractor for the least error at the inner groove diameter, since it is here, where the waveforms are compressed, where the distortion can be at its highest.

A well designed 8in arm with an overhang of 0·55in and an offset angle of 24 degrees would have zero error at 3½in and 9in diameters and errors of about 2½ and 3 degrees at diameters of 9in and 12in. The maximum errors are less with longer arms, but then there is the disadvantage of extra arm inertia.

For optimum tracking conditions $\phi_2$ reduces as $d_3$ increases, this making $d_4$, called the "linear offset", a constant. It has been determined that when $d_4$ is 3·47in, irrespective of arm length, the distortion due to tracking error is minimised over the swing of the disc after setting the overhang with an alignment protractor.

Distortion is proportional to the ratios of tracking error/groove radius and recorded velocity/turntable velocity. When calculations are made for the least distortion between the maximum and minimum groove diameters the parameters obtained differ slightly from those based on zero tracking error at the inner groove diameter.

Tangential arms which do not pivot in the usual way reduce the tracking error to a maximum of about ½ degree by using a pantograph style arm with parallel arms for adjusting the offset angle during playback.

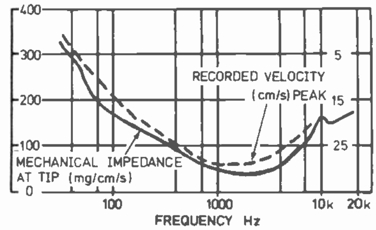



***Fig. 16. Curves relating stylus tip impedance to recorded velocities***

## STYLUS

Modern discs have groove dimensions suitable for styli of 0·0005in tip radius. Earlier LPs called for 0·001in radius styli. A compromise dimension is 0·0007in, suitable for early and recent discs, but for the best reproduction the smallest practicable active radius is desirable. This is because the recorded high frequency waveforms, particularly at inner groove diameters where they are more compressed, can only be defined by a tip of smaller dimension than themselves.

Tracing distortion, which is a harmonic distortion resulting from the recording cutter being chisel-shaped while the replay stylus is spherical, reduces as the active tip radius is reduced.

A hemi-spherical tip cannot be reduced to much less than 0·0005in for fear of it bottoming in the groove and causing excessive noise.

This, however, is overcome by the semi-ellipsoid or biradial tip, whose active minor radius is 0·0003in or sometimes less. The major radius which falls across the width of the groove is 0·0007in, thereby preventing bottoming. Such a tip improves replay definition at inner grooves while also minimising tracing distortion.

Diamond is the only material suitable for a hi fi stylus, although sapphire is still used for mass market equipment. The life of a sapphire stylus is shorter, being a softer substance, often of a composite mixture.

Stylus replacement nowadays demands either the return of the cartridge to the maker or the replacement of the stylus assembly which sometimes pulls from the main body.

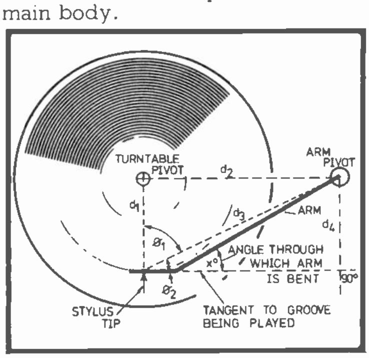



***Fig. 18. Factors involved in lateral tracking***

## SIDE-THRUST CORRECTION

Fig. 19 shows that owing to the arm offset angle $\phi$ and the forward drag $f$ of the stylus in the groove, a torque results at the arm pivot, which reflects as force $F$ pulling the cartridge inwards.

Cancellation of this force at the arm is achieved by a dangling weight device, spring or magnetism. Actual correction value cannot be calculated for the changing modulation conditions (e.g. changing drag) and a compromise correction is usually established by using a suitable test record.

The previously held view that $F$ diminishes with reducing stylus-to-groove velocity (such as at the inner diameters) is currently under question, some authorities claiming that the drag due to components other than modulation remains substantially constant over the disc.

Accurately corrected side-thrust can reduce the required tracking weight by as much as 20 per cent.

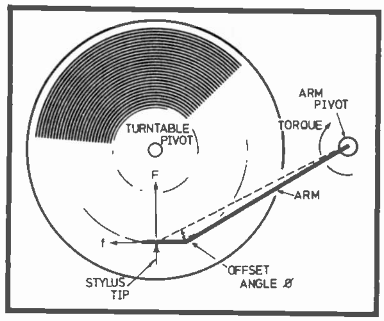



*Fig. 19. Illustrating side-thrust, where force F is equal to f sin $\phi$ × cos $\phi$.*

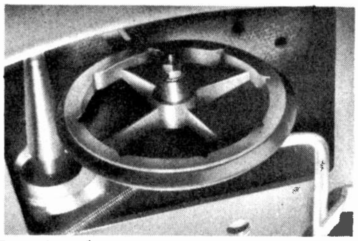
## TURNTABLE REQUIREMENTS

*Philips GA202 uses electronic controlled d.c. motor and belt drive*

One design angle is for minimal mechanical noise from the turntable unit which gives rise to "rumble" superimposed on the signal from the pickup. Pickup resonance must be prevented by designing the pickup shell and arm to avoid such effects being aggravated.

The motor is mechanically decoupled from the pickup by using rubber or spring suspension, and from the turn-table by the transmission, which might be a rubber idler wheel or belt. Any noise from this source is around 22·5Hz, the slip frequency of the motor, and can be aggravated by dynamic imbalance of the motor's rotor.

The main bearing of the turntable is responsible for a lower frequency noise, discerned more by feeling than hearing in a hi fi system. Special attention is given to the removal of this noise from transcription units, the bearing generally consisting of a single ball, rather than a ball race.



*Detail of the Goldring-Lenco continuously variable speed control*

Belt drive can ease the problem of noise coupling from the motor. With both belt and idler wheel systems speed change is provided by stepped or continuously variable diameters on the motor drive shaft, with the idler, like the belt, acting as pure transmission, and not affecting the drive ratio.

An interesting arrangement is adopted by Leak and Goldring-Lenco transcription units for continuously variable speed change, where the idler wheel is made to slide along a conical motor drive shaft (see photo) to its preset speed position.

Constant speed under all normal operating conditions including stylus drag and cleaning brush friction is essential to avoid wow and flutter. Large mass and dynamically balanced turntables help with this problem, so that the motor needs only to transmit a relatively small amount of energy to keep the turntable at constant velocity.

Drive motors are mostly a.c. mains operated and of quasi-synchronous nature. They are usually adequately decoupled from the turntable bearing by rubber buffers or springs. The whole motor board, too, may be decoupled from the plinth to reduce shock excitation of the pickup.

A fairly recent idea is the use of a Wien network oscillator for driving a synchronous motor, the motor speed thus being adjustable by varying the oscillator frequency. Servo controls have been mooted, but in general the a.c. motors and turntable units of today are well compatible with the associated components of the system and do not really justify such sophistication.

## SPEED ERROR

The DIN minimum speed error tolerance of +1·5 per cent and −1 per cent is generally well met and is reasonable since an error of 0·2 per cent corresponds to a change in pitch of less than 1/30th of a semitone. Nevertheless, listeners blessed with perfect pitch should consider a unit with limited speed control.

## RUMBLE

Rumble is quoted relative to a given level of modulation, the greater the level the greater the signal/rumble ratio. Rumble expressed as, say, 40dB below 5cm/s at 1kHz RIAA implies that the rumble is relative to a signal of that frequency and level, with the rumble itself being measured via RIAA equalisation.

Other filters may be incorporated in the readout to weight the disturbance and to eliminate high frequency noise. For meaningful comparisons the nature of the measurement must be known, and this is not always given in the specification.

## WOW AND FLUTTER

Wow, which is caused by turntable speed variations below 20Hz, and flutter, which results from speed variations at a higher rate, are far more disturbing than consistent speed error.

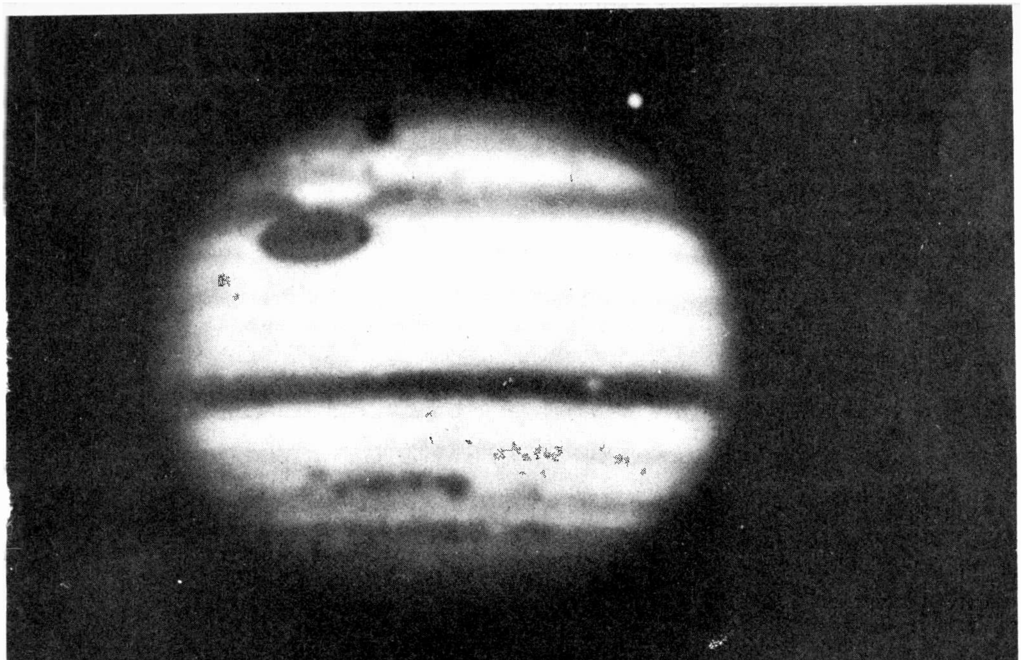
The percentage wow and flutter is given as

wow and flutter =

$$\frac{(f_{max} - f_{min}) \times 100}{f_{av}} \text{ per cent}$$

where $f_{max}$ and $f_{min}$ are the maximum and minimum frequencies and $f_{av}$ is the average frequency, usually based on 3kHz. Measurement is by a wow and flutter meter and the readout may be in peak or r.m.s. value.

The minimum DIN requirement is not greater than ±0·2 per cent peak, but to be undetectable to acute hearing the wow must not be greater than 0·3 per cent and the flutter not greater than 0·15 per cent.



Jupiter, in blue light, showing the great Red Spot. Satellite Ganymede and shadow (above). 200in Hale

(Mount Wilson and Palomar Observatories)

# RADIO ASTRONOMY TECHNIQUES

BY F.W.HYDE · PART 10

THIS is the concluding article in the present series: it is mainly concerned with a project for the detection of the decametre radiation from the planet Jupiter, but also explains how a radio map of the sky may be produced.

## RADIATION FROM JUPITER

In 1955 Burke and Franklyn in America were testing a large aerial system. With the team was F. Graham-Smith, one of the original team under Martin (now Sir Martin) Ryle at Cambridge. Graham Smith and the other members of the American team had noticed that there was a regular outburst of radiation which was very like the sun in some respects. Someone jokingly said perhaps it is Jupiter and in fact Jupiter was in the beam of the aerial when the radiation appeared. A check was made and it was indeed found that the planet was radiating on frequencies around 16 to 22MHz.

When listening to these radiations the sound from the loudspeaker is very much like the sound of the ebb and flow of the sea on a shingle beach. It is quite distinctive and easily recognised in the midst of other radiation; it changes in level very rapidly and may vary by as much has a hundred times in the course of a few seconds.

As this particular part of the frequency band is full of activity, daytime observation is difficult even with an interferometer; thus the majority of observations of Jupiter are made at night. This particular problem has received a great deal of attention by Warwick and others in America but not much elsewhere, apart from the author's work in collaboration with Florida State University.

There are a number of observatories in America involved and names associated with the work are Alex G. Smith and T. D. Carr at Florida University; and recently workers at Meudon Observatory in France have taken a new approach to the problem. It is not possible to do more than give a brief account of this phenomenon of the Jupiter radiations. Various theories have been proposed over the past several years.

Obviously, there is still much to be done in the way of observation, and as the aerials and receiving equipment needed are extremely simple, Jupiter is now a worthwhile project for the amateur. Indeed, work can now be done in the back garden, because of a simple type of aerial which the author has brought into use.

Formerly, a large corner reflector was required and remembering that at 18MHz, one of the particular frequencies used, the wavelength in physical length is some 54ft, a corner reflector is quite large even with a half-wave dipole—being some 40ft high and 40ft long (one of the author's large aerials is shown in the photograph).

## EQUIPMENT REQUIRED

The requirements for the Jupiter project are a suitable yet simple aerial, a pre-amplifier, a communications receiver, a d.c. amplifier, and a recording system. The block layout is shown in Fig. 10.1.

The simple aerial already alluded to is a loop which is nearly closed and it may be used in the normal way without a reflector, in which case it will have the usual figure of eight polar diagram. A reflector of mesh added gives an increase in gain

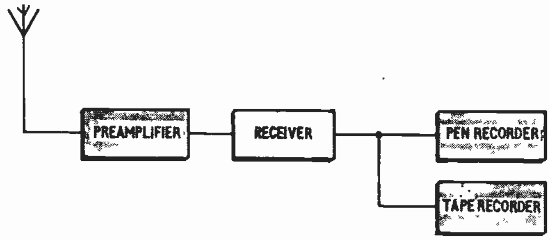



Fig. 10.1. Block diagram of Jupiter Receiving System

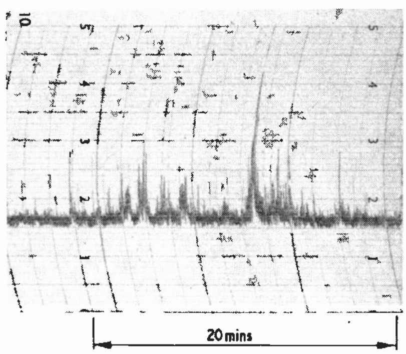



Fig. 10.2. A recording of radiations from Jupiter

with the loop facing the source of energy. This aerial is not unduly critical as to bandwidth so that an aerial designed for 20MHz will operate quite well between 18 and 22MHz. This is quite an important factor, because it may be that some radiations will appear in any part of this band. Also, if the band is somewhat crowded the tuning point can be changed to find a quiet spot.

Because of the nature of the Jupiter radiations the normal time constant of the communications receiver is used. If the pre-amplifier provides of the order of 20–30dB gain, it will be possible to use the direct output from the receiver, or to feed the d.c. amplifier direct from the second detector, with no intermediate long time constant detector section.

Much of the professional work that has been done in the past has been with high-gain receiver front-ends, and recordings made on low resistance recorders with an incorporated rectifier. If the recorder had no rectifier then a 1mA bridge rectifier such as the Westinghouse meter rectifier was used. The results of such observations are shown in the recorded chart in Fig. 10.2.

Bearing in mind the description of the sound of this radiation, it will still need some practice, both aurally and visually, to determine that which is of Jovian origin, and that which is from man-made and extraterrestrial sources. More will be said about this at the end of this article.

## AERIAL CONSTRUCTION

Details of the loop aerial are given in Fig. 10.3. The best material for the aerial element is half-hard aluminium tube of about one half inch diameter. The reflector should be of 1in to 1½in square mesh of 16s.w.g. galvanised wire with welded joints. This is a readily available item in most hardware stores.

The frame can be of timber or metal according to choice. If metal is used then make sure that all parts of metal that touch are electrically bonded.

The mounting of the aerial can be left to choice, but this is an opportunity to make up an equatorial mounting, and the diagrams in Fig. 10.4 give some suggestions in this respect. The aerial and pre-amplifier should be mounted on the back of the reflector. It is suggested that another additional pre-amplifier be employed at the receiver.

## PRE-AMPLIFIER

Two examples of suitable pre-amplifier circuits are shown in Fig. 10.5. The type of transistor can be changed to suit, provided the parameters are the same. Those shown are the types used in the original equipment and which have given reliable service.

