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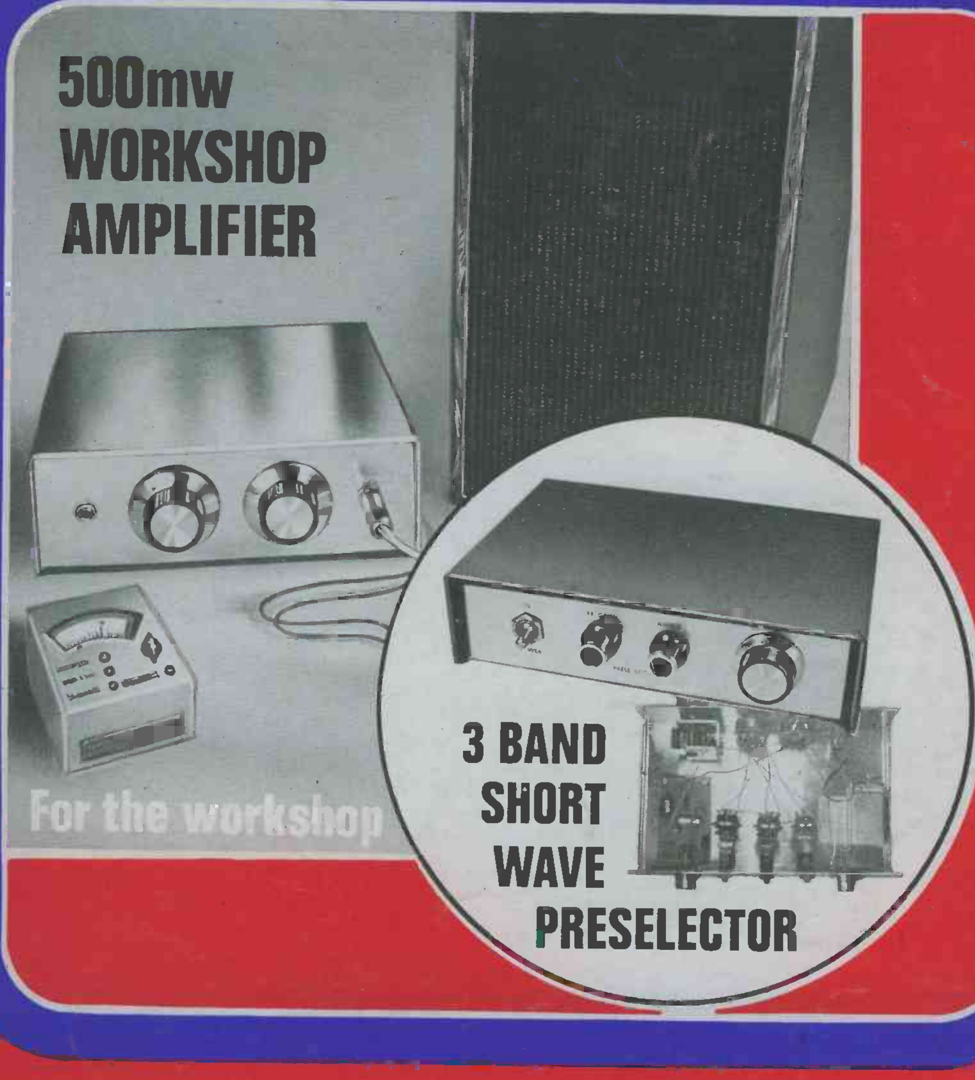

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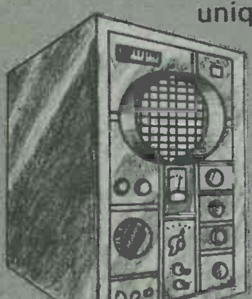

