# RADIO & ELECTRONICS CONSTRUCTOR

JANUARY 1977

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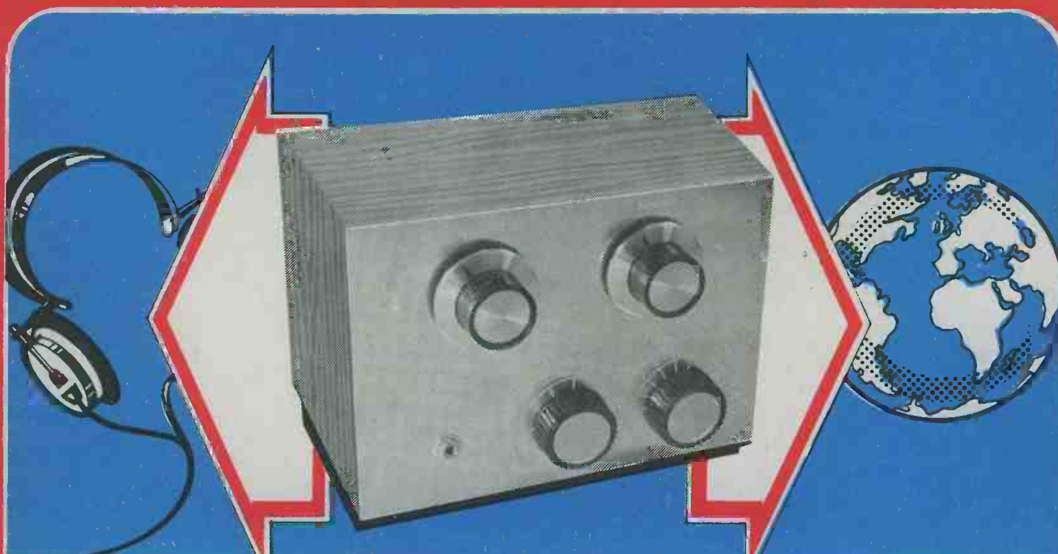

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CONTENTS

1. Semiconductors
2. Basic Semiconductor Devices
3. Semiconductor Diodes and the Unijunction Transistor
4. Bipolar Junction Transistors, Amplifiers & Logic Gates
5. Field-Effect Transistors, Amplifiers and Logic Gates
6. Monolithic Integrated Circuits
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# RADIO & ELECTRONICS CONSTRUCTOR

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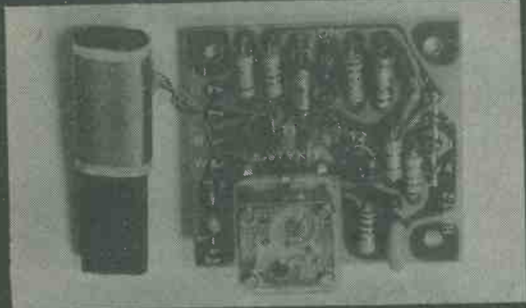

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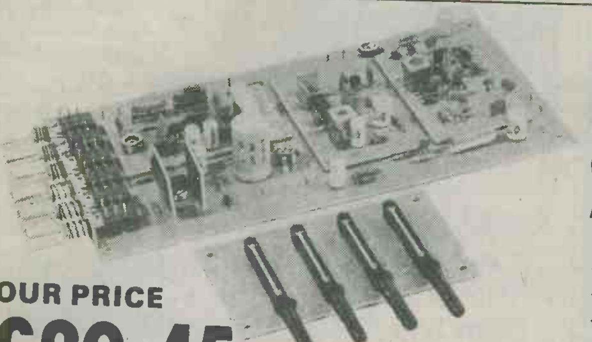

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| 7437 | 0.26 | 0.25 | 7496 | 0.70 | 0.68 | 74190 | 1.40 | 1.30 |
| 7438 | 0.26 | 0.25 | 74100 | 0.95 | 0.90 | 74191 | 1.40 | 1.30 |
| 7440 | 0.12 | 0.10 | 74104 | 0.40 | 0.35 | 74192 | 1.10 | 1.00 |
| 7441 | 0.60 | 0.57 | 74105 | 0.30 | 0.25 | 74193 | 1.05 | 1.00 |
| 7442 | 0.60 | 0.52 | 74107 | 0.30 | 0.25 | 74194 | 1.05 | 1.00 |
| 7443 | 0.95 | 0.90 | 74110 | 0.48 | 0.45 | 74195 | 0.80 | 0.75 |
| 7444 | 0.95 | 0.90 | 74111 | 0.75 | 0.72 | 74196 | 0.90 | 0.85 |
| 7445 | 0.80 | 0.75 | 74118 | 0.85 | 0.82 | 74197 | 0.90 | 0.85 |
| 7446 | 0.80 | 0.75 | 74119 | 1.30 | 1.20 | 74198 | 1.90 | 1.80 |
| 7447 | 0.70 | 0.68 | 74121 | 0.28 | 0.26 | 74199 | 1.80 | 1.70 |

Devices may be mixed to qualify for quantity price. Data is available for the above series of IC's in booklet form Price 35p

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| | |
|---|---|
| TBA 800 | •75p |
| 72709 14 pin DIL | •20p |
| 741P 8 pin DIL | •18p |
| 72747 14 pin DIL | •36p |
| 748P 8 pin DIL | •25p |
| NE 555 Timer | 38p |
| NE 556 Dual Timer | 78p |

## IC SOCKETS

| | |
|---|---|
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| BPS 14 14 pin 1612 | 10p |
| BPS 16 16 pin 1613 | 11p |

## TRIACS

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|---|---|
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| AC153K | 18p | OC45 | 12p |
| AC176 | 19p | OC71 | 9p |
| AC176K | 22p | OC72 | 14p |
| AC187K | 22p | OC81 | 14p |
| AC188 | 12p | ZTX107 | • 6p |
| AC188K | 22p | ZTX108 | • 6p |
| BC107 | 6p | ZTX109 | • 6p |
| BC108 | 6p | ZTX300 | • 7p |
| BC109 | 6p | ZTX301 | • 7p |
| BC118 | •10p | ZTX302 | • 9p |
| BC154 | •16p | ZTX500 | • 8p |
| BC147 | • 8p | ZTX501 | •10p |
| BC148 | • 8p | ZTX502 | •12p |
| BC149 | • 8p | 2N696 | 10p |
| BC157 | •10p | 2N697 | 11p |
| BC158 | •10p | 2N706 | 7p |
| BC159 | •10p | 2N706A | 8p |
| BC169C | •10p | 2N708 | 8p |
| BC170 | • 6p | 2N1613 | 15p |
| BC171 | • 6p | 2N1711 | 15p |
| BC172 | • 6p | 2N1893 | 18p |
| BC177 | 12p | 2N2217 | 18p |
| BC178 | 12p | 2N2218 | 15p |
| BC179 | 12p | 2N2218A | 18p |
| BC182L & K | • 9p | 2N2219 | 15p |
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| BC183 | • 9p | 2N2221 | 15p |
| BC184 | • 9p | 2N2221A | 16p |
| BC212L & K | •10p | 2N2222 | 15p |
| | | 2N2222A | 16p |
| BC213 | •10p | 2N2369 | 12p |
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| BC251 | • 6p | 2N2904 | 14p |
| BC327 | •12p | 2N2904A | 15p |
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| BC337 | •11p | 2N2905A | 15p |
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| BF194 | • 9p | 2N2926G | |
| BF195 | • 9p | | • 8p |
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| BF197 | •12p | 2N2926Y | |
| BF198 | •12p | | • 7p |
| BF199 | •12p | 2N3053 | 14p |
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| BF258 | 29p | 2N3702 | • 7p |
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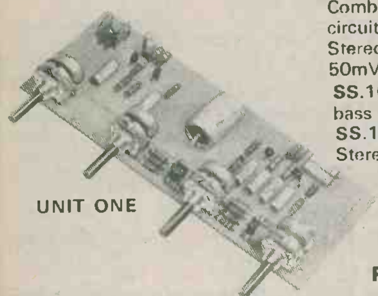

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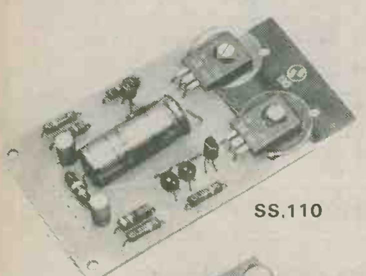

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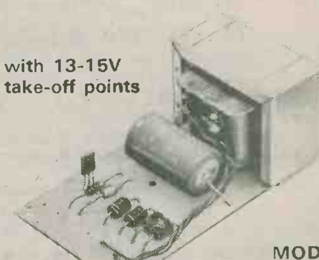

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| ACY28 | 19p | BCY40 | 50p | BFW57/58 | 17p |
| AD149 | 40p | BCY70/1/2 | 12p | BFX12/29/30 | 20p |
| AD161/2 | 33p | BD112/3 | 50p | BFX84/88/89 | 17p |
| AF116 | 16½p | BD115/6 | 31p | BFY51/52 | 13p |
| AF124/6/7 | 25p | BD131/2/3 | 35p | BFY90 | 50p |
| AF139 | 20p | BD135/7/9 | 30p | BR101 | 30p |
| AF178/80/81 | 30p | BD142 | 30p | BRY39/56 | 26p |
| AF239 | 30p | BD201/2/3/4 | 80p | BSV64 | 30p |
| ASY27/73 | 30p | BD232/4/5 | 49p | BSV79/80 F.E.T.s | 80p |
| BC107/8/9 + A/B/C | 6p | BDX77 | £1 | BSV91 Mosfet | 90p |
| BC147/8/9 + A/B/C/S | 6p | BF115/167/173 | 15p | BSX20/21 | 14p |
| BC157/8/9 + A/B/C | 6p | BF178/9 | 20p | BSY40 | 27p |
| BC178A/B, 179B | 12p | BF180/1/2/3/4/5 | 15p | BSY95A | 12p |
| BC184C/LC | 9p | BF194/5/6/7 | 6p | BU105-01 | 50p |
| BC186/7 | 20p | BF194A, 195C | 6p | CV7042 (OC41/44 ASY63) | 5p |
| BC213L/214B | 10p | BF200, 25B | 20p | GET111 | 40p |
| BC261B | 8p | BF202/3 | 30p | OC35 | 45p |
| BC327/8, 337/8 | 8p | BF336 | 27p | ON222 | 20p |
| BC547/8/8A | 10p | BFS28 Dual Mosfet | £1 | TIP30/3055 | 45p |
| | | | | TIS88A F.E.T. | 23p |
| | | | | ZTX300/341 | 7p |
| | | | | 2N393 (MA393) | 30p |
| | | | | 2N456A | 50p |
| | | | | 2N929 | 14p |
| | | | | 2N987 | 40p |
| | | | | 2N1507/2219 | 15p |

| | |
|---|---|
| 2N2401 | 30p |
| 2N2412 | 70p |
| 2N2483 | 23p |
| 2N2904/5/6/7/7A | 15p |
| 2N3053 | 14p |
| 2N3055 R.C.A. | 50p |
| 2N3704 | 8p |
| 2N3133 | 20p |
| 2N4037 | 34p |
| 2N5036 (Plastic 2N3055) | 30p |
| 2SA141/2/360 | 31p |
| 2SB135/6/457 | 20p |
| 40250 (2N3054) | 30p |

### BRIDGE RECTIFIERS

| Amp | Volt | | |
|---|---|---|---|
| ½ | 1,600 | BYX10 | 30p |
| 1 | 140 | OSH01-200 | 26p |
| 1.4 | 42 | BY164 | 40p |
| 0.6 | 110 | EC433 | 6p |
| 5 | 400 | Texas | 90p |

### RECTIFIERS

| | Amp | Volt | |
|---|---|---|---|
| IN4004/5/6 | 1 | 4/6/800 | 5p |
| IN4007/BYX94 | 1 | 1250 | 5p |
| BY103 | 1 | 1,500 | 18½p |
| SR100 | 1.5 | 100 | 7p |
| SR400 | 1.5 | 400 | 8p |
| REC53A | 1.5 | 1,250 | 14p |
| LT102 | 2 | 30 | 10p |
| BYX38-300R | 2.5 | 300 | 40p |
| BYX38-600 | 2.5 | 600 | 45p |
| BYX38-900 | 2.5 | 900 | 50p |
| BYX38-1200 | 2.5 | 1,200 | 55p |
| BYX48-300R | 2.5 | 300 | 26p |
| BYX49-600 | 2.5 | 600 | 35p |
| BYX49-900 | 2.5 | 900 | 40p |
| BYX49-1200 | 2.5 | 1,200 | 52p |
| BYX48-300R | 6 | 300 | 40p |
| BYX48-600 | 6 | 600 | 50p |
| BYX48-900 | 6 | 900 | 60p |
| BYX48-1200R | 6 | 1,200 | 80p |
| BYX72-150R | 10 | 150 | 35p |
| BYX72-300R | 10 | 300 | 45p |
| BYX72-500R | 10 | 500 | 55p |
| BYX42-300 | 10 | 300 | 30p |
| BYX42-600 | 10 | 600 | 65p |
| BYX42-900 | 10 | 900 | 80p |
| BYX42-1200 | 10 | 1,200 | 95p |
| BYX46-300* | 15 | 300 | £1.00 |
| BYX46-400* | 15 | 400 | £1.50 |
| BYX46-500* | 15 | 500 | £1.75 |
| BYX46-600* | 15 | 600 | £2.00 |
| BYX20-200 | 25 | 200 | 60p |
| BYX52-300 | 40 | 300 | £1.75 |
| BYX52-1200 | 40 | 1,200 | £2.50 |

*Avalanche type

### TRIACS

| Amp | Volt | | |
|---|---|---|---|
| 6 | 800 | Plastic RCA | £1.20 |
| 25 | 900 | BTX94-900 | £4.00 |
| 25 | 1200 | BTX94-1200 | £6.00 |

Mullard Data Book ........................ 40p

RS 2mm Terminals Blue & Black ...... 5 for 40p

Chrome Car Radio facia .. 15p

Rubber Car Radio gasket .. 5p

DLI Pal Delayline .. .. 50p

Relay socket .. .. 25p
Take miniature 2PCO relay

B7G or B9A valve can ... 5p

0-30, or 0-15, black pvc, 360° dial, silver digits, self adhesive 4½" dia. .. .. .. .. 10p

### OPTO ELECTRONICS

| | |
|---|---|
| BPX40 | 50p |
| BPX42 | 80p |
| BPY10 | 80p |
| (VOLTIAC) | |
| BPY68 / BPY69 / BPY77 | 80p |
| Diodes | |
| TIL209 Red | 10p |

Photo transistor

| | |
|---|---|
| BPX29 | 80p |
| OCP71 | 44p |

BIG L.E.D. 0.2"
2v 50m/A max.

| | |
|---|---|
| RED | 10p |
| ORANGE | 17p |
| GREEN | 14p |
| YELLOW | 14p |
| CLIP | 2p |

**PHOTO SILICON CONTROLLED SWITCH** BPX66 PNPN 10 amp £1.00

.3" red 7 segment L.E.D. 14 D.I.L. 0-9+D.P. display 1.9v 10m/a segment, common anode 61p
DL747.6" £1.25
Minitron 3" 3015F filament £1.10

CQY11B L.E.D.
Infra red transmitter £1
One fifth of trade

Plastic, Transistor or Diode Holder 1p
Transistor or Diode Pad 1p
Holders or pads 50p per 100

Philips Iron Thermostat ... 15p
McMurdo PP108 8 way edge plug 10p

### TO3 HEATSINK

Europlec HP1 TO3B individual 'curly' power transistor type. Ready drilled 12p

### Tested unmarked, or marked ample lead ex new equipment

| | | | |
|---|---|---|---|
| ACY17-20 | 8p | OC71/2 | 5p |
| ASZ20 | 8p | OC200-5 | 8p |
| ASZ21 | 30p | TIC44 | 24p |
| BC186 | 11p | 2G240 | £1 |
| BCY30-34 | 8p | 2G302 | 5p |
| BCY70/1/2 | 8p | 2G401 | 5p |
| BF115 | 10p | 2N711 | 25p |
| BY126/7 | 4p | 2N2926 | 4p |
| HG1005 | 10p | 2N598/9 | 6p |
| HG5009 | 3p | 2N1091 | 8p |
| HG5079 | 3p | 2N1302 | 8p |
| L78/9 | 3p | 2N1907 | £1 |
| M3 | 10p | Germ. diode | 1p |
| OA81 | 3p | GET120 (AC128 in 1" sq. heat sink | 15p |
| OA47 | 3p | | |
| OA200-2 | 3p | GET872 | 12p |
| OC23 | 20p | 2S3230 | 30p |

### NEW B.V.A. VALVES

| | |
|---|---|
| 6BW7 | 60p |
| EB91 | 34p |
| ECH81 | 34p |
| ECL80 | 36p |
| EF80 | 34p |
| EF183 | 34p |
| EY86/7 | 34p |
| PC86 | 53p |
| PC88 | 53p |
| PC97 | 36p |
| PCC84 | 34p |
| PCC89 | 45p |
| PCC189 | 45p |
| PCF80 | 34p |
| PCF82 | 34p |
| PCF801 | 46p |
| PCL82 | 34p |
| PL81 | 35p |
| PY500A | 80p |
| PY81/800 | 38p |
| R20/U26 | 50p |

### THYRISTORS

| Amp | Volt | | |
|---|---|---|---|
| 1 | 240 | BTX18-200 | 30p |
| 1 | 400 | BTX18-300 | 35p |
| 1 | 240 | BTX30-200 | 30p |
| 15 | 500 | BT107 | £1 |
| 6.5 | 500 | BT101-500R | 90p |
| 6.5 | 500 | BT109-500R | £1.00 |
| 20 | 600 | BTW92-600RM | £3.00 |
| 15 | 800 | BTX95-800R Pulse Modulated | £8.00 |
| 30 | 1000 | 28T10 (Less Nut) | £3.00 |

### PAPER BLOCK CONDENSER

| | | |
|---|---|---|
| 0.25MFD | 800 volt | 30p |
| 1MFD | 250 volt | 15p |
| 2MFD | 250 volt | 20p |
| 4MFD | 250 volt | 20p |

I.C. extraction and insertion tool 32p

### CHASSIS SOCKETS

Car Aerial **9p**, Coax **3p**, 5 pin 180° **9p**, 5 or 6 pin 240° din **6p**, speaker din switched **5p**, 3.5 mm switched **5p**, stereo ¼" jack enclosed **10p**.

### CRAZY OFFERS

| | | |
|---|---|---|
| 4700 mfd. | 40v | 35p |
| 2500 mfd. | 40v | 3p |
| 2200 mfd. | 25v | 30p |
| 2200 mfd. | 64v | 40p |
| 10000 mfd. | 15v | 12p |
| 1250 mfd. | 35v | 10p |
| 6800 mfd. | 10v | 6p |
| 32+32 mfd. | 275v | 8p |
| 16+32 mfd. | 350v | 12p |
| 8+8 mfd. | 350v | 8p |
| 150 mfd. | 35v | 4½p |
| 100 mfd. | 70v | 4½p |
| 1 mfd. non-polar | 350v | 3p |
| 680 mfd. | 100v | 10p |
| 15 mfd. | 160v | 3p |
| 4700 pf.sub min | 500v | 1½p |
| 47 k. log stereo slide pot | | 12p |

Philips electronic engineer kits add on series E1004 75p each

G.E.C. 5% Hi-stab capacitors .013, .056, .061, .066, .069, .075, .08, .089, .095, .1 2p each

3.5mm metal stereo plug 20p

### OTHER DIODES

| | |
|---|---|
| 1N916 | 6p |
| 1N4148 | 2p |
| BA145 | 14p |
| Centercel | 24p |
| BZY61/BA148 | 10p |
| BB103/110 Varicap | 15p |
| BB113 Triple Varicap | 37p |
| BA182 | 13p |
| OA5/7/10 | 15p |
| BZY88 Up to 33 volt | 7p |
| BZX61 11 volt | 15p |
| BR100 Diac. | 15p |

### INTEGRATED CIRCUITS

| | |
|---|---|
| TAA700 | £2.00 |
| 723 reg (TO99) | 45p |
| 741 8 pin d.i.l. op. Amp | 20p |
| TAD100 AMRF | £1 |
| CA3001 R.F. Amp | 50p |
| CD4013 CMOS | 36p |
| TAA300 1wt Amp | £1 |
| NE555v Timer | 35p |
| TAA550 Y or G | 22p |
| TAA263 Amp | 65p |
| 7400/10 | 9p |
| 7402/4/20/30 | 12p |
| 7414 | 56p |
| 7438/74/86 | 24p |
| 7483 | 69p |
| LM300, 2-20 volt | £1 |
| 74154 | 90p |

Push-to-Break or Push-to-Make Panel Switch .................. 24p

### ENAM. COPPER WIRE

| SWG. | PER YD. |
|---|---|
| 20-24 | 3p |
| 26-42 | 2.5p |

### GARRARD

GCS23T Crystal Stereo Cartridge 66p
Mono (Stereo compatible), Ceramic or crystal 60p

### HANDLES

Rigid light blue nylon 6¼" with secret fitting screws .. 5p

Belling Lee white plastic surface coax outlet box 20p

Miniature Axial Lead Ferrite Choke formers 2p

RS 10 Turn Pot 1% 250, 500 Ω, 1K, 50K ........... £1

Copper coated board 10" x 9" approx 25p

### TIE CLIPS

Nylon self locking 7" or 3½" 2p

Geared Knob 8-1 ratio 1⅞" diam, black 70p

1lb Mixed bolts, nuts, washers etc. 45p

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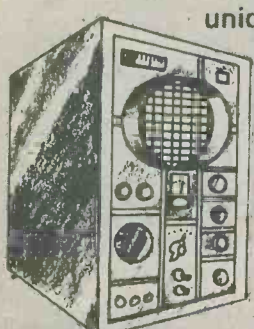

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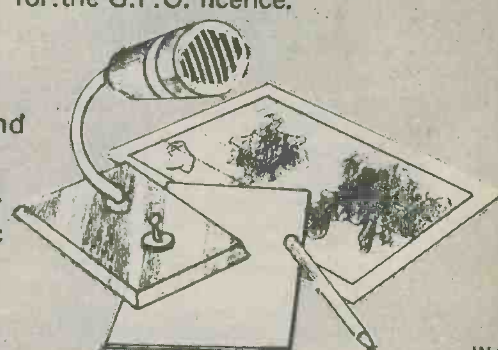

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## ELAC 10in WOOFER

10 watt, 15 ohm base unit. 35 to 8,000 c.p.s. Base res. 40 c.p.s.
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## R.C.S. DISCO DECK SINGLE RECORD PLAYER

Fitted with auto stop, compatible cartridge. Baseplate. Size 11in. x 8½in. Turntable. Size 7in. diameter. A/C mains. 220/250V motor has a separate winding 14 volt to power a small amplifier.
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Two for £13.

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Two full size loudspeakers 13½ x 10 x 3½in. Player unit clips to loudspeakers making it extremely compact. Overall size only 13½ x 10 x 8½in. 3 watts per channel, plays all records 33 rpm 45 rpm. Separate volume & tone controls 240v AC mains.

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Weight 13lbs.

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Full instructions supplied. Details S.A.E. £1.45 30p

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| 25/25V | 10p | 8+16/450V | 50p | 30,000/25V | 95p |
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FULL WAVE BRIDGE CHARGER RECTIFIERS:
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## R.C.S. STABILISED POWER PACK KIT

All parts including printed circuit and instructions to build this unit. Voltages available: 6v, 7·5v, 9v 12v. Up to 100mA output.
Please state voltage required. **£2.95** Post 45p

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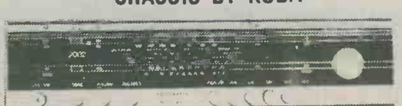

This all transistor chassis has push button selection for long, medium, short and V.H.F. wave bands. Features A.F.C. on V.H.F. band with automatic stereo beacon light. Volume tone and Balance controls with push button mains on/off switch. Amplifier accepts ceramic cartridge and has record player socket fitted. Four watts per channel output
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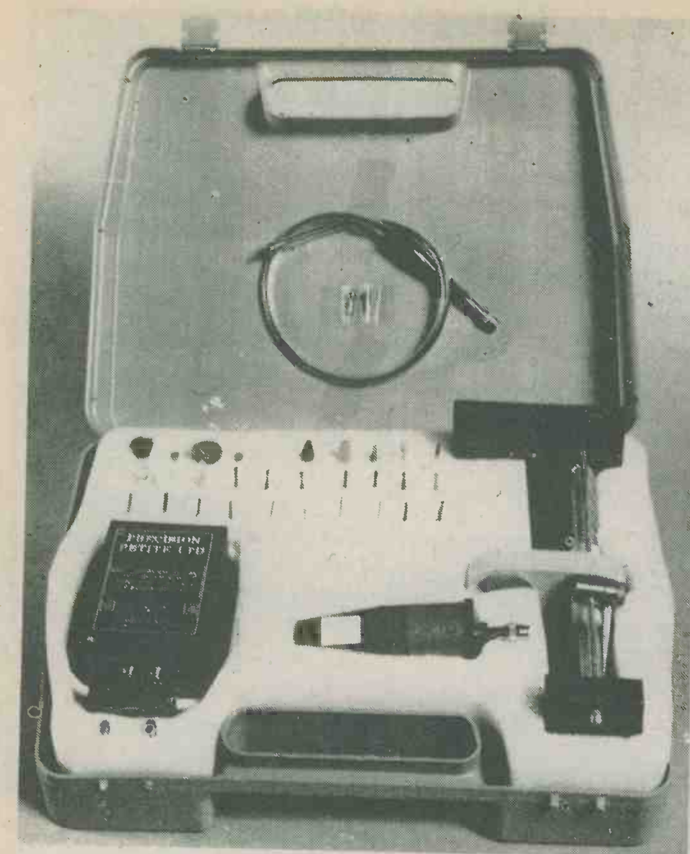

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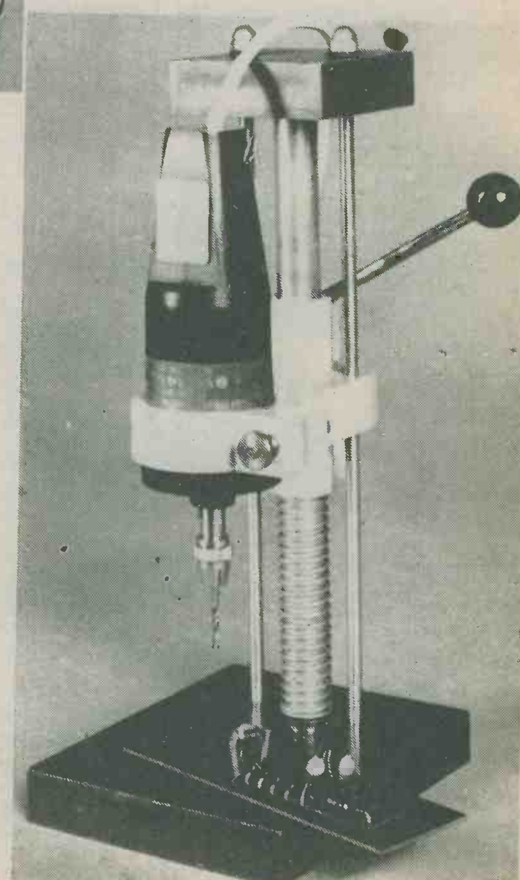


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# CMOS

**The introduction of the CMOS linear operational amplifier type CA3130T allows the construction of very simple circuits which take advantage of its extremely high input resistance. This article describes an electronic voltmeter incorporating the CA3130T and offering ranges of 0-1 volt, 0-5 volts, 0-10 volts and 0-50 volts.**

There hardly seems to be an issue of an electronics magazine these days that does not give details of at least one project incorporating an operational amplifier i.c. of some sort or, at least, that is the author's impression. Operational amplifiers are certainly very versatile with their inverting and non-inverting inputs, ultra high gains, high input impedances and low output impedances.