A warning is perhaps advisable here about break-through. If attempts are made to use this radio telescope where there is much commercial operation, breakthrough may be troublesome and in some cases damaging. A check should be made with an aerial located at the receiver to observe the state of the band before connecting the main aerial and its pre-amplifier. Also, it is as well to have the aerial pre-amplifier switched off when not in use, for it too could suffer from overloading.

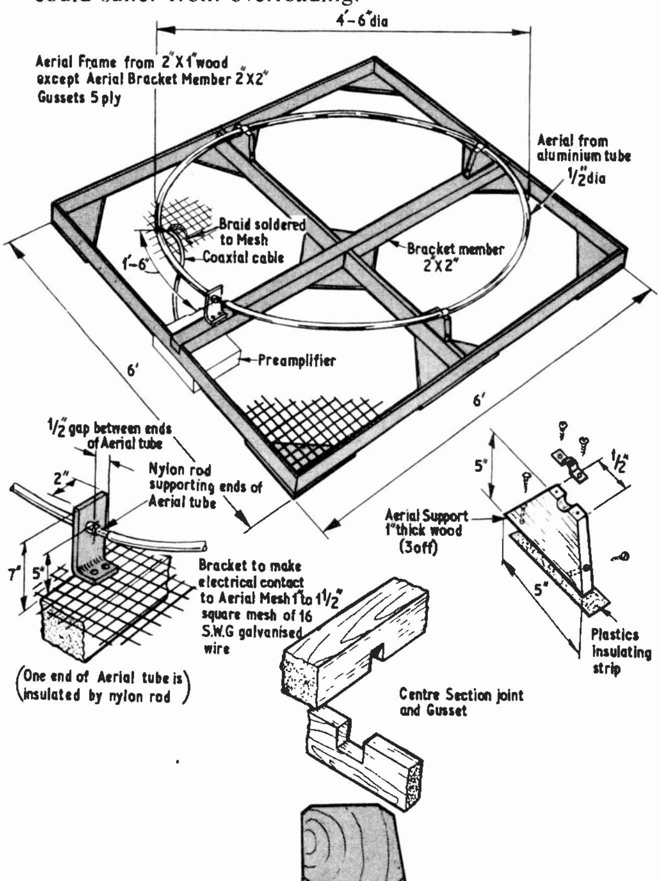



Fig. 10.3. Loop aerial constructional details

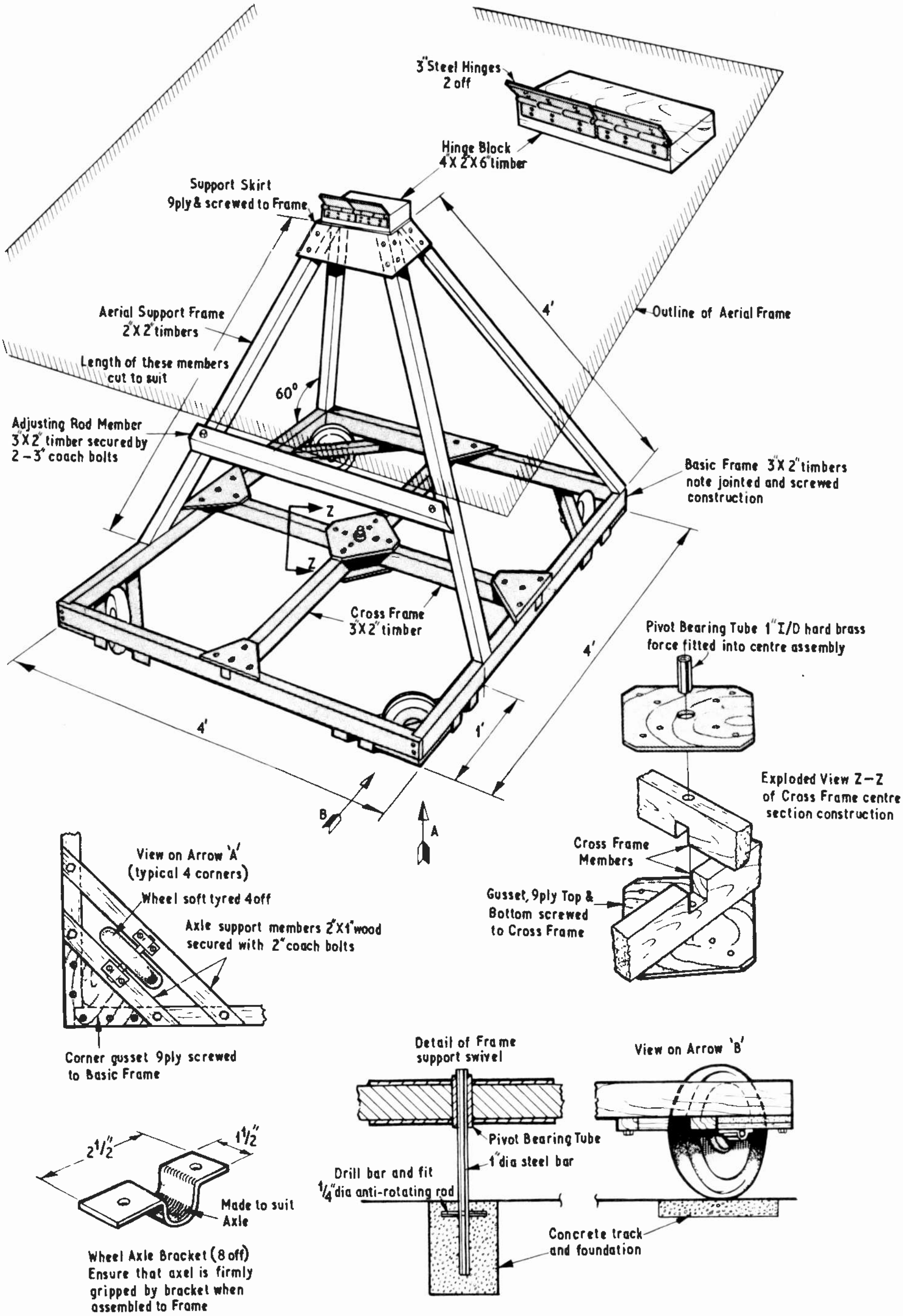



Fig. 10.4. Suggested mounting arrangement for loop aerial centred at 20MHz. This provides for equatorial and altazimuth adjustment

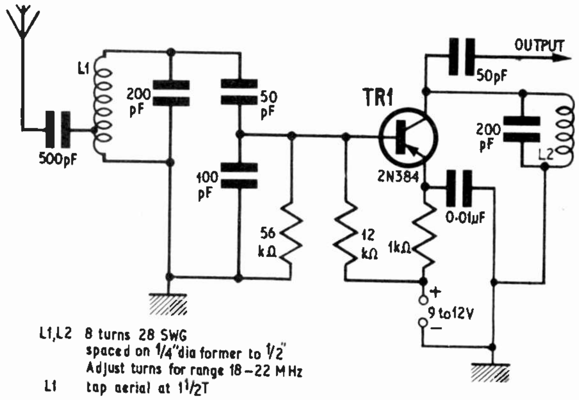



Fig. 10.5a. A simple aerial pre-amplifier

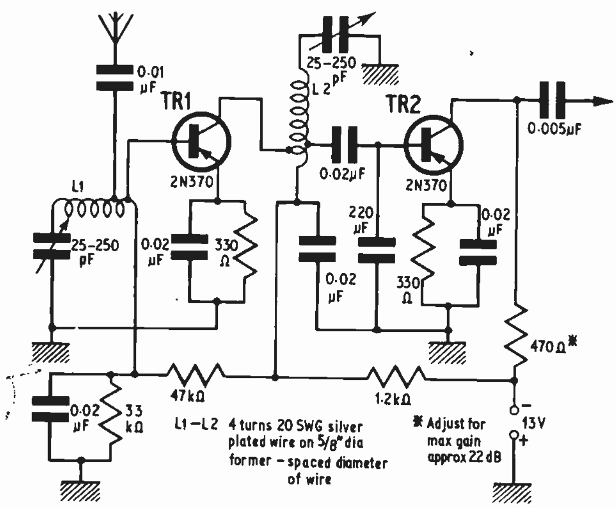



Fig 10.5b. A two transistor aerial pre-amplifier

## FORM OF OBSERVATION

After a few trial observations and recordings, it would be possible to let the system run without direct supervision. This is of course very simple in the case of the interferometer for most of the interference will be avoided. In the case of the simple one-aerial system, as just described, attendance of the observer is necessary to ensure acceptable observations and until sufficient experience has been gained in assessing the recordings obtained. If possible, the recordings should subsequently be examined by an observer who has this experience.

This is mentioned because to be useful the observations should be made over as long a period as possible, and it is not very convenient nor desirable to spend up to eight hours on direct observations.

The important times are in fact the two hours before and the two hours after the planet passes the meridian. There are special reasons why the earlier and later observations can be useful. For example: important information about the ionosphere after sunset can be obtained; and, after say 03.00 a.m., the rise of the dawn chorus can be recorded. This latter phenomenon is quite striking when first experienced, and the effect on the recording can be seen in the example given in Fig. 10.6.

## MAKING A RADIO MAP OF THE SKY

The list of sources given in Part 7 is short and covers only the more powerful sources, though even some of these may be below the threshold of recording where the simple telescope is used. It is however a practical and useful exercise to make a radio map of the sky from the point of observation. There will be a considerable difference between the maps made in the northern hemisphere and those made in the southern hemisphere. Such maps could be useful where correlation of results is at intervals ranging over the two hemispheres.

The procedure for building up a useful map is simple and involves two requirements: (1) a setting in altitude; (2) a sufficiently spaced scanning programme. The altitude changes will depend on the beamwidth in the vertical direction and the value of the scans will depend on having a number of days at the same scanning position. This latter requirement is necessary in order to take care of the varying conditions of the ionosphere and other effects on the transmission of the radiation through the atmosphere. Usually a four to six day run at each altitude selected should give a reliable set of data. The sequence is then as follows:

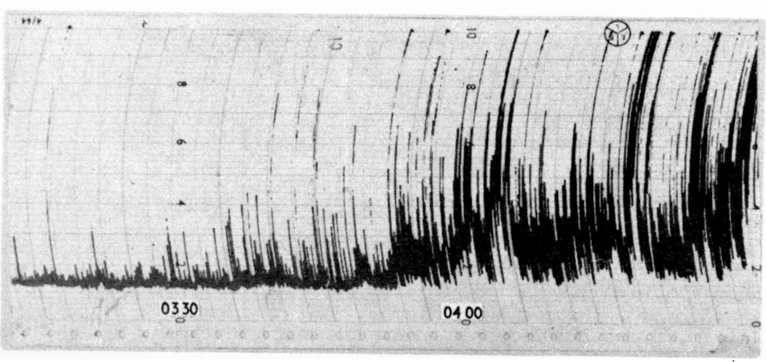



Fig. 10.6. Example of a pen recording of the dawn chorus

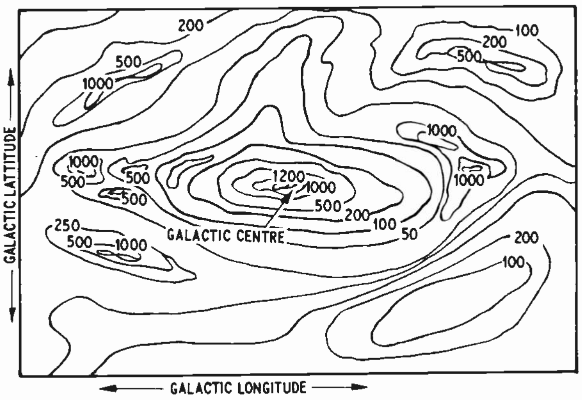



Fig. 10.7. Radio map of sky at 200MHz. Values in arbitrary units

Set the altitude; record the runs; carefully log the conditions; examine each day and compare it with the next; lay the records over each other with a bright light under to assess visually the changes.

Make careful notes of any unusual or odd items on the recording. From this it will be possible to learn the effects of satellites, man made interference, air radiation effects and, at the frequency chosen, the rain static effects.

As a normal programme, a month of scanning should yield sufficient data for a reasonably accurate map. When the map is completed it would look somewhat like that shown in Fig. 10.7. The contour lines are at the points of equal intensity, and the whole presents a kind of relief map of the part of the sky covered. The value of the lines are arbitrary in the case of this project, but there is a standard evaluation and this is given in the appendix for those who would like a little mathematical information.

## POLARISATION

One point that should be mentioned here is that the energy that is received from extra terrestrial sources is polarised. Since the aerials in use are horizontally polarised, only half the energy from space is received in the horizontal mode. It might be thought reception should be set up in both planes. This is, in fact, frequently done and does offer a means of roughly determining the way in which the radiation is polarised. This might be left handed or right handed.

One reason for the more common practice of using horizontal receiving elements is that mechanically they are easier to construct but there is also another reason which relates to the electrical properties.

It is a fact that there appears to be less interference on the horizontal mode compared with the vertical mode. One reason for this is the amount of reflected radiation from the ground which also seems to carry a good deal of man-made interference.

With the corner reflector aerial there is protection from this type of reflection. If the aerial is turned so that the bottom edge of the reflector is near the ground the "spill-over" of the beam will mean that radiation from the ground is picked up. It is sometimes necessary to set another horizontal reflector to overcome this. Where the sensitivity of the system is low as in the first simple project described in this series, the ground radiation (or temperature as it is described) will dominate in any case. The appendix also deals with this aspect.

## IN CONCLUSION

If there is sufficient interest in the promotion of projects that have so far been described in this series, it could be possible to organise them on a group basis, and so make a worthwhile contribution to knowledge.

Those wishing to follow such a line of observation, whether it be solar noise and/or polarisation measurements, together with the study of the Jupiter radiations, should contact the editor. This would enable the author to arrange the correlation of data with a view to publication of the results and credits to those who take part. It could also result in an exchange of information between like minded readers. ★

## APPENDIX

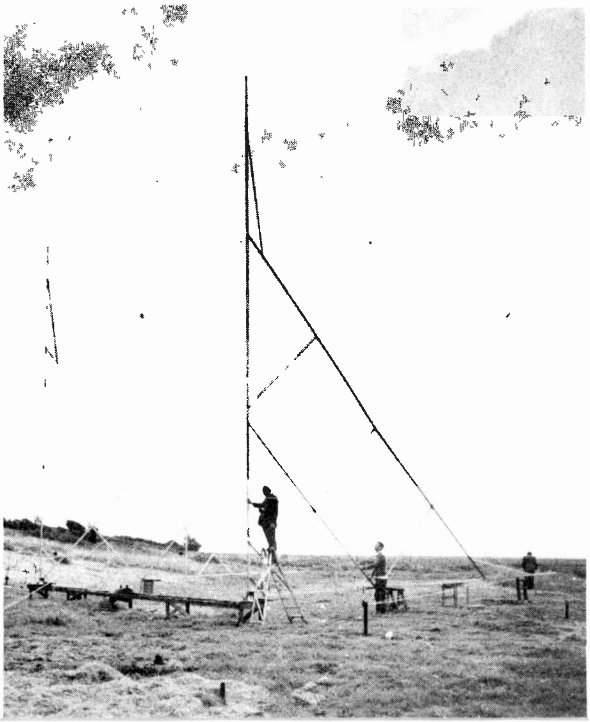
One method of assessing the intensity of the radiations received is based on Planck's law relating to the emission of electromagnetic energy at all frequencies from a "black body". This energy is related to the temperature of the body. For radio frequencies the Rayleigh-Jeans formula can be used and this is:

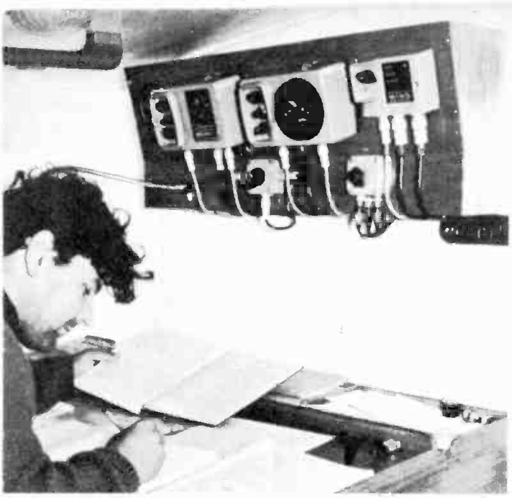
$$B = \frac{2KT}{\lambda^2}$$

This gives the brightness of the source in terms of $T$ which is the temperature in degrees Kelvin and the wavelength $\lambda$ where $K$ is Boltzman's constant and is equal to $1{\cdot}38 \times 10^{-23}$ in MKS units.