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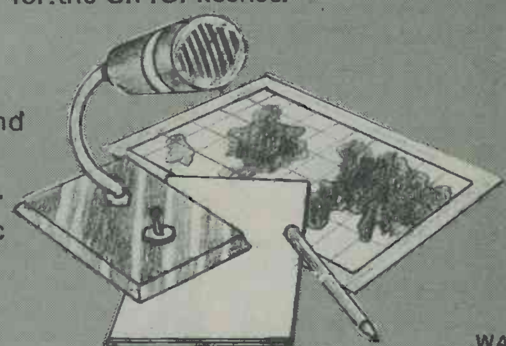

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Printed circuit B9A – B7G 4p
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Speaker, 6" x 4", 5 ohm, ideal for car radio etc. **£1**

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30p with Needle Lock

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Closed $9\frac{1}{2}$", open $38\frac{1}{2}$"
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Geared Knob, Inner to Outer Ratio 8:1 .. .. .. **60p**
Bulgin, 5mm Jack plug and switched socket (pair) **30p**
12 volt solenoid and plunger **40p**
250 RPM 50 c/s locked frequency miniature mains motor .. **50p**
200 OHM coil, $2\frac{1}{4}$" long, hollow centre **10p**
Belling Lee white plastic surface coax outlet Box **30p**
R.S. 12 way standard plug and shell **30p**

SWITCHES

Pole	*Way*	*Type*	
4	2	Sub. Min. Slide	18p
6	2	Slide	20p
4	2	Lever Slide	15p
2	2	Slide	10p
1	3	+ off Sub. min. edge	10p
1	3	13 amp small rotary	12p
2	2	Locking with 2 to 3 keys	£1.50
2	1	2 Amp 250V A.C. rotary	24p
1	2	Toggle	10p

Wafer Rotary, all types **30p**
S.P.S.T. 10 amp 240v. white rocker switch with neon. 1" square flush panel fitting **30p**

PIANOKEY SWITCH UNIT

5 lever, interlocking 2 pole mains + 3 pole 2 way + 3 of 6 pole 2 way **15p**

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VARYING PANELS WITH ZENER, GOLD BOND, SILICON, GERMANIUM, LOW AND HIGH POWER TRANSISTORS AND DIODES, HI STAB RESISTORS, CAPACITORS, ELECTROLYTICS, TRIMPOTS, POT CORES, CHOKES ETC.
3lb for 85p + 60p post and packing
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Slider, horizontal or vertical standard or submin. 5p

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For component storage or projects, sliding lid. $1\frac{3}{4}$" x $1\frac{1}{2}$" x 1" 10p

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1" DIAM. WITH $1\frac{1}{2}$" SKIRT SPUN ALUMINIUM GRUB SCREW FIXING, $\frac{1}{4}$" 30p EACH.

ZM1162A INDICATOR TUBE

0-9 Inline End View. Rectangular Envelope 170V 2·5M/A **£2.00**

RESETTABLE COUNTER

English Numbering Machines LTD.
MODEL 4436-159-989
6-14 volt, 6 digit, illuminated, fully enclosed. **£2.50**

Ferric Chloride, Anhydrous mil. spec. 1lb. bag **50p.**

RESISTORS

$\frac{1}{8}$–$\frac{1}{4}$–$\frac{1}{2}$ watt .. **1p**
1 watt **2p**
Up to 5 watt wire **10p**
10 watt wire wound **12p**
15 watt **14p**

Philips transformer, safety fused. In 200-220-240v. Out 240v 60ma + 6.3v 1a approx 2" x $2\frac{1}{4}$" x $2\frac{1}{2}$" **£1.50**

POTS

Log or Lin carbon **13p**
Switched **27p**
Dual Pots **38p**
Dual & switch **50p**
Lin wirewound **25p**
Slider Pot **25p**
Dual Slider **35p**

THERMISTORS

VA1008, VA1034, VA1039, VA1040, VA1055, VA1066, VA1082, VA1100 } **10p**
VA1077, VA1005, VA1026 } **15p**

RELAYS

12 volt S.P.C.O octal mercury wetted high speed **75p**
P.O. 3000 type, 1,000 OHM coil, 4 pole c/o **60p**
12 volt d.p.c.o. heavy duty octal **80p**