Inexpensive devices such as the 741 and 748 do have limitations, however. Theoretically, an operational amplifier should have an infinite voltage gain, infinite input impedance and zero output impedance. No real operational amplifier achieves all these characteristics, of course, but most are suitable, with regard to gain and output impedance, for the majority of practical applications.

Devices such as the 741 and 748 have bipolar transistor input stages and, although very high input impedances can be attained, practical amplifiers tend to be well removed from the theoretical ideal in this respect. This is not a problem of academic importance, but is one that can complicate what would otherwise be a very simple circuit or can make a particular circuit completely impractical.

## BASIC VOLTMETER

An example of a possible circuit which could not function adequately with an operational amplifier having a bipolar transistor input is shown in Fig. 1. This circuit is for an electronic voltmeter having a high input resistance. The output of the operational amplifier is returned to its inverting input, whereupon the amplifier acts as a voltage follower with its output voltage being equal to the input voltage. The meter and series resistor form a voltmeter which can have a full-scale deflection of 1 volt. Voltages to be measured are applied to the test terminals, across which is an attenuator having four resistors. The switch taps into the attenuator to provide four voltage ranges.

A circuit of this type has several advantages over more conventional electronic voltmeters, such as those incorporating field-effect transistors. An electrical zero set adjustment for the meter is not required nor is there any need for thermal stabilization. Also, the linearity of the circuit is very nearly perfect,

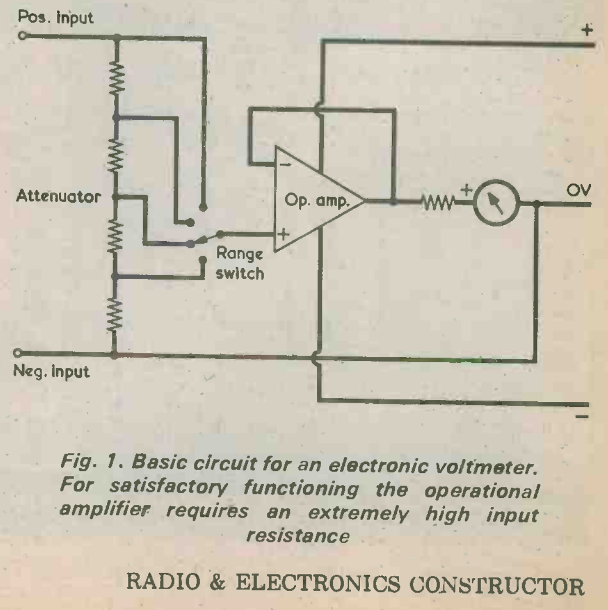



*Fig. 1. Basic circuit for an electronic voltmeter. For satisfactory functioning the operational amplifier requires an extremely high input resistance*

# VOLT METER

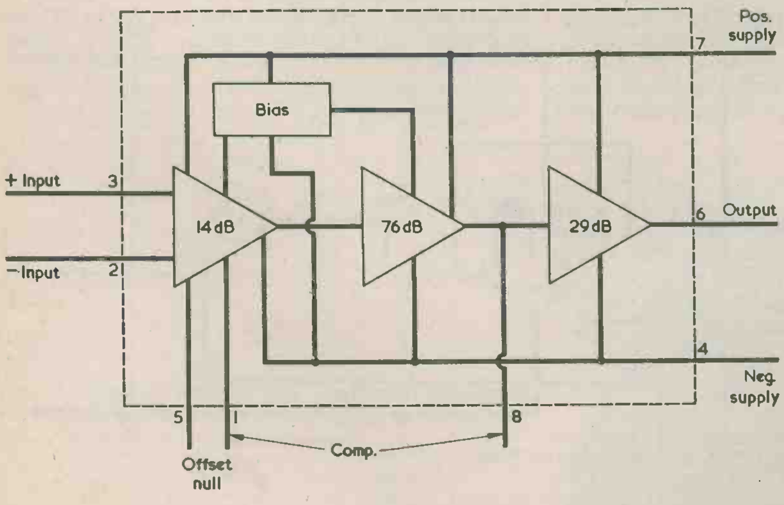
**By R. A. Penfold**

and accuracy is virtually limited to the accuracy and resolution of the meter itself. The only obvious disadvantage is the necessity for a dual voltage power supply.

The circuit cannot be used successfully with an operational amplifier having a bipolar transistor input because the input resistance of such an amplifier, although high, is still too low to allow high value resistors to be employed in the attenuator. Satisfactory functioning calls for an operational amplifier having an input resistance of many hundreds, or preferably even thousands, of megohms. Suitable operational amplifiers have been available for some time but have been expensive. They incorporate a JUGFET input stage, but this is contained on a single chip separate from the main bipolar circuitry.

The situation has recently changed and it is now possible to obtain, at reasonable cost, an operational amplifier with a CMOS input, this being the RCA CA3130T. This i.c. has an extremely high input impedance and readily lends itself to use in a circuit of the type shown in Fig. 1. This article describes an electronic voltmeter, incorporating the CA3130T, which has an input resistance of 15MΩ on all ranges. There are four ranges, these being 0-1 volt, 0-5 volts, 0-10 volts and 0-50 volts. The unit can be assembled in very compact form.

The CA313OT is an 8-lead device contained in a TO-5 style package. Its lead connections and a block diagram showing its internal stages are illustrated in Fig. 2. The device has a typical voltage gain of 320,000 times, most of this being provided by the second stage, which incorporates a bipolar transistor. The input and output stages employ CMOS circuitry. Although of no consequence in the present application, the CA313OT has a gain-bandwidth product of 15MHz, a high slew rate of 30 volts per microsecond and is capable of a peak-to-peak output voltage swing which is only some millivolts inside the supply voltage.



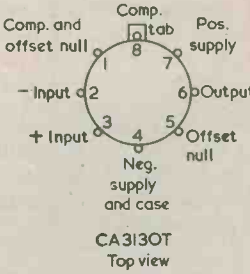
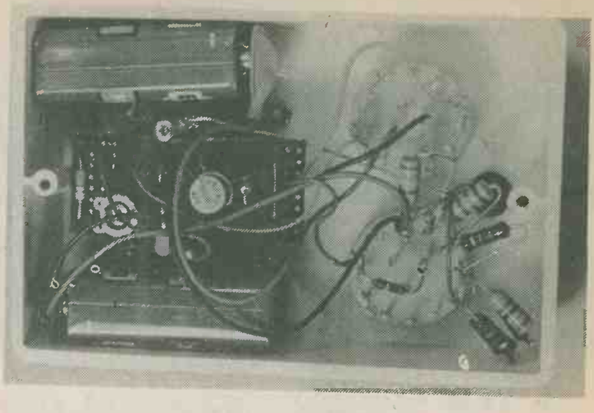




*Fig. 2. Block diagram illustrating the internal stages of the CA313OT and a top view showing lead allocations*



*The prototype has a simple layout, with the Veroboard panel located between the two meter terminals*

## THE CIRCUIT

The complete circuit of the CMOS voltmeter appears in Fig. 3. This is similar to the basic circuit of Fig. 1, with a few additions which are necessary for practical operation.

R1 to R7 form the input attenuator and the accuracy of the voltmeter depends upon the tolerance of the resistors employed here. The widest tolerance to be considered acceptable is 5%., and all the values listed are available in this tolerance from Electrovalue Limited. The first attenuator resistor requires a value of 12MΩ and it is unlikely that a suitable component will be available. The value is therefore made up by connecting four separate resistors in series. A 300kΩ resistor is needed for R7 and, in the prototype, this was made up of two 150kΩ resistors in series. S2 is the range switch.

The CA3130T has internal diodes to protect its input gates against breakdown voltages but it is still necessary to ensure that an excessive voltage cannot be accidentally applied to the non-inverting input. In consequence current limiting resistor R8 is inserted in series with the non-inverting input, and it provides protection against overloads of up to 100 volts when the instrument is switched to 0-1 volt, on which range the i.c. is most vulnerable. The input resistance of the CA3130T is so high that R8 has no significant effect on normal circuit operation.

There is a 100% negative feedback loop from the output to the inverting input, causing the i.c. to have unity gain and thus act as a voltage follower. The i.c. does not have internal compensation, but only a single external compensating component is required. This is C1.

VR1 and R11 provide the series resistance for the meter. VR1 is set up so that the meter gives a full-scale reading at an output voltage, from the i.c., of 1 volt.

A supply voltage of between 3 and 16 volts can be used to power the CA3130T or, in the case of a dual

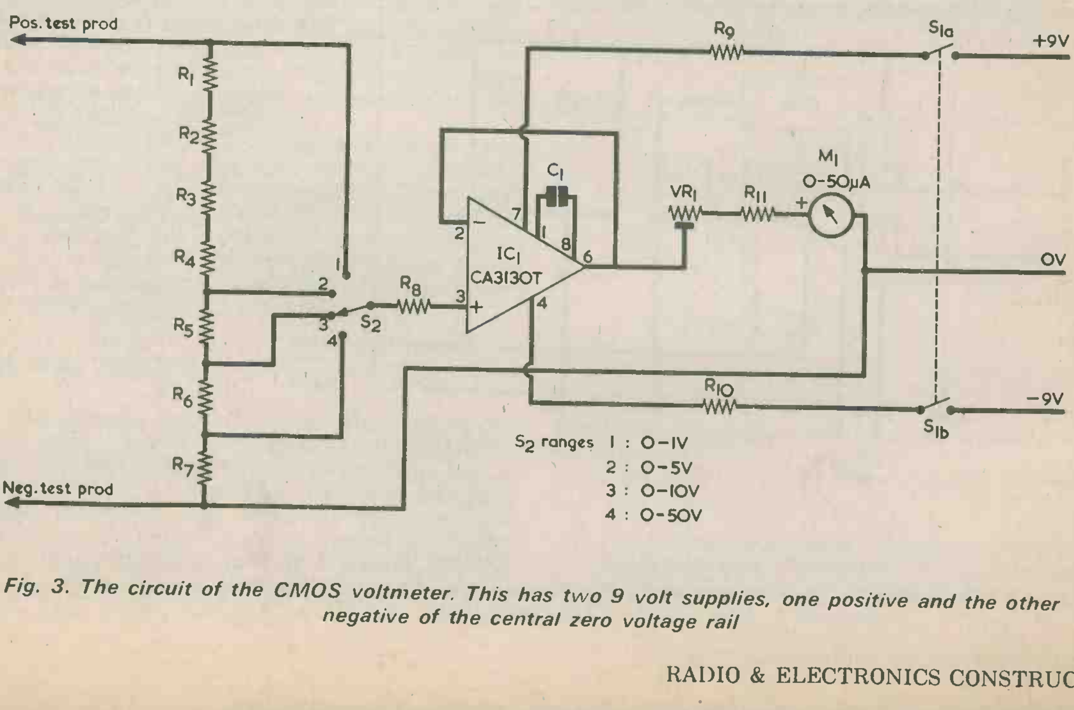



*Fig. 3. The circuit of the CMOS voltmeter. This has two 9 volt supplies, one positive and the other negative of the central zero voltage rail*

## COMPONENTS

*Resistors*
(All fixed values ¼ or ½ watt. R1-R7 5% or less. R8-R11 10%.)

- R1 2.7MΩ
- R2 2.7MΩ
- R3 3.3MΩ
- R4 3.3MΩ
- R5 1.5MΩ
- R6 1.2MΩ
- R7 300kΩ
- R8 100kΩ
- R9 3.3kΩ
- R10 3.3kΩ
- R11 15kΩ
- VR1 10kΩ pre-set potentiometer, 0.1 watt skeleton, horizontal

*Capacitor*
- C1 120pF ceramic plate or silvered mica

*Integrated Circuit*
- IC1 CA3130T

*Meter*
- M1 0-50μA moving-coil (see text)

*Switches*
- S1 2-pole 2-way, rotary
- S2 3-pole 4-way, rotary

*Miscellaneous*
- 2 batteries type PP9 (Ever Ready)
- 2 battery connectors
- 2 knobs
- Veroboard, 0.1in. matrix
- Plastic case (see text)
- Test prod, red
- Test prod, black
- Wire, grommet, etc.

supply, voltages from 2.5 to 8 volts positive and negative. The i.c. cannot therefore be operated directly from two 9 volt batteries. A dual 4.5 plus 4.5 volt battery such as the PP11 could be used, but this is rather bulky for what is intended to be a miniature instrument. Also, since the current consumption of the unit is only 1.5mA, the use of a high capacity battery is not really justified.

The solution finally adopted is to employ two PP3 9 volt batteries, with series resistors R9 and R10 dropping the voltage which is actually applied to the CA3130T. This receives approximately 4.5 volts positive and negative, which is more than adequate for present requirements. No decoupling capacitors or supply stabilization are required.

Apart from the range switch the unit has only one other control, this being the on-off switch, S1(a)(b).

### CONSTRUCTION

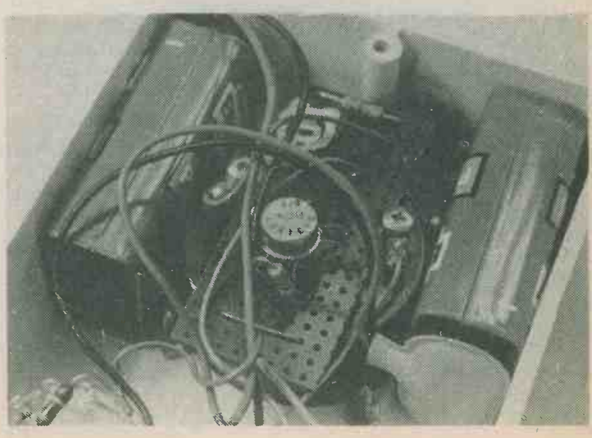
The author employed a 0-50μA meter from the Henelec 38 series having a square front measuring 42 by 42mm. With this meter it was possible to position the Veroboard panel between the terminals and to house all the components in a plastic case having internal dimensions of 110 by 75 by 33mm. Any plastic case which is not smaller in any of these dimensions may be employed. The general layout is shown in the photographs. However, any other 0-50μA meter (or, as is explained later, 0-100μA meter) may be used, the layout and case being chosen to suit this. Using the author's layout the case stands vertically with the meter central and at the top. With the author's case there is just sufficient space for the batteries on either side of the meter.

The two switches are mounted below the meter, and a hole of about ¼in. diameter is drilled below these and is fitted with a grommet. The test leads pass through this grommet.

Some of the components are assembled on a piece of Veroboard of 0.1in. matrix, and having 20 holes by 8 strips. Details of this board together with the remainder of the wiring are given in Fig. 4. To prevent possible damage to the CA3130T, all soldering must be carried out with an iron whose bit is reliably earthed.

Start by cutting out a panel of the required size and then make the five breaks in the copper strips by means of a Vero spot face cutter or a small twist drill held in the hand. Next solder in the components and the link wire. If a case and meter similar to those

*A close-up view of the Veroboard assembly. There are two PP9 batteries, one on either side of the meter*



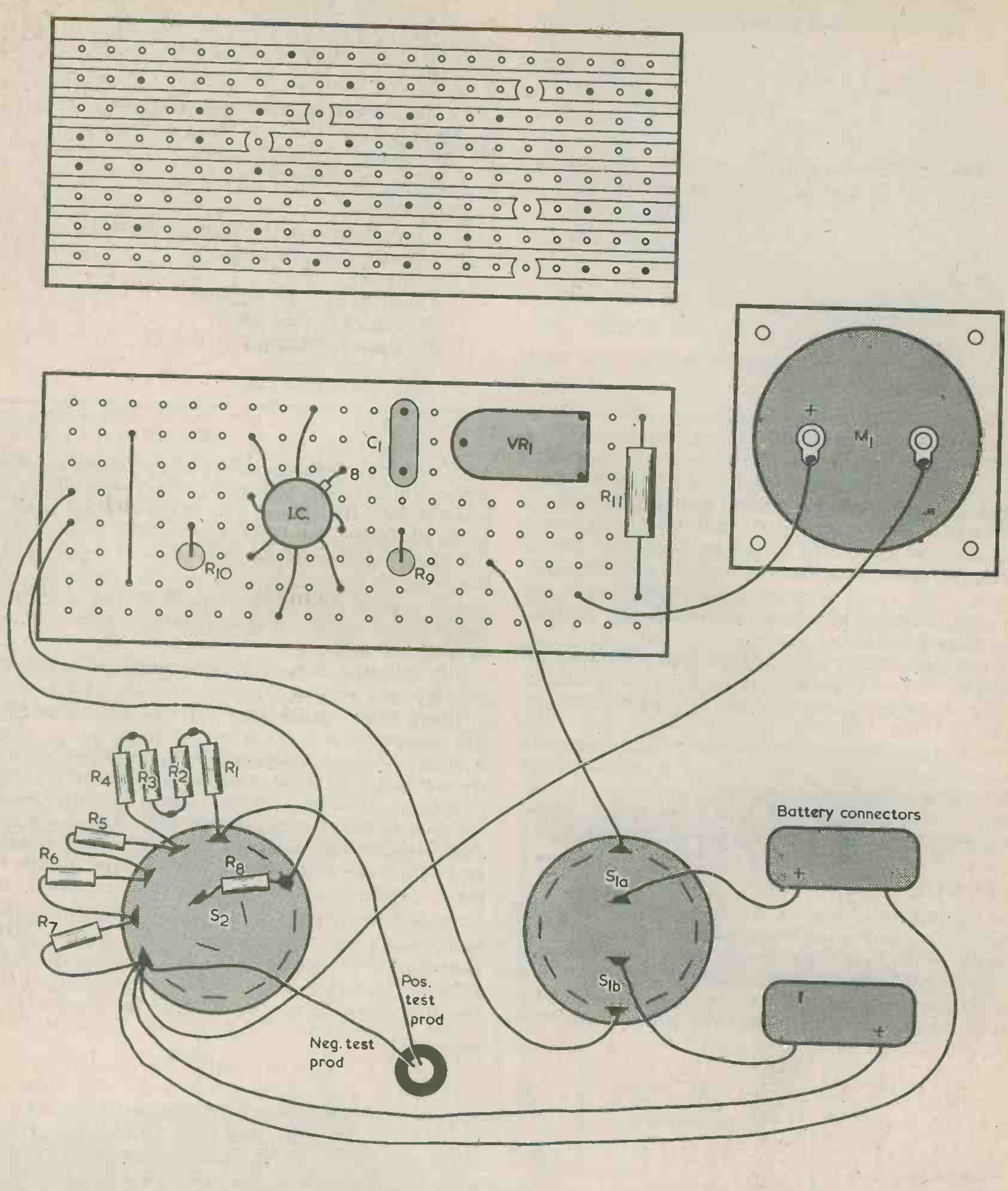
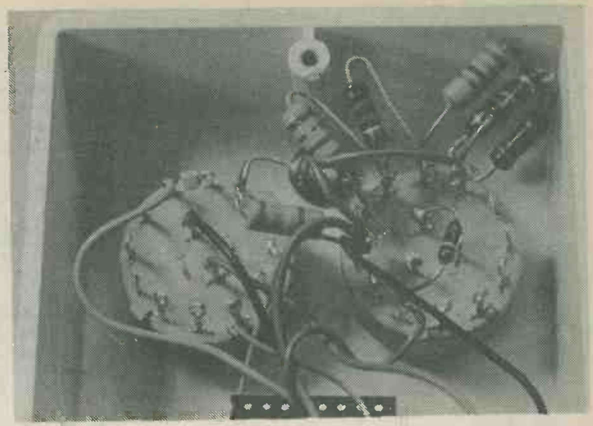



*Fig. 4. Wiring details for the voltmeter, including the Verobard panel assembly*

employed by the author are used, the Veroboard assembly should not be more than about 10mm. high or it will not fit the case; this requires that the components are kept close to the board.

R1 to R8 are soldered to switch S2, and it should be noted that two of the switch tags, on unused poles, are employed as anchor tags for one lead of R7 and one lead of R8. To avoid mistakes, first identify the four outer tags corresponding to the inner switch arm tag by visual examination or with the aid of a continuity tester or an ohmmeter, then wire R1 to R6 inclusive to these. It should be noted that the relative positioning between the inner and outer tags may be different on some switches from that shown in Fig. 4. R7 and R8 may then next be wired in. S1(a)(b) is shown as a component having 12 outer tags, but any small 2-pole



*The attenuator resistors are wired directly to the tags of the range switch*

2-way rotary switch can be employed here.

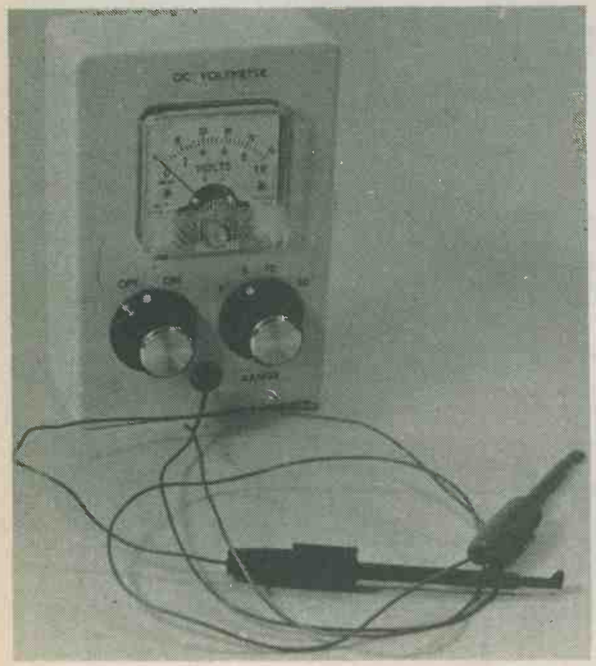
The wiring between the switches, the board, the meter and the battery connectors is then completed. In the author's instance, the component board and batteries are held in place by the back of the case.

## SETTING UP

Only one adjustment is required before the completed voltmeter can be used, and this consists of setting up VR1 to give the correct f.s.d. sensitivity.

This adjustment can be carried out in the following manner. Set VR1 to insert maximum resistance into circuit (slider fully anticlockwise), select the 0-10 volt range and switch on. Then measure the voltage of the battery supplying the positive rail with a multimeter and note the reading. Remove the multimeter and apply the positive test prod of the voltmeter to the positive terminal of the battery which has just been checked. Adjust VR1 so that the meter gives a reading which is exactly the same as that obtained with the multimeter.

The CMOS voltmeter is then ready for use.



*Another view of the CMOS voltmeter, with its test prods all ready for use*

## FINAL NOTES

Some final points need to be mentioned before concluding this article.

The author added the figures 0, 2, 4, 6, 8 and 10 to the scale of his 0-50$\mu$A meter to give a graduation from 0 to 10 in addition to the existing graduation from 0 to 50. Also added was the legend VOLTS. The figures and the legend were taken from Panel Signs Set No. 4, which is available from the publishers of this journal. Since the process of adding the figures and the legend involves removing the meter movement from its case, constructors who wish to do the same are advised to do so only if they feel confident to dismantle and reassemble the meter without damage. It should be borne in mind that a single speck of dirt can virtually ruin the operation of a meter if it finds its way into the moving parts. Legends on the front panel of the voltmeter were also taken from Panel Signs Set No. 4.

The output from the CA3130T will drive a 0-100$\mu$A meter, and a meter with this sensitivity may, in consequence, be employed instead of the 0-50$\mu$A meter listed in the Components List, should this be desired. With a 0-100$\mu$A meter, R11 requires a value of 7.5k$\Omega$ and VR1 a value of 5k$\Omega$ or 4.7k$\Omega$.

The voltmeter circuit does not incorporate an offset null adjustment, with the consequence that the meter may possibly give an indication other than zero when no voltage is applied to the test prods. Judging from the data on the CA313OT the maximum offset voltage will be less than 10mV, and would not be discernible on a meter of the type employed by the author although it might just be visible with a large meter having a clearly graduated scale. Should such an offset voltage appear the meter needle may be returned to zero simply by adjusting the mechanical zero-set on the meter itself. The author has checked three CA313OT i.c.'s in the circuit and in each case the offset voltage was only about 1mV. ■

SUGGESTED CIRCUIT

# T.T.L. SEQUENTIAL SWITCH

**By G. A. French**

Excusably, there is a tendency with modern electronics to look upon integrated circuits as enclosed "black boxes" with convenient terminal pins protruding for the connection of external components. In many cases, however, it is beneficial to be aware of at least part of the internal circuit of an i.c., especially if the i.c. is to be employed in an application other than that for which it was originally designed.

These remarks apply particularly to digital i.c.'s in the 74 t.t.l. series, and a knowledge of their input and output circuits reveals a capability for controlling surprisingly heavy loads.

## 74 SERIES CIRCUITRY

The input circuit for a standard 74 series digital i.c. has the basic form shown in Fig. 1(a), this applying to NAND gates, NOR gates, flip-flops and other devices. The input transistor has one or more emitters, each emitter coupling to an input pin. The input pins may be connected to the outputs of other i.c.'s of the 74 family. The base of the transistor couples to the positive supply rail via a resistor with a nominal value of 4kΩ. The positive supply rail is 5 volts stabilized, and should lie between 4.75 and 5.25 volts.

If a logic 0 is applied to the input terminal in Fig. 1(a) this terminal is drawn down very nearly to the zero volt rail. In consequence, a current flows through the emitter-base junction of the transistor and the 4kΩ resistor. Assuming that the base-emitter junction of the transistor drops 0.6 volt, that the base resistor is exactly 4kΩ and that the supply voltage is exactly 5, the maximum calculated current which can flow is 1.1mA (given by 4.4 volts divided by 4kΩ). In practice there are fairly wide tolerances on the value of the resistor and other factors, and the maximum logic 0 input current quoted in the manufacturers' specifications is 1.6mA.

When the input is in the logic 1 state, it is raised above the zero volt rail by around 3.3 volts or more. Under this condition (and assuming that no other emitter is held at logic 0) the transistor base of Fig. 1(a) takes up a positive potential lower than that of the emitter due to the other circuitry in the i.c., and the emitter current which flows is proportionately very low, consisting of reverse bias leakage current. The maximum current figure quoted here by the manufacturers is 40μA. If, as in a NAND gate, one emitter moves to a logic 1 whilst a second emitter remains at logic 0, the second emitter holds down the transistor base to a low level and the junction of the first emitter and the base again become reverse biased. The only current which then flows in the first emitter is the leakage current in the reverse biased emitter-base junction.

These points explain, incidentally, why an unconnected input pin in 74 series logic automatically takes up the logic 1 state. The input has to be actively drawn down to a low voltage by an external circuit if it is to be in the logic 0 condition. It is in order, with

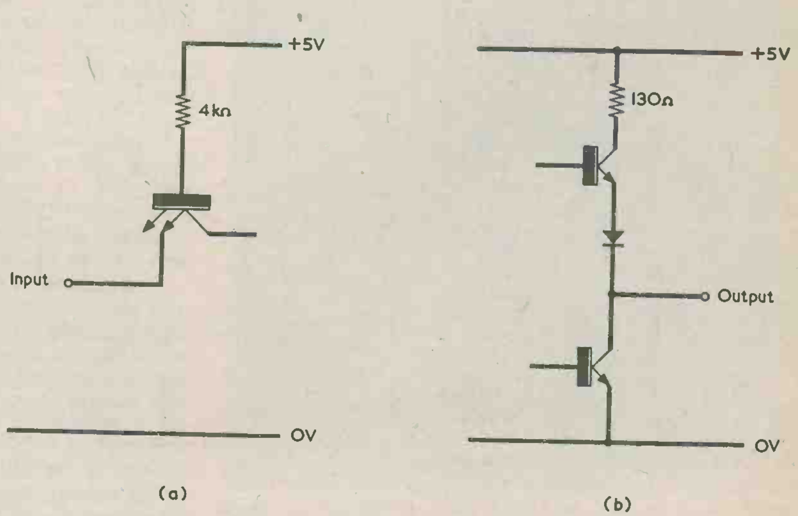



*Fig. 1(a). The basic form of a 74 series gate input stage (b). A basic output stage* simple slow speed circuits, to leave a 74 series input open if it is desired that it take up a logic 1; but such an input should be taken to a suitable positive voltage or to the positive supply rail via a 1kΩ resistor if the i.c. is employed in a complex or high speed circuit.