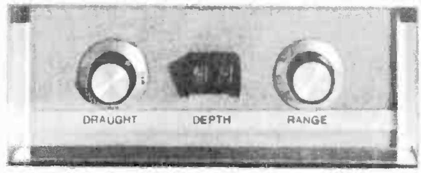
The temperature of the earth radiation is of the order of 100° Kelvin and this sets the lower limit of temperature that can be measured. This is one advantage of the large dish type aerial since the aperture can be trained away from the surface of the earth and so avoid these limiting factors.

Although there are not many books on Radio Astronomy there are sufficient in most libraries for the enthusiast to pursue these theoretical considerations.

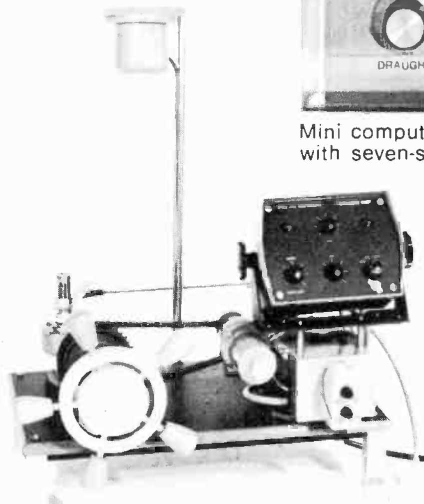




This photo shows Chay Blyth at the chart table of the boat *British Steel* which uses Brooks and Gatehouse electronic instruments, including speed, depth and wind indicators; depth transducer selection switch is at bottom right of the panel. The instrument dials are often duplicated in a waterproof housing on the top of the cabin as shown on the 36ft cruiser racer below

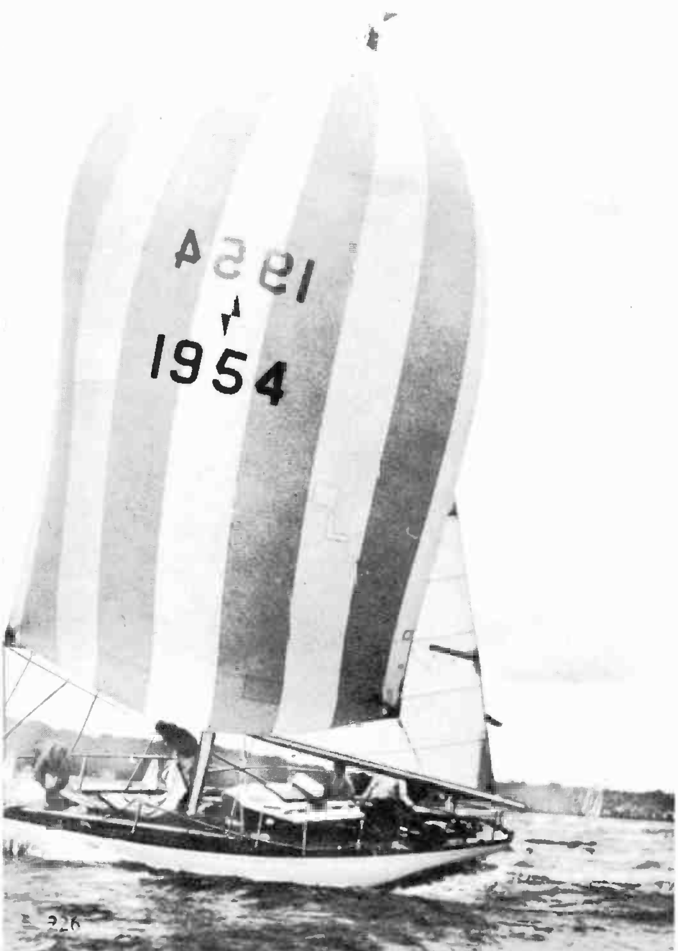



Mini computer using medium integration with seven-segment displays



An electronic polar locking compass (EPL) is incorporate in this "Command Pilot" from Space Age Electronics. It is mounted on the post

# ELECTRONORAMA




ANOTHER boat show—another year of marine electronic development, although quite often it is hard to find what has been developed by who. This is mainly due to the lack of organisation in the press office at the show and not the firms concerned.

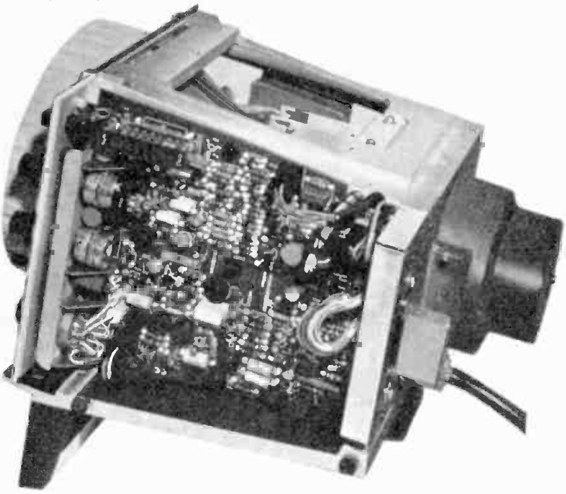
Medium scale integration has now found its way into the sailing scene and is incorporated in a depth indicator with seven segment digital readout, by G. M. Systems Ltd. Having ranges from 0 to 99 feet and 0 to 99 metres the unit has no moving parts (except a range, on/off switch and a draught compensator control) and is very compact. Main disadvantages are: no facilities for remote readout and the possibility that it is more difficult to judge the rate of change of depth from a digital display than from a meter or graph readout.

The G1000-F chart recording echo sounder for inshore fishermen, yachtsmen and small coasters has been introduced by Ferrograph. The new sounder is unusual in that it uses a specially prepared paper that is marked electrically avoiding the need for a special pen and ink.

Another new product is the 050 radar from Decca. Smaller than the 101 and less expensive this new radar should be of interest to many small boat owners. Decca tell us that no corners have been cut to get the price down.

Other developments in small boat radar were announced by Kelvin Hughes (Type 17 radar developments) and EMI (new version of the Elecstrascan); no price increases have been made on the developed sets by either of these firms.

Brookes and Gatehouse have this year come up with no less than five new developments, admittedly one of those is a skin fitting for the existing boat speed indicator, but the other four are significant developments in the small boat electronics field. Three new B and G equipments are a sailing performance computer to calculate speed made good to windward, a "single signal" df receiver—a development of the Homer K receiver, The Decca 050 radar is suitable for small boats under 40ft



The interior of the Decca 050 display unit showing all the display electronics mounted on one printed circuit board

# AT THE BOAT SHOW

and a long-range echo sounder (100 fathoms).

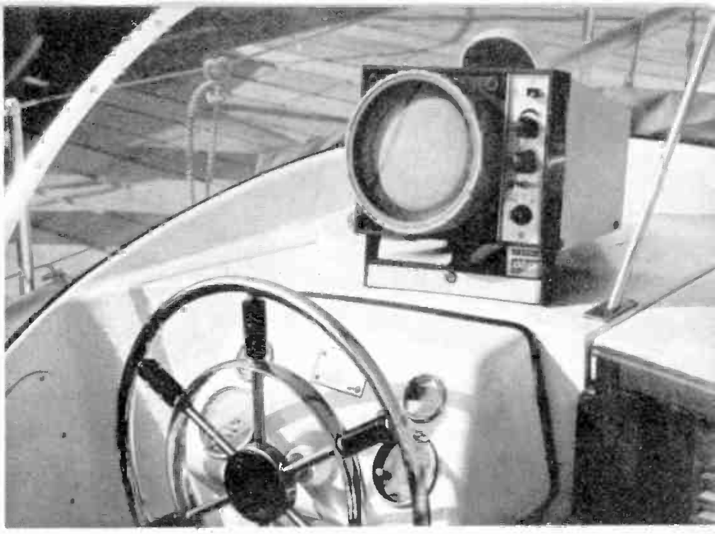
The fifth development is an improved distance-off-course computer. This computer uses a "new design" master compass which we believe has only recently been released for sale for non-military applications. This electronic polar locking (EPL) compass is also used in the "autopilots" made by Space Age Electronics. The main feature is that the bearing is unaffected by the movement of the boat however violent. The command pilot from Space Age Electronics shown on the facing page has EPL unit on the raised mounting and incorporates a remote hand held steering control unit —shown fixed to the pilot under the main control panel.

A new speedo/log that does not use an impeller or straingauge, merely a small transducer, and provides seven segment digital readout is now being offered by Detronic Ltd. The transducer is formed by an electrostrictive crystal transmitting an ultrasonic signal of 500kHz. The unit works by measuring the frequency change of the signal reflected by the water (the signal is transmitted about 9 inches) due to the doppler effect. Hence a very accurate measurement can be made —0·1 of a knot from 0—9·9 knots and 1 knot from 10–99 knots.

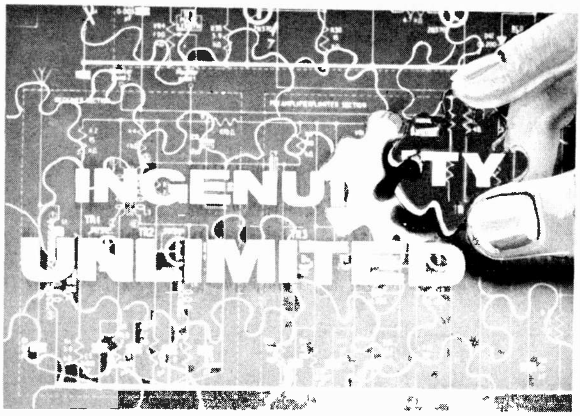
The Baron Squire range is new this year, the main difference from their original range seems to be the housings and sealed indicators, some of which incorporate the electronics. They had an impressive display of units working under about a foot depth of water It is a pity that they do not improve their meter face design as this tends to be complicated and not very easy to read.

All in all plenty of new developments for the boat owner to consider and, with the advance of micro-electronics, perhaps some smaller, better equipments still to come.

The waterproof glass fibre radome houses the Decca 050 aerial and transceiver. This arrangement, fitted to a mast is most suitable to small motorised sailing boats where unshielded rotating scanners are unsuitable



Fairey Marine "Huntsman 31"



A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merits.

## UNIJUNCTION TIMER

Although it might be argued that a monostable could perform the same function as the circuit shown in Fig. 1, it should be borne in mind that this is true for relatively short periods only. The circuit under consideration will perform happily for tens of minutes but to achieve the same time scale with a monostable would require enormously large electrolytic capacitors.

This particular circuit is also more straightforward in operation. To obtain the proper sequence from a monostable would necessitate the reversal of the initial states, i.e. the transistor which is initially off would have to be triggered initially on.

The purpose of the circuit is to manually switch on a power supply for a pre-determined period and leave it to switch itself off automatically. The power supply may be connected to a motor or some other piece of apparatus. In my project, it was used for a high-frequency transmitting oscillator.

When push switch S1 is pressed, TR1 is brought into conduction via R1 and the relay is energised. The operation of the relay closes contact RLA1 across the switch to act as a self-hold. Capacitor C1 begins to charge via R4.

When the voltage on C1 has risen to the triggering level of the unijunction TR3, C1 discharges into R3 which produces a pulse of sufficient magnitude to turn TR2 on. The base-emitter junction of TR1 now has the $V_{ce}$ saturation voltage of TR2 across it. This voltage is lower than the requisite turn-on voltage so TR1 is turned off, the relay is de-energised and contact RLA1 opens. The supply is thus switched off.

The main requirement in the project was to consume as little power as possible since the equipment was battery operated. An RS Components, type 15, relay was therefore chosen because it requires only 60mW operating power.

The unijunction transistor TR3 is the popular GEC type 2N2646 and the values of R2 and R3 are those recommended by the manufacturer. Capacitor C1 was chosen to be 1,000μF so that C1, R3 has a time constant of 100ms, which is twice the release time of the type 15 relay.

The value for R4 is only a guide since there is a variation in the value of $\eta$ for the 2N2646 and electrolytic capacitors have such a wide tolerance. R4 will have to be finally chosen by trial and error. In the circuit which was constructed, a time delay of 5 minutes was achieved by using 100kΩ for R4.

The ballast resistance for the Zener diode may conveniently be a suitable indicator lamp. For example, with a supply voltage of 36V one may employ an S6/8 type of lamp (RS Components) at 28V, 0·04A. A current of 40mA through the Zener diode will provide good regulation since the greatest shunt path will be the 20mA relay current.

J. Wilson, C.Eng., M.I.E.R.E.,
Reading.

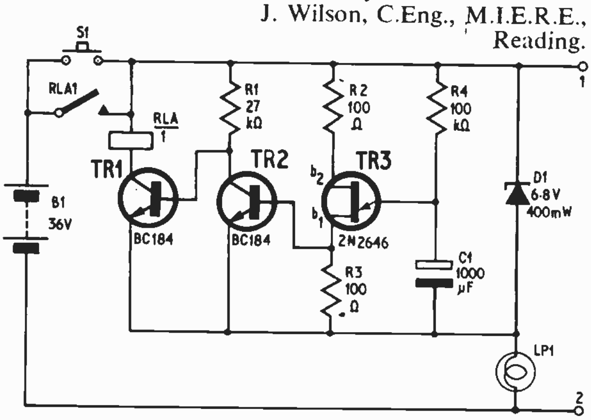



Fig. 1. Circuit diagram of the unijunction timer. Terminals 1 and 2 go to equipment

## R.F. AMPLIFIER FOR CAR RADIO

By using a low noise transistor in the circuit shown in Fig. 1 the average car radio's performance is greatly enhanced and stations previously beneath noise level become reasonably clear.

The circuit, having a high output impedance, is effectively tuned by the input circuitry of the car radio.

The gain control VR1 should be advanced as far as possible consistent with absence of cross-modulation and car ignition interference.

Using a separate battery B1, eliminates earth loop problems, the need for elaborate decoupling and will last at least nine months with continuous use.

P. E. J. Lacey,
Crediton, Devon.

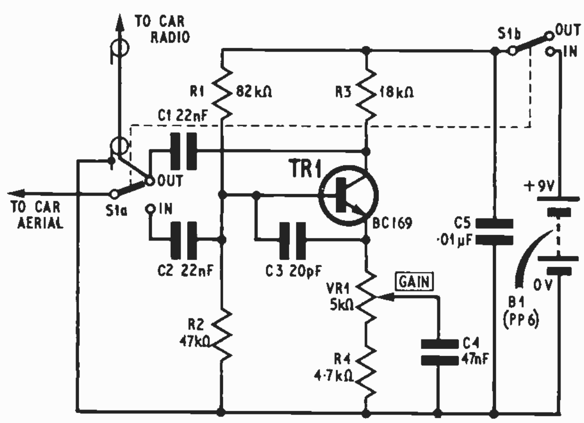



Fig. 1. Circuit diagram of the r.f. amplifier for car radio

# PATENTS REVIEW...

## TONE GENERATORS

IN the new British Patent 1 245 714 Standard Telephones and Cables Ltd. (STC) discuss the problems inherent in constructing tone generators for telephone dialling.

Electrical oscillators can be used for this purpose but the problem in this case is that the associated switch is of necessity heavily used and its contacts may show early wear. A contact-less generator uses a reed of magnetised material which is set in vibration by plucking; but the vibration of the reed is not easily sustained and the plucking and plucked parts are also susceptible to wear.