Boxed GEC KT88 valve **£3**

JAP 4 gang miniature sealed tuning condensers **25p**

ELECTROLYTICS MFD/VOLT. Many others in stock

MFD	Up to 10V	25V	50V	70–75V	100V	200–250V	300–350V	450–500V
10	4p	5p	6p	8p	8p	12p	16p	20p
25	4p	5p	6p	8p	8p	15p	18p	20p
50	4p	5p	6p	9p	13p	18p	25p	—
100	5p	6p	10p	12p	19p	20p	—	—
250	9p	10p	11p	17p	28p	—	85p	£1
500	10p	11p	17p	24p	45p	—	—	—
1000	13p	17p	40p	75p	—	£1.50	—	—
2000	23p	37p	45p	—	—	—	—	—

As total number of values are too numerous to list, use this price guide to work out cost of your actual value requirements, i.e. 2MFD, 30V would be **5p**, or 330MFD, 50V would be 14p, etc. etc.

8/20, 10/20, 12/20 **Tubular tantalum 15p each**
16–32/275, 32–32/275, 100–100/150, 100–100/275 50–50/300 .. .. **20p each**
50/50–385 .. .. .. **30p**
12,000/12, 32–32–50/300, 700/200, 100–100–100–150–150/320 .. .. **50p each**
20–20–20/350 .. .. **40p each**

INDICATORS

Bulgin D676 red, takes M.E.S. bulb **20p**
12 volt red, small pushfit **20p**
Mains neon, red, pushfit **20p**

CAPACITOR GUIDE – maximum 500V

Up to .01 ceramic **2p.** Up to .01 poly **3p.** Up to 1000PF silver mica **5p.** 1,200PF up to .01 silver mica **10p.** .013 up to .25 poly etc. **4p.** .27 up to .68 poly etc. **6p**
Over 500 volt order from above guide and few others listed below.
6p. .1/600: **10p.** .01/1000, 1/350, 8/20, .1/900, .22/900, 4/16. .25/250 AC (600vDC) .1/1500 **40p.** 5/150, 9/275AC, 10/150, 15/150, 40/150.

TRIMMERS, 20p each

100PF Ceramic, 30PF Beehive, 12PF PTFE 2500PF 750 volt, 33PF MIN. AIR SPACED 5PF, MIN. AIR SPACED, 50PF CERAMIC.

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Belling Lee L1469, 4 way polythene. **3p each**

Strong grey plastic box same design as die cast ali $4\frac{3}{8}$" x $2\frac{3}{8}$" x $1\frac{1}{4}$" **40p**

1" or $1\frac{3}{8}$" or $\frac{3}{4}$" **CAN CLIPS** .. **2p**

MAINS DROPPERS

36+79 ohm **20p**
66+66+158 ohm, 66+66+137 ohm
17+14+6 ohm, 266+14+193 ohm **25p**
50+40+1k5 ohm
285+575+148+35 ohm } **35p**
25+35+97+59+30 ohm

$5\frac{1}{4}$" x $2\frac{3}{4}$" Speaker, ex-equipment 3 ohm **30p**
2 Amp Suppression Choke **5p**
3 x $2\frac{1}{2}$ x $\frac{1}{16}$" } **PAXOLINE** . **2p**
$4\frac{5}{8}$ x $\frac{1}{2}$ x $\frac{1}{8}$", ... 2 for **1p**
220K & 100 ohm 3 watt resistors .. **4p**
VALVE RETAINER CLIP, adjustable **2p**

OUTPUT TRANSFORMERS

Sub-miniature Transistor Type .. **25p**
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Full spec. marked by Mullard, etc. Many other types in stock