The basic output stage for an i.c. gate in the 74 family appears in Fig. 1(b). When the output is in the logic 0 state the lower transistor is turned fully on and the upper transistor is cut off. Contrarily, when the output is at 1 it is the upper transistor which is turned on and the lower transistor which is off. There are several gates with open-collector outputs which omit the upper transistor and have the lower transistor only, but we can dismiss these for the time being.

The primary object of the output stage of Fig 1(b) is to drive one or more 74 series inputs. Since a considerably higher current is required to draw an input down to the logic 0 state, the lower transistor in the output stage has its emitter connected directly to the zero volt line and its collector connected directly to the output terminal so that the only voltage dropped in the circuit is that across the transistor itself. With a silicon transistor turned well on, this voltage will be of the order of 0.2 volt. The maximum voltage quoted by the manufacturer is 0.4 volt with 0.22 volt typical.

The current requirement for an output at logic 1 is very much smaller, and the output voltage can rise to an acceptably high value even though the upper transistor of Fig. 1(b) has in series with it a 130Ω resistor and a diode.

It is obvious that, if we wish to drive an external load from a 74 series output, we shall be able to draw a much larger current and have a higher voltage across the load if it is connected between the output and the positive rail rather than between the output and the negative rail. When the load is between the output and the positive rail the only item in series with it is the lower transistor of Fig. 1(b), and this is intentionally designed to pass a relatively high current.

The number of logic inputs to which a logic output can be connected is known as the output fan-out, and for 74 series logic the fan-out normally has a maximum value of 10. Thus, one output can draw ten inputs down to logic 0, each input having a maximum current rating of 1.6mA, whereupon the total output current has a maximum rating of 16mA. A 74 series output will, in consequence, drive any load connected between the output and the positive rail which does not consume more than 16mA.

The same remark applies to a gate having an open-collector output intended for coupling to the 5 volt positive rail. Driver gates with high voltage open-collector outputs have different criteria, and are in any case designed for relatively high output currents.

## RELAY CIRCUIT

The fact that an ordinary 74 series gate can drive a load at currents up to 16mA opens up a number of interesting applications, of which the most obvious is that the load be a relay coil. An almost tailor-made component here is the "Miniature Open P.C. Relay" with 410Ω coil which is retailed by Doram Electronics Limited, P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds, LS12 2UF. The current drawn by this relay with 5 volts across the coil is 12.2mA, which fits comfortably inside the 16mA maximum output current figure.

The specified coil operate voltage range for this relay is 4.8 to 35 volts. The voltage across the relay coil will be 4.8 volts if the 74 series gate supply is exactly 5 volts and the voltage across the gate output transistor is 0.2 volt, and so the specifications just coincide. In practice, of course, the supply voltage may be a little lower than 5 volts and the voltage across the output transistor a little higher than 0.2 volt, whereupon the minimum specified voltage of 4.8 volts will not appear across the relay coil. However, the writer's experience with several samples of the Doram relay has shown that it just energises at voltages around 3.5 volts and operates reliably at a voltage of 4.35 volts. This is the minimum possible voltage if it is to be driven by a 74 series i.c. and is given when the supply rail is at 4.75 volts and 0.4 volt is dropped across the output transistor in the 74 series gate. If it was desired to definitely ensure that the relay operating voltage was within specification the supply voltage could be stabilized at about 5.2 volts but, in the writer's opinion, there should be no neccessity to work to such close limits.

A simple circuit in which a JK flip-flop type 7470 directly controls the Doram relay is given in Fig. 2. This is a sequential switch in which the relay energises when push-button S1 is pressed and then releases when it is pressed again. Pressing S1 a further time will cause the relay to be energised once more, and so on. The only discrete components are the relay, diode D1 and the push-button itself.

Pressing S1 results in a positive-going pulse edge being applied to the clock input of the flip-flop at pin 12, and this causes the Q output at pin 8 to change from its previous state. When the Q output is low the relay energises, and in the author's circuit the voltage at pin 8 was then only 0.15 volt positive of the zero volt rail, which is lower than the manufacturers' typical figure of 0.22 volt. The voltage at the not-Q output at pin 6 is opposite to that at the Q output, and the relay could alternatively be connected to this pin. The J and K inputs at pins 3, 4, 10 and 11 are all returned to the positive rail. The 7470 has inverting J

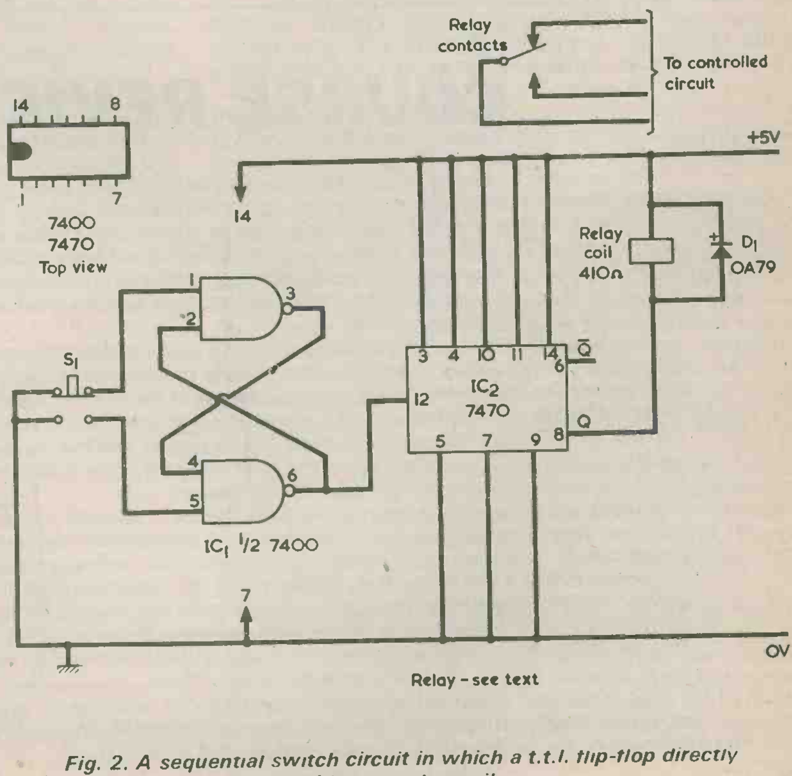



*Fig. 2. A sequential switch circuit in which a t.t.l. flip-flop directly drives a relay coil*

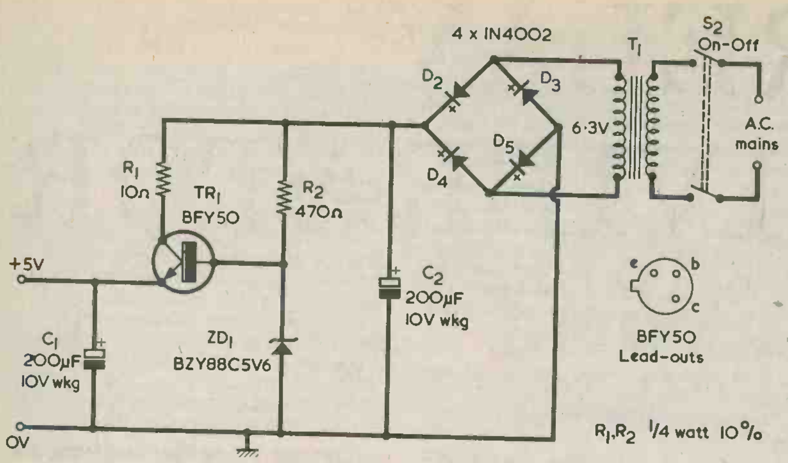



*Fig. 3. A suitable power supply for the sequential switch*

and K inputs at pins 5 and 9 and these are returned to the zero volt rail.

A JK flip-flop cannot be controlled directly by a switch because of contact bounce when the switch closes. Two NAND gates of a 7400 are, in consequence, interposed between the push-button and the clock input of the 7470. Pin 14 of the 7400 is taken to the positive rail and pin 7 to the negative rail. No connections are made to any of the pins of either integrated circuit which do not appear in the diagram.

The two NAND gates form an RS latch and the configuration is a standard one when a switch is coupled into a digital circuit. When S1 is not pressed the input at pin 1 of the upper NAND gate is low and so its output at pin 3 is high. As a result, both pins 4 and 5 of the lower NAND gate are high and the output at pin 6 is low. The circuit remains latched in this state when S1 is partially pressed and its upper contacts break because of the low input at pin 2, but it changes dramatically when the two lower contacts are connected together. Input 5 of the lower gate goes low, the output at pin 6 goes high and the output at pin 3 goes low. The circuit remains in this condition despite contact bounce in S1 and only reverts to its previous state when the switch is released and its upper contacts close again.

Turning to components, the push-button is an s.p.d.t. type, as indicated. The diode across the relay coil, D1, is included to prevent the formation of a high back-e.m.f. in the coil when the relay releases. A germanium type is chosen in order to limit the back-e.m.f. to around 0.2 volt positive of the positive rail. The relay specified has changeover contacts rated at 5 amps for 250 volts a.c. or 30 volts d.c. It is intended for soldering to a printed circuit board, but it can also be mounted in conventional fashion by means of two 8BA bolts and nuts. Its metal frame is common with its moving contact and this fact must be borne in mind if the relay is employed to switch mains voltages.

Constructors will probably have their own approaches towards obtaining the 5 volt stabilized supply. If it is intended to make up a power supply specifically for the sequential switch, a suitable circuit is given in Fig. 3. The mains transformer, T1, can be any small heater transformer with a secondary voltage of 6.3 volts.

A chassis symbol is shown in both Figs. 2 and 3. This may be ignored if the circuits are fitted in an insulated housing such as a plastic case. ■

# COURSE REVIEW

Of interest to beginners will be the series of books on "Basic Electronics" which has been produced by Project Technology, a body set up by the Schools Council at the College of Education, Loughborough. The aim of Project Technology is to promote a better understanding by pupils at all ability levels of the relevance of technology to society, and it has produced material which directly involves the pupil in the application of scientific knowledge to practical problems. The material on electronics is, of course, just as useful and helpful to those who have left school and are embarking on electronics as a hobby or a career.

The "Basic Electronics" course consists of five books which are intended to be read in numerical order. Book 1 (79 pages) is entitled "Introducing Electronics, Measuring Instruments", and shows how electronics is employed in all sections of modern life. It then deals with measuring instruments, these including the oscilloscope, the signal generator and the multimeter. "Resistors in Circuits, Capacitors in Circuits" is the title of Book 2 (112 pages), and the first section deals extensively with resistors, describing the various types and illustrating their functioning in circuits. The second part of the book deals with capacitors in a similar manner.

Book 3 (96 pages), "Inductors in Circuits, Diodes in Circuits", takes the reader further into the world of electronics and starts to demonstrate the properties of semiconductor devices. Book 4 (80 pages) covers "Meters, Voltage-dividers". The section on meters deals fully with meter shunts, series voltmeter resistors and ohmmeter circuits, whilst the remaining part of the book covers the field of voltage dividing circuits and their applications in such instruments as the Wheatstone bridge. "Transistors in Circuits, Transistors in Action, Post-transistor Projects" is the title of Book 5 (192 pages). This completes the course and takes the reader through transistors, transistor operation and transistor circuits, leading up to the operational amplifier.

The books are well illustrated with clear diagrams and include projects such as simple radio receivers, intercom amplifiers, intruder alarms, light operated devices and metal locators. Books 1 to 4 inclusive are priced at £1.25 each, and Book 5 at £2.00.

# RELAY MULTIVIBRATOR

## By D. W. Savage

**The addition of a single capacitor allows two relays to function as a 50:50 multivibrator.**

This useful little relay circuit appeared in the April 1976 issue of the Soviet journal *Radio*. When we tried it out in practice with two P.O. 3000 relays we found it worked so well that we felt it should be brought to the notice of readers of *Radio & Electronics Constructor.*

### THE CIRCUIT

The circuit appears in the accompanying diagram, in which the blocks designated A/2 and B/2 are the coils of relays A and B respectively. Contact B1 is a normally closed contact set of relay B, and contact A1 is a normally closed contact set of relay A.

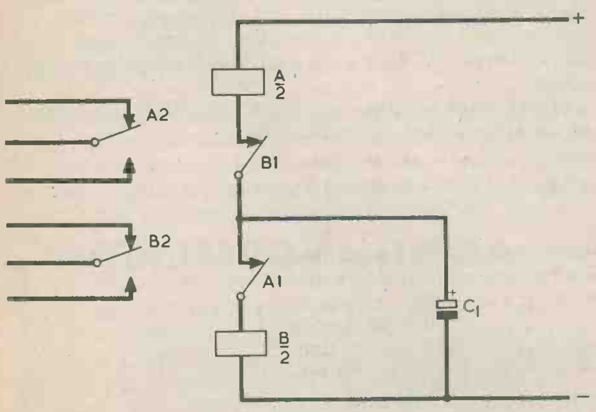
When the supply is applied both contact sets are closed. A charging current flows via the coil of relay A to the electrolytic capacitor C1 and relay A energises, causing its contact set A1 to open. The voltage across the capacitor increases as it charges. Relay B cannot energise as the circuit to its coil is broken by contact set A1.

After a period the voltage across C1 rises to a level at which the remaining voltage available for coil A/2 is too low to allow relay A to remain energised. Relay A releases and contact set A1 closes, connecting the charged capacitor across the coil of Relay B. Relay B energises and its contact set B1 opens, breaking the circuit to the coil of relay A.

The capacitor now discharges into the coil of relay B, until the voltage across it falls to the level at which relay B releases. Contact set B1 closes and the voltage now available for coil A/2 is more than sufficient for relay A to energise. Contact set A1 opens and the capacitor starts to charge again via the coil of relay A. This continues until the voltage across the coil of relay A falls to the release level. Contact set A1 closes, the capacitor discharges into coil B/2, and the cycles continue.

External circuits can be switched by a second contact set on either relay A, or relay B, or both.

The two relays should be of the same type and have the same coil resistance. Relays having a release coil voltage which is considerably lower than the energise voltage are to be preferred. The supply voltage may be approximately twice the voltage normally employed to energise a single relay.




*The circuit of the relay multivibrator. The relays energise alternately as the capacitor charges and discharges*

### PRACTICAL RESULTS

The circuit was checked with two P.O. 3000 relays having 500 Ωcoils. The supply was an 18 volt battery. Initially, C1 was 1,000μF.

The circuit functioned satisfactorily with a 50:50 cycle being completed in about 2.5 seconds. This is much longer than the time constant given by 1,000μF and 500Ω would lead one to believe; doubtless the relay coil inductance, in opposing changes in current flow level, adds considerably to the length of each half-cycle. Changing the capacitor to 2,000μF roughly doubled the length of the cycle to approximately 5 seconds. Further increases in the value of the capacitor will result in roughly proportional increases in cycle length.

Rather surprisingly, the circuit operated well with quite low values of capacitance, and the minimum which gave good results was 50μF. With this value the relays completed a cycle in about 0.4 second. Relay operation was quite definite, with sharp energising and release actions.

These notes should enable constructors to set up similar circuits. The relay coil resistances do not, of course, have to be 500Ω provided that both resistances are the same. It is probable that best results will be given with relays having fairly high resistance coils, say above 300Ω or so. The value of capacitance required for a particular cycle length can be found by experiment. ■

# NEWS . . . AND .

## LABORATORY TWIN STABILISED POWER SUPPLY

The new Twin Stabilised Power Supply from Linstead Electronic Instruments of Roslyn Road, London, N15 5JB is the S10. Intended for laboratory use it is a highly stable, completely isolated twin supply giving up to 2 amps over the range of 0 to 30

pedance is less than 0.2 ohms up to 1MHz.

The output voltage is controlled by a 5 volt step switch and a 0-5 volt fine control potentiometer. The ripple at all loads is less than 300 microvolts r.m.s. and the line regulation better than 0.01%. The output resistance is less than 0.005 ohms and the output impedance is less than 0.2 ohms up to 1Mhz.

Over current protection is variable and calibrated over two ranges 0-200mA and 0-2 amps. It is easy, therefore, to set the maximum current very accurately. If this current is exceeded the volts automatically fall back to zero and a manual reset cutout operates.

Remote sensing is provided to compensate for voltage drop, where long leads are being used.

Both supplies are completely isolated with respect to each other and earth allowing series or parallel connections and ± supplies to be constructed. It is, therefore, possible to obtain up to 60 volts at 2 amps or up to 30 volts at 4 amps.

Both outputs are metered and can be selected to monitor voltage or current.

The small size of the S10 (20.5 cm x 20 cm x 17.5 cm) means that it occupies a minimum amount of bench space and with its very high performance specification makes it an ideal piece of laboratory equipment.

Price: £137.

## DESIGN CENTRE DISPLAY TO AID HI-FI UNDERSTANDING

Technical terms freely used by manufacturers can be baffling, but a display in The Design Centre, closing date 8th January 1977, will help all those who know little about hi-fi. As well as showing a selection of well-designed British hi-fi equipment, the display will show how hi-fi is achieved, and a specially prepared hi-fi guide will available to help the non-specialist to understand what hi-fi is all about.

The centrepiece of the display will illustrate how the hi-fi system works while a commentary recorded by John Borwick, audio editor of the 'Gramophone', will explain in non-technical terms the various components needed for a successful hi-fi system. In conjunction with this exercise a 'Design Centre Guide to British Hi-Fi' has been compiled in association with the 'Gramophone'. An invaluable guide to prospective purchasers, if offers advice on selecting the right hi-fi equipment, illustrates some well-designed products take from Design Index, and explains how hi-fi is measured and the technical specifications used.

Several well-known manufacturers will be exhibiting their products in the display. The Acoustical Manufacturing Company's Quad 405 amplifier, which won a Design Council award earlier this year, will be on show and other amplifiers will be supplied from Armstrong Audio Ltd., Spendor Audio Systems Ltd. and Lecson Systems Ltd. A variety of loudspeakers will be displayed by Gale Electronics, Jordan-Watts Ltd., Monitor Audio Ltd. and Rank Audio Visual Ltd.

Those who prefer more compact stereo systems and 'musicentres' will be interested in the models from Rank Radio Ltd and ITT Ltd. Other equipment on display will include turntables, pick-up arms and headphones, together with record and cassette storage racks.

The Design Centre is situated near Picadilly Circus at 28 Haymarket, London SW1.

## ANNOUNCEMENT

Owing to rising costs we regret that the cover price of this magazine will be 40p, commencing with the next issue. Annual Subscriptions will remain at £5.50.

We have a number of exciting projects lined up and our next issue will contain extra pages, thus enabling us to continue our policy of giving more space for articles than most of our contemporaries.

To make sure of your copy place a regular order with your newsagent.

# . . . COMMENT

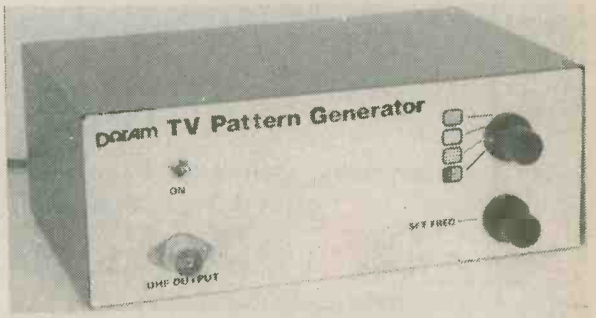
## UHF TV PATTERN GENERATOR INTRODUCED

Doram Electronics Limited, the Leeds based mail-order distributor of Electronic Construction Kits, audio and electronic components, have introduced a sophisticated yet simple to construct and operate UHF TV Pattern Generator.

As with all Doram construction Kits, this new and compact device has undergone extensive assembly and test trials with the result that graduate TV Service Engineers can build, with comparative ease, a really efficient test unit that will not only give long lasting service, but will be a very economical asset in the workshop or in field TV servicing.

The cleverly designed circuit with extensive use of integrated circuits does not require alignment and incorporates its own pulse generator to provide the added advantage of interlaced scan.

A special feature is the inclusion of a visually adjusted frequency control which exactly locks its drift-free oscillator to both the TV line and frame sync. The four test patterns namely blank, dots, grey-scale and crosshatch have been carefully selected to provide




fast but accurate alignment of static and dynamic covergence, geometry, focus, beam limiting, grey scale and black level clamp.

For operation the device only requires connection to mains and the aerial socket of the TV.

The dimensions are 200 x 75 x 125 mm. Further details from Doram Electronics Ltd., P.O. Box TR8, Leeds 12 2UF.

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## BBC SEEKS GO-AHEAD FOR SPECIAL TRAFFIC REPORTS SERVICE

It is always encouraging to learn of the possible use of radio to ease our traffic problems.

A BBC scheme for road traffic information service direct to the motorist was recently put though its paces. Senior policemen, top Civil Servants, representatives of the AA, RAC, the Road Research Laboratories and the press went on a circular coach tour of London to hear how motorists could be given local traffic information over a small, cheap, fixed-tuner receiver in their car.

The scheme gives separate local traffic information via a network of low-power transmitters operating on the same frequency in the medium wave band. As the motorist travels, a receiver in his car automatically picks up the information being transmitted locally.

The receiver, could cost as little as £7 and could be so wired that it cuts into any programme the driver may choose to listen to on his car radio.

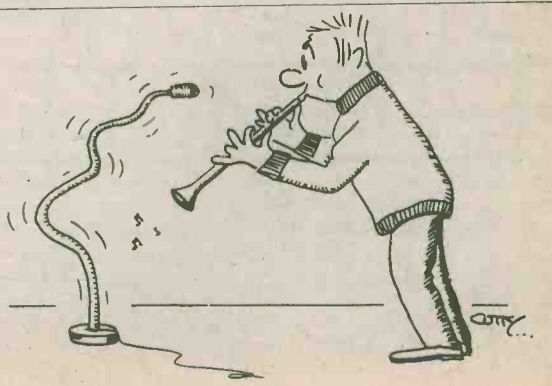
The key to the low-power system is that the information can be delivered in short messages repeated or updated at intervals, with longer periods of silence.

It was made clear the BBC was putting forward the scheme as an idea, and it was not proposed that the cost of the scheme should be a charge on the licence fee.

## ELECTRONICS SUMMER SCHOOL FOR TEACHERS

The Department of Electrical Engineering Science at Essex University will be holding its annual Electronics Summer School for teachers during the week July 11-15 1977. Two courses will be run simultaneously. The Linear Circuit Design course is concerned with the use of transistors and operational amplifiers in analogue applications and the basic circuits of a hi-fi amplifier are investigated in detail. The Digital Circuit Design course concentrates on the use of the transistor as a switch and develops design using integrated logic circuits; a digital patchboard is used to introduce the concepts of combinational and sequential logic design.

Further information on the Summer School can be obtained from R. J. Mack at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.



# THE '6-9' GAME

By R. J. Caborn

**An amusing game for two contestants which can be programmed to offer a test of skill or provide a pure gamble.**

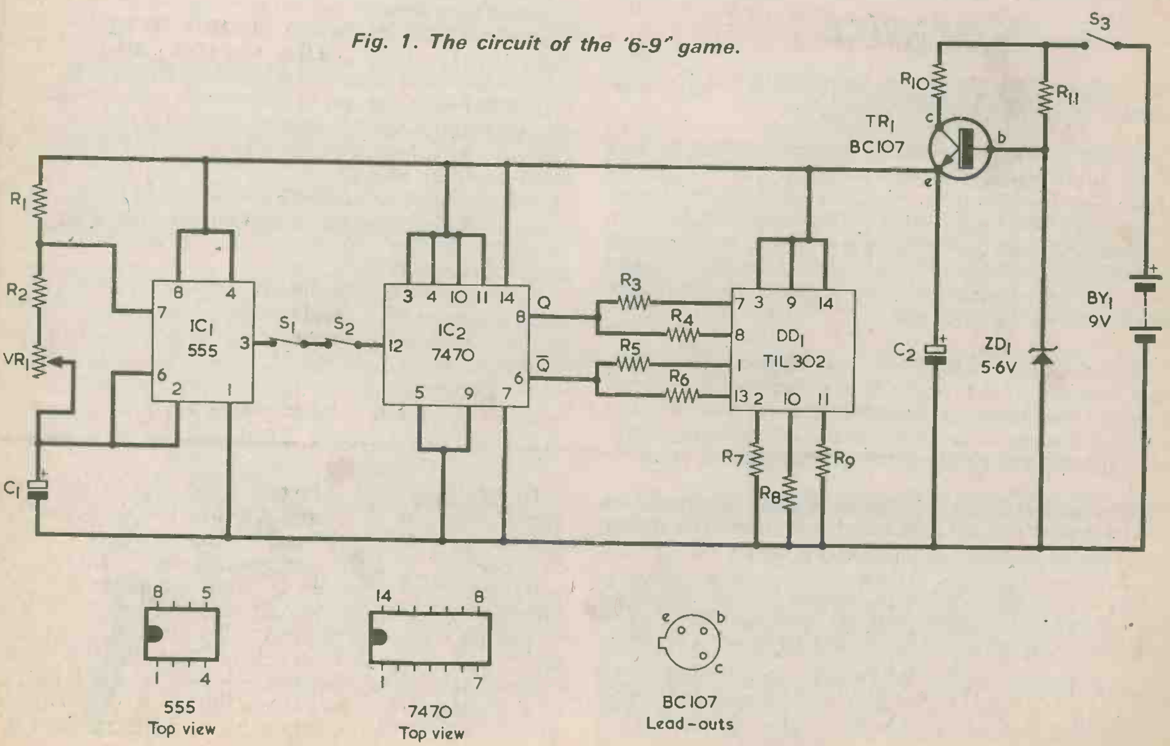
This is a simple electronic game for two players, and it incorporates two inexpensive integrated circuits, a seven-segment digital l.e.d. display and a few other components. The seven-segment display alternately shows the figure 6 and the figure 9. The contestants each have a switch which causes the display to 'freeze' at the number which is showing when the switch is operated, whereupon one player endeavours to hold the display at the figure 6 and the other at the figure 9. If a player operates his switch at an incorrect time, the number shown is that of his adversary who thereby gains a point. The length of time in each cycle when the figure 6 is displayed is exactly equal to the time when the figure 9 is shown, with the result that there is a complete lack of bias towards one number or the other.

A continuously variable speed control changes the length of the cycle over a range of 0.7 second to 0.1 second. At the slower cycle speeds operation of the switches is a test of the reaction time of the contestants. At the higher speeds the number displayed after operation of a switch is purely a matter of chance.

## CIRCUIT OPERATION

The circuit of the '6-9' game appears in Fig. 1. This

*Fig. 1. The circuit of the '6-9' game.*



employs a 555 timer in conjunction with a J-K flip-flop type 7470. A device employing these two integrated circuits to produce a continually changing 50-50 output has been described earlier in this journal, and was used in a simpler application which demonstrated flip-flop operation in "In Your Workshop" in the June 1976 issue. Credit for the idea is therefore due to the erudite Smithy and his enthusiastic associate, Dick.