STC have devised and patented a tone generator which uses a transducer (e.g. piezo electrical material) mounted on a reed coupled to a bowed leaf spring, Fig. 1. Once the transducer is excited a circuit keeps the reed vibrating, but this vibration is normally suppressed by a mechanical damper, see Fig. 2. As the reed is on a bowed spring, however, it can be snapped between one of two positions and it is only damped in one of these positions. In the other position it is free to vibrate and, what is more, this snapping motion serves to start the reed vibrating. Vibration is then maintained by the electric circuitry.

In Fig. 2 STC show such an arrangement in side view.

The leaf spring is snap controlled by a push button loaded by springs, and in its up-bowed position the leaf forces its reed and transducer against a mechanical damping bar. When the push button is pressed, the leaf snaps into its down-bowed position so that the transducer is brought well clear of the damper, the snapping motion mechanically jolts the reed into vibration. This vibration is then maintained by an amplifier with two high gain transistors functioning as an oscillator by virtue of a feedback loop, Fig. 3.

Usually the reed will be formed by a tongue cut out of the spring by a U-shaped incision and the transducer by a sandwich of piezoelectric material between metal electrode layers.

## NEUTRALISED AMPLIFIERS

IN BP 1 241 285 Mullard Ltd. outline the advantages and disadvantages to date of neutralised transistor amplifiers.

According to Mullard the advantages of neutralising the base-collector capacitance of a transistor in an amplifier (to minimise unwanted feedback due to such capacitance) are increased gain and stability. Such neutralisation can be achieved by a neutralising capacitor circuit.

However, as there is frequently a spread in the value of the base-collector capacitance and as a fixed value component is normally used for neutralisation, there is clearly a problem that under some circumstances the transistor may be over-neutralised and have a tendency to oscillate, while under other circumstances the transistor may be under-neutralised and have its gain seriously reduced. Ideally the neutralising capacitor would be matched to a particular transistor for the best possible compromise, but this is hardly practical for normal use.

The Mullard solution is to use a semiconductor body which has a transistor and a neutralising capacitor incorporated in the one case, the latter having a value appropriate for neutralising the capacitance of the base-collector junction.

The neutralising capacitor is formed from the same material as the transistor, but with opposite conductivity type regions as the base-collector junction. Usually this will be by the same diffusions.

## BP 1 241 285

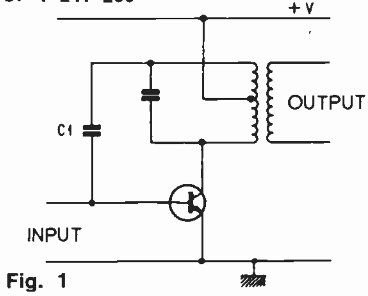



**Fig. 1**

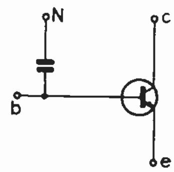



**Fig. 2**

The collector or base region of the transistor is connected to the region of corresponding conductivity type of the capacitor and the amplifier circuits so arranged that during operation there will always be a virtually complete cancellation of signals fed back to the base of the transistor via the two junctions.

By making the neutralising capacitor in the same semiconductor body as the transistor, it becomes possible to hold the ratio of their capacitances to within 5 per cent or better even though their actual capacitance values may vary by ±30 per cent.

In Fig. 1 Mullard show how conventionally a neutralising capacitor C1 is connected between the base of a transistor and the side of a parallel LC tuned circuit away from the transistor collector. In Fig. 2 there is shown the manner in which the transistor and neutralising component C1 of Fig. 1 is realised as an integrated circuit.

The patent gives full details of the actual semiconductor bodies that can be used for realisation.

## BP 1 245 714

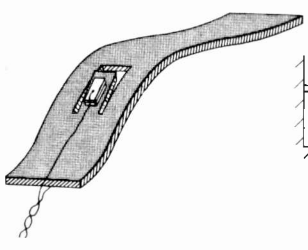


**Fig. 1**

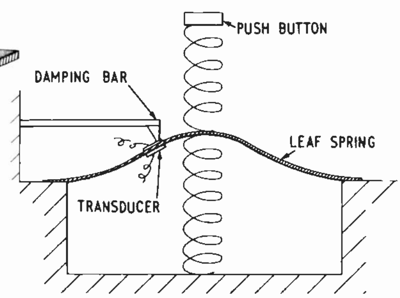



**Fig. 2**

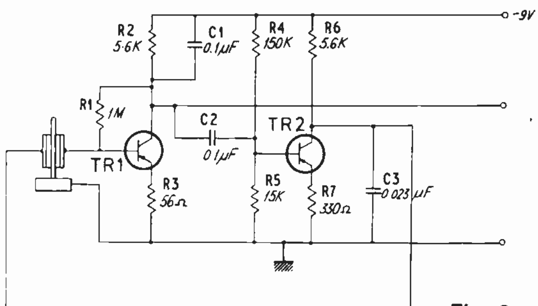
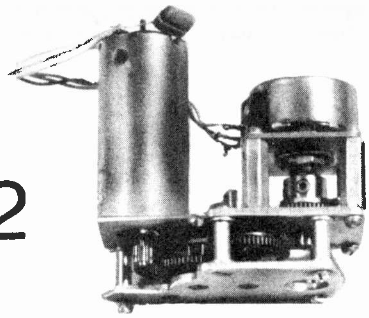
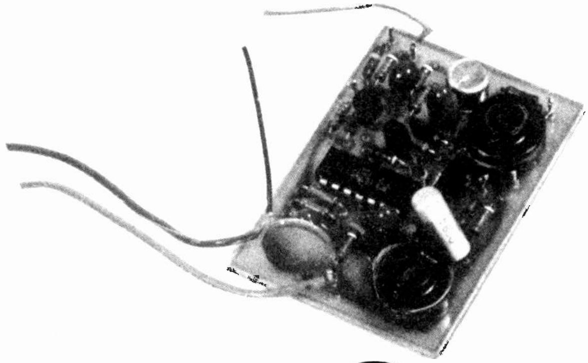



**Fig. 3**

Part 2





# Model Servo Control

By A.J. Dunn

THE circuit of servo amplifier "B" is basically similar to that of servo amplifier "A" and with the exception of D1, C2, VR2, VR3, D2, C3 (Fig. 5) the action is the same. In this circuit TR1 is complementary to TR2 and $V_{be}$ voltage changes with temperature are therefore eliminated. TR10 replaces the resistor R8 of the long-tailed pair in amplifier "A" and acts as a constant current source, bias being determined by R10, R8a and R9b. Note that reducing R8b increases the dead zone.

The use of a complementary emitter pair enables R2 to have a higher value and the input impedance is high. If large values of C1 and R1 are used, R2 (approximately 10 × R1) may be fitted to swamp the leakage effects of C1.

## DEAD ZONE OPERATION

The function of D1, C2, VR2 is as follows: if the input signal is increased, TR5 conducts more and TR3 and TR4 are turned on.

The collector of TR3 (bottomed) is approximately 0·2V below the +6V supply and, according to the setting, the wiper of VR2 may be at +4V. The diode D1 is therefore forward biased and C2 discharges to 5·2V, there being a drop of 0·6V across D1 and 0·2V across TR3. This can be considered as being equivalent to connecting a 5·2V supply to the wiper of VR2 in place of +4V; the voltages associated with all sections of VR1 are consequently increased.

If the input signal increase is not large the wiper of VR1 would have been initially not far from the dead zone and the rapid voltage increase at VR1 would cause TR6 to conduct more, TR5 less, and TR4 and the motor to be switched "off" before it would have otherwise done without the action of D1, C2, VR2. The effect of motor inertia is therefore to carry the wiper into the normal position of the dead zone and not beyond.

When TR3 is cut off its collector is held by R5 and R6 at 0V and D1 is reverse biased. C2 therefore charges to the voltage set by the position of VR2 wiper and the voltages associated with VR1 return to the normal condition, reducing the voltage applied to the base of TR6. If the wiper of VR2 is set to more than +5·2V then D1 is not able to conduct as above and hence plays no part.

## OVERCOMING HUNTING

If the wiper of VR2 is set to progressively lesser voltages than +5·2V, then the voltage change at this point and consequently at the wiper of VR1 becomes greater. If the voltage change at the wiper is made equal to the equivalent dead zone in use, the effect is to overcome hunting effects without the necessity of increasing R16 and R17, or alternatively to increase resolution. If the voltage change at VR2 wiper is increased further, then another effect is involved.

If bottomed, TR3 and D1 discharge C2 relatively rapidly; thus in the example quoted, the motor is switched off prior to entering the "normal" position of the dead zone. On cut off, C2 is charged through VR2 relatively slowly; this time must elapse before the voltage at VR1 is restored and the motor reverse should have traversed the dead zone.

The damping effect of C2 can be tuned by means of VR2 to damp out persistent hunting. The components D2, C3 and VR3 have the complementary effect to D1, C2, VR2 and cause, by an amount set by VR3, the early cut-off of the motor in the reverse direction.

The fail safe operation is effected by changing the connection of R18 from 0V when it has no significant effect to +6V. This can be performed remotely, by using a relay. If R18 is less than R4 TR2 will cut off, and by selection the required torque unit setting can be obtained.

## CONSTRUCTION AND TESTING

The components should be assembled on a printed circuit board, the pattern and layout being similar to that of Servo A (see Figs. 6 and 7). On completion VR2 and VR3 should be set to have no action.

If hunting takes place, when testing with the decoder for a given time constant for R1-C1, then VR2 and VR3 should be adjusted to damp out the hunting.

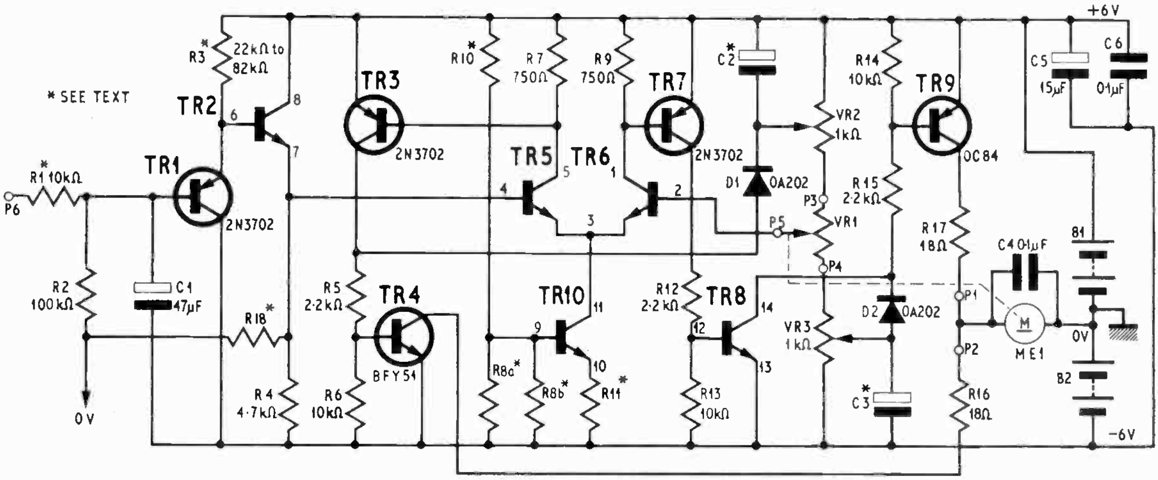



Fig. 5. Circuit diagram of servo amplifier "B". The connection to R18 should be brought out separately if "fail safe" operation is contemplated

# COMPONENTS . . .

## SERVO AMPLIFIER "B" (Fig. 5)

### Resistors

| | | | |
|---|---|---|---|
| *R1 | 10kΩ | *R10 | 9·1kΩ |
| R2 | 100kΩ | R11 | 680Ω |
| *R3 | 22k to 82kΩ | R12 | 2·2kΩ |
| R4 | 4·7kΩ | R13 | 10kΩ |
| R5 | 2·2kΩ | R14 | 10kΩ |
| R6 | 10kΩ | R15 | 2·2kΩ |
| R7 | 750Ω | R16 | 18Ω |
| *R8a and b | 2 × 2·2kΩ | R17 | 18Ω |
| R9 | 750Ω | R18 | 4·7kΩ |

All ±10% ⅛W carbon

### Potentiometers

VR1 500Ω linear, linked to servogeared motor
VR2 1kΩ linear preset
VR3 1kΩ linear preset

### Capacitors

C1 47μF tantalum
*C2 47μF tantalum
*C3 47μF tantalum
C4 0·1μF polyester (mounted on motor)
C5 15μF tantalum
C6 0·1μF disc ceramic

### Transistors

| | |
|---|---|
| TR2, TR5, TR6, TR8, TR10 | Contained in IC1 CA3046 (RCA) |
| TR1, TR3, TR7 | 2N3702 (3 off) |
| TR4 | BFY51 |
| TR9 | OC84 |

### Diodes

D1, D2 OA202 (2 off)

### Batteries

B1, B2 Two 6V dry batteries

### Miscellaneous

Printed circuit board
Solder pins
*See text

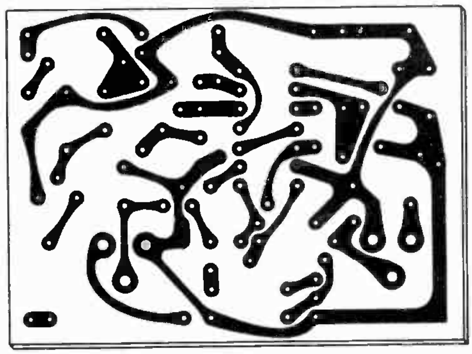


Fig. 6. Printed circuit pattern (full size) for servo amplifier "B"

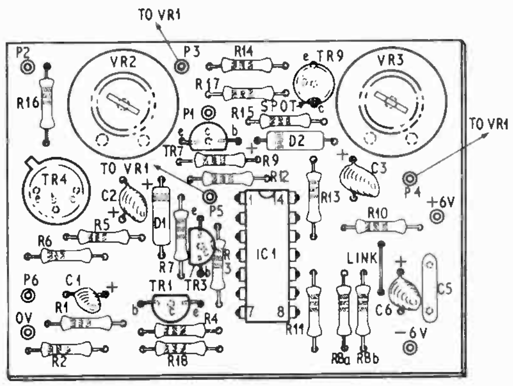



Fig. 7. Component layout for servo amplifier "B"

## SERVO AMPLIFIER "C"

As shown in Fig. 8 the circuit is similar in form to servo amplifier "A" but fewer components are used. The unit is compact and may be mounted directly on the torque unit. TR1 and TR2 (not thermally coupled) operate as a long-tailed pair with R4 adjusted to define the current so that TR3 and TR4 cannot be on simultaneously.

Changes in temperature and supply voltages markedly change the width of the dead zone which should for safety be made approximately 15 per cent of the range.

TR3 is operated directly from TR1 which despite a gain of 100 may turn on slowly in relation to TR5. The selection of component values follows as for Servo amplifier "A."

## CONSTRUCTION AND TEST

The components should be assembled on a printed circuit board; the copper pattern is as in Fig. 9 and component layout Fig. 10.

The unit should be tested as for servo amplifier "A" noting the absence of "fail-safe" circuitry and that the switching action of TR3 and TR5 in Fig. 8 is reversed with respect to the motor.