AC107	14p	BC179B	14p	BF180/1/2/3	22p
AC127/128/176	11p	BC184C	10p	BF184/5	15p
ACY28	18p	BC186/7	18p	BF194/5/6/7	8p
AD149	40p	BC213L	10p	BF194A	12p
AD161/2 matched pr.	69p	BC214B	11p	BF200	20p
AF116/7	12p	BC327/8	15p	BF262/3	23p
AF124/6/7	20p	BC337/8	14p	BF336	25p
AF139/178	30p	BC547	11p	BFS28 Dual Mosfet	92p
AF180/1	30p	BC548	9p	BFW10/11 F.E.T.	45p
AF239	20p	BC558A	11p	BFW57/58	20p
ASY27/73	25p	BCX32/36	12p	BFX29/30	16p
BC107A or B	9p	BCY40	60p	BFX84/88	16p
BC107/8/9	7p	BCY70/1/2	9p	BFY50/1/2	11p
BC108A/B/109B/C	10p	BD112/3/5/6	50p	BFY90	50p
BC147/8/9	7p	BD131/2/5	30p	BR101 (Programmable Unj Junction)	30p
BC147A/B	8p	BD201/2/3/4	£1.00	BRY39 (Programmable Unj Junction)	34p
BC148A/B, 9B/C/S	8p	BD232/4/5	47p	BRY56 (Programmable Unj Junction)	34p
BC157/8/9	9p	BDX77	£1.40	BSV64	40p
BC158A/B	11p	BF115	15p	BSV79 F.E.T.	£1
BC159B/C, 157A	11p	BF167/173	20p	BSV80 F.E.T.	90p
BC178A/B	13p	BF178/9	25p	BSV81 Mosfet	9[illegible]p

BSX20	13p
BSX21	16p
BU105/01	93p
CV7042 (OC41 OC44, ASY63)	7p
GET111	40p
OC35	32½p
ON222	30p
TIP30	52p
TIP3055	50p
TIS88A FET	33p
ZTX300	11p
2N393/MA393	30p
2N706	8p
2N987	35p
2N2219	18p
2N2401 (ASY26-27)	20p
2N2904/5/6/7	13p
2N2907A	15p
2N3053	13p
2N3054	35p
2N3055 (or equiv.)	37p
2N3704	10p
2N3819 FET	16p
2N4037	35p
2N5036	60p
2SA141/2	31p
2SA360	28p
2SB135/6	20p
40250	60p

OTHER DIODES

IN916	6p
IN4148	1.5p
BA145/148	12p
Centercel	10p
BZY61	10p
BB103/110 Varicap	20p
BA182	24p
OA5/7/10	10p
BZY88 Up to 33 volt	7p
BZX61 11 volt	16p
BR100 Diac.	19p

INTEGRATED CIRCUITS

741 8 pin d.i.l. op. Amp	20p
TAD100 AMRF	£1.00
TAA570	£1.20
CA3001 R. F. Amp	£1.00
TAA300 1wt Amp	£1.25
NE555v Timer	42p
TAA550 Y or G	40p
TAA263 Amp	65p
SN7483 TTL	80p
7400/10 TTL	13p
7402/4/20/30	14p
ZN414 RX	88p
7414	60p
7438	27p
7474	29p
74154	£1.50

BRIDGE RECTIFIERS

Amp	Volt		
½	1,600	BYX10	30p
1	140	OSH01-200	30p
1.4	42	BY164	35p
2	30	LT120 type	30p
0.6	110	EC433	15p
5	400	Texas	75p

RECTIFIERS

	Amp	Volt	
IN4004	1	400	5p
IN4005	1	600	6p
IN4006	1	800	6p
IN4007	1	1,000	6p
BY103	1	1,500	15p
SR100	1.5	100	7p
SR400	1.5	400	8p
REC53A	1.5	1,250	14p
LT102	2	30	10p
BYX38-600	2.5	600	40p
BYX38-300R	2.5	300	36p
BYX38-900	2.5	900	45p
BYX38-1200	2.5	1,200	50p
BYX49-600	2.5	600	34p
BYX49-300	2.5	300	26p
BYX49-900	2.5	900	40p
BYX49-1200	2.5	1,200	52p
BYX48-300	6	300	40p
BYX48-600	6	600	50p
BYX48-900	6	900	60p
BYX48-1200	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	£2.00
BYX46-400*	15	400	£2.50
BYX46-500*	15	500	£2.75
BYX46-600*	15	600	£3.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
BYX52-1200	40	1,200	£2.50