In the present circuit the 555 timer is employed in a standard astable multivibrator circuit in which C1 charges via R1, R2 and VR1, and discharges via R2 and VR1. The length of the cycle can be varied by adjusting VR1, which is a front panel control.

A series of regularly spaced pulses appear at the output, pin 3, of the timer and are passed via S1 and S2 to the clock input, pin 12, of IC2. S1 and S2 are the two switches operated by the contestants, and they are normally closed. IC2 is a t.t.l. J-K flip-flop with the J and K inputs at pins 3, 4, 10 and 11 taken to the positive rail. Pins 5 and 9 are inverting J and K inputs, and these are connected to the negative rail. Pins 14 and 7 are positive and negative supply pins.

The flip-flop outputs at pins 8 and 6 are Q and not-Q respectively. (Not-Q is represented by the letter Q with a bar over it.) These change state from the 1 to the 0, or from the 0 to the 1, condition with each pulse from the 555 timer. Since pin 8 is Q and pin 6 is not-Q, pin 8 is always at 1 when pin 6 is at 0, and vice versa. Both outputs are capable of drawing 16mA from the positive supply when they are in the 0 state. In the 0 condition, either output is about 0.2 volt positive of the negative supply rail.

The seven-segment display is a TIL302 or equivalent, and has the pin allocations shown in Fig. 2. Here, "D.P." refers to the decimal point, which is to the left of the displayed figure and which acts as a convenient orientation marker for determining the pin numbers of the display. The pins are behind the body of the display, pointing away from the reader.

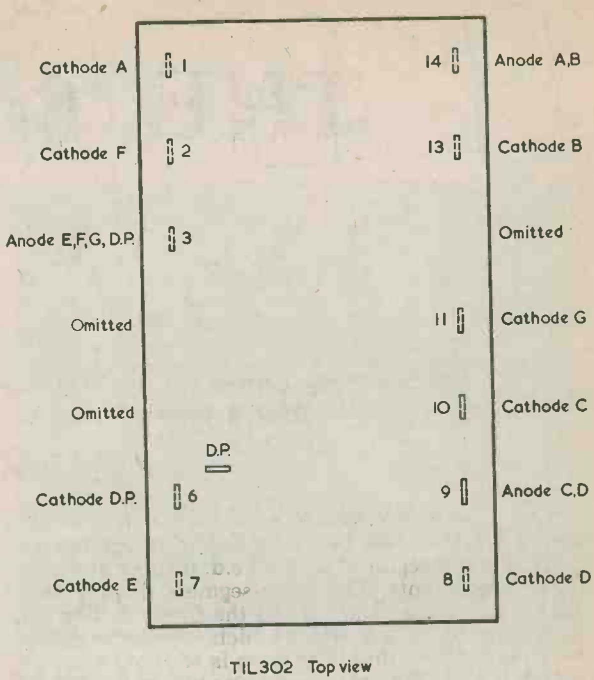



*Fig. 2. Pin allocations for the seven-segment digital display type TIL302*

## COMPONENTS

| | |
|---|---|
| *Resistors* (All fixed values ¼ watt 5%) | *Capacitors* |
| R1 4.7kΩ | C1 10µF electrolytic, 10 V. Wkg. |
| R2 1kΩ | C2 100µF electrolytic, 10 V. Wkg. |
| R3 1kΩ | *Semiconductors* |
| R4 1kΩ | IC1 555 |
| R5 1kΩ | IC2 7470 |
| R6 1kΩ | TR1 BC107 |
| R7 1kΩ | ZD1 BZY88C5V6 |
| R8 1kΩ | DD1 TIL302 or equivalent (see text) |
| R9 1kΩ | *Switches* |
| R10 39Ω | S1 s.p.s.t. toggle |
| R11 1kΩ | S2 s.p.s.t. toggle |
| VR1 20kΩ potentiometer, linear | S3 s.p.s.t. toggle |
| | *Battery* |
| | BY1 9-volt battery (see text) |

The seven segments of the display which make up the figures are identified by the letters A to G, as illustrated in Fig. 3(a). Figure 6 is formed by lighting up the segments shown in Fig. 3 (b), whilst 9 is formed in the manner illustrated in Fig. 3(c). It will be seen that segments F, G and C are illuminated for both numbers.

Returning to Fig. 1, the three common anodes of the display, at pins 3, 9 and 14, are connected to the positive rail. Pins, 2, 11 and 10, for segments F, G and C, are returned to the negative rail via R7, R9 and R8, with the result that these three segments are continually illuminated. When the Q output of IC2 is at 0, segments E and D of the display are lit up via pins 7 and 8 and resistors R3 and R4. The figure 6 is consequently displayed. Similarly, when the not-Q output is at 0, segments A and B are illuminated, by way of pin. 1 and 13 and resistors R5 and R6, to form the

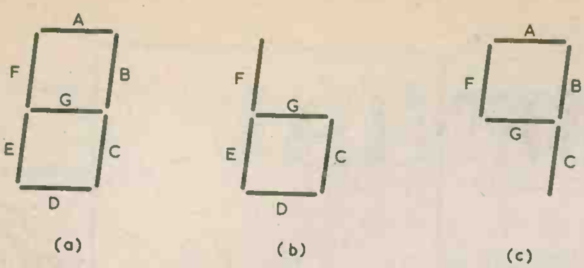



*Fig. 3(a). The seven segments of the display are identified by letters, as shown here*
*(b). The segments which are illuminated for figure 6*
*(c). Here the segments light up to form figure 9*

figure 9. Thus, the numbers 6 and 9 appear alternately in the display.

The values of R3 to R9 allow a current of approximately 3mA to flow in each segment when it is illuminated. This rather low current is chosen in the interests of battery life, but the resulting display is still more than adequately bright.

The 7470 requires a supply voltage of 5 volts for correct operation, and this is provided by the simple zener regulating circuit comprising ZD1, TR1 and R11. R10 is included to limit surge current on switching on as C2 charges. S3 is the on-off switch. The current drawn by the circuit is approximately 35mA and so a large battery, such as the PP9, is recommended. A better choice would be three 3-volt cycle lamp batteries (Every Ready No. 800) connected in series.

## SWITCH OPERATION

As already mentioned, S1 and S2 are the contestants' switches, and are normally closed. If either switch is opened, the output of the 7470 remains in the condition it held at the instant of opening the switch, and the seven-segment display retains a 6 or a 9, as applicable. When one contestant's switch is opened the other switch has no control over circuit operation. S1 and S2 are toggle switches since this type gives a definite switching action. If simple push-buttons which open when pressed were employed it would be possible to cheat by pressing these lightly and "nudging" the output to the alternative number if the one selected happened to be incorrect. Push-button switches having a definite toggle action could, however, be employed.

One of the features of the game is that, so far as scoring is concerned, it does not matter which switch is opened. If the player favouring 6 inadvertantly selects a 9 then the advantage accrues to his opponent. The switches can be operated at any time, although each contestant will naturally try to operate his own switch as many times as possible in order to score the highest number of points for the display of his figure. When a figure has been displayed and noted, the switch which has been opened is closed again and the game proceeds.

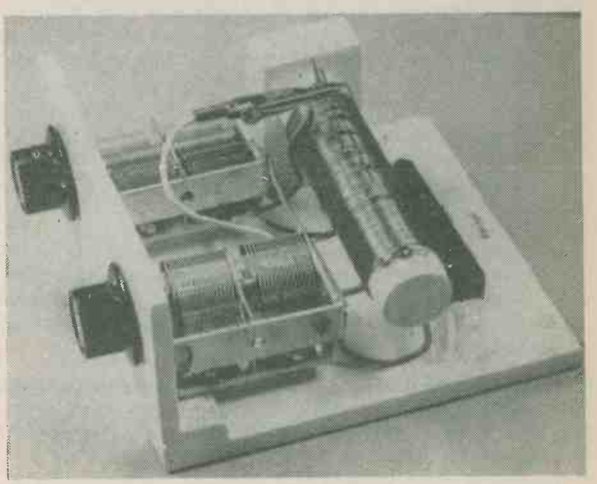
The total length for a complete cycle from the 555 timer depends upon the setting of VR1. When VR1 inserts maximum resistance into circuit the cycle time calculates at approximately 0.35 second, giving a total cycle period at the 7470 outputs of 0.7 second. If VR1 inserts zero resistance into circuit, the calculated time for a cycle from the 555 is approximately 0.05 second, whereupon that from the 7470 is 0.1 second. Because of component tolerances, the cycle times given in practice will vary somewhat from the calculated figures. With the cycle period at its longest it is a relatively easy matter to operate S1 or S2 to select a particular figure but, even at this slow speed, errors can be surprisingly frequent. About the best cycle length when skill is to be assessed is given with an overall cycle length of about 0.4 second. Each figure is then illuminated for 0.2 second, as opposed to the normal human reaction time of around 0.3 second. The game, incidentally, can offer a convincing demonstration that, contrary to the beliefs of some drivers, a few drinks do *not* speed reaction time!

VR1 is a normal carbon track potentiometer. If difficulty is experienced in obtaining a 20kΩ component, a 22kΩ or 25kΩ potentiometer may be employed instead, with a consequent increase of the longest cycle period available.

The TIL302 will plug into a 14 pin d.i.l. integrated circuit holder. There are a number of similar seven-segment displays available with a nominal display height of 0.3in. Notable amongst these is the SLA7, which has a single common anode for all segments connecting to pin 14. With this display, pins 3 and 9 are omitted. The other pins are the same as with the TIL302.

The components can be assembled in any small metal or plastic case large enough to accommodate them. The three switches and the seven-segment display are mounted on the front panel, with S1 and S2 near opposite edges. To avoid argument, it is of advantage to have one of these switches identified by the figure 6 marked on the front panel and the other similarly identified by the figure 9. ■

# EXPERIMENTAL AERIAL TUNING UNIT



*The tuning unit in its completed form. The two variable capacitors are mounted on the front panel with the coil positioned horizontally behind them. The tinned copper wires at the coil taps project upwards, and the crocodile clip connects to whichever of these is required*

By
Henry Hatch

**Intended for boosting signal strength on the short wave broadcast bands, this low-cost design takes advantage of homely materials in its construction.**

This simple and inexpensive piece of home-constructed equipment is intended for connection between a short wave receiver and an aerial, and it should in almost every instance increase signal to noise ratio on the international short wave bands. Cost is low and only essential components have been used.

As can be seen from Fig. 1, the unit employs a pi matching circuit incorporating a series tapped coil with two variable capacitors at either end coupling to earth. Each tap in the coil corresponds to one of the short wave broadcast bands.

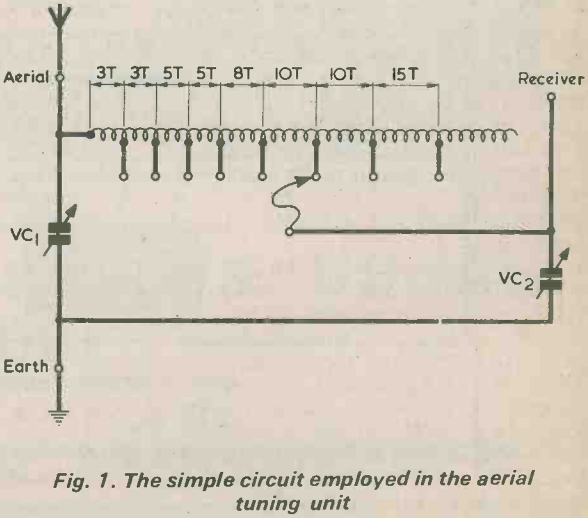



*Fig. 1. The simple circuit employed in the aerial tuning unit*

## CONSTRUCTION

The first step in construction is to acquire a former for the coil. This is approximately 1 in. in diameter and can be very conveniently provided by about 5¼in. cut from a broom handle. (Almost all broom handles checked by the writer are 1 in. in diameter.) The wood should be perfectly dry and can, if desired, be painted.

About 80 turns of 20 s.w.g. enamelled wire are close-wound on this former, the ends being anchored by soldering at two tags screwed into the wood. The start of the coil is about 1¼in. from one end of the former. The coil has 8 taps, one for each of the main short wave broadcast bands of 11, 13, 16, 19, 25, 31, 41 and 49 metres.

The first tap, for 11 metres, is 3 turns from the start, and the second tap, for 13 metres is at 3 turns further on. The 16 metre tap is 5 more turns on, and the 19 metre tap another 5 turns after this. The 25 metre tap appears after 8 more turns, the 31 metre tap after 10 more turns and the 41 metre tap after another 10 more turns. The final tap, for 49 metres, follows a further 15 turns. There are about 20 turns of the coil remaining and these are available for experimental purposes later on.

Of these taps the only critical one is the first for 11 metres, and it may be found necessary to shift this tap by half a turn on one side or the other of the position specified. If taps are made every 5 turns after the 19 metre tap it would be possible for the unit to cover *any* frequency in the range. However, this requires some skill in soldering and the taps will all be rather close together.

The easiest way of making a tap consists of inserting a small thin screwdriver blade under the coil wire at the required tapping point and levering it up slightly. Then, leaving the screwdriver in place, about ¼in. of the enamel is scraped off and a piece of 20 s.w.g. tinned copper wire ¾in. long with ¼in. bent at right angles at the bottom is soldered to the coil wire. The tinned copper wire projects upwards. The screwdriver is next removed and the coil wire pressed back into its original position.

## PANEL AND BASEBOARD

A panel and baseboard are required, and these can be assembled as shown in Fig. 2 and the photograph. Two pieces of ⅜in. plywood are quite suitable. In the author's unit the coil former is passed through a 1in. hole in a wooden block measuring 2½ by 1½ by ⅝in. thick. Any other means of mounting the former may be used provided that the material employed is mainly wood or another insulating material. VC1 and VC2 are mounted on the front panel. These two capacitors can have values of 350 to 500pF. The author used the rear sections of two 2-gang capacitors which happen-

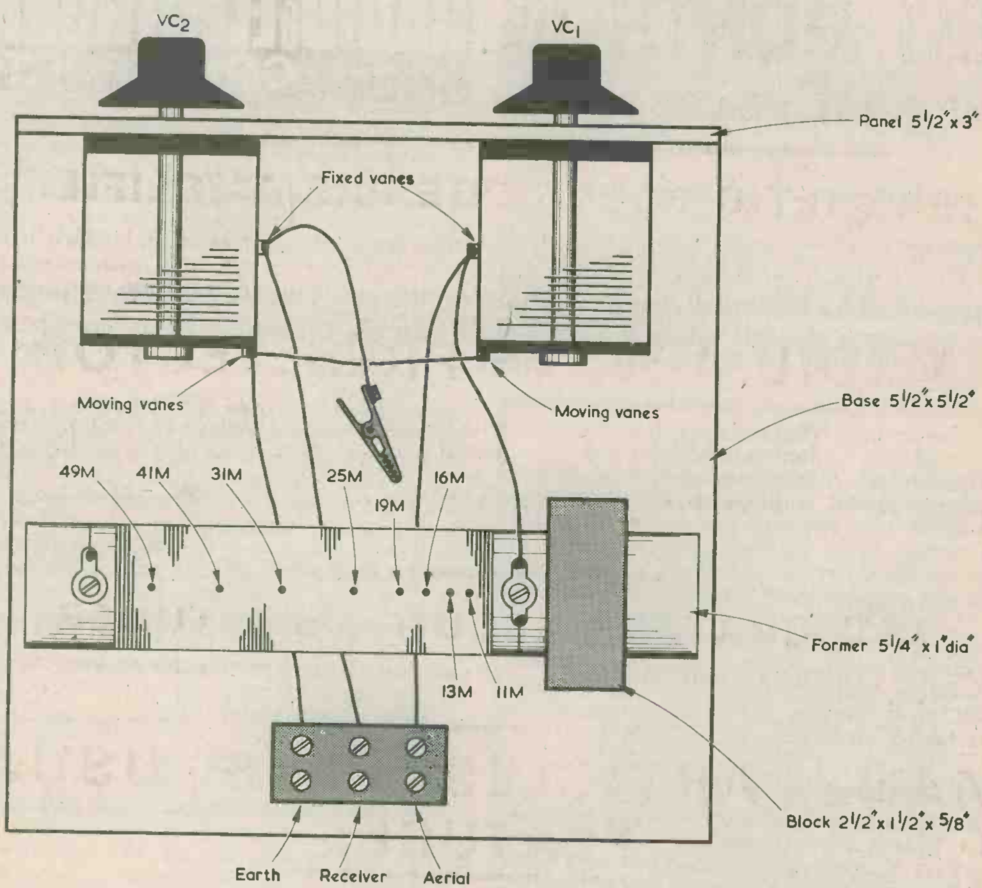



*Fig 2. Practical appearance of the unit. Dimensions are not critical provided that the general layout is observed*

ed to be available, but single gang capacitors will normally be employed. The capacitors must be air-spaced types.

A 3-way terminal strip is fitted at the rear of the baseboard for connections to the aerial, earth and receiver, after which the unit is wired up as shown in Fig. 2. The crocodile clip lead from the fixed vanes tag of VC2 uses flexible wire and should be long enough to allow the clip to connect to any of the coil taps. All the remaining wiring uses single core tinned copper wire of around 20 s.w.g.

The unit is now ready to be tried out. First tune in a short wave signal with the aerial connected to the receiver in the normal manner, then connect the tuning unit between the aerial and the receiver. The aerial and earth connect to the appropriately identified terminals on the tuning unit, with the earth connection to the receiver being maintained. The 'Receiver' terminal connects to the aerial input of the receiver. Select the appropriate coil tap and adjust VC1 and VC2 for maximum signal level. If the receiver is fitted with an S-meter it is probable that the tuning unit will increase meter deflection by some two S-points or more. There has always been disagreement amongst amateurs as to how many decibels are represented by an S-point, although most will agree to a minimum of 4dB, which corresponds to a voltage ratio of more than 1.5. Clearly, an improvement of several S-points in signal strength is really worth-while.

Beginners may ask how it is possible to achieve an increase in signal strength with the aerial tuning unit when it employs no amplifying device such as a transistor or a valve. The answer is that the unit ensures that as much as possible of the signal energy picked up on the aerial is passed to the receiver by providing optimum matching between the two.

As a final point, a warning must be given concerning mains operated receivers. The unit must not be used with a mains operated receiver unless the receiver chassis and earth terminal are fully isolated from the mains supply by way of a double-wound mains transformer. ■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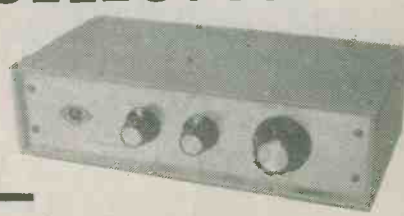

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# SIMPLE REGENER

B
A. P. F

**This little receiver employs an unus**
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**headphone level, and it may alternativ**
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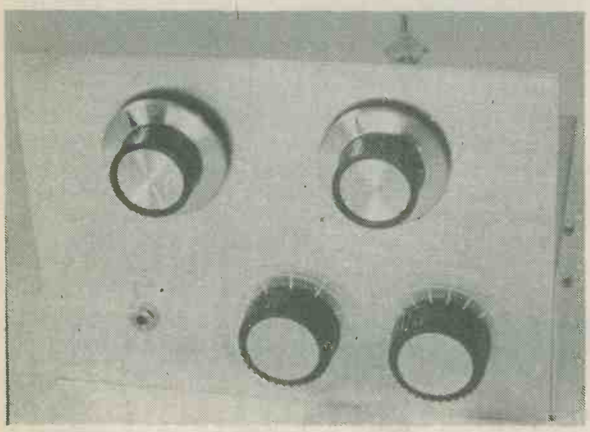

*The front panel layout of the receiver*

This simple receiver covers what is virtually the complete short wave spectrum from approximately 1.5 to 36MHz. There are three ranges, these being selected by plugging in Denco Miniature Dual Purpose coils. Quoting the Denco range numbers, these are Range 3, 1.5 to 5.5MHz; Range 4, 5 to 17MHz; and Range 5, 10 to 36MHz. The use of plug-in coils makes construction much easier than would be the case if bandswitching were employed. The coils are the Green type, and are normally associated with valve usage.

The basic receiver circuit employs two transistors, one of which is a field-effect type functioning as a regenerative detector whilst the other is a bipolar transistor providing a.f. amplification. The output is suitable for magnetic headphones having a resistance of 2kΩ per phone, or for any other load of 4kΩ or more. If desired, an optional untuned r.f. amplifier, which employs another f.e.t., can be added before the regenerative detector stage.

Excellent results have been obtained with the basic receiver using an indoor aerial only 6 metres long. A long outdoor aerial will provide better results, but an indoor aerial will suffice in locations where a proper outdoor type is not feasible. Current consumption of the basic receiver is about 2mA, this rising to about 3.5mA if the untuned r.f. amplifier is fitted. A 9 volt PP3 battery provides many hours of operation.

## CIRCUIT DETAILS

The circuit of the basic two transistor receiver is given in Fig. 1. TR1 is the regenerative detector with feedback, or regeneration, being controlled by VC2. Since the drain and source are in phase at signal frequencies the feedback is positive. VC2 functions as a coarse feedback control, with VR1 acting as a fine

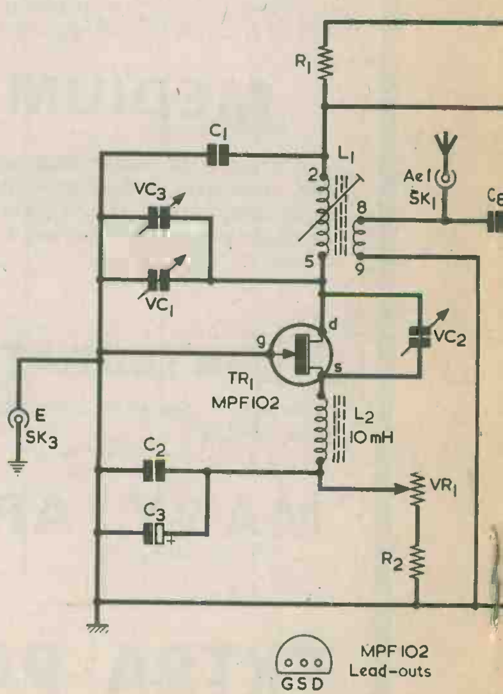


*Fig. 1. Circuit of the two tran*

# ATIVE S.W. RADIO

oberts

ual regenerative f.e.t. detector circuit
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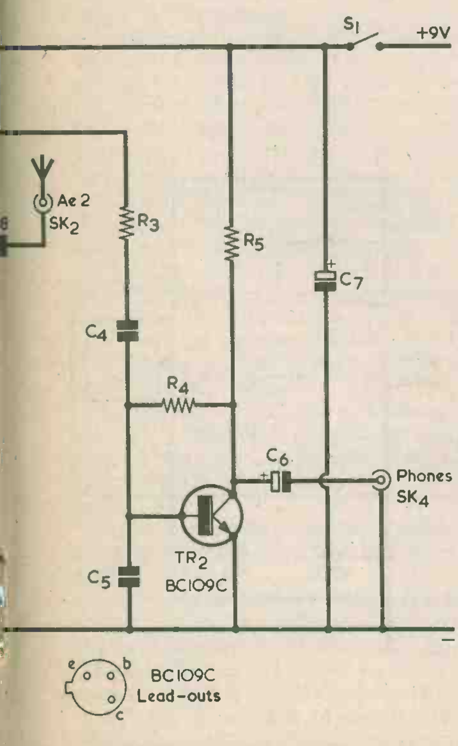
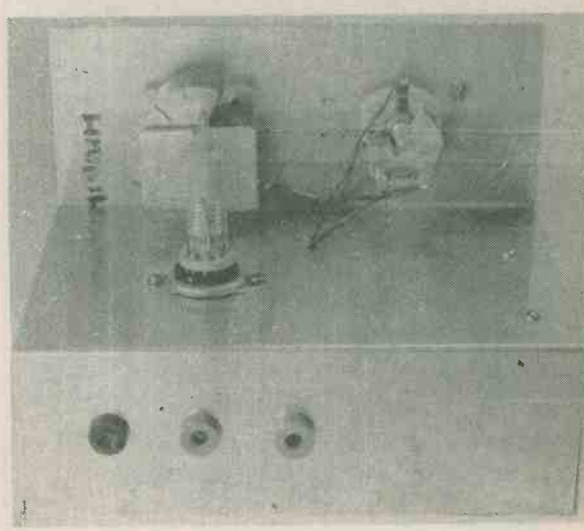
attery.

feedback control. For normal a.m. listening the feedback is adjusted to a point just below that at which oscillation commences.

A regenerative detector relies upon the fact that it distorts the r.f. signal by amplifying one set of half-cycles more than the other set. The result is a partial rectification which produces the required detection. The use of regeneration increases the distortion and




nsistor basic receiver



*The only components appearing above the chassis are the plug-in coil, the bandset tuning capacitor and the variable feedback capacitor*

thus enhances detection efficiency. Regeneration also increases the gain of the amplifier to which it is applied and for these two reasons regenerative detectors are extremely sensitive. However, in order to obtain optimum results the detector regeneration level must be adjusted very carefully, as will be described more fully later.

The r.f. choke in the source circuit of TR1 provides a fairly high impedance at r.f., and also allows a ready path for the d.c. supply current for the transistor. The source resistance, given by VR1 and R2 in series, is bypassed at r.f. by C2 and at a.f. by C3. The circuit will in fact function without C3, but there is a slightly higher output when it is included. C2 is employed as well because some electrolytic capacitors do not provide an efficient bypass at high radio frequencies.

The tuned circuit which selects the required signal consists of the parallel combination of VC1 and VC3 and the winding of L1 between pins 2 and 5. VC1 is the main tuning or bandset capacitor whilst the lower value VC3 is the bandspread control. The aerial input is applied to the coupling winding between pins 8 and 9, with the aerial plugging into SK1 or SK2. The aerial is normally coupled to SK1, but if propagation conditions are good and the set is being swamped by strong signals the aerial is tranferred to SK2. C8 then attenuates input signals to some degree and prevents the overloading. It should be noted that the coils

# REGENERATIVE S.W

By
A. P. Roberts

**This little receiver employs an unusual regenerative f.e.t. detector circuit and covers 1.5 to 36MHz by means of three plug-in coils. The output is at headphone level, and it may alternatively be applied to an a.f. amplifier. A particular attraction is the low current which is drawn from the 9 volt supply battery.**

## CIRCUIT DETAILS

The circuit of the basic two transistor receiver is given in Fig. 1. TR1 is the regenerative detector with feedback, or regeneration, being controlled by VC2. Since the drain and source are in phase at signal frequencies the feedback is positive. VC2 functions as a coarse feedback control, with VR1 acting as a fine feedback control. For normal a.m. listening the feedback is adjusted to a point just below that at which oscillation commences.