## COMPONENTS . . .

### SERVO AMPLIFIER "C" (Fig. 8)

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 10kΩ | *R6 | 4·7kΩ |
| R2 | 750Ω | R7 | 10kΩ |
| R3 | 750Ω | R8 | 18Ω |
| R4 | 6·2kΩ | R9 | 18Ω |
| R5 | 2·2kΩ | *R10 | 100Ω |

**Potentiometer**
VR1 500Ω linear, linked to servogeared motor

**Capacitor**
C1 47μF tantalum

**Transistors**

| | | |
|---|---|---|
| TR1, TR2 | 2N3702 | (2 off) |
| TR3, TR4 | 2N3704 | (2 off) |
| TR5 | OC84 | |

**Batteries**
B1, B2 Two 6V dry batteries

**Miscellaneous**
Printed circuit board
Solder pins
*See text

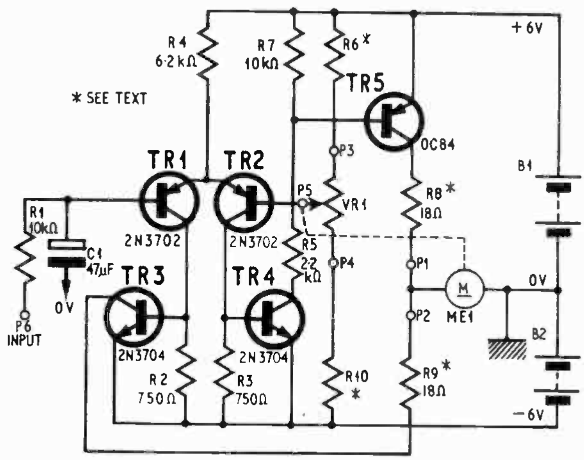



Fig. 8. Circuit diagram of servo amplifier "C"

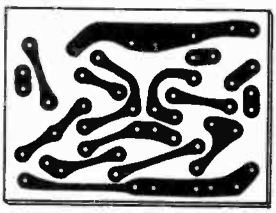


Fig. 9. Printed circuit pattern (full size) for servo amplifier "C"

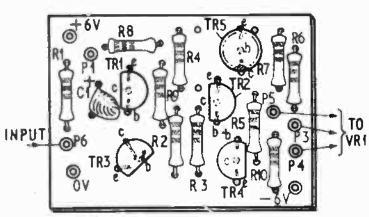
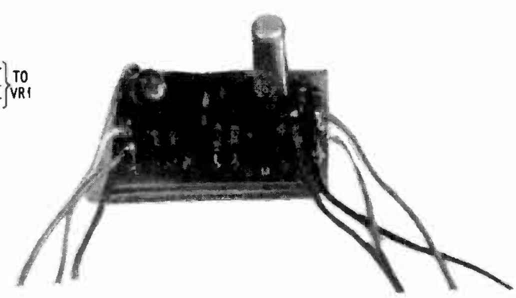


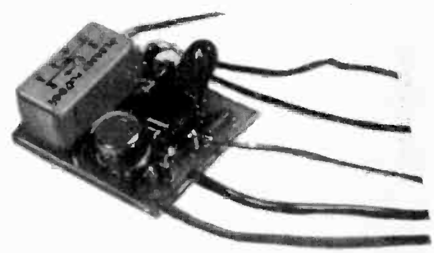

Fig. 10. Component layout for servo amplifier "C"

## FAIL SAFE SYSTEM

As shown in the servo amplifier circuits, a means is provided to preset the torque unit rotation in the event of a transmitter or system failure. This is effected by changing the connection of grouped servo amplifier leads by means of a lightweight relay.

As shown in Fig. 11, a decoder output pulse is also applied through R1 and D1 to the base of TR1. Capacitor C1 charges rapidly during the period of the pulse, the source impedance being R1 and the collector resistance Rx of the logic unit used (approx. 4·7 kilohms).





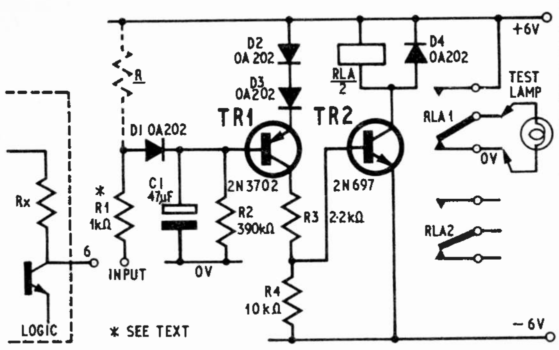



Fig. 11. Circuit diagram of "fail safe" system

## COMPONENTS . . .

**FAIL SAFE CIRCUIT (Fig. 11)**

**Resistors**

| | |
|---|---|
| R1 1kΩ | R3 2·2kΩ |
| R2 390kΩ | R4 10kΩ |

**Capacitor**
C1 47µF

**Transistor**
TR1 2N3702
TR2 2N697

**Diodes**
D1, D2, D3, D4 OA202 (4 off)

**Relay**
RLA 12V 37mA, two sets of change over contacts (minimum resistance 240 ohms)

**Miscellaneous**
Printed circuit board
Solder pins
Test lamp

### CHARGE TIME CONSTANT

Diode D1 prevents discharge back through R1 and the discharge time constant is $C_1 \times R_2$. Assuming a decoder pulse of 1ms per cycle period of 40ms this ratio of 40 : 1 makes an effective charging time constant which is still greater than the discharge time and C1 steadily charges. The base of TR1 is 0·6V $V_{be}$ + (2 × 0·6V) (D2 + D3) below the +6V rail (i.e. approx. + 4V). When C1 is charged to this value TR1 cuts off and R4 ensures that the base of TR2 goes to −6V cutting it off and allowing the relay RLA to release to the position indicated in Fig. 11 connecting the test lamp to 0V.

Referring to servo amplifier B, this is the normal working state; the fail safe acts as inoperative and no current is drawn by the circuit shown.

### PULSE FAILURE MODE

In the event of pulse failure, the charge on C1 falls relatively slowly to about +4V when TR1 turns on. The base current would be $4/R_2$ and, assuming a gain of 100 for TR1, the collector current is

$$\frac{4\times100\times10^3}{390\times10^3}\text{ mA.}$$

or approximately 1mA base current for TR2.

Assuming a gain of 50, the collector current of TR2 would be about 50mA sufficient for a small relay of more than about 240 ohms. The diode D4 is normally reverse biased but conducts when the relay is switched off protecting TR2 from the inductive back e.m.f. pulse from RLA.

### CONSTRUCTION AND TEST

The components should be assembled on a printed circuit board as shown in Figs. 12 and 13 with R1 fitted and a 6V lamp connected for test, as shown. The copper strips retained under the relay must be arranged to suit the relay used.

With the −6, +6 and 0V supply lines connected, the input should be connected to +4·5V (from a battery or from a potentiometer across 0V and +6V). The time taken for the relay to operate and release on the application of +4·5V should be noted. If the "make" time is slow and the "release" time less than half second, then C1 should be checked for excess leakage current.

The unit should then be tested in connection with the working decoder, it being noted that any output could be used, but it is preferable to use one with a defined pulse-to-cycle time ratio, such as the ungated complex one previously described.

The unused contacts may be wired for servo amplifier "A" or used with any non-proportional model function. The resistor R1 forms a means to protect the logic units from accidental shorts.

The positive going logic output is derived from Rx and in certain circumstances this may produce only about 4·2V at C1.

A momentary interruption of pulses may therefore cause the fail safe device to operate after too short an interval. In this case R1 should be connected as shown. In cases where an exceptionally long interval (+5 seconds) is required before fail safe operation, D2 and D3 should be replaced by a 3·5V Zener diode. ★

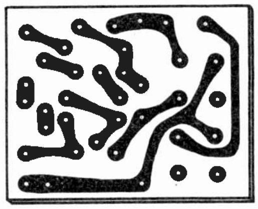


Fig. 12. Printed circuit pattern (full size) for "fail safe" system

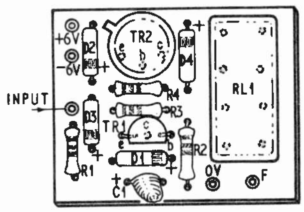



Fig. 13. Component layout for "fail safe" system

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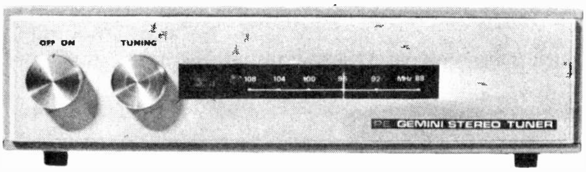


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**Published by Iliffe Books (Butterworth Group)**
**614 pages, 9in × 6in. Price £4·75**

PREVIOUS editions of this work have been referred to as "Scroggie" and one wonders whether this well-known electronics engineer, who graduated in 1922, is ever likely to retire. The amazing quality of this latest edition is the maintenance of the established down to earth style coupled with a massive quantity of technical information, updated to present day techniques.

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M.A.C.

### I.T.V. 1972

**Published by the Independent Television Authority**
**240 pages, 9in × 7¾in. Price 75p**

THE latest edition of the guide to Independent Television is packed with information about every facet of television broadcasting from the making of a programme to audience rating techniques. There is liberal use of colour and all the statistics are presented in a clear, easy to read, manner.

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S.R.L.

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**Published by B. T. Batsford**
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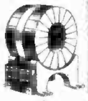

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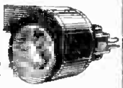

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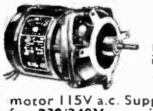

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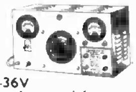

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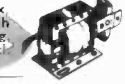

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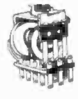

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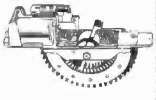

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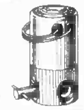

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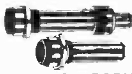

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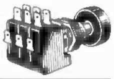

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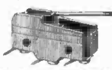

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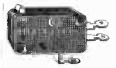

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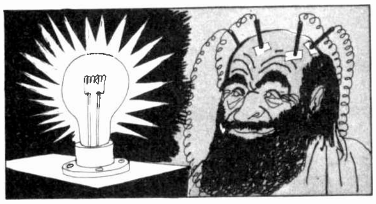

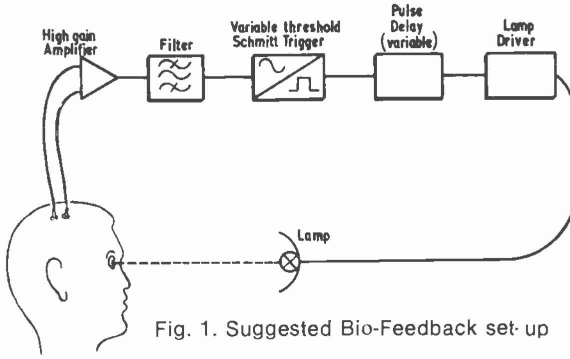


Fig. 1. Suggested Bio-Feedback set-up

### *ELECTROPSYCHEDELIA ?*

Flicker phenomena, discussed by many and at some length by Dr W. Grey Walter in his book "The Living Brain", is the effect which sometimes manifests itself as the result of the pulsating nature of the light from cine projectors, or the intermittent flashing of sunlight through roadside trees during a drive in the car. This phenomena is often exploited in such places as discotheques where strobed xenon lamps are employed.

The effect is difficult to describe in purely objective terms, but, for most observers, this generally seems to evidence itself as a form of pleasant swimming sensation or a feeling of moving through time. To a large extent the degree of influence appears to be related to the flicker rate of the lamp and, in this context, probably has the greatest effect when it is synchronous with the frequency of the "alpha" waveform produced by the brain.

The amplitude of this alpha rhythm seems, in most cases, to be very much suppressed so that for many individuals the phenomenon may be either just noticeable or entirely absent.

However, a method for selecting and, even, raising the intensity of the elusive rhythm has just been rediscovered. This has resulted in the brand-new craze which is currently sweeping through the U.S.A., previously called "photic" stimulation back in the 1950's, and now enjoying the title "bio-feedback".

In reality, the concept behind this bio-feedback lark is an attempt to help people teach themselves the art of controlling their brain rhythms, with the intention of encouraging an equivalent condition of that transcendental experience, only hitherto reached by masters of deep meditation!

Basic operation of a bio-feedback set-up will be seen from Fig. 1. Electrodes, dampened in saline solution and attached to the subject's scalp, pick up the very much attenuated signals originating in the cortex of the brain. They are then amplified several hundred thousand times and, subsequently, filtered since the required signals are almost always buried deep in either noise, or unwanted signals of greater amplitude.

The resulting output is fed to a Schmitt trigger prior to operating a simple delay circuit which either flashes a lamp into the subject's eyes, or controls an audio oscillator. In this way the flash-rate and delay can be adjusted to achieve a constant positive feedback such that the lamp flashes at the most effective point in the brain's alpha waveform.

This, essentially, instant way of "mind-travelling" could have quite exciting possibilities and, although not a therapy worthy of recommendation to epileptics, may hold some of the keys to the more arcane aspects of psi phenomena.

I notice that this rather costly form of "everyman's electroencephalography" is already beginning to catch on in this country. Anyone for back-pocket hypnosis?

### *FAST TALKER*

For too long now the blind have been forced to contend with "talking-books" which produce far fewer words per unit time than could be read visually. Up till quite recently, unless these people were prepared to tolerate a kind of "chipmunk" sound, the speed of playback could not be increased.

The visually handicapped are not the only ones who have cause for complaint. How about education for adults and children having high IQs and capable of absorbing data at great rates, but who are tied by the speed at which the most backward can understand the same information?

Such problems are almost as good as solved, because by next summer the Cambridge Research and Development Group in Westport, Conn, U.S.A. is scheduled to have a helpful little i.c. device available. Priced as low as $10 (£6) the i.c. will permit normal speech rate to be electronically varied from about 100 to 500 words per minute without the annoyance of an accompanying change in pitch! (useful for solid-state echo too).

Operation of the device, Fig. 2, is, I understand, similar in principle to one developed by Phillips a short while ago. This relies on the so-called "bucket-brigade" technique employing chains of capacitors interposed between charge-transfer transistors forming an analog version of the shift-register. Data is passed from "bucket" to "bucket" in the form of charge deficits clocked through the entire register at a rate determined by an external clock-generator.

While such an idea must represent a considerable boon to the handicapped, I cannot help feeling that its total value will need to be revised if ever the disc-jockeying fraternity latch-on to its possibilities!

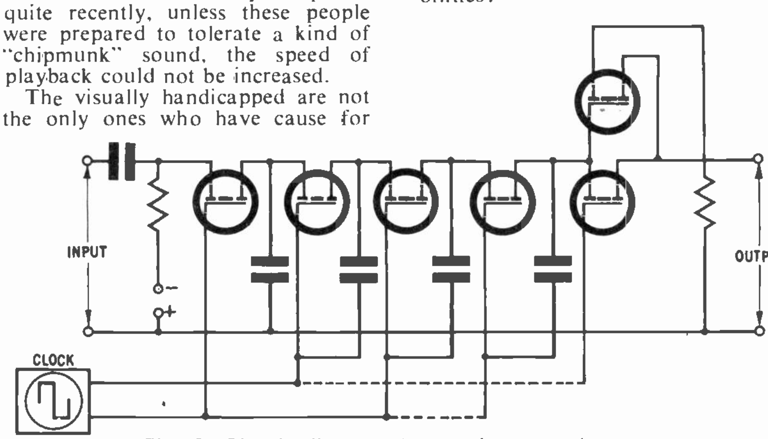


Fig. 2. Circuit diagram for varying speech rate

# THE UNIJUNCTION TRANSISTOR

**By E. C. Copperthwaite**

ALTHOUGH it is only in the last few years that unijunction transistors have found popularity among non-professional users, they were demonstrated by Henrich Welker in France as far back as 1948. This device was made commercially available due to the efforts of I. A. Lesk of Motorola in 1952.

There is no other solid state counterpart to the unijunction transistor (UJT), nor is there any vacuum tube that is functionally similar. Its unique characteristics make it particularly suitable for use in oscillators, timing circuits and thyristor trigger circuits.

## TYPES OF CONSTRUCTION

Most commercially available unijunction transistors are of the cube or bar structure (see Fig. 1), and these have been in use for many years. But as these components were not readily adaptable to automatic production methods, Motorola's design team have produced an annular construction type.

The die used to produce this annular type is fabricated using techniques similar to those used for making silicon annular transistors. This relatively new construction method is now batch-processed like conventional transistors for extensive availability and considerable lowering of costs.

Tests have proved that the resultant uniformity also simplifies various applications and intrinsic stand-off ratios (see below) are confined to a narrow range of variation.