**Avalanche type*

TRIACS

Amp	Volt		
6	400	Plastic	74p
25	900	BTX94-900	£5.00
25	1200	BTX94-1200	£7.00

Cinch 10-way terminal block 15p

Pair of LA2407 Ferrox cores with adjuster 25p

Chrome Car Radio facia 15p
Rubber Car Radio gasket 5p

DLI Pal Delayline 80p

Relay socket 10p
Take miniature 2PCO relay

B7G or B9A valve can 2p

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

OPTO ELECTRONICS

ORP12	44p
BPX40	65p
BPX42	£1.50
BPY10 (VOLTIAC)	£1.00
BPY68 / BPY69 / BPY77 Diodes	£1.00

Photo transistor

BPX29	£1.00
OCP71	44p

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

RED	14p
ORANGE / GREEN / YELLOW	16p

PHOTO SILICON CONTROLLED SWITCH BPX66 PNPN 10 amp £1.00

THYRISTORS

Amp	Volt		
1	240	BTX18-200	50p
1	400	BTX18-300	65p
1	240	BTX30-200	40p
6.5	500	BT102-500R	75p
10	700	BT106	85p
15	500	BT107	£1.00
6.5	500	BT101-500R	90p
6.5	500	BT109-500R	75p
20	600	BTW92-600RM	£3.00
15	800	BTX95-800R Pulse Modulated	£10.00
30	1000	28T10 (Less Nut)	£4.00

.3" red 7 segment L.E.D. 14 D.I.L. 0-9 + D.P. display 1.9v, 10m/a segment 73p

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

Wire ended glass neons 5p

Plastic, Transistor or Diode Holder 1p
Transistor or Diode Pad 1p
Holdersorpads 50pper100

PAPER BLOCK CONDENSER

0.25MFD	800 volt	30p
1MFD	250 volt	15p
2MFD	250 volt	20p
10MFD	500 volt	80p
4MFD	250 volt	20p
15MFD	150 volt	50p

METAL CHASSIS SOCKETS

Car Aerial / Coax / 5 or 6 pin 240° din / Speaker din switched / 3.5mm Switched Socket — 9p

SOLDER

Multicore - 2½p foot

ENAM. COPPER WIRE

SWG.	PER YD.
18	3p
20-24	2p
26-42	1p

GARRARD

GCS23T Crystal Stereo Cartridge £1.00

HANDLES

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

14 D.I.L. socket, gold plated contacts, NOT cheap type 13p

Miniature Axial Lead Ferrite Choke formers 2p

DEE PLUG

McMurdo DA15P 15 way chassis plug 15p

Fairway 18009 Coax. socket 3p

TIE CLIPS

Nylon self locking 7" or 3½" 2p

CINCH 150

12 way edge socket 10p

1lb Mixed nuts, bolts, washers etc. 35p

Philips Iron Thermostat 15p
Bulgin 2-pin flat plug and socket 10p
McMurdo PP108 8 way edge plug 10p

TO3 HEATSINK

Europlec HP1 TO3B individual 'curly' power transistor type. Ready drilled 20p

Tested unmarked, or marked ample lead ex new equipment

ACY17-20	8p	OC71/2	5p
ASZ20	8p	OC200-5	10p
ASZ21	15p	TIC44	24p
BC186	11p	2G240	2-50
BCY30-34	10p	2G302	6p
BCY70/1/2	8p	2G401	10p
BF115	10p	2N711	25p
BY127	8p	2N2926	7p
BZY88 series	5p	2N598/9	6p
HG1005	2p	2N1091	8p
HG5009	2p	2N1302	8p
HG5079	2p	2N1907	2-50
L78/9	2p	Germ. diode	1p
M3	10p	GET120 (AC128 in 1" sq. heat sink)	20p
OA81	2p		
OA47	2p		
OA200-2	3p	GET872	12p
OC23	20p	2S3230	30p