A regenerative detector relies upon the fact that it distorts the r.f. signal by amplifying one set of half-cycles more than the other set. The result is a partial rectification which produces the required detection. The use of regeneration increases the distortion and

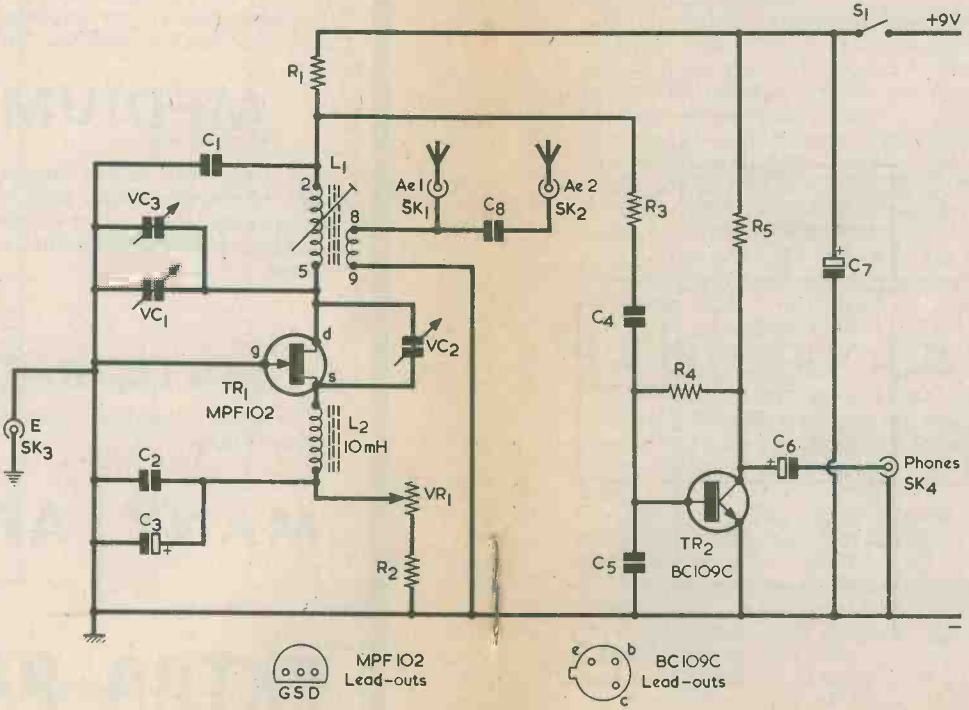



*Fig. 1. Circuit of the two transistor basic receiver*

specified for L1 have a third winding between pins 3 and 4. This winding is not employed in the present circuit and is not shown in Fig. 1.

TR2 is a high gain common emitter a.f. amplifier, with R5 as its collector load and R4 providing base bias. The detected signal from TR1 drain is applied via R3 and C4, the latter providing d.c. blocking. R3 and C5 function as a filter which prevents any r.f. signal from the detector reaching the base of TR2.

## COMPONENTS

*Resistors*
(All fixed values ¼ watt 5%)
- R1 3.3kΩ
- R2 390Ω
- R3 680Ω
- R4 3.3MΩ
- R5 5.6kΩ
- R6 3.9kΩ
- R7 680Ω
- R8 680Ω
- VR1 5kΩ potentiometer, linear, with switch S1.

*Capacitors*
- C1 0.01μF ceramic
- C2 6,800pF polystyrene
- C3 10μF electrolytic, 10 V. Wkg.
- C4 0.1μF type C280 (Mullard)
- C5 0.01μF type C280 (Mullard)
- C6 10μF electrolytic, 10 V. Wkg.
- C7 100μF electrolytic, 10 V. Wkg.
- C8 5.6pF ceramic or silvered mica
- C9 0.047μF type C280 (Mullard)
- C10 0.01μF type C280 (Mullard)
- VC1 365pF variable, type 01 (Jackson)
- VC2 50pF variable, type C804 (Jackson)
- VC3 15pF variable, type C804 (Jackson)

*Inductors*
- L1 Miniature Dual-Purpose Coils, Green, Ranges 3, 4 and 5 (Denco)
- L2 10mH r.f. choke, type CH4 (Repanco)

*Transistors*
- TR1 MPF102
- TR2 BC109C
- TR3 2N3819

*Sockets*
- SK1, 2, 3 wander plug insulated sockets
- SK4 3.5mm. jack socket (see text)

*Switch*
- S1 s.p.s.t. toggle (part of VR1)

*Miscellaneous*
- B9A valveholder
- 4 knobs (see text)
- Veroboard, 0.15. matrix
- Veropins, 0.15in.
- 9 volt battery type PP3 (Ever Ready)
- Battery connector
- 16 s.w.g. aluminium sheet
- Wire, nuts, bolts, etc.

Such filtering is essential as the frequency response of the a.f. amplifier can extend well into the r.f. spectrum, and any r.f. entering this stage could cause instability. R3 and C5 also attenuate the higher audio frequencies, with a consequent improvement in signal-to-noise ratio.

The output signal is taken from SK4, C6 giving d.c. blocking. There is only one supply bypass capacitor, and this is C7. S1 is the on-off switch and is ganged with VR1.

## CHASSIS AND PANEL

A home-made chassis and front panel are employed, these being constructed from 16 s.w.g. aluminium sheet. Fig. 2 gives the dimensions of the chassis and it is advised that this be made before the front panel is drilled.

A ¾in. diameter hole is punched in the deck of the chassis and a B9A valveholder is mounted in this. This valveholder takes whichever coil is in use. If a suitable chassis punch is not available, an alternative method of making the hole is to drill a series of closely spaced small holes just inside the circumference of the cut-out and then break out the centre piece of aluminium. The rough edges are then removed and the hole filed out to the required diameter with the aid of a small half-round file. The valveholder is used as a template for marking out the positions of the two 6BA clear mounting holes. The valveholder is mounted with the orientation shown in Fig. 4, and there is a 6BA solder tag under one of its mounting nuts.

The remaining small hole in the chassis deck will allow the passage of several leads, and its precise positioning is not important. Also shown in Fig. 2 are the positions of the a.f. and r.f. panels. The mounting holes for these are drilled later.

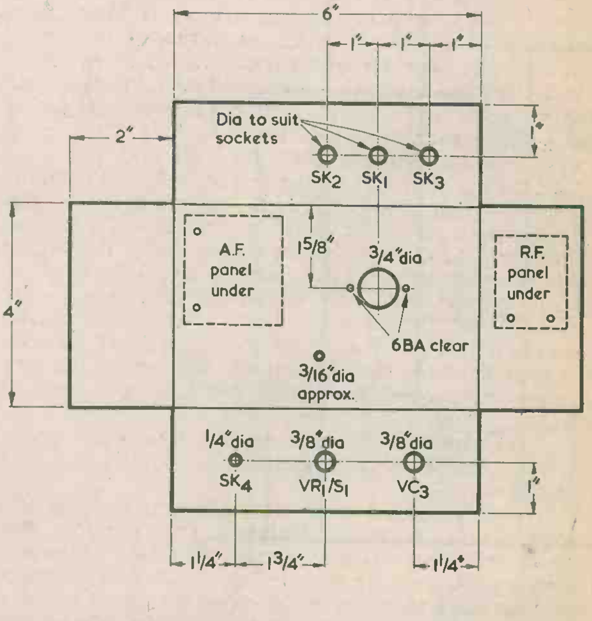



*Fig. 2. Details of the chassis. The four flanges are bent down, away from the reader*

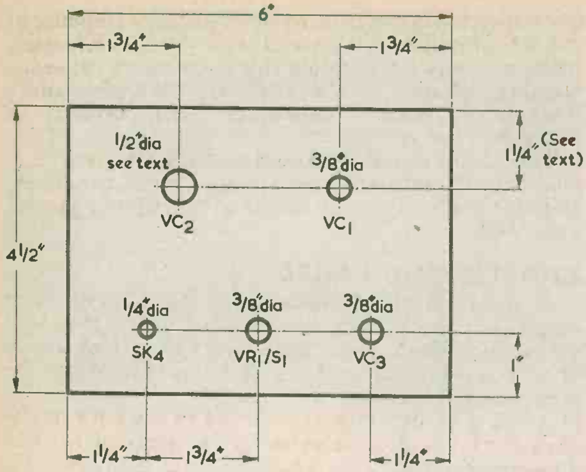



*Fig. 3. The front panel is drilled out in the manner shown here*

The front panel is illustrated in Fig. 3 and this should be cut out and the three lower holes only, those for SK4, VR1/S1 and VC3, drilled. The front panel is assembled to the chassis by the mounting bushes and nuts of these three components, and so the holes in the front panel must accurately match the corresponding holes in the chassis.

Temporarily assemble the chassis and panel together, then take up VC1 and check that the underside of its frame will be clear of the upper surface of the chassis when its spindle centre is 1¼in. down from the top of the front panel, as indicated in Fig. 3. Working to manufacturer's specification there should be a little less than ¼in. spacing between the capacitor frame and the chassis although in practice the spacing may be significantly greater than this. If there is adequate spacing, the holes for VC1 and VC2 may take up the positions shown in Fig. 3. If not, then the holes for these two components should be made slightly higher than is indicated in the diagram so that there will be no interference between VC1 frame and the chassis surface. There was no difficulty at all on this account with the prototype but, considering dimensional tolerances in home-constructed chassis and other factors, it is better to confirm that the position of the hole for VC1 spindle will be satisfactory rather than spoil the panel by drilling unwanted holes.

After confirming this point, the chassis and panel may be disassembled and the holes for VC1 and VC2 marked out.

VC1 is mounted by three 4BA bolts passing into tapped holes in the front plate of the capacitor, and three 4BA clear holes are required in the front panel. These holes are not shown in Fig. 3 and their positions may be marked out in the following manner. Cut out a ¼in. hole in a piece of paper and pass it over the capacitor spindle. Mark the positions of the three 4BA tapped holes on the paper, then use this as a template to mark out the corresponding holes in the panel. Drill these 4BA clear and lightly countersink them on the front. The three mounting bolts are short countersunk types and it is advisable to fit some washers or short spacers over them between the rear of the panel and the front plate of the capacitor. It is important to ensure that the ends of these bolts do not pass more than marginally beyond the capacitor front plate as they may then damage the fixed or moving vanes.

Since neither the fixed or moving vanes of VC2 are at chassis potential, this capacitor must have its mounting bush and nut insulated from the front panel. Fig. 3 shows the hole for VC2 as having a diameter of ½in. Insulating washers made of thin s.r.b.p. and having a ⅜in. hole can be fitted over the capacitor bush on either side of the front panel; the capacitor is then held so that its bush is approximately central in the panel hole as the mounting nut is tightened. After this process an electrical check is made with a continuity tester or ohmmeter to ensure that the capacitor bush is reliably insulated from the front panel. An additional measure which can be employed here is to initially affix one of the insulating washers to the front panel with adhesive, positioning it so that its hole is concentric with the ½in. hole in the panel. The capacitor bush will then be automatically centred in the panel hole.

## WIRING

Fig. 4 shows the wiring for the basic receiver including that on the a.f. amplifier board. The latter employs a piece of Veroboard of 0.15in. matrix having 15 holes by 10 copper strips. There are no breaks in the strips.

First drill the two 6BA clear holes in the Veroboard and then use it as a template for the marking out, and drilling, of the two corresponding 6BA clear holes in the chassis. The board takes up the approximate position, under the chassis, which is shown in Fig. 2. Next, assemble the components on the Veroboard, employing 0.15in. Veropins for the external connections to S1, SK4 and the junction of R1 and C1. The board takes up its chassis connection from the sleeve contact

*Layout of components and amplifier boards under the chassis*

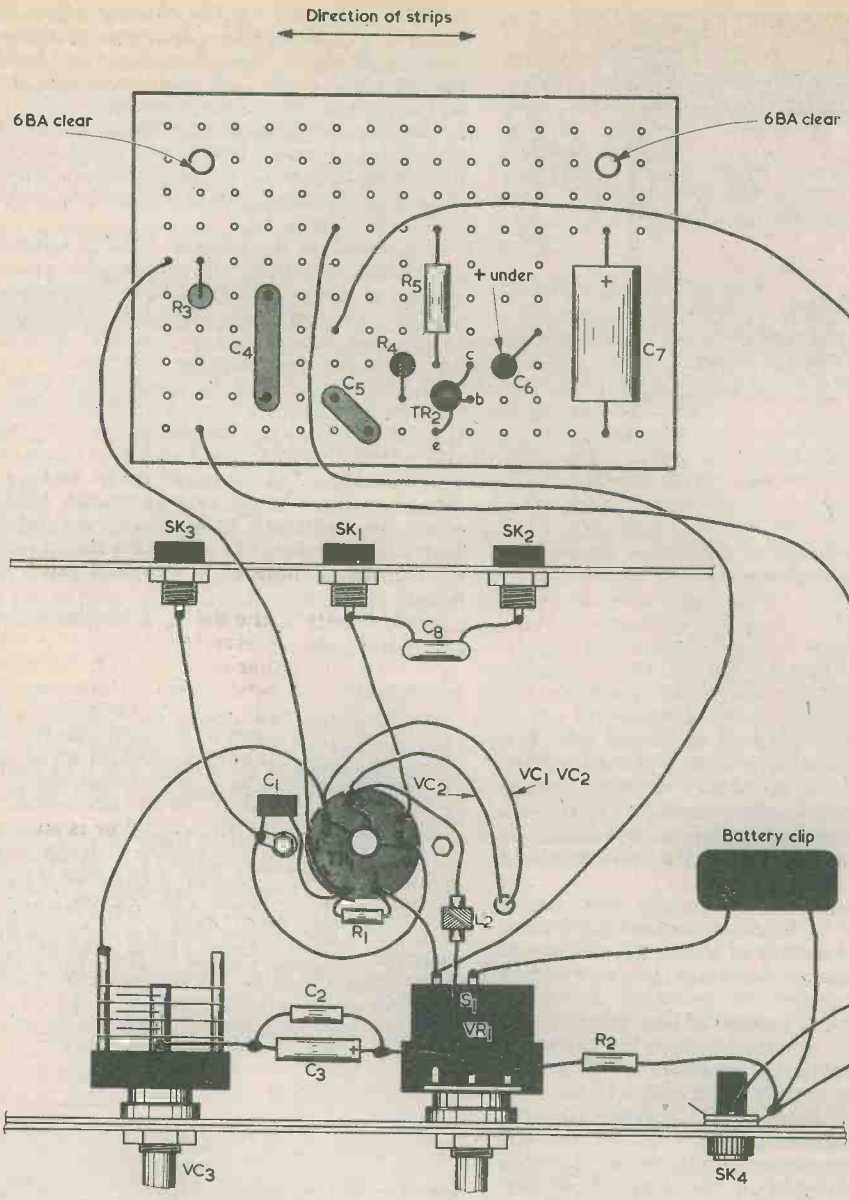


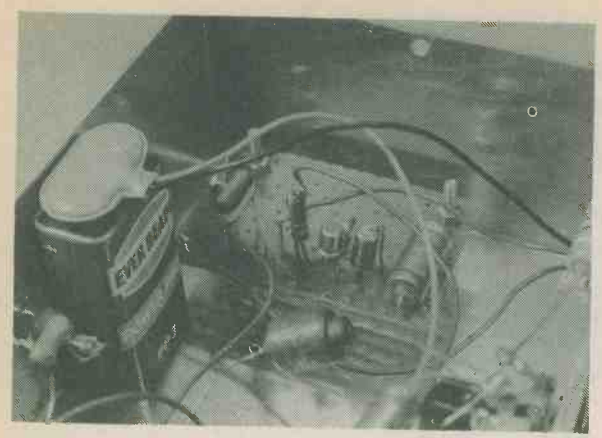

*Fig. 4. Wiring diagram showing the connections around the B9A valveholder together with the component layout on the a.f. amplifier board*

of SK4, and it is necessary for this socket to be of open construction (i.e. not insulated) so that this connection is automatically made by way of its mounting bush and nut.

The Veroboard is next mounted to the chassis, employing ½in. spacers on the mounting screws to keep the board underside clear of the chassis surface. All the remaining wiring shown in Fig. 4 is then completed.

Two wires pass through the chassis hole mentioned when discussing Fig. 2. One wire, from the source of TR1, connects to the moving vanes of VC2. The other from TR1 drain, connects first to the fixed vanes of VC2, then to the fixed vanes of VC1.

There is plenty of space under the chassis for the battery, and it can be held in place by a simple clip or clamp. The four control knobs must be wholly or partly made of plastic. All-metal knobs cannot be used as they would allow the fingers to contact VC2 moving vanes when adjusting this capacitor.



*A closer look at the a.f. amplifier board*

## USING THE RECEIVER

It is probably best to use the Range 4 coil when initially testing the receiver as there is usually a large number of strong signals present in this frequency range. The set operates most efficiently with VR1 turned back almost fully anticlockwise, with VC1 being advanced to a point that permits the detector to be brought to the threshold of oscillation when VR1 is slightly advanced. The receiver should always be adjusted to just below the point of oscillation by the use of VR1, as it is at this level that the receiver is most sensitive and has the highest degree of selectivity. If the regeneration is advanced beyond the threshold point proper reception of a.m. transmissions will not be possible, and heterodynes of varying pitch will be heard as the receiver is tuned across a.m. stations. Always carry out fine adjustment of regeneration by means of VR1, and not by VC2 which does not give such precise control.

Towards the low frequency end of each band it may be necessary to set VC2 at maximum capacitance and have VR1 well advanced in order to reach the threshold of oscillation. The circuit will still give good results, however, even though it will be operating at slightly less than optimum conditions. The regeneration controls are not like an ordinary volume control, and they will need resetting each time the tuning is significantly altered. It is well worthwhile spending some time experimenting with different settings of these controls in order to obtain the best possible results.

Do not try to accurately tune to stations by means of VC1. This is adjusted to the part of the band which is to be searched for stations, and then the tuning is carried out with VC3. As VC3 has a very low value it covers only a small part of each range, and tuning is much easier with this control.

It occasionally happens that a very strong signal blots out all the stations around it. If this happens, the aerial plug should be transferred from SK1 to SK2.

A suitable aerial for the set merely consists of a length of insulated wire set as high up as possible. A length of 10 metres or more is preferable, but as little as 3 metres will give reasonable results.

An earth connection will not be found necessary on Ranges 4 and 5, but it will considerably improve results on Range 3. A simple earth connection can be made by attaching a length of wire to a piece of metal pipe which is then buried in moist soil. The free end of the wire connects to SK3, and this lead-in should be no longer than is necessary.

The Denco coils have adjustable iron-dust cores with threaded brass stems, and these are screwed fully down for packing purposes. If a signal generator is available the cores can be adjusted to give the approximate frequency ranges referred to at the start of this article. In the absence of a signal generator it will be in order to adjust each core so that about ¼in. of the brass stem protrudes above the top of the former. This will give roughly correct frequency ranges and, as there is a large overlap between ranges, it is highly unlikely that there will be any gaps in the overall coverage.

## R.F. AMPLIFIER

Satisfactory reception of s.s.b. and c.w. (morse) signals can be obtained by advancing VR1 to a point when the detector is just gently oscillating. VC3 is then carefully adjusted to resolve the s.s.b. signal or to obtain an a.f. note of the desired pitch with a c.w. signal.

Unfortunately, the detector oscillation will then be radiated by the receiver aerial and this can cause interference with other receivers. The solution is to add an r.f. amplifier between the detector and the aerial. The amplifier will prevent the detector oscillation from reaching the aerial, and will also give a small increase in gain which is very useful when only a short aerial is in use. It is essential that the r.f. amplifier be fitted if s.s.b. and c.w. reception is intended.

The circuit of the r.f. amplifier is shown in Fig. 5. This is a very simple untuned design employing a common source f.e.t. amplifier with its output connected to the coupling winding on L1. R7 and C9 provide supply decoupling.

The amplifier is assembled on a piece of Veroboard of 0.15in. matrix having 8 holes by 9 strips, as il-

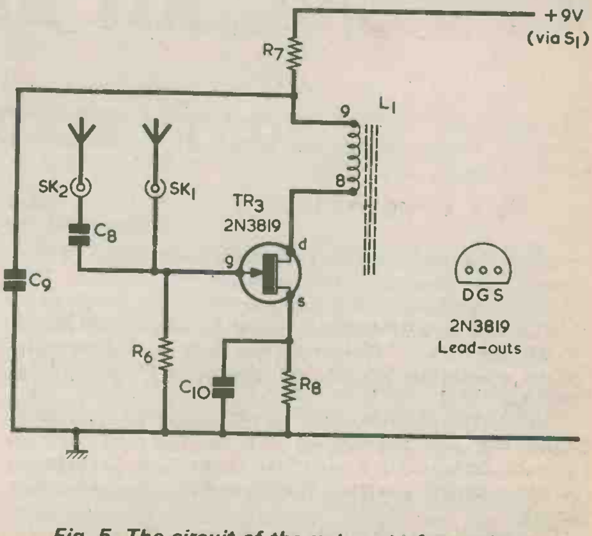



*Fig. 5. The circuit of the untuned r.f. amplifier*

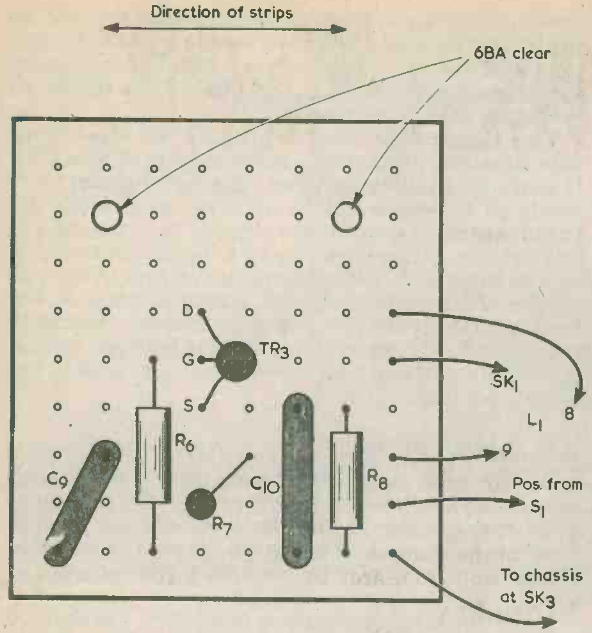
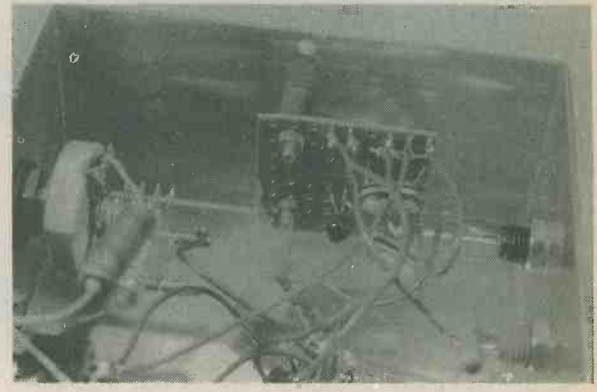



*Fig. 6. The r.f. amplifier is assembled on a small piece of Veroboard as illustrated here*

lustrated in Fig. 6. It is constructed, mounted and wired into circuit in the same manner as the a.f. panel, and it takes up the approximate position shown in Fig. 2.

Some small alterations are required in the wiring of the basic receiver when the r.f. stage is added. The lead from SK1 to pin 8 of the coil is unsoldered from the valveholder and reconnected to the input of the r.f. amplifier board. TR1 gate lead-out and the chassis lead are disconnected from pin 9 of the coil and reconnected at pin 7. The board is then wired up as shown in Fig. 6, whereupon the receiver is once again ready for use, and the controls are operated exactly as before.



*The optional r.f. amplifier board is mounted on one side of the chassis*

The accompanying Components List gives details of the parts required for the complete receiver with the r.f. amplifier. If it is intended to build the basic two transistor receiver only there is no necessity to obtain R6, R7, R8, C9, C10 and TR3. ■

# KIT REVIEW

## JOSTY ELECTRONIC KITS

Now available in the U.K. is a wide range of electronic kits presented by Josty Kit (U.K.) Ltd., P.O. Box 68, Middlesbrough, Cleveland TS1 5DQ. Josty Kit is the largest manufacturer of electronic kits in Scandinavia and almost all the kits can be supplied with attractive "Module" cases of Scandinavian design.

There are over 50 kits in the range as well as 12 cases. The designs extend from simple t.r.f. medium wave receivers to a.f. amplifiers and disco equipment. Also included are f.m. tuners, stereo decoders, ambiophonic converters, electric guitar tremulo units and power supplies, as well as such items as photo cell relay controllers, electronic roulette and a TV game.

Each kit is accompanied by an instruction book which discusses the components employed, deals with the assembly of the kit and then describes its technical functioning. In addition, the book gives notes on component handling, paying particular attention to the art of successful soldering.

Also available from Josty Kit is a book entitled "Applied Electronics", which has been especially produced for beginners and which includes a chapter describing 10 easily constructed projects. Nearly 200,000 copies of this book have been printed and it has appeared in 5 languages.

# SHORT WAVE NEWS
## FOR DX LISTENERS

**By Frank A. Baldwin**

*Times* = GMT    *Frequencies* = kHz

In addition to the broadcast bands, amateur frequencies can also provide much of interest to the all-rounder SWL. Listening to the local net 'ragchews' on the LF bands or Dx-chasing on the HF bands make a change from operating over the various broadcast bands. Recent forays on the amateur bands, using the CW mode, resulted in the following:

**TOP BAND (1800-2000kHz)**
DJ9LS, DL7CY, GD4BEG, GI3JEX, GM3YOR, HB0NL, HB9RM, K1PBW, KV4FZ, OK1ATP, OK1DUJ, OK2BPK, OL1AUQ, OL4ATY, OL5ATE, OL5AUZ, OL6AUE/P, OL8CGS, PA0HIP, W1BB/1, W1HGT, W8LRL, WA8IJI.

For the transatlantic signals, listen from around 0445 especially at weekends from 1800 to 1805kHz, 1802 and 1804 being the favourite "windows". For the signals of those from this side of the Atlantic trying to contact the U.S.A. etc., listen from 1830 to 1835kHz.

**FORTY (7000-7100kHz)**
CO2PY, HI8MOG, KP4EAJ, KP4CM, KP4WL, PY7DDA, UD6DII, VE3HUL, YV5BNR, ZL2ARN, ZL2UV, ZL3CC, ZL4CU.

These were all heard during late night or early morning sessions. At other times, "forty" is apt to be covered with CW signals from the USSR and Eastern Europe.

The writer does not find a great deal of time for amateur band operating but will from time to time report some of the Dx callsigns logged.

For those of my readers who aspire to collecting amateur QSL cards, equip yourselves to operate over the CW portions of the various bands — you will acquire a greater return reply ratio than reporting to SSB signals!

### CURRENT SCHEDULES

**● MONGOLIA**
An External Service is radiated at various times throughout the period 1100 to 2125 from Ulan Bator. Probably the best times for listeners here in the U.K. would be as follows — from 1715 to 1745 (not Sundays) when in English to South East Asia and the Far East on **9574** and **11858** or from 1945 to 2015 (not Sundays, Mondays or Thursdays) when in French to the same areas on **17788** and **17860** or from 2100 to 2125 daily when in Standard Chinese on **7236** and on **7261.** During these time periods the whole of the signal path is in darkness during this month.

**● VIETNAM**
The "Voice of Vietnam" operates a Domestic Service from Ho Chi Minh City (formerly Saigon) from 2200 to 1605 on **6165** and **9620.** The most favourable times for logging this transmitter would be from 2200 sign-on (at 2300 until 2330 the newcast is a relay of the Voice of Vietnam Domestic Service from Hanoi) and from around 1520 until 1605 sign-off.

**● NIGERIA**
The "Voice of Nigeria", Lagos, presents an External Service in English to Africa, the Middle East and Europe from 0655 to 0835, 1530 to 1700 and from 1800 to 1930 on **7275** and on **15120.**

**● CLANDESTINE**
"Voice of the Eritrea Revolution" (in Arabic "Sawt ath-Thawrah al-Eritrea") is a pro-Eritrean Liberation Front transmitter operating on **9635** from 1500 to 1530 on Sundays, Tuesdays and Thursdays in Arabic. The location is thought to be Baghdad.

### FOR THE SWL

**● ALGERIA**
Algiers on **11810** at 1850, a drama in Arabic in the "Voice of Palestine, Voice of the Palestine Revolution" programme, schedule from 1800 to 1900 and logged in parallel on **15150.**

Algiers on **21565** at 1157, OM with song in Arabic, flute accompaniment, in an Arabic Network programme.

**● PORTUGAL**
Lisbon on **11925** at 1630, OM in Portuguese in a relay of the Domestic Service to the Azores, Madeira and Cape Verde Islands, scheduled from 0700 to 2400.