## GENERAL PRINCIPLES

The UJT (originally called a double base diode) has three terminals namely the emitter, base-one and base-two (Fig. 2a). The emitter is composed of a $p$-type junction and is positioned near the centre of a pair of dissimilar bases of $n$-type silicon (B1, B2). Between B1 and B2 the unijunction has the characteristics of an ordinary resistance; this resistance is called the interbase resistance ($R_{BB}$) and at a temperature of 25°C can vary between 4·7 kilohms and 9·1 kilohms for different devices.

It is simplest to describe the action of a unijunction with reference to the equivalent circuit of Fig. 2b. With no current flowing in the emitter a voltage will appear at the emitter proportional to the interbase voltage ($V_{BB}$). For current to flow into the emitter this voltage plus the forward voltage drop of the emitter junction ($V_D$) must be exceeded. When this occurs, the injection of holes into the silicon bar causes an increase in the number of electrons in the base and hence the resistance of base-1 drops, producing the negative resistance region shown in Fig. 3.

The threshold voltage is called the emitter peak point voltage ($V_P$). When the emitter voltage ($V_E$) is below $V_P$ only a small leakage ($I_{EO}$) flows.

The peak voltage ($V_P$) of the unijunction transistor varies in proportion to the interbase voltage ($V_{BB}$) according to the equation

$$V_P = \eta V_{BB} + V_D$$

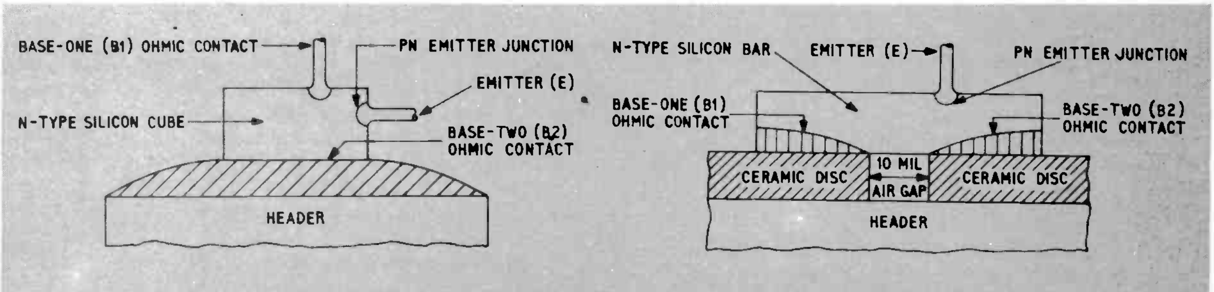


Fig. 1. Cross sectional views of unijunction structures. (a) cube structure; (b) bar structure

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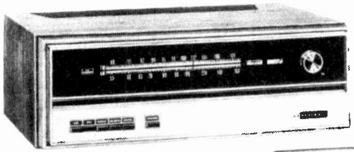

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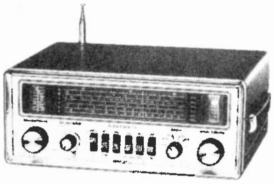

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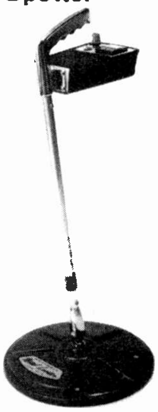

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| 2N1599 | 122p | 2N4062 | 12p | ACY17 | 31p | BC107 | 12p | BD135 | 38p | MPS6531 | 35p | 5D1 | 10p |
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| 2N1711 | 26p | 2N4126 | 27p | ACY19 | 23p | BC109 | 12p | BD141 | 227p | NKT211 | 25p | V763 | 28p |
| 2N1893 | 54p | 2N4284 | 24p | ACY20 | 20p | BC122 | 21p | BDY20 | 92p | NKT212 | 25p | W106B1 | 45p |
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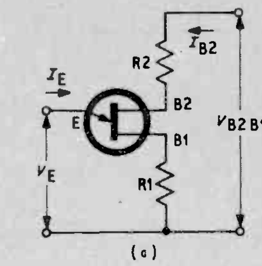


Fig. 2a. Unijunction symbol and nomenclature

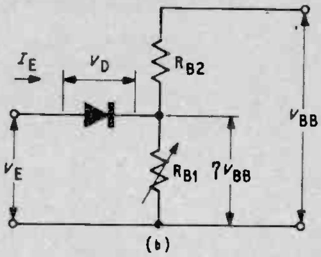


Fig. 2b. Equivalent circuit of UJT

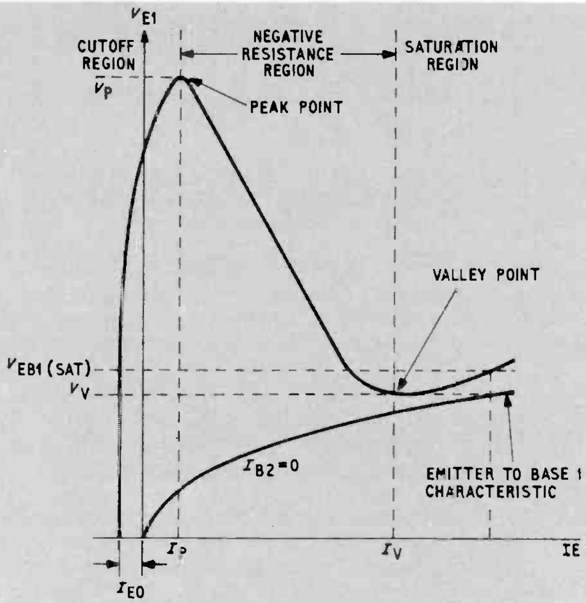


Fig. 3. Static emitter characteristic of UJT

The parameter $\eta$ is a constant and is termed the intrinsic stand-off ratio. It is that fraction of the interbase voltage which appears as part of the peak point voltage, this important parameter is a constant for a given device and the value lies between 0·51 and 0·82. The equivalent diode emitter voltage ($V_D$) is in the order of 0·5 volts depending on the UJT and the temperature. With an increase of temperature $V_D$ decreases, but it is possible to overcome this variation by making use of the positive temperature coefficient of $R_{BB}$. If a resistor $R_2$ is used in series with base-two (see Fig. 2) the temperature variation of $R_{BB}$ will compensate for the original loss.

## TYPES OF UJT

Fig. 4a shows the conventional type (UJT) which is a single junction device having an emitter and two dissimilar bases.

Fig. 4b is called a complementary type (CUJT) and works by applying opposite current and voltage polarities to those used in the conventional UJT. A greater circuit flexibility is now obtainable and can be comparable to *pnp* and *npn* transistors. The CUJT has shown better stability, improved uniformity and closer intrinsic standoff ratio. It is more reliable over the specified temperature range allowing less compensation control.

**TABLE 1: UJT NOMENCLATURE**

| SYMBOL | DEFINITION |
|---|---|
| $I_E$ | Emitter current |
| $I_{EO}$ | Emitter reverse current |
| $I_P$ | Peak point emitter current. The total emitter current that can flow without permitting the UJT to go into the negative resistance region. |
| $I_V$ | Valley point emitter current. Represents the current flowing in the emitter when the UJT is biased to the valley point. |
| $R_{BB}$ | Interbase resistance. The resistance measured between base-two and base-one at a specified interbase voltage. |
| $V_{BB}$ | Voltage existing across base-two and base-one. |
| $V_P$ | Peak point emitter voltage. |
| $V_D$ | Forward voltage drop of the emitter junction. |
| $V_V$ | Valley point emitter voltage. |
| $\eta$ | Intrinsic stand-off ratio. |
| $\alpha R_{BB}$ | Interbase resistance temperature coefficient. Variation of resistance between B2 and B1 over the specified temperature range. |

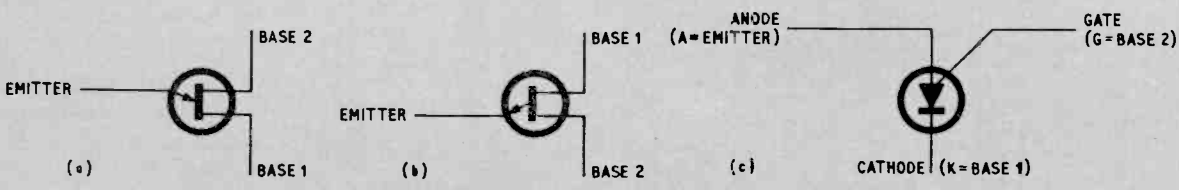


Fig. 4. Types of UJT. (a) conventional UJT; (b) complementary UJT; (c) programmable UJT (PUT)

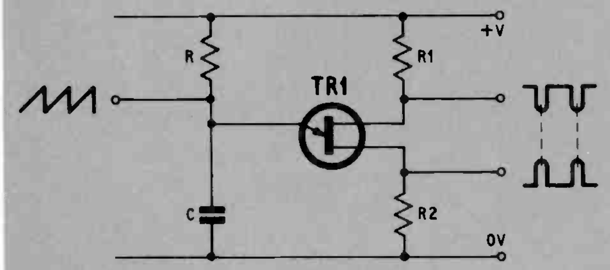


Fig. 5. Relaxation oscillator circuit showing waveforms available

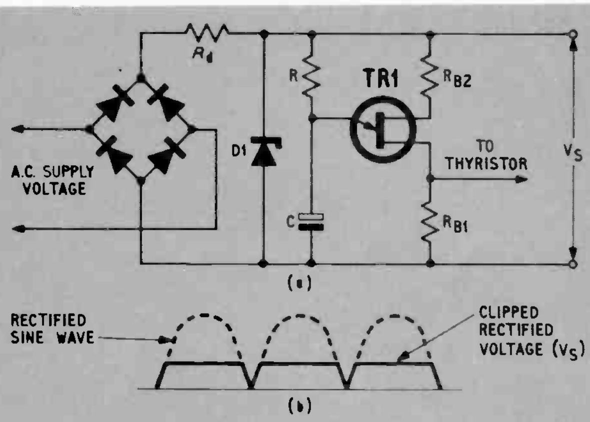


Fig. 6. (a) Full wave control circuit; (b) Zener clipped rectified voltage

Fig. 4c illustrates a third configuration, termed a programmable type (PUT). The PUT is programmable in that a number of characteristics that are set in the conventional type (i.e. valley current, peak current and interbase resistance) can be adjusted accordingly or programmed into the PUT at the designer's discretion. With careful selection of additional resistors the designer can turn the device into any one of a large number of discrete UJT's.

The PUT is a planar passivated *pnpn* element and hence is not a true UJT, it is conventionally represented by a symbol similar to the SCR. The PUT's electrodes are known as the anode, gate and cathode, which correspond to emitter, base-two and base-one respectively.

## FLEXIBILITY

The UJT is a unique device in that it can be used for any number of applications involving oscillation, timing circuits and triggering devices for turning-on thyristors.

UJT's offer the advantage of being excellent circuit simplifiers allowing the elimination of a number of components. For example, one UJT used in the bistable mode (see Fig. 5) can provide the function that normally would require two transistors and the associated capacitors and resistors. Outputs can be taken from any of the three electrodes: an approximation of a sawtooth waveform from the emitter; a positive pulse from base-one and a negative pulse from base-two. A high degree of frequency stability and accuracy can be obtained by the careful selection of the timing constants RC.

## APPLICATIONS

A full-wave control circuit shown in Fig. 6a with Zener clipped rectified voltage Fig. 6b. The resistor $R_d$ is chosen to limit the current through the diode D1 enabling this device to work within its rated specification.

Fig. 7a shows a unijunction trigger circuit for a gated thyristor and its associated waveforms Fig. 7b. As capacitor C1 is being charged current ($I_{EO}$) flows through the interbase resistance ($R_{BB}$) of the unijunction, say of the order of 1μA. Resistance $R_{B_1}$ is included in the circuit to provide a path for this current and prevent an undesirable turn-on of the thyristor through its gate. $R_{B_1}$ is calculated so that a maximum voltage developed across it will be less than 0·2 volt. For a typical UJT the resistance of $R_{BB}$ lies between 4·7 kilohms and 9·1 kilohms, so with an applied operating voltage of 20 volts, the value of $R_{B_1}$ would be:

$$R_{B_1} = \frac{0{\cdot}2 \times R_{BB}\,(\text{min})}{V_S} = \frac{0{\cdot}2 \times 4{\cdot}7\text{k}\Omega}{20} = 47 \text{ ohms}$$

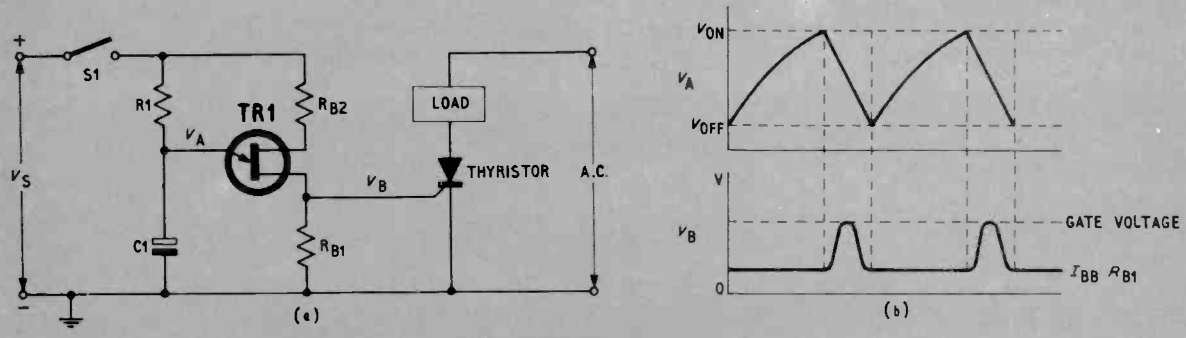


Fig. 7. Relaxation oscillator trigger circuit and associated waveforms

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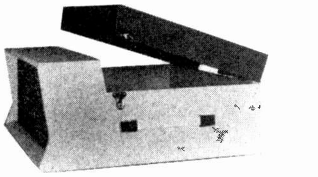

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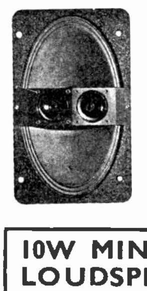

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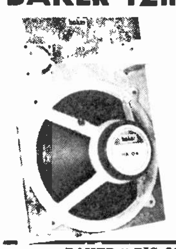

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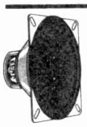

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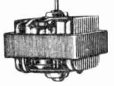

E.M.I. TAPE MOTORS. 120v. or 240v. AC. 1,200 r.p.m. 4 pole 135mA Spindle 0·187 × 0·75in. Size 3½ × 2½ × 2¼in. (illustrated). Post 15p. **£1·25**

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To ensure the UJT remains stable during an increase of temperature an additional resistance $R_{B2}$ is connected in series with base-2.

A half-wave trigger circuit is shown in Fig. 8, where the thyristor is acting as a rectifier and power control device. No power is supplied to the load during the negative half cycle, but a variable power is supplied to the load during the positive half cycle.

During the positive half-cycle the gated thyristor is switched on by a time (phase angle) determined by the control current. The relative power in the load can be controlled by varying the phase angle when the thyristor is switched on.