8 way Cinch standard 0.15 pitch edge socket 20p

U.E.C.L. 10 way pin connector 2B6000 OA1P10 10p

U.E.C.L. 20 way pin connector 2A60000A1P20 20p

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BELLING LEE L1354 TV Aerial diplexer 10p

Philips electronic engineer kits add on series E1004 £1.00 each

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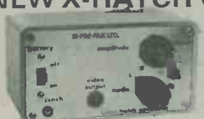

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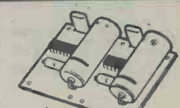

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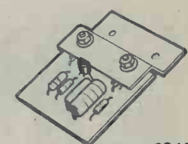

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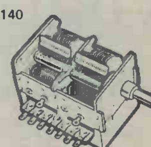

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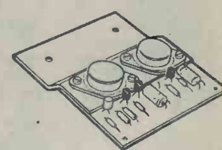

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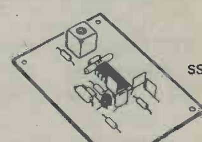

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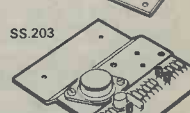

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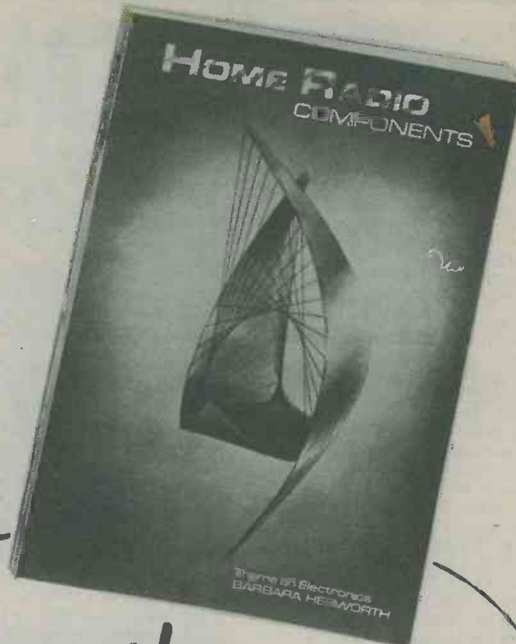

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This conversation set me thinking, Home Radio Components really do produce a catalogue that will last and last, *and* a service to back it up. So if you are keen to save the pennies, send for a copy today. You may still be using it in 1977. On the other hand, if you really like to keep up with the latest developments, Home Radio will be happy to sell you a new one. Each year they spend at least 5 or 6 months revising it in order to bring the latest trends to your notice. Either way you cannot lose. Especially when you bear in mind, that although the initial cost is 65p plus 33p postage and packing, they enclose 14 vouchers each worth 5p if used as directed. Add to that the fact you could easily make it last two or three years . . . well, to borrow a phrase, "You never had it so good". *Don't wait, send off the coupon today with your cheque or P.O. for 98 pence.*

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THREE BAND SHORT WAVE PRESELECTOR

By A. P. Roberts

Covering 1.65 to 32.5MHz in three switched bands, this preselector provides an extra tuned amplifier stage for insertion between the aerial and a short wave receiver

THERE ARE MANY RELATIVELY SIMPLE AND INEXPENSIVE short wave receivers in use at present, and most of these are capable of a fair performance. They do have limitations, however, and if they are of t.r.f. design are liable to suffer from a lack of sensitivity due to the low level of r.f. amplification provided, as well as a lack of selectivity because of the small number of tuned circuits incorporated.