**● ROMANIA**
Bucharest on **15250** at 1309, OM and YL alternate with the news in English. English to Europe programme, schedule 1300 to 1330 and in parallel on **9690** and **11940.**

**● EGYPT**
Cairo on **7050** at 1905, OM with the news in Arabic in the "Voice of the Arabs" programme. Also in parallel on **11630.**

**● ISRAEL**
Jerusalem on **9355** at 2058, OM with a talk in Hebrew in a relay of the Domestic Service Network B to overseas listeners, schedule from 2000 to 2305. Also

in parallel on **12077.5** and **15512.5** (measured).

● **S. YEMEN**
Aden on **11770** at 1815, OM with a song in Arabic and some local-style music under QRM.

● **N. YEMEN**
Sana'a on **9780** at 1806, typical local music, songs in Arabic in the Domestic Service, also in parallel on **4853.**

● **VIETNAM**
Hanoi on **6450** at 2249, YL with songs in Vietnamese, chorus and orchestra in the Domestic 1st Network and to the former South Vietnam. Schedule from 2055 to 1600 and in parallel on **7375.**

● **ANDORRA**
Radio Andorra on **6230** at 0801, pop records (U.K. made) after identification by OM (Sunday morning).

● **AFGHANISTAN**
Kabul on **15195** at 1141, YL with listeners letters answered in the English to Europe programme, schedule from 1130 to 1200.

● **NORTH KOREA**
Pyongyang on **6600** at 2105, OM and YL alternate with the news in Korean in the Domestic Service, schedule from 2000 to 0830.

Also on a measured **6398** at 1958 when opening one of the daily transmissions with repeated chords on an organ as interval signal, identification in Korean by OM, 3 pips time-signal and National Anthem. This is the Domestic Service beamed to South Korea from 1500 to 1800, 2000 to 2130 and from 2200 to 1030.

● **KUWAIT**
Radio Kuwait on **15345** at 0530, YL with news of the Arab world in English to East and Southeast Asia, scheduled from 0500 to 0800.

● **EGYPT**
Cairo on **17625** at 0612, OM with chants and readings from the Holy Qur'an in the Palestine Service, scheduled from 0600 to 0800 and also in parallel on **15475** and **17745.**

Cairo on **15135** at 1311, a programme of Arabic songs and music in the "Sudan Corner" transmission, schedule from 1200 to 1625.

● **SUDAN**
Omdurman on **11835** at 1339, OM with songs in Arabic, local-style music.

● **GREECE**
Athens on **9760** at 1139, OM in Arabic in a programme directed to Egypt and Libya, scheduled from 1130 to 1150.

**FOR THE DX'ER**
In which are listed some of the transmissions that may be of interest to the Dx'er.

● **BURMA**
Rangoon on **5039** at 1547, orchestral music Euro-style, hetro QRM. Rangoon is the capital city of Burma and is situated on the eastern arm of the Irrawaddy delta. The city has two cathedrals and many pagodas.

● **INDIA**
Lucknow on **3205** at 1550, OM in vernacular amid very heavy commercial QRM. Generally speaking, if you can hear this one then the remainder of the Indian transmitters on the 90 metre band may be logged — QRM permitting of course! The power is 10kW, schedule from 0025 to 0215 and from 1130 to 1830.

● **SRI LANKA**
Colombo on **4902** at 1840, Buddhist chants on full moon day. This is Channel 1 of the Sinhala Service which is scheduled from 0015 to 0230, 1125 to 1730 and additionally on full moon days from 1030 to 0800. The power is 10kW.

● **NEPAL**
Katmandu on **5007** at 1543, OM in Nepali, local music and song by YL. The schedule is from 0020 to 0350 and from 1150 to 1720 and in parallel on **3425**: the power is 5kW. Katmandu is the capital of Nepal and is sited on the Vishnumati River some 75 miles from the Indian frontier.

● **INDONESIA**
Jakarta on **4805** at 1550, YL with local song in Malindo through CW QRM. This is the Home Service of RRI with a schedule from 2155 to 0100 and from 1000 to 1600, the power is 20kW.

● **MALAYSIA**
Penang on **4985** at 1540, programme of classical music Euro-style. This is the English/Vernacular service of Radio Malaysia, the schedule here being from 2230 to 0130 (Sundays to 1630), from 0530 to 0630 (Saturdays till 1630) and from 0930 to 1630, the power is 10kW.

● **CHINA**
PLA Fuzhou on **3535** at 2015, YL in Standard Chinese under hetro QRM. This transmission, like that following, is directed to Taiwan and other offshore islands. The schedule on this channel is from 1413 to 2241.

PLA Fuzhou on **4045** at 2030, OM in Standard Chinese under unmodulated carrier. The schedule here is from 1000 to 0530.

Lanzhou on **4865** at 2327, YL in Standard Chinese. The schedule is from 2150 to 0600 and from 0950 to 1600.

● **RWANDA**
Radio Kigali on **3330** at 0519, African orchestra, YL's with chants. This is the Home Service, scheduled from 0300 to 0600 (Saturdays and Sundays until 0700), 0900 to 1200 (Saturdays and Sundays until 2100) and from 1330 to 2100, the power is 5kW.

● **COLOMBIA**
Emisora Nuevo Mundo, Bogota, on **4755** at 0525, OM with the local news in Spanish, many mentions of Bogota. This one has a 24-hour schedule and sometimes identifies as "Radio Caracol"; the power is just 1kW.

● **BRAZIL**
Radio Timbira, Sao Luiz, on **4976** at 2134, OM with announcements in Portuguese, local songs and music. The schedule is from 0700 to 0430 and the power is 5kW.

● **NOW HEAR THIS**
Clandestine "Radio Iran Courier" on **11415** at 1802, OM with a harangue in Farsi. The schedule is from 1720 to 1810 and also in parallel on **11695.** It is not Dx but it is interesting!

# THE OSCAR SATELLITE PROGRAMME

## THE FUTURE

By Arthur C. Gee

In the September 1976 *AMSAT Newsletter*, Vol. 7, No. 3, p.3 the following note appears: "In professional circles it is customary to call a spacecraft by one name prior to launch, and then give it its flight name after it leaves the ground. In the past we at AMSAT have also tried to keep to that custom. In the past when we were building one spacecraft at a time, it did not really matter if a spacecraft was called AMSAT-OSCAR B or AMSAT-OSCAR 7."

"Following the announcement of the Phase III satellite programme there has been a tendency to use OSCAR 8 and Phase III interchangeably. Again if only one spacecraft was in the works this would not really matter. But, now there are more than one spacecraft in the works. The launch of the FIRST Phase III spacecraft has slipped to about 1980. There is serious thought to a Phase II or AMSAT-OSCAR 6/7 follow on to replace AMSAT-OSCAR 6 and a lot of talk is coming from AMSAT-UK on the feasability of a 21/28 MHz transponder communications satellite, also in the Phase II series."

"Thus at this time, no one is sure what AMSAT-OSCAR 8 will be, so let's refer to the spacecraft by the correct nomenclature."

The author has endeavoured to keep to the spirit of this note in the information given here. — Ed.

With OSCAR 6 and OSCAR 7 still "going strong" and with plans for the first Phase III OSCAR being somewhat uncertain, (see page 149, 'R. & E. C.' Oct. '76), it was interesting to receive from AMSAT-UK recently, a handout outlining the future possibilities for forthcoming OSCARs.

Quite apart from the Phase III OSCAR, there are a number of other amateur satellites, some only in the planning stage; others actually under construction, which might be launched in the near future.

**AMSAT-USA A.O.D.** is well advanced and could be launched in June 1977 from one of the ITOS Mission rockets, which may be launched around June '77. It is virtually identical to OSCAR 6, being a 2 to 10 metre repeater, but has more solar panels than 0.6, so that it could be used full time and would not need turning off from ground control to conserve batteries, as has to be done with 0.6. It would help to fill the gap until OSCAR Phase III is launched, particularly if 0.6 fails completely in the near future. OSCAR 6 has already outlived its expected life-span by many months!

**JAMSAT 2—70.** This is a Japanese planned amateur satellite with a 2 watt 70cm downlink and 2 metre uplink. The transponder unit has been built and is being tested on a mountain top by AMSAT-JA. The Japanese may launch this themselves or it could be launched along with the AMSAT-USA A.O.D. mentioned above, on the June ITOS Mission.

**AMSAT-USA PHASE III OSCAR.** This is the highly sophisticated satellite now under construction and described in this magazine in the issue for June 76, p.690. Not surprisingly, a satellite as sophisticated as this is taking rather longer than anticipated to progress and its possible launch date has been advanced to 1980.

**"THE SHUTTLE".** This spacecraft is being planned for ferrying personnel and equipment to manned orbital platforms. The first may be launched in 1979. They are planned for low orbits — around 300 miles, so the possibilities of satellites being launched from them are limited. However, the proposed AMSAT-UK 15-10 metre satellite might make use of them for propagation research and night-time path communication during low MUF years.

**AMSAT-UK 10-15 METRE SATELLITE.** A proposal has been put forward by some OSCAR enthusiasts in the U.K. for the design and construction of a satellite operating on the 10 and 15 metre bands. Suitable components, a qualified designer, and time and facilities to build it will all have to be found before this project can materialise. However, if these difficulties can be overcome, the project could be launched from The Shuttle.

**THE "ARIANE" LAUNCHES.** The European Space Agency are planning three launches from their Koror launching site in French Guiana, commencing 1979, upon which on-load space is available. The AMSAT-USA Phase III OSCAR might well be launched from one of these.

So we see that there are numerous possibilities for continuing the OSCAR Project and there is likely to be continued activity on an extensive scale in this field of amateur radio. Just what the next OSCAR will be, we shall have to wait and see. It will obviously depend on the progress made with the various projects and how this progress fits in with facilities for launching.

■

# CURRENT MIRROR

## By M. G. Robertson

**Background details on a common integrated circuit constant current source.**

A rather puzzling configuration which is often seen in the internal circuitry of linear i.c. operational amplifiers is shown in Fig. 1(a). Here, there are two n.p.n. transistors with their emitters connected to the negative supply rail for the amplifier. The two collectors are in the supply feeds to internal stages or components in the amplifier. The two bases are connected together, and the collector of one transistor is also taken to the common base connection.

A p.n.p. version of the configuration, with emitters connected to the positive rail, appears in Fig. 1(b).

### CURRENT MIRROR

The configuration is a "current mirror" circuit, and its operation can be explained with the aid of Fig. 2. In this diagram the two transistors are silicon and have identical characteristics. This latter requirement can be very closely approached in two adjacent transistors on a silicon chip. It has to be remembered that the collector of a conductive silicon transistor can assume a potential with respect to its emitter which is lower than that at its base.

In Fig. 2 nearly all of the current I1 flows into the collector and base of TR1. Most of the current flows into TR1 collector and the only current flowing into TR1 base is that which is required to maintain the collector current. The collector and base assume a potential VBE with respect to the negative rail which is of the order of 0.6 to 0.7 volt.

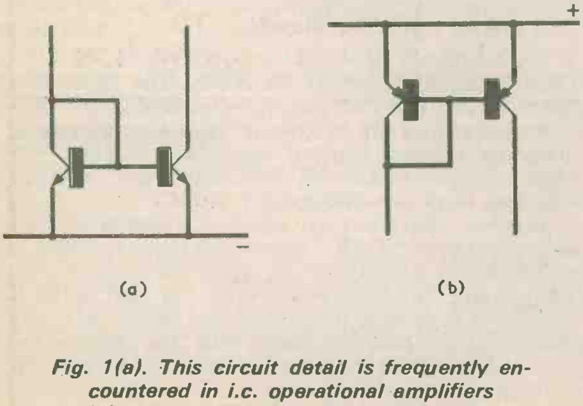



*Fig. 1(a). This circuit detail is frequently encountered in i.c. operational amplifiers (b). P.N.P. version of the configuration*

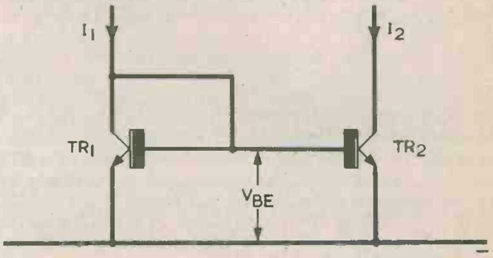



*Fig. 2. The collector currents and base-emitter voltage at the two transistors*

The base of TR2 takes up this potential also. A small current flows through the base-emitter junction of TR2, this adding to that flowing into the collector and base of TR1 to constitute the whole of I1. Since a current flows into the base of TR2 this transistor passes a collector current I2. The two transistors are identical and so, at a common value of VBE, I2 is equal to I1 (less the small base currents).

If I1 is increased the value of VBE will rise slightly, causing I2 to increase to the same level as I1. Similarly, if I1 is decreased, VBE drops slightly and I2 falls to the same value as I1.

The functioning of the circuit can alternatively be described without referring to changes in VBE. As the two transistors are identical each base-emitter junction presents the same forward resistance to current flow. In consequence the current available for the two base-emitter junctions divides equally between them.

TR2 functions as a constant current source, and the value of the constant current, I2, is controlled by the amplitude of I1. The constant current may be of the order of 1mA or less.

The p.n.p. version of Fig. 1(b) functions in the same manner as that described in Fig. 2 except that the potentials and directions of current flow are reversed.

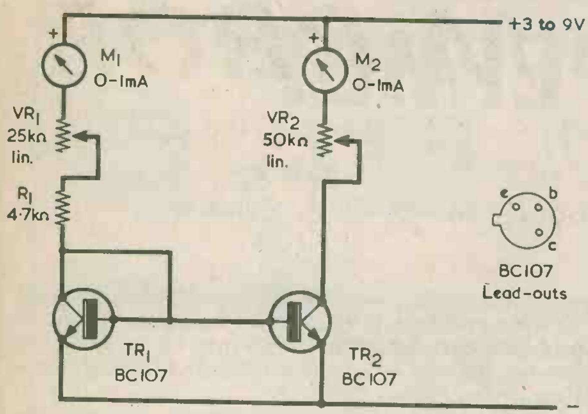



*Fig. 3. A test set-up employed for evaluating the performance of discrete transistors in the circuit*

## PRACTICAL CIRCUIT

The configuration can be made to work quite well with two discrete transistors even when these have markedly different characteristics.

The author made up the test circuit shown in Fig. 3 employing BC107's. The current in TR1 could be varied by means of VR1, with R1 acting as a current limiting resistor to prevent the accidental flow of excessive current in meter M1. The current passed by TR2 was measured by M2, with VR2 being adjusted over the appropriate section of its track to assess constant current performance.

Half a dozen BC107's of varying make and age were tried in the TR2 position. In every case the current in TR2 increased and decreased in sympathy with the current in TR1, but with no transistor was TR2 collector current equal to TR1 collector current. The greatest discrepancies were given when TR2 collector current was about 40% of TR1 collector current and when TR2 collector current was about 120% of TR1 collector current. With one pair of transistors, TR2 collector current was approximately 90% of TR1 collector current.

All the transistors in the TR2 position gave good constant current performances at collector currents of 0.3mA and less, with two working well in this respect up to 0.45mA. At higher collector currents the constant current performance was poor or virtually non-existent with all transistors.

The discrete transistor circuit of Fig. 3 has the practical advantage that it is capable of providing a low constant current with a minimum voltage drop of 0.2 volt across TR2. There is no thermal coupling between the two transistors as is given in an integrated circuit but, at the low currents involved, the transistors should run virtually at room temperature. The current flowing in TR1 has to be pre-set to a value which takes up the different characteristics of the particular transistor employed for TR2. ■

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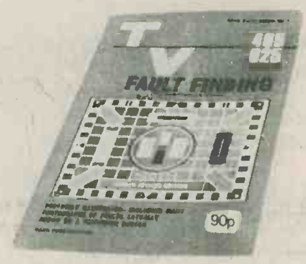


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BLOCK LETTERS PLEASE

# MEDIUM WAVE DX SUPERHET

**The concluding article deals with the assembly of the mixer and oscillator stages, the i.f. amplifier, the a.f. amplifier and the S-meter circuit. The process of alignment is then described.**

**Part 2**

**By R. A. Penfold**

In the article which appeared in last month's issue the circuit of this sensitive and selective receiver was discussed, after which constructional details were given for the case and chassis. Next to be dealt with is the mixer-oscillator wiring.

## MIXER-OSCILLATOR

The mixer-oscillator wiring is carried out under the chassis, as illustrated in Fig. 4. The two trimmer capacitors are mounted by having one tag soldered to a chassis tag and the other to the appropriate valveholder tag.

For clarity the wiring is shown spread out in Fig. 4 but in practice component leads should be kept fairly short. All components and wiring should be within ¾in. of the chassis underside, as they will otherwise come into contact with the bottom cover of the case. All wiring other than component lead-outs should be insulated. Component lead-outs may be covered with sleeving if there is any risk of their touching other wires or the chassis.

Four wires pass through the chassis. Two of these connect to the fixed vane tags of VC1 and VC2. Of the remaining two, one carries the positive supply from the i.f. board whilst the other is the connection from TR1 drain to the mechanical filter, which is also on the i.f. board.

Although the 40673 is a MOSFET it can be wired into circuit in the same manner as an ordinary bipolar transistor, since internal protective diodes are connected to its gates. The manufacturer states that the soldering iron bit used for soldering it into circuit must be earthed.

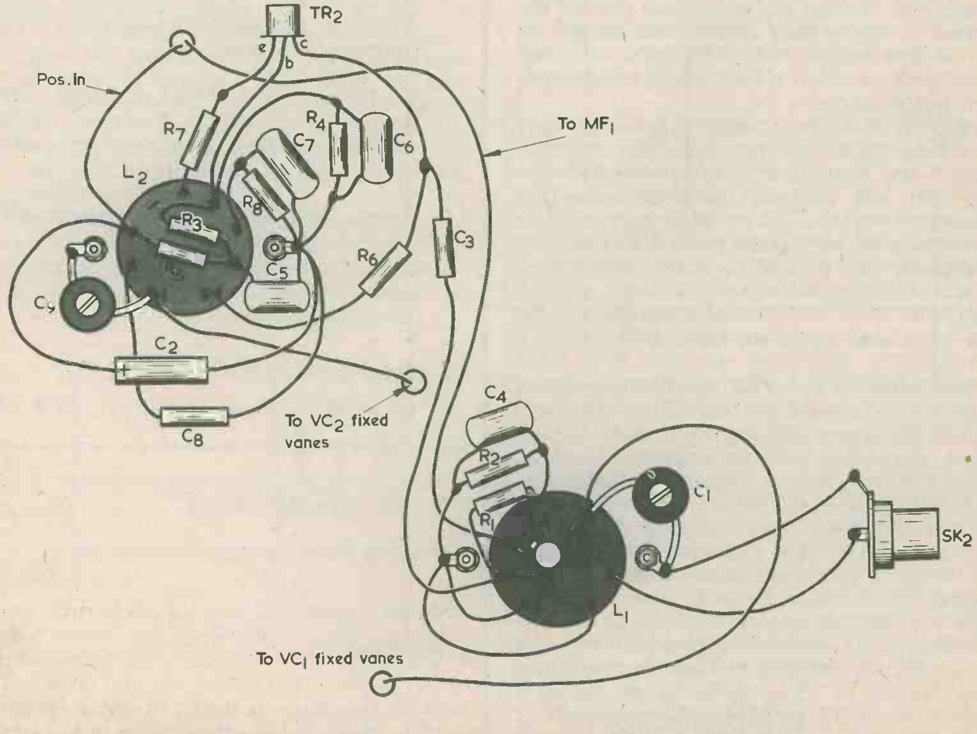



*Fig. 4. Under-chassis wiring for the mixer and oscillator stages*

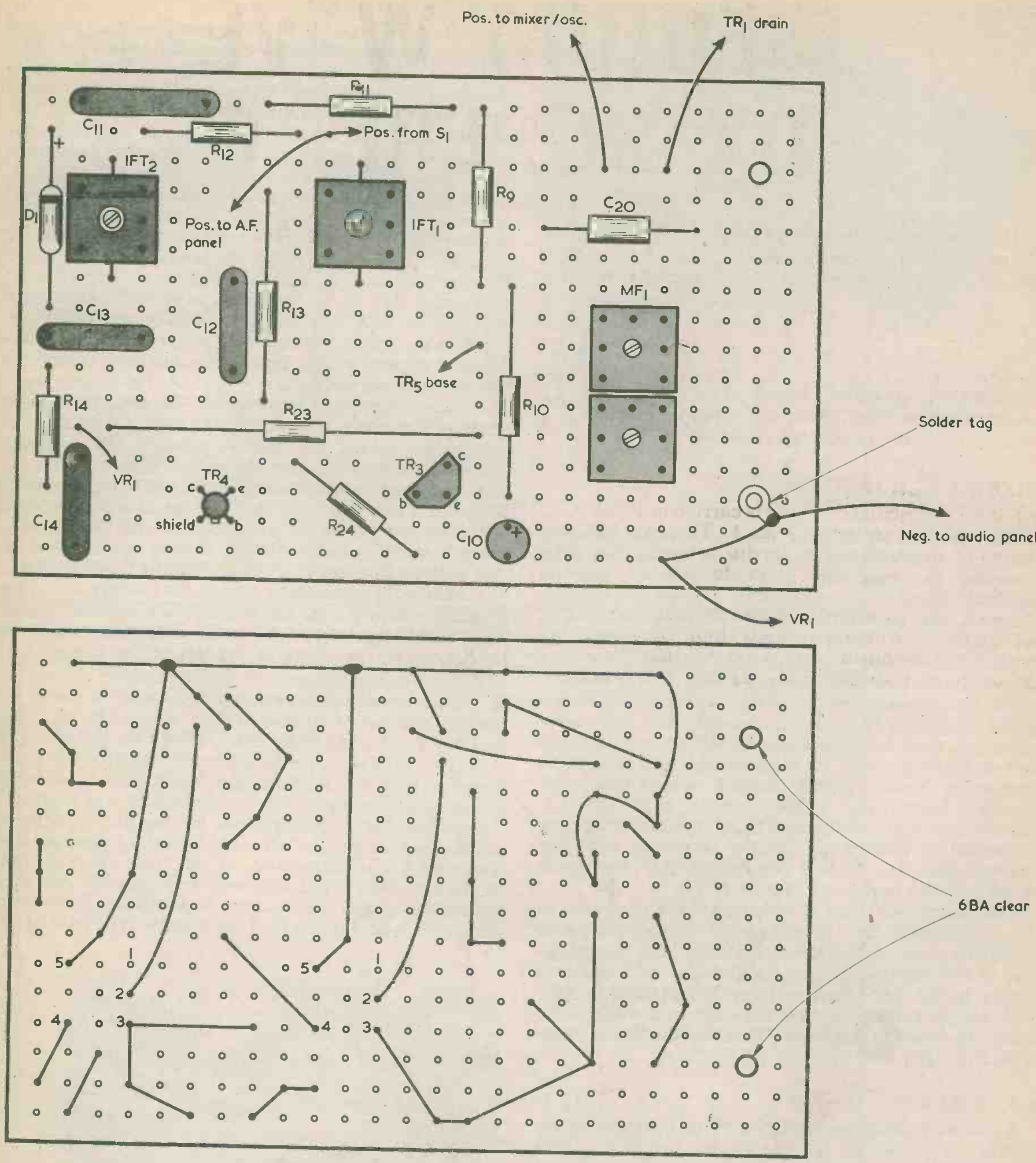
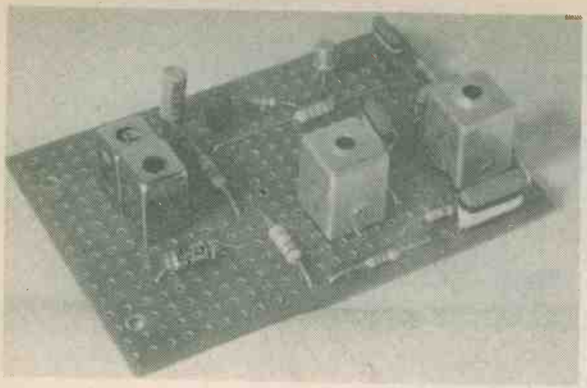



*Fig. 5. The component and wiring sides of the i.f. amplifier board*

## I.F. BOARD

Fig. 5 shows the component and wiring sides of the i.f. board. The components are assembled on a plain Veroboard of 0.15in. matrix measuring 3¾ by 2½in. This is a standard size in which the board is sold. Veroboard of 0.15in. matrix is ideal for the present application as it can be easily adapted to accept both the Denco i.f. transformers and the mechanical filter.

Before fitting any components, drill out the two 6BA clear mounting holes. The board may then be used as a template to enable the corresponding holes in the chassis to be marked out and drilled. The board takes up the position shown in Fig. 3 (published last month). Some of the holes in the board next have to be enlarged to enable the i.f. transformers and mechanical filter to be fitted. A No. 42 drill, or



*The i.f. amplifier board. This takes the mechanical filter, the two i.f. transformers and their associated components*

similar, is used to do this. All seven holes for each Denco i.f. transformer must be enlarged but only those for the mounting lugs of the filter and its matching transformer need to be altered. As may be gathered, the mechanical filter actually consists of two parts, the filter proper and its matching transformer. 0.15in. Veropins are fitted at the points where external connections are made to the board.

The components are now fitted and wired as shown in the diagram. Sleeving is passed over any wires which run close to other wires. In some cases the component lead-outs will be long enough to reach their connecting points. Tinned copper wire is employed for the remaining wiring. Note that the i.f. transformer and mechanical filter mounting lugs are connected to chassis so that the screening cans are earthed. Also, the chassis connection to C11 is made by way of the mounting lugs of IFT2.

The completed panel is mounted to the chassis with ½in. spacers over each mounting bolt to keep the panel underside clear of the chassis surface. With the exception of the leads carrying the positive and negative supply to the a.f. board and that connecting to TR5 base, all the external connections are now made. VR1 should be fitted to the front panel and the two connections from the board are to its track.

## A.F. BOARD

A piece of plain perforated s.r.b.p. board of 0.1in. matrix is employed for the audio amplifier. This board has 22 by 14 holes and it must be carefully cut down from a larger piece by means of a hacksaw. The two 6BA clear mounting holes are drilled out and the board is then used as a template to mark out and drill the corresponding holes in the chassis, with the board taking up the position shown in Fig. 3. The components are then mounted and wired as illustrated in Fig. 6. Veropins are fitted for external connections. If the board is of Vero manufacture the pins should be 0.1in. Veropins; if it is of different manufacture, 0.15in. Veropins will be found to give a better fit.

The board is then mounted on the chassis in the same way as was the i.f. board, and all the external wiring to it is completed.

## S-METER BOARD

In the prototype the S-meter components are wired up on a piece of plain 0.15in. Veroboard having 14 by 10 holes. Details are given in Fig. 7. The board is mounted on the S-meter terminals themselves, two of the Veroboard holes being enlarged to take the terminal screws. If the meter employed has different spacing between its terminals than has that employed by the author the Veroboard layout is modified accordingly, and it may be necessary to use a larger piece of board. The same general layout may still be employed. 0.15in. Veropins are fitted to the board for external connections. After the board has been wired up and mounted, its external wiring is completed. At this stage R17 is set to insert maximum resistance into circuit, with its slider turned fully anticlockwise.

The two track tags of VR2 are connected to the positive supply at S1, and to the negative supply at the earthed tag of VR1.