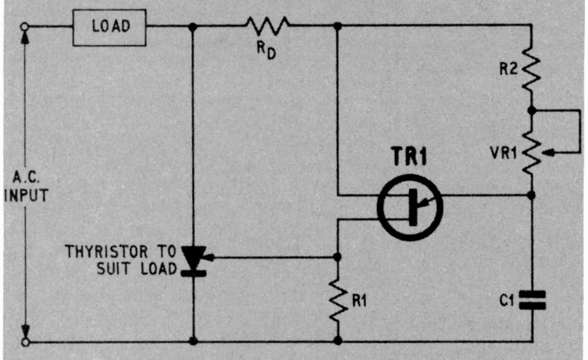


Fig. 8. Half wave UJT trigger circuit

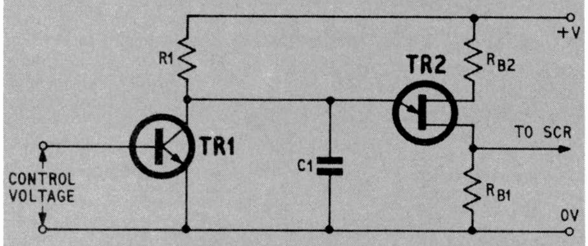


Fig. 9. Shunt transistor control of UJT

## SHUNT TRANSISTOR CONTROL OF UJT

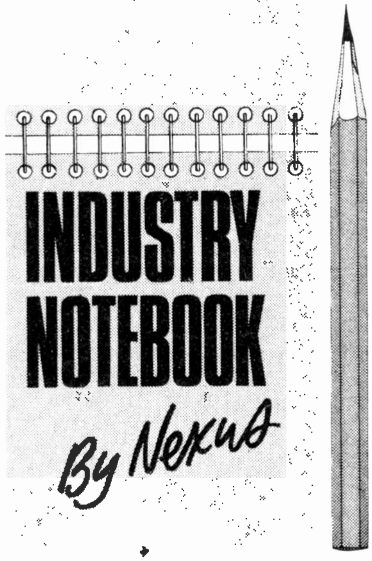
Phase control can be obtained by use of a *pnp* or *npn* transistor connected to shunt with the emitter capacitor of the unijunction. The amount of current in the base of the transistor will control the effective charging current to the capacitor, and hence will control the trigger angle of the UJT and the SCR.

Fig. 9 shows a phase control circuit and functions as follows. Transistor TR1 shunts some of the charging current supplied to capacitor C1 by resistor R1 in an amount dependent on the base drive of TR1. The more TR1 is turned-on, the later the UJT will trigger, consequently lowering the output of the SCR. Depending on the value of R1 and the base drive to TR1 the diversion of charging current from C1 will advance or retard the trigger angle accordingly. ★

## YEAR BS9000?

It's been a long time coming but this could be Year BS9000. Just to refresh your memory, BS9000 was the outcome of the Burghard Report or, to give its full title, "2nd Report of the Committee on Common Standards for Electronic Parts." The Report was published by H.M.S.O. in 1965.

The following year the Report was accepted on behalf of the electronics industry by the Conference of the Electronics Industry and the British Standards Institution was given the task of implementing the recommendations. Supervision of the operation on a practical day-to-day basis is the responsibility of the Electrical Quality Assurance Directorate of the Ministry of Defence.




The BS9000 scheme set out with the finest ideal and that was to formulate a new and up-to-date set of specifications for electronic components which would ultimately supersede the rag-bag of specifications originated in the United States and Europe over the years. Clearly this would be a major operation but few people, in my opinion, realised what a mammoth task it would become. The technical problem was big enough to begin with. Add to it the democratic process involving countless committees on which were representatives not only of BSI and the Ministries but also of manufacturers and users, all trying to reach a consensus, and you get some idea of why BS9000 has been so long on the runway, so to speak, without getting airborne. But movement is now in sight.

Mr John Hinchcliff, Assistant Director (Components), Electrical Quality Assurance Directorate, Ministry of Defence, is at the centre of BS9000. At a recent dinner organised by component distributors he revealed a few facts and figures on progress to date.

All the basic BS9000 specifications and many supplementary specifications have now been published. Almost 200 component manufacturers, distributors and test houses have applied to join the scheme and over 80 have so far been fully approved to operate it. More than 100 components (or component families) have been or are being approved and this figure is doubling every six months. About 200 military semiconductor specifications have been brought into the system and military digital integrated circuits are soon to be included. Nevertheless, stated Hinchcliff, there is still an enormous way to go. Several thousand components will eventually be drawn in.

BS9000 has been a source of irritation to the Americans. They see it as a protectionist policy under which their long established military specifications and quality assurance procedures will become obsolete and will no longer be specified in British equipment to the detriment of American exports.

Meantime, the Europeans have not been idle. In 1967 they instituted their own Harmonised System of Quality Assessment for Electronic Components under the title CENEL 1. Britain joined CENEL 1 as a full member with France, Germany and Italy with an understanding that each country would mutually recognise standards, approvals, and methods of inspection as equal to their own. Other European countries are in process of joining.

To cap it all, the International Electrotechnical Commission (IEC) is considering a similar system to operate on a world-wide basis. Clearly, world standards would be best of all but will take many more years to achieve leaving, as one disgruntled components man remarked to me, the fall guy in the middle hacking his way through a jungle of national and international specifications as best he can.

## ABSENTEES

The British contingent at this year's Paris Components Show (April 6–11) will be one of the smallest on record, numbering little over 20 companies. Last year's show was both expensive and disappointing and this, I suspect, is why so many "regulars" of previous years have decided to stay at home this year despite our imminent entry into the Common Market.

But this doesn't explain why industry giants GEC and Plessey have decided to stay away from the big IEA Show at Olympia in May. Selectivity seems to be the answer. Publicity managers with restricted budgets have spent sleepless nights worrying over the optimum split of funds between direct mail shots, press advertising, exhibitions, and even the supply of book matches. And exhibitions seem to be losing out.

## TOTAL CAPABILITY

Total capability, it's a hackneyed phrase but it still means something when attached to Decca Radar, still proudly holding the Number One Spot as world suppliers of marine radar and determined as ever to stay there in what, by any standards, is a highly competitive business.

Decca launched the biggest radar event of the year. Not half a dozen, nor even a dozen, but a dazzling two dozen new models on show for the first time, twenty of them for coastal and open sea use and four river radars. All the new radars owe a lot to the solid state RM914, introduced just a year ago and which won the Queen's Award for technological innovation.

The RM914, already topping 3,000 sales, was a runaway success. Big features were a solid state local oscillator, solid state modulator, and wide use of integrated circuits. The same modules, or derivations of them, are in all the new models which come in a huge choice of display sizes, scanner sizes, transmitter powers and optional facilities.

Decca's competence in advancing the state of the art in marine radar is perhaps most convincingly demonstrated by one simple fact. The latest 25kW radar with a 60 mile range consumes no more power than the 3kW, 24 mile range D202 model which Decca introduced as the first commercial marine radar to use transistors in 1963.

## DIVERSIFICATION

The high-powered "think-tank" at Frimley which we have known as E-A Space and Advanced Military Systems Ltd and more conveniently as EASAMS since 1962 has now officially become EASAMS Ltd.

Reason for the change of name is a change of emphasis although marketing manager R. M. French assures me that EASAMS still has plenty of military work. But the sort of systems analysis and engineering which made EASAMS famous is now being applied equally effectively in the civil field and not only in electronics. Examples are the design, construction and commissioning of new hospitals, the development of transport and distribution systems, and ports and harbour management.

At the same time there is plenty of electronic work such as studies for ESRO and on the MRCA project.

# Readout—
## A SELECTION FROM OUR POSTBAG

**Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.**

## Abysmal writing

Sir—As a regular subscriber to your normally excellent magazine, I feel that I must protest at what has become its present standard of presentation. You have excellent news columns, excellent features, and many highly interesting projects, *but* I have now become convinced that the standard of presentation of your projects has now fallen to a level where they are intelligible only to those who are experts in your pseudo-scientific jargon.

This situation was drawn to my attention about a year ago during the course of 6th Form Electronics that I teach. I use, for this, back copies of P.E. as source material for student projects, but increasingly I have been aware that these 17- and 18-year-old Grammar School pupils were just unable to understand what your projects were about. Often I am faced with the plaintive, "What on Earth are they trying to say." My initial reaction was to blame them, but now I realise that I have been quite unjust, some of what appears is quite unintelligible unless you have prior knowledge of what the project is about.

In your December 1971 issue your article about *Logical Radio Control* is the most abysmal example of semi-scientific writing I have seen in many years as a professional scientist. By pooling the resources of two physics graduates, two graduate electrical engineers, the 6th Form and myself, we have worked out how this system can be used to control six channels, but it has taken us two weeks to work it out. God help those who are less adept than ourselves—they will just move on disillusioned.

How much simpler it could have been if someone had taken the trouble to explain the significance of each pulse, the significance of each pulse length and the significance of the need to transmit pulse trains. If you search, some of this material is present, mixed up with the wonders of the technicalities. But most is absent.

In the same issue your article *I.C. Digital Dice* reduced some of my 6th Form to glassy eyed disbelief. I offer the following paragraph as an example of how this article could be made much more intelligible to a much wider public:

"A dice generates the numbers 1 to 6 in a random order. This device achieves this in the following manner. A signal generator produces a series of electrical pulses, which are then counted in binary form. The counter counts from 1 to 6, and then returns to 1. The sequence of numbers is repeated over and over again just as long as pulses are fed to the counter.

To make the dice random, and cheat proof, we must be able to stop the counter when we do not know what the count is, and we must make the rate of counting very high.

The dice described generates pulses at 4,800 per second, so that each number from 1 to 6 appears 800 times a second, and each time it appears for only 1/4,800 second. This is too fast for the eye and hand to see, and so when ever the counter is stopped the numbers must be in a random order."

I am prepared to admit that many readers would not require such a simple approach to a project, but such an approach to presentation would take all the mystery out of electronics. If you or your staff are intent on producing working diagrams that are easy to follow, even to the non-expert, surely it is more than worth while making the description of what a device is supposed to do, and the broad principles upon which it works as clear as possible.

In conclusion may I pass the opinion that the now defunct *Beginners Columns*, and your complimentary magazine, EVERYDAY ELECTRONICS also have the same problem, a pre-occupation with jargon, little thought being given to clarity.

I hope my comments are of interest and assistance.

W. G. Jones,
Lancs.

## Not logic

Sir—I have noticed with considerable interest your recent articles in P.E. on *Logical Radio Control*. It does however seem to me that you appear to have contradicted yourself on the shift-register section of the decoder.

You say that following the "clear" pulse the first signal pulse "turns on" the first flip-flop and the second signal pulse causes the second output to change to "1" and the first output to revert to "0" However, in Fig. 19b the waveform for the output (Q1) of this flip-flop remains up for five of the signal pulses, not resetting to 0 after the first.

The way I see it is that following the clear pulse the first signal pulse will, as you say, set the first flip-flop to "1". The second pulse will also set to "1" the second flip-flop, but since the input conditions to the first and sixth flip-flops have not changed neither will change state and the first flip-flop will remain in the "1" condition. So after six pulses all the flip-flops will be set which will not really work as a proportional system.

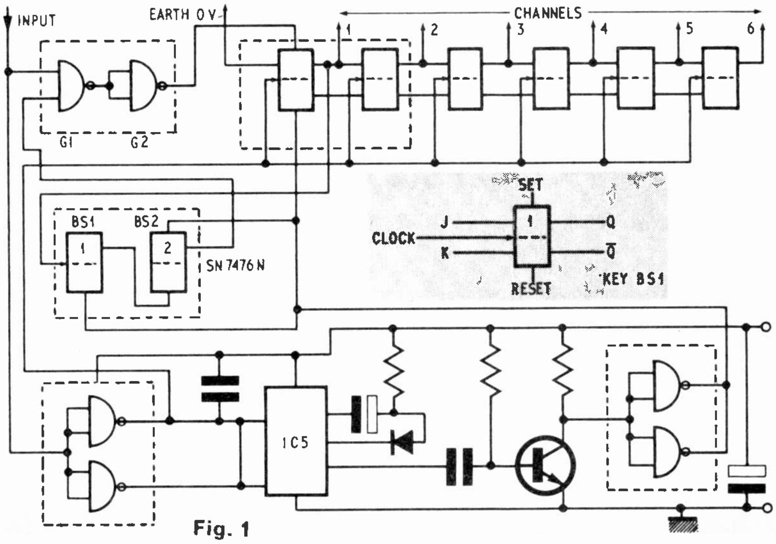



Fig. 1

# Readout—
## A SELECTION FROM OUR POSTBAG

Another point to note is that the master-slave type of flip-flop recommended triggers on the *trailing* edge of the clock-pulse; thus, assuming your circuit did work as you suggested, following the clear pulse the first flip-flop would not set until after the first pulse and would remain set for the interval plus the duration of the *second* pulse, thus the first channel would be "lost".

The enclosed circuit, Fig. 1, is my idea for the answer to the problem.

The clear pulse resets BS1, and sets BS2, the latter providing one input for G1 which, together with G2, forms an AND gate. Thus the leading edge of the first pulse will enable G1 and G2, and hence set the first flip-flop in the shift register for the duration of the signal impulse. The trailing edge of the pulse will reset the first flip-flop, set the second, and will also indirectly (via the first flip-flop) set BS1 which, in turn, resets BS2, closing the AND gate, preventing the setting of the first flip-flop until the next clear pulse.

The second and subsequent flip-flops in the chain will each set for the pulse length plus the interval. The clear pulse is applied to the first flip-flop in the register, to ensure correct triggering of BS1.

I hope my comments have been constructive, and look forward with great anticipation to your article on the Servo Motor Control. In fact, I was wondering whether, now you have gone so far, you might go the whole way and describe a suitable transmitter and receiver, possibly using integrated circuits as well?

M. C. Tiend,
Chelmsford.

## Triggered.

Sir—First may I compliment A. J. Dunn for a very interesting series on *Logical Radio Control*. It has created a great deal of enthusiasm amongst myself and friends, but also some queries were raised.

One of these was with regard to Mr Dunn's circuit for sync detection using a retriggerable monostable, as the majority of constructors seem to prefer the Texas SN74—range of TTL i.c.s and many suppliers do not stock retriggerable monostables.

To try to alleviate this problem I have designed the following circuit. It can be used to detect long "0" or "1" pulses as required and uses a 5-bit shift register as counting timer (see Fig. 2).

As shown here the clear signal to JK flip flops is produced when a "1" has existed at the input for a time set by the frequency of the multivibrator. This could be made up from NAND gates (see *Digital Dice* article, December P.E.) to make this circuit exclusively TTL.

To detect "0"s instead of "1"s merely invert the input.

L. Cook,
Lancs.

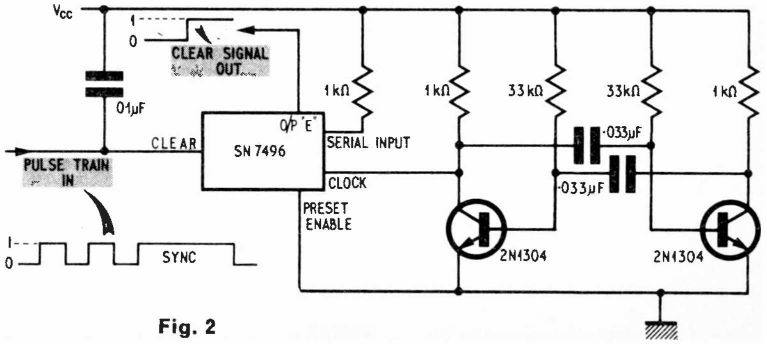



Fig. 2

## P.E. Scorpio ignition system

### TACHOMETERS

A large number of constructors have enquired about the possible effects of the ignition system on electronic impulse tachometers. Unfortunately none of the cars on which the system was tested were fitted with electronic tachometers and so we have no personal experience of these. As there are a large number of different types available, differing considerably in their requirements, we obviously could not make any positive recommendations without buying a sample of every available type, which would be impracticably expensive. There are, however, two basic types and we recommend that the constructor ascertains which type he has and experiments to obtain the best results.

### CURRENT OPERATED

These contain a current transformer which is normally connected in series with the ignition coil, or else the SW lead is wrapped around a small magnetic pick-up on the tacho. It should be possible to operate this type with the Scorpio by connecting it into the lead from the coil to C6/7 (tag 5) as there is a 10A current pulse through this lead

### VOLTAGE OPERATED

These are normally connected between the contact breaker and earth and work either on the 12V change of d.c. level when the contact points open or on the high voltage spike produced when the points open. With the Scorpio it should be possible to operate the low voltage type from the contact breaker, as normal, but the high voltage type should be connected to terminal 5 on the unit, or the tag on the ignition coil to which terminal 5 is connected.

### CARS WITH MULTIPLE CONTACT BREAKERS

A number of constructors have asked about using the Scorpio with two-stroke, three-cylinder engines having a separate contact breaker and coil for each cylinder. Unfortunately as there is no distributor it would be necessary to use three separate units and in view of the high cost we cannot recommend the use of the Scorpio with this type of engine.