Simple superhet designs are better in both these respects but they may suffer alternatively from image, or second channel, interference due to the relatively low intermediate frequency of 455 to 470kHz which is usually employed. Normally, a superhet is designed so that the oscillator frequency is higher than the required signal frequency by the intermediate frequency. If a signal which is higher than oscillator frequency by the intermediate frequency breaks through to the mixer, this signal will also pass into the receiver i.f. amplifier. It will then be detected and reproduced by the receiver loudspeaker or headphones or, at least, produce spurious beat notes with the required signal. This interfering signal is the image or second channel signal, and it is required of the r.f. tuned circuit or circuits before the mixer that it be rejected and that the required signal only is accepted. With simpler superhets the amount of second channel rejection may not be sufficiently high to give adequate protection against image interference.

When propagation conditions are poor, then of course virtually any simple short wave receiver will benefit from an increase in gain.

The use of a tuned short wave preselector such as that described in this article can improve the adjacent channel selectivity of a t.r.f. receiver, reduce second channel interference with a superhet receiver, and increase overall gain with any receiver. Provided it is operated sensibly, it can make a worthwhile improvement to the performance of many simple short wave receivers.

PRESELECTOR DESIGN

The preselector to be described consists basically of a tuned amplifier which is inserted between the aerial and the receiver. Thus it provides additional selectivity and sensitivity for the whole receiving set-up.

The design uses two transistors, one of these being an f.e.t., and covers a range of approximately 1.65 to 32.5MHz (182 to 9.2 metres) in three switched bands. It obtains power from its own internal 9 volt battery, from which it consumes a current of 3mA. Construction is easy to carry out, and is aided by the use of commercially wound coils.

The circuit is given in Fig. 1. Here, the aerial is coupled to a normal carbon track potentiometer, VR1, which functions as a simple variable input attenuator. The signal from the slider of VR1 passes to the primary winding of L1, L2 or L3 according to the position of S1(a). The tuned winding of the selected coil is then coupled to the tuning capacitor, VC1, and the gate of TR1 via S1(b). S1(a)(b) is the range switch.

The f.e.t., TR1, operates as a grounded source amplifier, with R1 functioning as the source bias

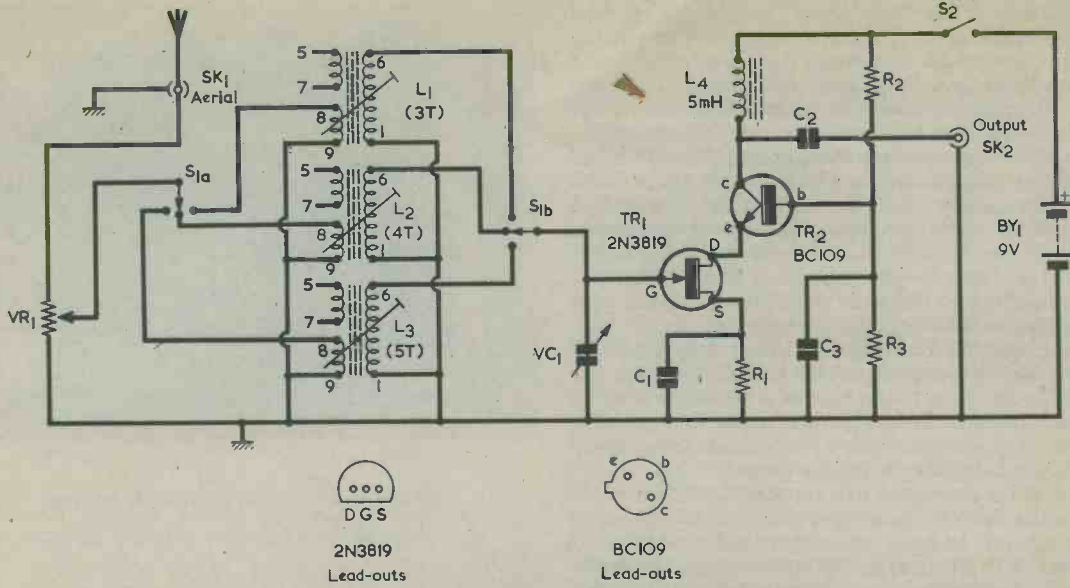


Fig. 1. The circuit of the three band short wave preselector

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)

R1	470Ω
R2	39kΩ
R3	39kΩ
VR1	10kΩ potentiometer, linear

Capacitors

C1	0.01μF disc ceramic
C2	0.022μF plastic foil
C3	0.005μF disc ceramic
VC1	365pF variable, air spaced type '01' (Jackson Bros.)