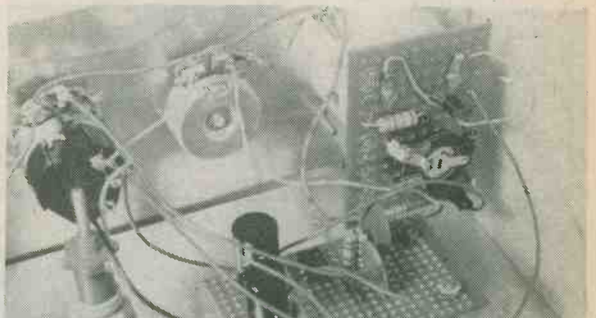
As was mentioned last month, the S-meter can be omitted if desired, whereupon the meter, VR2 and the component panel are not required. This will not adversely affect the performance of the receiver.

A solder tag is fitted to one of the mounting screws of M1, and a lead from the earthed tag of VR1 connects to this to provide an earthing point for the front panel. If the S-meter is to be omitted, the tag can be fitted on one of the mounting bolts of the tuning drive instead.

It then only remains to wire in the battery clip. The negative battery lead connects to the earthed tag of VR1 and the positive lead to S1. The battery can be positioned in the space to the left of the chassis.

The current consumption of the receiver is about 9 to 10mA under quiescent conditions, this rising to peaks in excess of 100mA at high volume levels. The unit can be economically run from a PP3 battery if it is only to be used with headphones or with a modest power output to a loudspeaker. For higher volumes it would be advisable to use the larger PP6 size battery.

Any speaker or headphones having an impedance of 8Ω or more can be connected to the output of the receiver. A load impedance of less than 8Ω must not be used as this could overload and possibly damage the output stage. The output is available from jack socket SK1, and if this is of the normal type having an



*The S-meter and a.f. amplifier boards mounted in position. The S-meter board secures directly to the meter terminals*

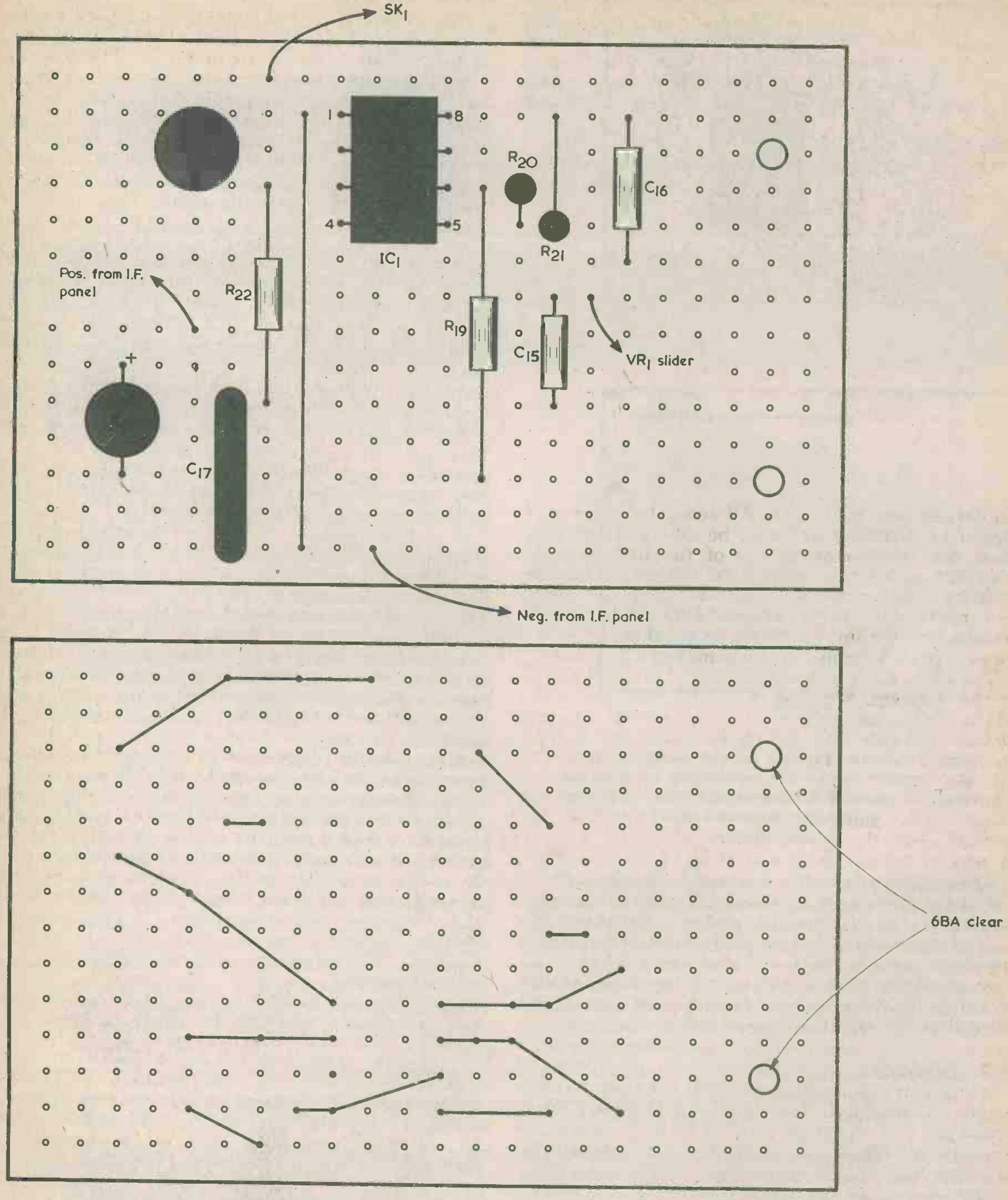



*Fig. 6. Due to the use of an integrated circuit the a.f. amplifier board is quite simple to wire up and requires few discrete components*

open construction the sleeve connection to chassis will be automatically provided by its mounting bush and nut. A slight disadvantage given by using a jack socket for the output connection is that the two contacts can be momentarily short-circuited when a plug is inserted or withdrawn. In consequence, volume should be turned to a low level whenever a plug is fitted or removed.

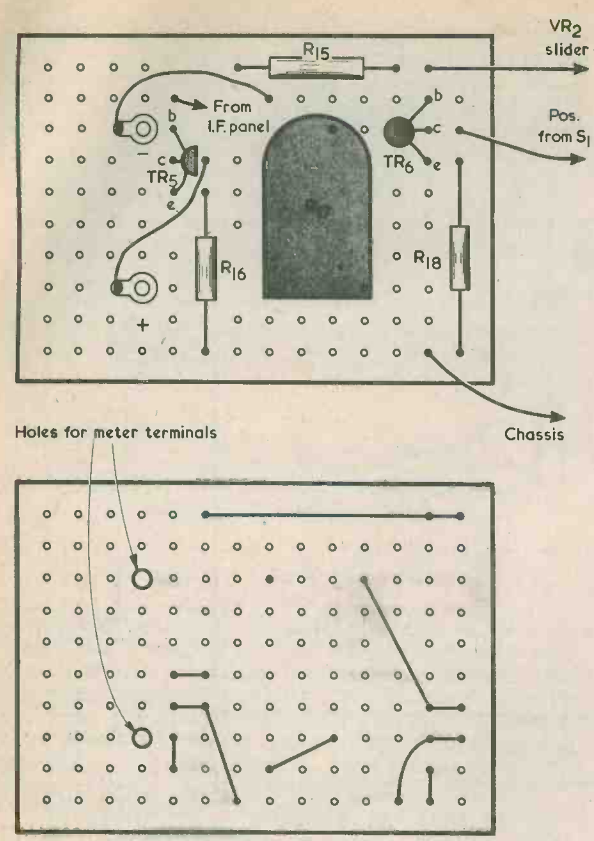



*Fig. 7. Apart from VR2, all the components in the S-meter circuit are assembled on a board which is secured to the back of the meter by the meter terminals*

## ALIGNMENT

Testing and alignment can be carried out with the aid of a few feet of wire acting as an aerial. A suitable loudspeaker or pair of headphones should be plugged into the output socket.

For packing purposes, L1 and L2 are supplied with the brass threaded stems of the iron-dust cores screwed fully down. Adjust the core of L1 so that about ½in. of the threaded stem protrudes above the former, and adjust the core of L2 so that about ⅜in. protrudes. Set C1 to about half capacitance and C9 close to maximum capacitance. If 10-60pF trimmers are being employed, C1 is set to about a third of maximum capacitance and C2 to about two-thirds maximum capacitance. Set VR2 so that its slider is at chassis potential.

Switch on. M1 should immediately give a forward indication, whereupon VR2 is adjusted to zero the meter.

Adjusting the tuning capacitor should enable a few stations to be received although, even with VR1 nearly fully advanced, the volume may not be very high at this stage. Tune accurately to one of these stations, using the S-meter as a tuning indicator. If the S-meter is not fitted, a tuning indicator can be provided by an electronic voltmeter or a multimeter having a sensitivity of 20kΩ per volt or more on its voltage ranges. The positive test lead of the meter is connected to the junction of R9 and R10 and the negative lead to chassis, and its reading reduces as signal strength increases.

The cores of the Denco i.f. transformers must be adjusted with a proper trimming tool and not with an ordinary screwdriver, which could easily damage them. A suitable trimming tool is the Denco type TT5. The cores of the mechanical filter and its matching i.f. transformer are very different in construction and a small screwdriver can be safely employed for their adjustment. Care must nevertheless be observed as the cores are made of ferrite and are rather brittle.

The cores of IFT1 and IFT2, and those of the mechanical filter and its matching transformer are now carefully adjusted for maximum signal strength. It will be found that the filter core adjustment is much less critical than is that of the transformers. Repeat the procedure several times until no further improvement in sensitivity can be obtained.

R.F. alignment commences by adjusting the core of L2 to give the correct coverage at the high frequency end of the band. Should a reasonably accurate signal generator be available, this can be used to set the limit of high frequency coverage at 1.6MHz.

If no signal generator is to hand the adjustment can be made after darkness has fallen, when the medium wave band is usually crammed with stations. With the tuning capacitor set for minimum capacitance, the core of L2 is unscrewed until short wave marine stations are heard in place of the medium wave broadcast stations. The core is then screwed back until a medium wave station is once again received. L2 then has the correct setting. If the receiver seems a little insensitive, the core of L1 can be adjusted to peak sensitivity.

Next tune the receiver to a station near, but not fully at, the high frequency end of the band. Choose a station that has a fairly constant signal strength, then adjust C1 for maximum signal. Find a station of fairly constant strength near the low frequency end of the range, with the tuning capacitor vanes almost fully enmeshed, and then adjust the core of L1 for optimum signal strength. Retune to the station at the high frequency end and readjust C1, then return to the low frequency end and readjust the core of L1. Continue this procedure until no further improvement is possible.

It will be noted that trimmer C9 is not adjusted during the alignment just described. If, however, it should be found that the coverage at the low frequency end of the range is obviously too small or too great, this can be corrected by a readjustment of L2 core at the low frequency end and an adjustment of C9 to set the limit at the high frequency end. C1 and the core of L1 will then have to be reset, in the manner just described, to take up the altered oscillator range.

R17 is adjusted with the receiver connected to a proper aerial. The strongest signal available is tuned in and R17 is then adjusted so that the meter reading is slightly above the S-9 point, or is at about 0.75mA if an ordinary 0-1mA meter movement is employed. Should it be subsequently found that another very strong signal causes the meter needle to overshoot the end of the scale, R17 is set to insert a little more series resistance.

This completes the alignment and adjustments needed in the receiver, which is now ready for use.

## AERIALS

An ordinary long wire aerial can be used with the receiver, but better results will in many cases be obtained with some form of ferrite or frame aerial. These have the advantage of being directional.

The directional property is particularly useful, as it will frequently be found that two stations are received on virtually identical frequencies. The directivity of the aerial then often permits one of the stations to be nulled, producing intelligible reception of the other.

Employing a directional aerial that has to be tuned has the disadvantage that it is necessary to adjust the aerial tuning every time the setting of the receiver tuning is significantly altered. This disadvantage is more than outweighed, however, by the freedom from breakthrough of spurious responses that a tuned aerial produces. It also reduces cross modulation by reducing the r.f. bandwidth.

A suitable preselector will be described in next month's issue, and this will feature an internal ferrite aerial and a dual gate MOSFET r.f. stage.

(Concluded)

# Trade News . . .

## BLOB BOARD

**S-DeC manufacturer, P. B. Electronics, 57 High Street, Saffron Walden, Essex, has launched a new concept in prototype printed circuit boards.**

**Normally half the price of previously competitive boards, they allow the user to go direct from circuit diagram to completed board in a matter of minutes and without the use of messy chemicals.**

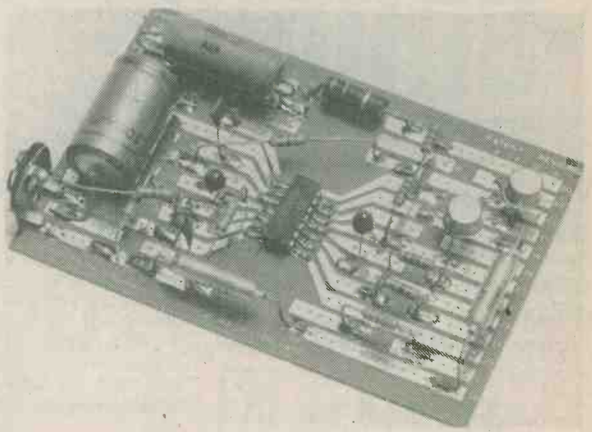
**Component layout can be drawn direct onto the Blob Board eliminating many of the errors which can occur in transferring from circuit diagram to ordinary PCBs.**

**Blob Board is extremely simple to use. Draw component layout on the Blob Board pattern using an ordinary felt pen. Lay components over their respective drawings and 'Blob' on some solder making the final soldered joint.**

**Components can be re-used and re-soldered making circuit prototype modifications and amendments both fast and easy.**

**All Blob Boards are roller-tinned to facilitate easy and reliable soldering.**

**Initially, there are twelve different Blob Boards available in a wide variety of patterns which, between them, will accomodate all components from discretes to ICs. One pattern for example, matches the S-DeC modular breadboard connections.**



*One of the twelve new Blob Boards launched by P. B. Electronics Ltd., showing a finished prototype.*

**The smallest discrete Blob Board (there are others for ICs) measures 3.6 x 2.4 in. and costs only 20p.**

**Blob Boards come in a range of standard sizes which match those already accepted by both professional prototype engineers and hobbiests. No drilling or special mounting of components is necessary and all Blob Boards are re-useable.**

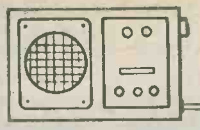
## CLOSED CIRCUIT TV EXPORT ORDER

Crow of Reading Limited have received an export contract, valued at £40,000. for planning, design, installation and commissioning of a comprehensive close-circuit television system for the Kuwaiti stock exchange.

This system will enable dealers and members of the stock exchange to review central display boards and teleprint machines directly from their offices, and is expected to ease the load on local telephone systems, obviate delays and errors caused by indirect transfer of data and reduce the number of personnel required.

The Contract, which includes the supply of 40 professional television monitors, with cameras and associated video distribution equipment, was obtained as a result of an open tender to the Kuwaiti Ministry of Information in the face of international competition. Crow of Reading are recognised as one of the world's leaders in television broadcast engineering, and extend the same degree of professionalism to non-broadcast applications such as this closed circuit system. They are able to provide significantly higher standards of performance and reliability than those normally achieved by television engineers outside the broadcast field. This is believed to be an important factor in the selection of Crow as contractor.

# In your workshop



**In this month's episode, Smithy the Serviceman, aided as always by his able assistant Dick, takes a look at a typical medium and long wave mixer-oscillator stage.**

Dick walked happily towards the Workshop, swinging a medium sized a.m.-f.m. transistor radio from his left hand. It was a cold and misty New Year's Day morning, and Dick's breath condensed into small vaporous clouds that hovered around his head. As he approached the Workshop he was suddenly surprised to see all its lights come on, with their cheerful yellow rays streaming out of the windows.

Dick paused cautiously, edged to one of the windows and peered in. He gave a sigh of relief as he saw the familiar figure of Smithy divesting himself of his raincoat, then he went to the door and quietly let himself in.

"Happy New Year, Smithy!"

Smithy, who had his back to the door, jumped.

"Blimey, you gave me a shock. What are you doing here?"

"I could well," said Dick, as he walked over and placed the transistor radio on his bench, "ask the same question of you. After all, we did say we'd take New Year's Day off this year."

"I came in to get a few tools and a meter," explained Smithy. "One of our electric fires at home has started blowing fuses and I want to do a quick repair job on it. And now what brings you in?"

## PRIVATE JOB

"A little private job," stated Dick, pointing to the transistor radio. "It's my Auntie Eff's and one of her darned cats knocked it off the table. I promised her I'd fix it up today if I could."

"Well," said Smithy, "let's hope the printed board hasn't got broken."

"I don't think it has," replied Dick, turning the receiver on and selecting medium waves. "It's quite all right on f.m., but it's weak on medium waves and even weaker on long waves."

He tuned in the local Radio 4 transmission. As he had said, this was weak. It was also accompanied by a whistle which changed in frequency as he tuned through the signal. He then switched to long waves, to demonstrate that the Radio 2 signal was, also as stated, even weaker.

"I've got a pretty good idea what's happened here," stated the Serviceman, grinning.

"Stap me," snorted Dick. "Don't tell me you're going to diagnose the trouble before I've even got the flipping back off."

"I'd hazard a guess, stated Smithy, "that the ferrite aerial rod is broken."

Dick glared at him then opened the rear of the radio case. The ferrite aerial rod was, indeed, broken. One half, with the medium wave coil on it, was still secured by a plastic clamp at what had been its centre. A small portion of the rod now protruded from the clamp on the side opposite to the medium wave coil, terminating at a jagged break. The remainder of the rod, with the long wave coil on it, lay forlornly on the bottom of the receiver case.

"You must," said Dick irritably, "have X-ray eyes or something. How the heck did you know that the ferrite rod was broken?"

"I only *guessed* that it was broken," replied Smithy soothingly, "but everything pointed towards it. For a start the set had had a fall, and one of the first things to go in a case like that is the ferrite rod. Second, you said the set was working all right on f.m., and so it was unlikely that there'd be a fault in the common a.m. and f.m. stages. Third, you could tune in signals on medium and long waves and, since you didn't remark on the matter, presumably these were coming up at the proper points on the tuning scale. So the receiver oscillator was working correctly. Fourth, the local Radio 4 signal was weak and had what sounded like a second channel whistle on it when it would normally come belting in clear of interference, and the Radio 2 signal on long waves was also weak. The last three facts pointed to serious detuning of the aerial tuned circuits, and the first fact made it almost a hundred per cent certain that the circuits had become detuned because the ferrite aerial rod was broken."

Dick gazed at the Serviceman with reluctant admiration.

"Well," he remarked eventually, "you certainly used some logical reasoning there. I don't quite get the second channel whistle bit, though."

"That was a bit of luck," confessed Smithy. "But consider the situation. Say you've got an a.m. radio with an i.f. of 470kHz and you tune in a signal at 1,100kHz. The receiver oscillator will run at 470kHz above this frequency, which is 1,570kHz. But if there is a signal which is 470kHz *above* 1,570kHz, that is at 2,040kHz, and if it finds its way into the mixer, this signal will also pass into the i.f. amplifier. This is the second channel signal. What you normally hear with second channel interference is a whistle as the carriers of the two signals beat together. This whistle changes in pitch as you tune through the required signal because the difference frequencies from the mixer vary. If oscillator

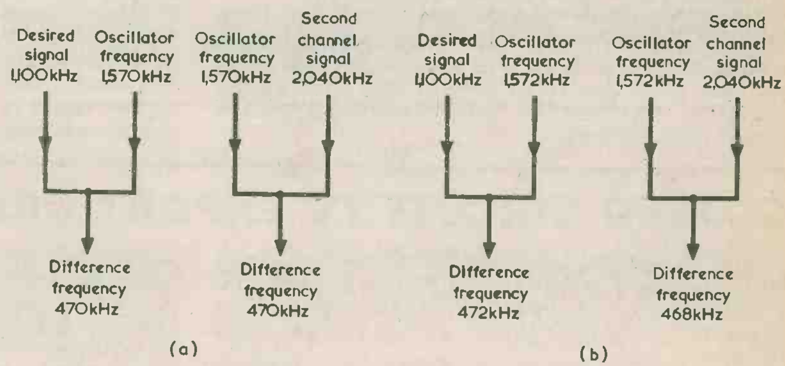



*Fig. 1(a). If a second channel signal, which is higher than oscillator frequency by the intermediate frequency, finds its way into a receiver mixer stage input, an output is produced at intermediate frequency*
*(b). Variations in oscillator frequency alter the pitch of the beat note given by the carriers of the desired signal and the second channel signal. Here, the oscillator frequency has been shifted upwards by 2kHz*

frequency is increased a little the difference frequency given with the required signal goes up and the difference frequency given with the second channel signal goes down." (Figs. 1(a) and (b).).

"I know all about that," said Dick impatiently. "But why did the presence of that second channel whistle make you think that the aerial tuned circuit in the receiver was off-tune?"

"It's pretty obvious, isn't it?" retorted Smithy. "The job of the aerial tuned circuit of a superhet is to bring up the strength of the desired signal to as high a level as possible. This has two results. First, you get maximum sensitivity for the desired signal. Second, the desired signal is so much stronger than any second channel signal which may be knocking around that interference from the latter is either negligible or completely non-existent. You can expect a little second channel interference with a simple transistor a.m. superhet if you're tuned in to a weak signal and there happens to be a really strong signal at the second channel frequency, but not the other way round."

## OSCILLATOR FREQUENCY

"Fair enough," conceded Dick. "Incidentally, there's something that's just occurred to me. Why *is* the oscillator frequency higher than signal frequency on these medium and long wave a.m. sets?"

"It has to be," replied Smithy. "One reason which comes immediately to mind is that if the oscillator frequency is below signal frequency and the set covers the long wave band of about 150 to 300kHz, the intermediate frequency would have to be lower than 150kHz. This would make the spacing between wanted and unwanted second channel signals too low and would increase the chances of second channel interference."

"All right then," said Dick. "How about having oscillator frequency lower than signal frequency on medium waves?"

"Okay, let's look at that next. Let's say that the medium wave band is 600 to 1,600kHz and that we are still using our intermediate frequency of 470kHz. If the oscillator runs above signal frequency it will require a range of 1,070kHz to 2,070kHz. And if it runs below signal frequency it will require a range of, let me see now, 130 to 1,130kHz." (Fig. 2.).

"What's wrong with that?"

"A very great deal," replied Smithy. "A frequency range of 1,070 to 2,070kHz represents a ratio between bottom and top frequencies of about 1 to 2 only. But a frequency range of 130 to 1,130kHz gives a ratio of about 1 to 8. The signal frequency range of 600 to 1,600kHz gives a ratio which is a little less than 1 to 3, and we consider this a sufficiently high ratio to be covered by a variable tuning capacitor. If we tried to cover an oscillator range with a ratio of 1 to 8 between the bottom and top frequencies we would need an absolutely enormous tuning capacitor!"

"Gosh," exclaimed Dick. "I can see it all now. Having the oscillator frequency above signal frequency means that the oscillator tuning capacitor has a shorter range to cover, and this in turn will mean that it can have a lower maximum value than that needed for the aerial tuned circuit."

"Exactly," confirmed Smithy. "What you normally find in practice these days with a.m. superhets is that both sections of the 2-gang tuning capacitor have the same value, but the effective value of the oscillator section is reduced by connecting a capacitor in series with it. Which is, by the way, known as a padding capacitor." (Fig. 3).

Smithy glanced at the receiver with the broken ferrite rod, then started.

"Dash it all," he complained irately, "you've done it again! In the very first half hour of our getting together in this New Year you've done it again!"

"Blimey, Smithy," protested Dick, "you don't half carry on. What have I done again?"

"Conned me into nattering about radio and electronics when there are other things to be done. You're *always*

| | | |
|---|---|---|
| Signal range | 600kHz to 1,600kHz | 600 : 1,600 ≈ 1 : 3 |
| Oscillator range (oscillator high) | 1,070kHz to 2,070kHz | 1,070 : 2,070 ≈ 1 : 2 |
| Oscillator range (oscillator low) | 130kHz to 1,130kHz | 130 : 1,130 ≈ 1 : 8 |

*Fig. 2. Medium wave signal and oscillator frequency ranges with oscillator frequency above and below signal frequency. An intermediate frequency of 470kHz is assumed*

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doing it. Let's get this set of your Auntie Eff's fixed up without any further messing around."

"I wonder," asked Dick dubiously, "if we could stick the two halves of the rod back together again? Say, with that new high-speed glue that people are using to stick their fingers together with?"

"Funnily enough," replied Smithy, "it is quite in order to stick the two halves of a broken ferrite rod together with adhesive. The adhesive can be any good cold setting type and the two parts must be nested together so that the interruption in the rod structure is as thin as possible. However, that rod in your aunt's set looks like a standard size to me, so we'll present her with a new one."

Smithy picked up a rule, held the two parts of the broken rod together and measured their length.

"Six inches," he announced. "No problem."

He walked over to the spares cupboard and, after a little searching, found a rod of the required length and diameter. He returned and handed it over to his assistant.

"Here you are, Dick" he announced. "I'll leave you to fit this. Don't forget to put the coils on the new rod the same way round as they are on the broken rod. Usually the two tuned coils are in series on long waves and if you put one the wrong way round they'll be out of phase with each other."

## MIXER-OSCILLATOR

Dick loosened the plastic clamp which secured the broken rod, removed it and then fitted the new one. After this, he slipped the two coils, on their formers, over the ends of the rods. He switched on the receiver and turned its tuning control.

"Stap me, Smithy," he said, pleased, "there's no end of an improvement here. This set's as lively as anything now."

"Good show. Well, all you've got to do now is set the coils in their right positions on the rod. For a quick job we can assume that the aerial and oscillator trimming is all right whereupon the first thing to do is to tune in a station on medium waves that is near the low frequency end of the band and move the medium wave aerial coil along the rod for maximum signal strength. Then tune in to Radio 2 on long waves and adjust the long wave coil on the rod for optimum signal."

"That doesn't sound very technical to me," objected Dick.

"It isn't," confessed Smithy. "But it should be adequate if, as I say, we can assume that the trimming is correct. I hardly need to tell you that there's a trimmer across the aerial tuned circuit and another across the oscillator tuned circuit. The normal routine is to trim each tuned circuit with its trimmer at the high frequency end of the range and to adjust, or pad, each tuned circuit by changing the inductance at the low frequency end of the range. You change the inductance of the oscillator coil by adjusting its iron-dust core, and you change the inductance of the aerial coil by moving it along the ferrite rod." (Fig. 4).

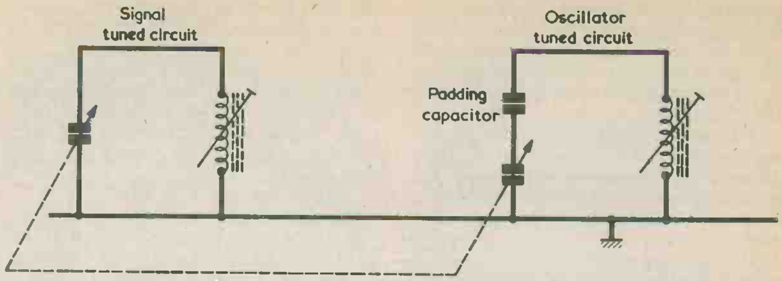


*Fig. 3. Normally, the signal and oscillator sections of the 2-gang tuning capacitor have the same value, and a padding capacitor is connected in series with the oscillator section*

"I've always understood why you trim at the high frequency end," commented Dick. "And that's because the tuning capacitor is then at minimum capacitance and the effect of the small trimming capacitor is at its greatest. But you don't have quite the same effect when you adjust coil inductance. Adjusting coil inductance seems to cause as much shift in resonant frequency at the high frequency end of the range as it does at the low frequency end."