D. S. Gibbs & I. M. Shaw

## Ferret tracker

Sir—I would be most grateful if any reader can offer any advice. I intend to start ferreting rabbits and previously I have used a ferret on a collar and line, digging up to the ferret by means of holes every 2 to 3ft.

Would it be possible to attach a device to the ferret collar which can be tracked above ground level by some kind of electronic detector?

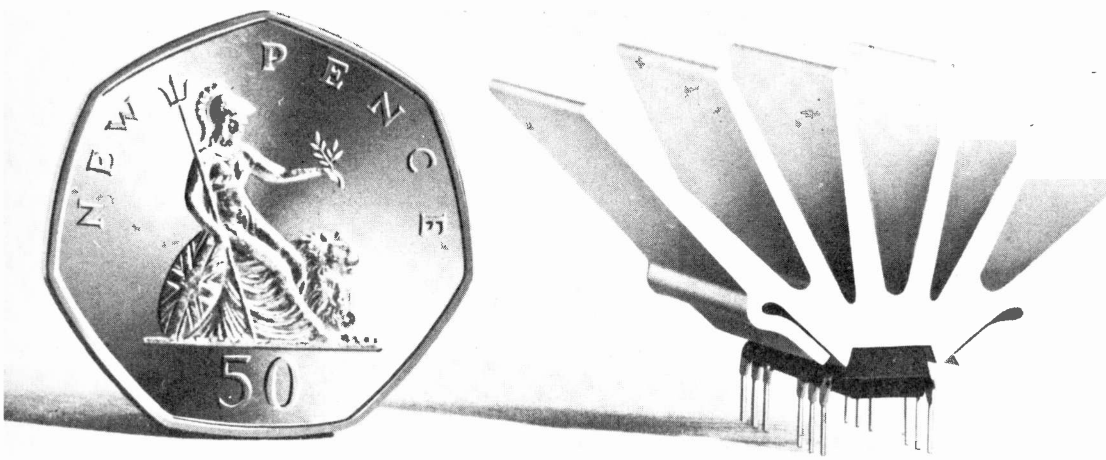
The ferret's collar is leather ⅝in wide. The average depth we dig is 18in to 24in deep, some odd holes 36in deep.

If such equipment can be purchased would you be kind enough to forward on any details, it would be a tremendous asset.

D. Nunn,
Suffolk.

# new

# Super IC-12

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**Input Impedance** 250 Kohms nominal.

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**Supply Voltage** 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

**Quiescent current** 8mA at 28 volts; low enough to make the IC.12 ideal also for battery operation.

**Size** 22 x 45 x 28 mm including pins and heat sink.

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project-60 range such as the Stereo 60 and A.F.U. may be added

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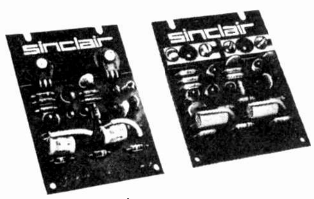
## Z.30 & Z.50 power amplifiers




The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

**SPECIFICATIONS** ***(Z.50 units are interchangeable with Z.30s in all applications).***
**Power Outputs**
**Z.30** 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
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**Signal to noise ratio:** better than 70dB unweighted.
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For speakers from 3 to 15 ohms impedance.
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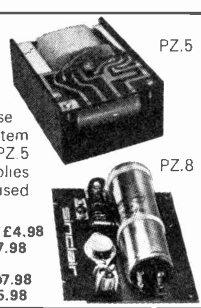
## Power Supply Units




Designed special for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

**PZ.5** *30 volts unstabilised* **£4.98**
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*If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.*

## Project 60 Stereo F.M. Tuner

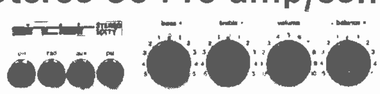
***First in the world to use the phase lock loop principle***

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Good reception is possible in difficult areas, and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

**SPECIFICATIONS—Number of transistors:** 16 plus 20 in I.C. **Tuning range:** 87.5 to 108 MHz. **Capture ratio:** 1.5dB. **Sensitivity:** 2μV for 30dB quieting: 7μV for lock-in over full deviation. **Squelch level:** 20μV. **A.F.C. range:** ±200 KHz. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10 Hz – 15 KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. **Operating voltage:** 25-30 VDC. **Indicators:** Power on/tuning/stereo. **Size:** 93 x 40 x 207 mm.

*Built and tested. Post free.* **£25**

## Stereo 60 Pre-amp/control unit



Designed for Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

**SPECIFICATIONS—Input sensitivities:** Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve ±1dB: 20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 15 to —15dB at 10 KHz: BASS + 15 to —15dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.
*Built tested and guaranteed.* **£9.98**

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For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28KHz to 5KHz. L.F. cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V. supply ( 0.02% at rated output. **Size:** 66 x 40 x 90 mm. *Built tested and guaranteed.* **£5.98**

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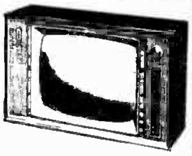

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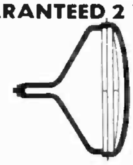

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| AC125 | 17p | AF118 | 30p | BC143 | 40p | BCY34 | 20p | BF308 | 35p | MAT101 | 17p | ST141 | 17p |
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| ACY21 | 20p | ASY55 | 25p | BC179 | 17p | BF164 | 35p | BSY41 | 35p | OC75 | 15p | 2G417 | 25p |
| ACY22 | 19p | ASY56 | 25p | BC180 | 20p | BF165 | 35p | BSY95 | 12p | OC76 | 15p | 2N388 | 30p |
| ACY27 | 18p | ASY57 | 25p | BC181 | 22p | BF167 | 22p | BSY95A | 12p | OC77 | 25p | 2N388A | 50p |
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| ACY35 | 18p | BC109 | 11p | BC184L | 13p | BF180 | 30p | C425 | 40p | OC84 | 20p | 2N697 | 15p |
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| ACY40 | 15p | BC114 | 30p | BC187 | 27p | BF182 | 30p | C428 | 20p | OC140 | 17p | 2N699 | 55p |
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| BA126 | 22p | BYZ16 | 35p | OA91 | 7p |
| BY100 | 15p | BYZ17 | 35p | OA95 | 7p |
| BY101 | 12p | BYZ18 | 30p | OA200 | 6p |
| BY105 | 15p | BYZ19 | 25p | OA202 | [illegible] |
| BY114 | 12p | OA5 | 17p | SO10 | [illegible] |
| BY126 | 15p | OA10 | 22p | SO19 | 4p |
| BY127 | 17p | OA47 | 7p | IN914 | 6p |
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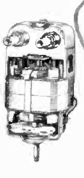

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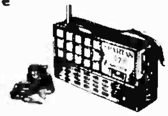

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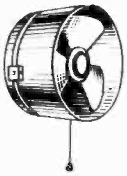
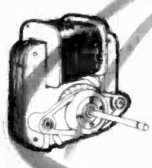
## EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic ft per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc., its so quiet it can hardly be heard. Compact, 5½in casing with 5¼in fan blades. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. **£2** plus 36p post and ins.

## MAINS MOTOR



Precision made — as used in record decks and tape recorders—ideal also for extractor fan, blower, heaters, etc. New and perfect. Snip at **50p.** Postage 15p for first one then 5p for each one ordered.

## TELEPHONE DIAL

Ex-G.P.O. Perfect working order. **50p** each.

## TELEPHONE HANDSET

Ex-G.P.O. Perfect order. **50p** each plus 20p P. & P.

## SELECTOR SWITCHES

Ex-G.P.O. All in good working order.

| | | | |
|---|---|---|---|
| 3 pole | **£1·25** | 5 pole | **£1·75** |
| 4 pole | **£1·50** | 6 pole | **£2·00** |

plus 20p P. & P.

## QUICK CUPPA

Mini Immersion Heater, 350w. 200/240v. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. **£1·25**, post and insurance 14p. 12v. car model also available same price. Jug heater **£1·50** plus P. & P. 14p.

## MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **83p**, plus 18p postage.

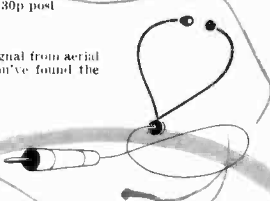
## MICRO SWITCH

5 amp. changeover contacts. **9p** each. **£1** doz. 15 amp. on/off Model. **10p** each or **£1·05** doz. 15 amp changeover **15p** each 10 for **135p**.

## CAPACITOR DISCHARGE CAR IGNITION


This system which has proved to be amazingly efficient and reliable was first described in the Wireless World about a year ago. We can supply kit of parts for improved and even more efficient version. (P.W. June), price **£4·95.** When ordering please state whether for positive or negative systems. Plus 30p post

## RADIO STETHOSCOPE



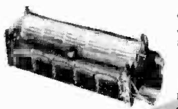
**Easiest way to fault find**—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **£2**—twin stetho set instead of earpiece **75p** extra—post and ins. 20p.

## STANDARD WAFER SWITCHES

Standard size 1½ wafer—silver-plated 5-amp contact, standard ¼in spindle 2in long—with locking washer and nut.

| No. of Poles | 2 way | 3 way | 4 way | 5 way | 6 way | 8 way | 9 way | 10 way | 12 way |
|---|---|---|---|---|---|---|---|---|---|
| 1 pole | 40p | 40p | 40p | 40p | 40p | 40p | 40p | 40p | 40p |
| 2 poles | 40p | 40p | 40p | 40p | 40p | 40p | 40p | 70p | 70p |
| 3 poles | 40p | 40p | 40p | 40p | 70p | 70p | 70p | 95p | 95p |
| 4 poles | 40p | 40p | 40p | 70p | 70p | 70p | 70p | £1·20 | £1·20 |
| 5 poles | 40p | 40p | 70p | 70p | 95p | 95p | 95p | £1·45 | £1·45 |
| 6 poles | 40p | 70p | 70p | 70p | 95p | 95p | 95p | £1·70 | £1·70 |
| 7 poles | 70p | 70p | 70p | 95p | £1·20 | £1·20 | £1·20 | £1·95 | £1·95 |
| 8 poles | 70p | 70p | 70p | 95p | £1·20 | £1·20 | £1·20 | £2·20 | £2·20 |
| 9 poles | 70p | 70p | 95p | 95p | £1·45 | £1·45 | £1·45 | £2·45 | £2·45 |
| 10 poles | 70p | 70p | 95p | £1·20 | £1·45 | £1·45 | £1·45 | £2·70 | £2·70 |
| 11 poles | 70p | 95p | 95p | £1·20 | £1·70 | £1·70 | £1·70 | £2·95 | £2·95 |
| 12 poles | 70p | 95p | 95p | £1·20 | £1·70 | £1·70 | £1·70 | £3·20 | £3·20 |

## TANGENTIAL HEATER UNITS



This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal lined case or cabinet. Only need control switch. **£3·50.** 2kW. Model as above except 2 kilowatts **£2·50.** Don't miss this. Control Switch 35p. P. & P. 40p.

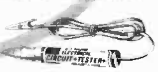
## THIS MONTH'S SNIP

### MULLARD AUDIO AMPLIFIER MODULE

Uses 4 transistors, and has an output of 750mW into 8 ohms speakers. Input suitable for crystal mic. or pick-up. 9V battery operated. Size 2in long × 1¼in wide × 1in high.

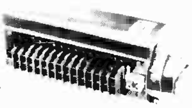
SPECIAL SNIP PRICE **60p** each. 10 for **£5.**

## POCKET CIRCUIT TESTER



Test continuity for any low resistance circuit, house wiring, car electrics. Tests polarity of diodes and rectifiers. Also ideal size for conversion to signal injector (circuit supplied). **30p** or 2 for **50p.** Post paid.

## HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 r.p.m. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines. Display lighting animated and signs, Signalling, etc. Price from makers probably over £10 each. Special snip price **£5·75** plus 25p post and insurance. Don't miss this terrific bargain.

## INTEGRATED CIRCUIT BARGAIN

A parcel of integrated circuits made by the famous Plessey Company. A once-in-a-lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first-grade device, definitely not sub-standard or seconds. 4 of the ICs are single silicon chip GP amplifiers. The 5th is a monolithic *npn* matched pair. Regular price of parcel well over **£5.** Full circuit details of the ICs are included and in addition you will receive a list of many different ICs available at bargain prices 25p upwards with circuits and technical data of each. Complete parcel only £1 post paid. *DON'T MISS THIS TERRIFIC BARGAIN.*

## BATTERY CONDITION TESTER

Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace" "weak" or "good". The tester is complete in its case, size 3½in × 6¼in × 2in with leads and prods. Price **£1·75** plus 20p postage.

## THERMOSTATS

**Type "A"** 15 amp. for controlling room heaters, greenhouses, airing cupboards. Has spindle for pointer knobs. Quickly adjustable from 30–80°F, **40p.** Calibrated dial 20p extra. Suitable box for wall mounting. **25p.**

**Type "B"** 15 amp. This is a 17in long rod type made by the famous Sunvic Co. Spindle adjusts this from 50–550°F. Internal screw alters the setting so this could be adjustable over 30° to 1000°F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flame-stat or fire alarm. **43p** plus 12½p post and insurance.

**Type "D"** We call this the Ice-stat as it cuts in and out at around freezing point. 2/3 amps. Has many uses one of which would be to keep the loft pipes from freezing, if a length of our blanket wire (16yd. **50p**) is wound round the pipes. **40p.**

**Type "E".** This is standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature. **50p.**

**Type "F".** Glass encased for controlling the temp. of liquid—particularly those in glass tanks, vats or sinks—thermostat is held (half submerged) by rubber sucker or wire clip—ideal for fish tanks—developers and chemical baths of all types. Adjustable over range 50° to 150°F. Price **80p.**

## TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as the circuit in Practical Wireless August issue. **£2·95** plus 20p post and insurance.

## DRILL CONTROLLER
### *NEW 1KW MODEL*


Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£1·50** plus 13p post and insurance. Made up model also available, **£2·25** plus 13p post and p.

## HIGH ACCURACY THERMOSTAT

Uses differential comparator I.C. with thermister as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack **£5·50.**

## AUTO-ELECTRIC CAR AERIAL

with dashboard control switch—fully extendable to 40in or fully retractable. Suitable for 12V positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. **£5·75** plus 25p post and ins.

## AUTO-LITE

as circuit in P.W. Kit of parts **£1·20** post paid.

## TOGGLE SWITCH

3 amp 250V with fixing ring **7½p** each, **75p** doz.

## CAR ELECTRIC PLUG

Fits in place of cigarette lighter. Useful method for making a quick connection into the car electrical system. **38p** each or 10 for **£3·42.**

## ROCKER SWITCH

13 amp self-fixing into an oblong hole, size approximately 1in × ⅝in. **6p** each. 10 for **54p.**

## MAINS RELAY BARGAIN

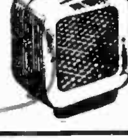
Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil wound for 240V a.c. Good British Make. Unused. Size approx. 1½in × 1in. Open construction

Single pole **25p** each **10 for £2·25**
Treble pole **40p** each **10 for £3·60**

## BALANCED ARMATURE UNIT

500 ohm, operates speaker or microphone, so useful in intercom or similar circuits. **33p** each. **£3·50** doz.

## 2½kW FAN HEATER



Three position switching to suit changes in the weather. Switch up for full heater (2½ kW), switch down for half heat (1¼kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto control and safety cut-out. Complete kit **£3·95.** Post and ins. 38p.

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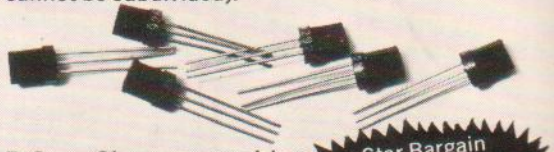

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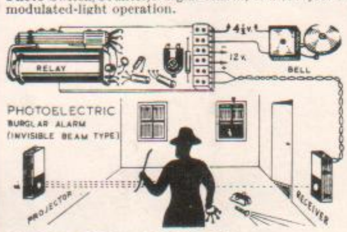


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