"That's true," confirmed Smithy. "The two adjustments are interdependent, which means that you usually have to carry them out several times before you reach the final correct settings. Most of these transistor portables have rather involved medium and long wave trimming arrangements so, as a matter of interest, let's see if I can find the service sheet for this receiver of your Auntie Eff's."

As Smithy walked towards the filing cupboard, Dick grinned to himself. Smithy had already completely forgotten his complaint, a few minutes earlier, that Dick had tricked him into spending his time talking about matters electronic. Once Smithy got into his stride on a particular subject there was no holding him back.

"Ah, here we are," said Smithy, returning with a service manual. "We happened to have this one in stock."

He opened the manual at its circuit diagram, placed it on the bench and indicated the circuitry around the a.m. mixer-oscillator transistor. (Fig. 5).

"Blow me," commented Dick. "There isn't much in the way of waveband switching is there?"

"There isn't," said Smithy. "All the switching is carried out by a double-pole double-throw switch. The overall set-up is quite typical of the sort of thing you encounter in the medium and long wave sections of portable a.m.-f.m. receivers."

"Let's see," said Dick, "what happens when the switch is set to medium waves. The left hand switch section circuit is quite easy to follow. All the switch does is couple the transistor base via a 0.01$\mu$F capacitor to a coupling winding alongside the medium wave ferrite aerial coil. Now what does the right hand switching section do? Oh yes, it short-circuits the long wave ferrite aerial coil."

"There's not a direct short-circuit,"

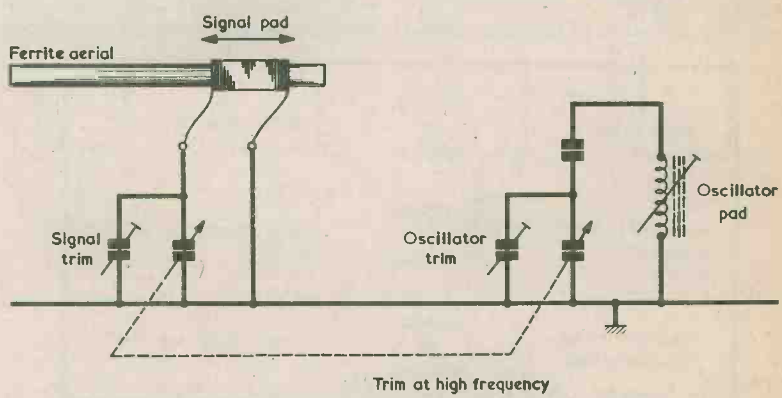


*Fig. 4. Basic trimming and padding procedure for an a.m. broadcast band receiver*

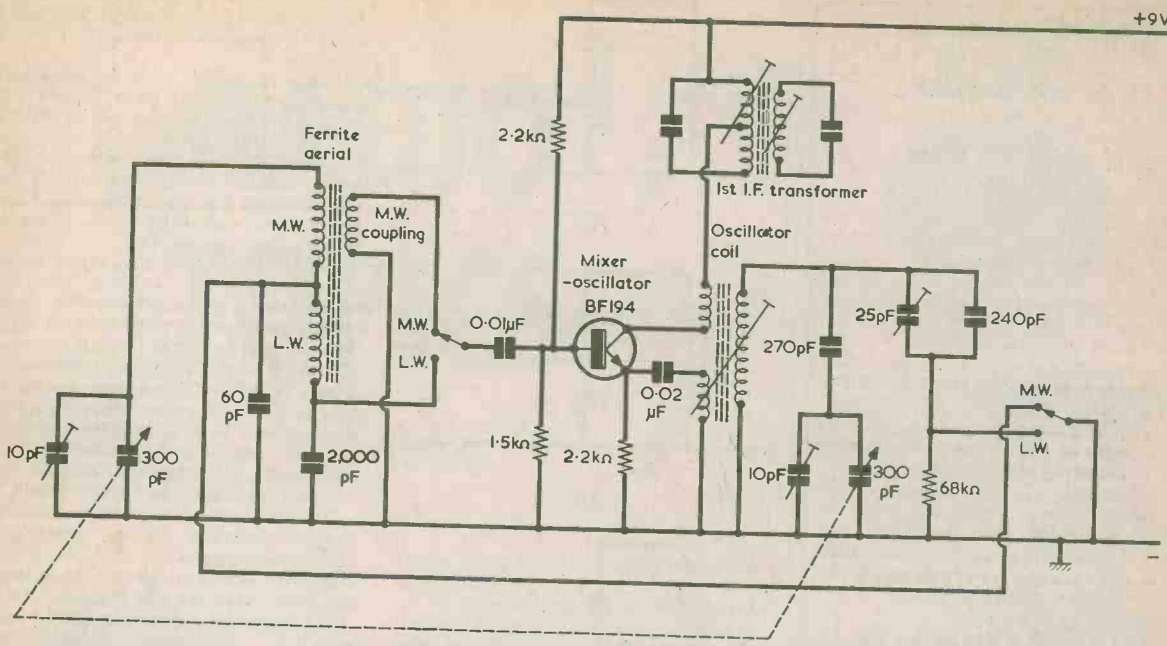


*Fig. 5. Typical medium and long wave mixer-oscillator stage with representative component values and a d.p.d.t. wavechange switch. The bottom-end long wave signal coupling and medium wave oscillator damping circuits are encountered in some B.R.C. receivers*

Smithy corrected him. "The right hand switch section connects the upper end of the long wave coil to chassis, whilst the lower end of the long wave coil couples to chassis via a 2,000pF capacitor."

"That's as good as a short-circuit so far as I'm concerned."

"It's not, you know," persisted Smithy. "That 2,000pF capacitor has a reactance of around 250 to 500Ω at long wave frequencies. What happens is that the long wave coil becomes resonant at a very low frequency which is well below long wave frequencies. And this overcomes an ever-present problem which occurs whenever you have a medium and a long wave coil on the same ferrite aerial rod. If the long wave coil is open-circuit when medium waves is selected it may resonate with its own self-capacitance at a frequency in the medium wave band and cause awkward absorption effects. In some sets the long wave coil is directly short-circuited on medium waves. In this set it's tuned well away from the medium wave band."

## OSCILLATOR SWITCHING

"As you like," said Dick carelessly. "Now let's have a look at the oscillator part. This seems simple enough, too, with the transistor emitter and collector connecting to coupling windings alongside the tuned coil. The oscillator section of the 2-gang tuning capacitor has a trimmer across it and it connects to the top end of the coil by way of a 270pF capacitor."

"It does," agreed Smithy, "and that 270pF capacitor is the padding capacitor. Both sections of the 2-gang tuning capacitor in this set have the same value."

"There's something funny here," stated Dick, frowning. "The top end of the coil also connects to a 240pF capacitor and 25pF trimmer in parallel and these connect to a 68kΩ resistor going to chassis."

"Forget about them for the moment," advised Smithy, "and see what happens when the two switch sections are set to long waves."

"All right," replied Dick agreeably. "On long waves the right hand switch section disconnects the upper end of the long wave ferrite rod winding from chassis, with the result that the medium and long wave windings are now in series. And the left hand switch section disconnects the transistor base from the medium wave coupling winding and connects it to that 2,000pF capacitor below the long wave winding. Hey, Smithy, that's crazy!"

"No, it isn't. What you've got there is what is known as a bottom-end coupling."

"Bottom-end coupling? That's new to me."

"It is a bit unusual," conceded Smithy. "The best way of explaining it is to start off by saying that one way of taking a low impedence output from a tuned circuit is to take it from a coil tap near the earthy end. Okay?" (Fig. 6(a).).

"Yes, I can visualise that."

"And another way," continued Smithy, "is to take the low impedance coupling from a tap in the capacitive side of the tuned circuit. You can't tap into a capacitor as you can into a coil, but you can do what is effectively the same thing and have two capacitors in series and take the coupling from their junction. If the capacitor connecting to chassis has a much higher value than the other capacitor then it has a much lower reactance, and the coupling is equivalent to a tap low down a coil." (Fig. 6(b).).

"That," remarked Dick, his brow furrowed in thought, "seems to be reasonable enough. But the high value capacitor in the receiver circuit is in series with the coil."

"No difference," responded Smithy. "All that has happened is that the chassis connection has shifted to the junction of the two capacitors and the coupling is taken from the junction of the high value capacitor and the coil." (Fig. 6(c).).

"Oh, I get it! But there's still one thing that doesn't seem to be quite right. Since the low value capacitor is actually the signal frequency tuning capacitor, won't the ratio between the two capacitors change as the tuning capacitor is adjusted?"

"It will," stated Smithy, "and the impedance at the coupling point will change, too. If the large value capacitor has a value which causes a sufficiently low impedance to be given when the tuning capacitor is at maximum value, all that will happen is that the impedance reduces as the

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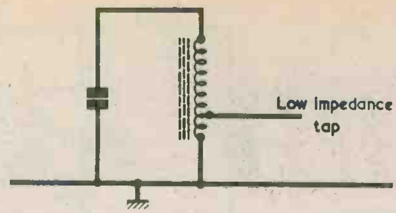
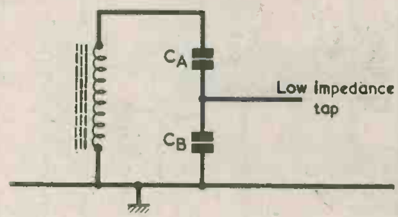



(a)

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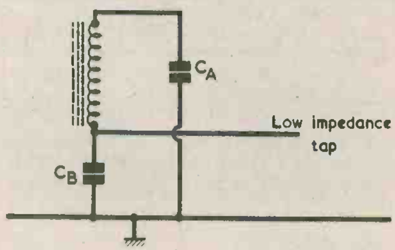


(c)

*Fig. 6(a). Taking a low impedance tap from the inductive side of a tuned circuit*
*(b). The tap can alternatively be taken from the capacitive side of the tuned circuit. CB has a much higher value than CA*
*(c). An alternative version of the circuit, with the connections to CB reversed*

tuning capacitance gets smaller."

"That seems to be all right then," yielded Dick. "Let's take a look at the oscillator section. The right hand switch section connects the 240pF capacitor and the parallel 25pF trimmer directly across the oscillator tuned coil."

"Whereupon," stated Smithy, "the oscillator frequency is much reduced and can now be tuned over the range required for long waves by the oscillator section of the 2-gang capacitor. Also, that 68k Ω resistor you were worrying about just now is short-circuited. The oscillator circuit is designed to run at correct level on long waves, when a relatively high capacitance is connected across the coil. But on medium waves, where there is much less tuning capacitance, the oscillator could run too violently unless some precaution were taken. The precaution consists of putting that 68k Ω resistor across the tuned circuit via the parallel 240pF capacitor and 25pF trimmer. The resistor damps the oscillator tuned circuit so that the oscillator runs at just about the same level on medium waves as it does on long waves."

"That's crafty," commented Dick. "Well, we seem to have picked the bones of this wavechange switching circuit pretty thoroughly. No, we haven't! There's one capacitor we haven't looked at yet. That's the 60pF one between the top of the long wave ferrite rod winding and chassis. What's that do, Smithy?"

"It's effectively a long wave trimming capacitor," replied Smithy. "Since there are relatively few turns on the medium wave aerial coil, that 60pF capacitor can be looked upon as trimming all the aerial coil inductance which is in circuit on long waves. It only comes into use on long waves and it's purpose is to give good tracking between aerial and oscillator tuned circuits on this band. And that's the lot so far as this circuit is concerned."

"It isn't quite," said Dick quickly. "What does the service sheet say about alignment?"

Smithy leaned over and examined the instructions in the manual.

"It's pretty well what you'd expect," he announced. "Briefly, the medium wave band has to be adjusted first. The trimmer across the oscillator tuning capacitor is adjusted at the high frequency end for correct reception frequency as indicated by the tuning scale, and the aerial circuit trimmer is adjusted for maximum signal strength. Then the oscillator tuned circuit is padded at the low frequency end for correct reception frequency by adjusting the oscillator core, after which the aerial circuit is adjusted by moving the medium wave aerial coil along the ferrite rod. These two operations are repeated until there is no further improvement. Then you switch to long waves and make adjustments at a single frequency a little higher than that of the Radio 2 transmission. The 25pF trimmer in parallel with the 240pF capacitor is adjusted for correct frequency of reception, after which the long wave coil is moved along the ferrite rod for optimum signal strength. If you want the alignment instructions in greater detail, then I'll leave you to read them for yourself."

## START OF THE YEAR

With which words, Smithy left his assistant, walked over to his own bench and proceeded to gather up some tools and a testmeter.

"Hey, Smithy," called out Dick. "You aren't going to leave just like that, are you?"

"I am," came Smithy's purposeful reply, as he put on his raincoat.

"But," wailed Dick, as Smithy opened the door, "haven't you forgotten something?"

"No, I haven't," said Smithy, half-way out of the door. "But this is the first chance I've had of saying it. And a Happy New Year to you, too!" ■

# RADIO TOPICS

**By Recorder**

Up till now I had always looked upon the 741 as offering pretty well all that one could ask for in an operational amplifier working at d.c. or fairly low frequencies. It is extremely robust, has a typical voltage gain of 200,000 times and its input resistance is 0.3MΩ minimum and 2MΩ typical. Practical checks have shown that, if preceded by a silicon emitter follower transistor, the input resistance at the transistor base is well in excess of 1MΩ, with the proviso that this assumes leakage currents in the transistor that are lower than manufacturers' maximum specification figures. The combination of emitter follower and 741 was used, to effect, in G. A. French's 'Low Cost Electronic Voltmeter' in the July 1975 issue and, to even greater effect, in the resistance bridge described in 'In Your Workshop' in the October 1975 issue of this journal.

## NEW DEVICE

But things never remain static in electronics and we now have a new operational amplifier, from RCA, which completely out-performs the 741 so far as input resistance is concerned. This is the CA3130 and the reason for its superior performance is that it is a CMOS device with a MOSFET input, whereupon the input resistance goes up to astronomical levels.

The internal circuitry of the CA3130 is a lot simpler than is that of the operational amplifiers we have become used to in recent years. Two p-channel MOSFET's appear in a differential amplifier in the first stage, with the inverting and non-inverting inputs connecting to their gates. Their drains couple to the collectors of two bipolar transistors in a modified current mirror configuration, a single-ended output being taken from one of the transistors. If desired, an offset null potentiometer may be connected to the emitters of the bipolar transistors, but even without this the input offset voltage is low.

The single-ended output connects to the base of another bipolar transistor. This is in the earthed emitter mode and has a constant current source as its collector load. The collector also connects directly to the gates of the output transistors, these being a p-channel and an n-channel MOSFET in a totem-pole complementary output stage. And that, apart from the input gate protecting diodes and a bias network, is the lot. Most of the voltage gain in the device is provided by the bipolar transistor which feeds the output MOSFET's.

A single external compensating capacitor is needed to prevent the i.c. from taking off. This couples effectively across the high gain bipolar transistor and requires a value of about 47pF.

The input current to the CA3130 is typically 5 picoamps at 25 degrees Centrigrade, rising to about 1,000 picoamps at 120 degrees. And 1,000 picoamps is, of course, one-thousandth of a microamp. This input current is mainly leakage current in the input gate protecting diodes. The typical input resistance at 25 degrees Centigrade is also quoted, as 1.5TΩ. I had to look up the reference books for 'T', which is short for 'tera'. 1.5TΩ is the same as 1.5 million megohms!

As with all CMOS devices, some care is needed in handling the CA3130. The soldering iron bit used for connecting it into circuit should be reliably earthed, and if the input gate protecting diodes are made to conduct due to improper circuit operation the input current must not exceed 1mA. The CA3130 is normally supplied in an 8 lead TO-5 style package, whereupon it is referred to as the CA3130T.

The CA3130 will not be the op-amp to end all op-amps. But it certainly takes development towards that ideal a very considerable step forwards.


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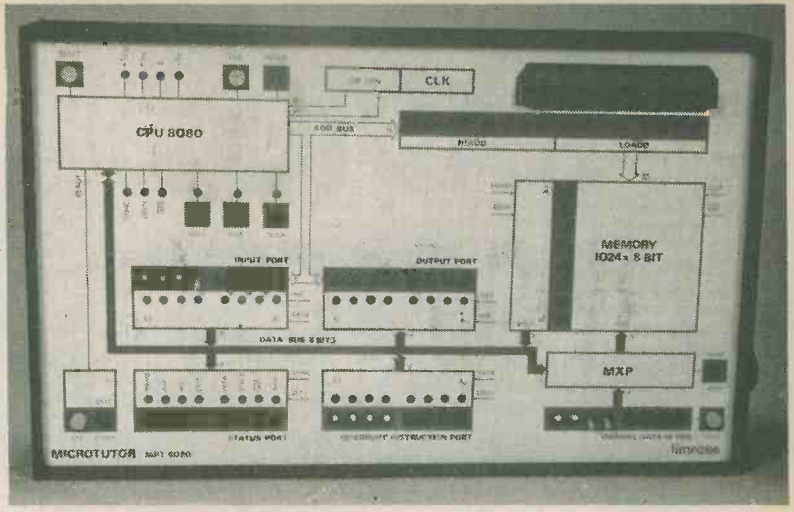



*The Limrose Microtutor 8080. This is a microcomputer in its own right and can be employed for developing an understanding of microprocessors and their software*

## PREFIXES

Since I had to look up 'T' for 'tera', it occurs to me that there are other prefixes denoting magnitude which are likely to crop up in the future, now that electronics deals more and more with very large and very small quantities. For the record, let's list them all here. Kilo (k) means a thousand, of course, whilst mega (M) stands for a million. The next one up is giga (G) which means a thousand million, followed by tera (T) which, as we've just seen, stands for a million million.

Going down in scale we have the familiar milli (m) which represents a thousandth part, micro ($\mu$) a millionth, nano (n) a thousand millionth and pico (p) a million millionth. Now comes the unfamiliar ones. These are femto (f) a thousandth of a pico, and atto (a) a millionth of a pico.

And you can't get much smaller than that.

## MICROTUTOR 8080

The accompanying photograph illustrates the Limrose Microtutor 8080, which is described as offering a fast, simple and inexpensive way of developing a fundamental understanding of microprocessors. It gives the 'hands on' experience needed to master and apply microprocessors.

The Microtutor 8080 is a full 8-bit microcomputer with an 8080 c.p.u., 1K x 8-bit random access memory, an input port, an output port, an interrupt instruction port and a status port. It has facilities for manual loading of the memory and for single stepping of the processor, and can therefore be used as a prototyping computer for development of applications software. It can also be expanded with additional memory and a teletype interface, using plug-in cards, for more advanced work.

All important signals, data bits and addresses are continuously displayed by means of over 40 l.e.d. indicators. Inputs are provided on several switch registers and press-button switches. Data paths and the manner in which they relate to various registers are shown on the front panel.

By following the instruction book provided with the Microtutor, a person with limited technical knowledge can rapidly learn how microprocessors work. Trained electronic engineers can quickly bridge the gap between conventional hardware and microprocessor software by making a step-by-step progression from developing simple algorithms to complex programmes.

The Microtutor 8080 is available fully tested and assembled in a portable cabinet weighing only a few kilogrammes. It has merely to be plugged into the a.c. mains for the user to have a powerful microcomputer ready for use.

Further information is available from the manufacturers, Limrose Electronics Limited, 241-243 Manchester Road, Northwich, Cheshire.

## GIM CATALOGUE

General Instrument Microelectronics Ltd., of 57-61 Mortimer St., London W1N 7TD, announce that, because of the large number of standard microcircuits now comprising their range of off-the-shelf MOS/LSI devices, they have published their latest product catalogue in a convenient, easy-to-use paper back form. The new catalogue is available at no charge to existing GIM customers or purchase managers and can be bought by first-time users from GIM distributors at a nominal cost.

The 320 page publication provides comprehensive data including functional descriptions, pinning, timing and peripheral circuit details for all MOS microcircuits in GIM's fast growing products range. This now comprises over 200 different MOS/LSI devices for the consumer, calculator, telecommunications and data management product areas. General Instrument manufacturers MOS/LSI circuits for clocks, clock radios, TV tuners, remote control, appliance timers, radio and high fidelity systems.

GIM is also the leading supplier of LSI video game microcircuits. The AY-3-8500 was the first single chip LSI product to provide six different games with on-screen scoring and realistic sound.

## SEEING HEAT

Presented by Marconi Space and Defence Systems Limited at the 1976 Farnborough International Air Show were details of a new lightweight thermal imaging night sight.

The new sight, probably the smallest and lightest, of its type in Europe, is designed primarily to give a night-fighting capability to anti-armour guided weapon systems, but it has many applications in the fields of security and safety. Due to its ability to detect people in conditions of complete darkness it has considerable potential as an intruder detection device.

The sight has two magnifications, enabling a wide field of surveillance mode to be switched instantly to a narrow field of view at higher magnification whilst retaining the centre-field sight-line. Field-of-view, aspect ratio, spatial resolution and viewing optics can be provided to meet customer requirements. A graticule is fitted and a variable focus eyepiece is supplied which ensures that both graticule and scene are in focus.

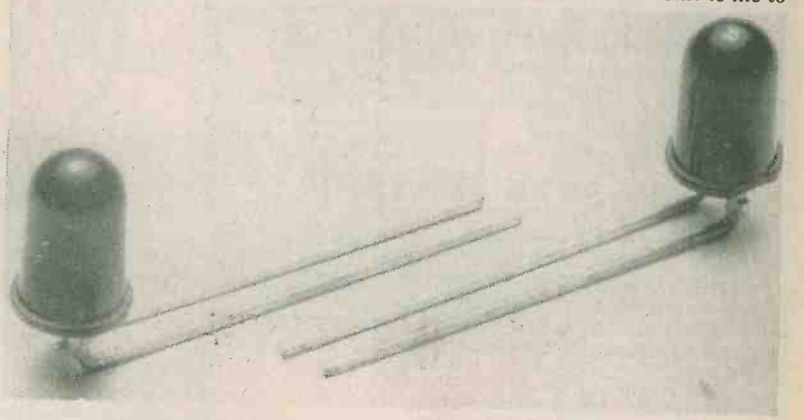
Infra-red radiation from the scene is focused by a large aperture afocal lens system onto cadmium mercury telluride detector elements via an optic-mechanical scanner and a collimator. The detector output is fed via the processing electronics to a vertical multi-element light emitting diode array. The light from the l.e.d.'s is then directed via a collimator to the scanner, which reflects the output into the variable focus eyepiece.

## LIGHT-EMITTING DIODES

Recently introduced by Litronix, 24 Sun Street, Hitchin, Herts, are two new red light-emitting diodes having a particularly high light output.

In these, the semiconductor material is gallium arsenide phosphide, and voltage drop is 2 volts at a forward current of 20mA. The lens is red diffused polypropylene and provides a large full flooded front radiating area with wide angle viewing.

Type numbers are RL-4403 and RL-4415. The RL-4403 is of conventional construction with its lead-outs extending backwards. As can be seen in the photograph, the RL-4415 has its lead-outs angled at 90 degrees to facilitate direct mounting to a printed circuit board. Snap-on clips are available for both types for panel mounting applications.



*These rather unusual l.e.d.'s have their lead-outs at right angles for direct mounting to a printed board. They are high brightness types manufactured by Litronix*

## UNUSUAL TRIMMER

I was digging into a rather old valve signal generator the other day and had reason to take the screen off the coil and range switch department. Although the signal generator was housed in its own metal case the tuned circuits were contained in a further internal screened compartment. This is a pretty standard practice with signal generators. It provides double screening of the tuned circuits, and it also ensures that they are well isolated from the outside world and are thereby more able to maintain their frequency accuracy in terms of the signal generator tuning scale.

Everything inside the tuned circuit compartment was as it should be, but I learned a little lesson about trimming capacitors. Each tuned circuit was trimmed by the capacitance between two twisted enamelled copper wires!

A thick enamelled wire, of around 12 s.w.g., protruded outward from the chassis, to which it was connected. Close-wound around it was a thin enamelled wire, around 26 s.w.g., this connecting to the non-earthy side of the appropriate tuned circuit. The number of turns of the thin wire on each of these assemblies varied from ten to about thirty. The open end of each thin wire gave the appearance of having been removed and then cut off about half an inch from the thick wire.

The alignment procedure at the factory was quite obvious. Initially, the thin wire would be close-wound tightly on the thick wire, possibly by machine, and would intentionally have too many turns. When it became necessary to trim the tuned circuit concerned, the thin wire would then be carefully unwrapped from the thick wire until the resonant frequency was just at the correct level. This would be a one-way process, because it would be difficult to wind the thin wire back on tightly again if too much were removed.

The whole idea sounds rather primitive but, on reflection, is it? Two lengths of enamelled wire are cheaper than a physical trimmer having the long-term stability required in a signal generator, and the twisted wire assembly would certainly stand up to plenty of knocks and general maltreatment of the instrument. Patently, there should be no direct voltage between the two wires because of the thinness of the insulation between them but that seems to me to be the only serious disadvantage in the idea. So, the next time you require a stable low value trimmer, those two twisted enamelled wires may be just the job for you! ■

# 'Precedence Detector'

In the circuit description for this project it was stated, on page 232 of the November 1976 issue, that pin 3 of the 7400 is taken to 1 when S1 is pressed. It is, of course, pin 1 which is so taken.


## BACK NUMBERS

**For the benefit of new readers we would draw attention to our back number service.**

**We retain past issues for a period of two years and we can, occasionally, supply copies more than two years old. The cost is the cover price stated on the issue, plus 11p postage.**

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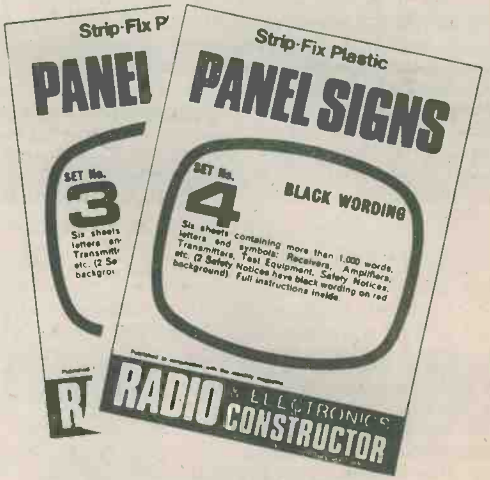


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(Continued on page 381)


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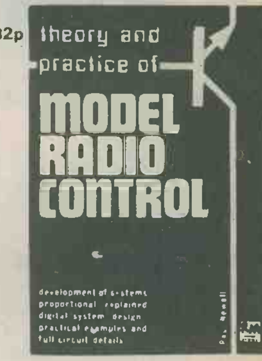


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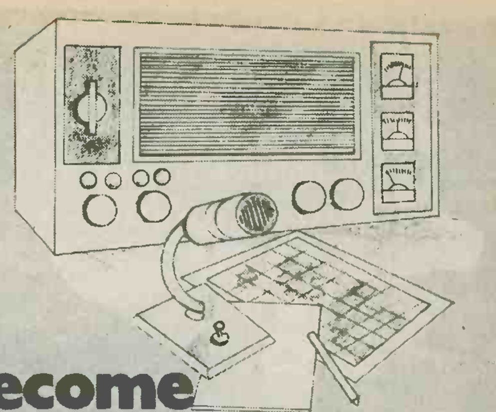
(Continued on page 382)

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(Continued from page 381)

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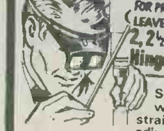

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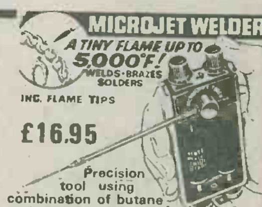

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