Inductors

L1	Miniature Dual Purpose coil, transistor usage, Blue, Range 3T (Denco)
L2	Miniature Dual Purpose coil, transistor usage, Blue, Range 4T (Denco)
L3	Miniature Dual Purpose coil, transistor usage, Blue, Range 5T (Denco)
L4	5mH r.f. choke, type CH2 (Repanco)

Transistors

TR1	2N3819
TR2	BC109

Switches

S1(a)(b)	4 pole 3 way miniature rotary (2 poles unused)
S2	s.p.s.t. toggle

Battery

BY1	9 volt battery type PP3 (Ever Ready)

Sockets

SK1,	2 coaxial sockets

Miscellaneous
Instrument case type BV1, 8 by 5¼ by 2in. (Bi-Pak Semiconductors)
1 knob, approx. 1½ in. dia.
2 knobs, approx. 1in. dia.
3 B9A valveholders
Battery connector
Perforated s.r.b.p. board, plain, 0.1in. matrix
Aluminium sheet (for battery bracket)
4 rubber feet
Nuts, bolts, wire, etc.

resistor and C1 as a parallel r.f. bypass capacitor. The gate of TR1 is held at chassis potential for d.c. by whichever tuned winding is selected by S1(b). The drain of the f.e.t. couples into the emitter of the n.p.n. transistor, TR2.

TR2 functions in the grounded base mode, and its base is biased by R2 and R3, with C3 as the r.f. bypass capacitor. The signal current from TR1 drain flowing in the emitter of TR2 results in a voltage amplified signal appearing across the collector load, r.f. choke L4. The two transistors form a hybrid cascode amplifier.

The amplified signal at TR2 collector is fed to the output socket SK2 via the d.c. blocking capacitor, C2. This output signal is then coupled to the short wave receiver by a short length of coaxial cable, the braiding of which connects via SK2 to the preselector chassis at one end and to the receiver chassis at the other end. There is just a slight possibility that the short wave receiver in use may be an early mains-driven valve model having its chassis connected to one side of the mains. *Because of the risk of shock, the preselector must on no account be coupled up to a short wave receiver of this type.* If the receiver is mains-driven it must have a mains transformer which gives its chassis complete isolation from the mains. The earth connection to the short wave receiver is retained, this automatically giving an earth connection to the preselector by way of the braiding of the coaxial coupling cable between them. It is necessary to use coaxial cable because this ensures that the output of the preselector is screened, whereupon there can be no undesired coupling to the aerial input, which will probably be unscreened, at socket SK1.

Power is obtained from the 9 volt battery BY1, with S2 being the on-off switch.

It will be noted that the coils each have three windings, of which only two are used. The unused windings are intended for coupling to the base of a bipolar transistor and are not required here. The f.e.t. in the TR1 position offers a very high impedance at its gate and the tuned circuit selected can couple to this directly.

All the parts employed are standard items and are readily available. VC1 is a small air-spaced single gang 365pF capacitor. In some catalogues it may be referred to as 'type OO'. S1(a)(b) can be conveniently obtained as a 4-pole 3-way miniature rotary switch, no connections being made to two of the poles.

CASE DRILLING

The preselector is housed in a ready-made instrument case measuring 8 by 5¼ by 2in. This consists of two pieces, one of which is aluminium and provides the front, rear and base, whilst the other is a vinyl covered steel top and sides. The latter is fastened to the base with self-tapping screws, which are supplied with the case.

Fig. 2 shows the drilling details for the front and rear panels.

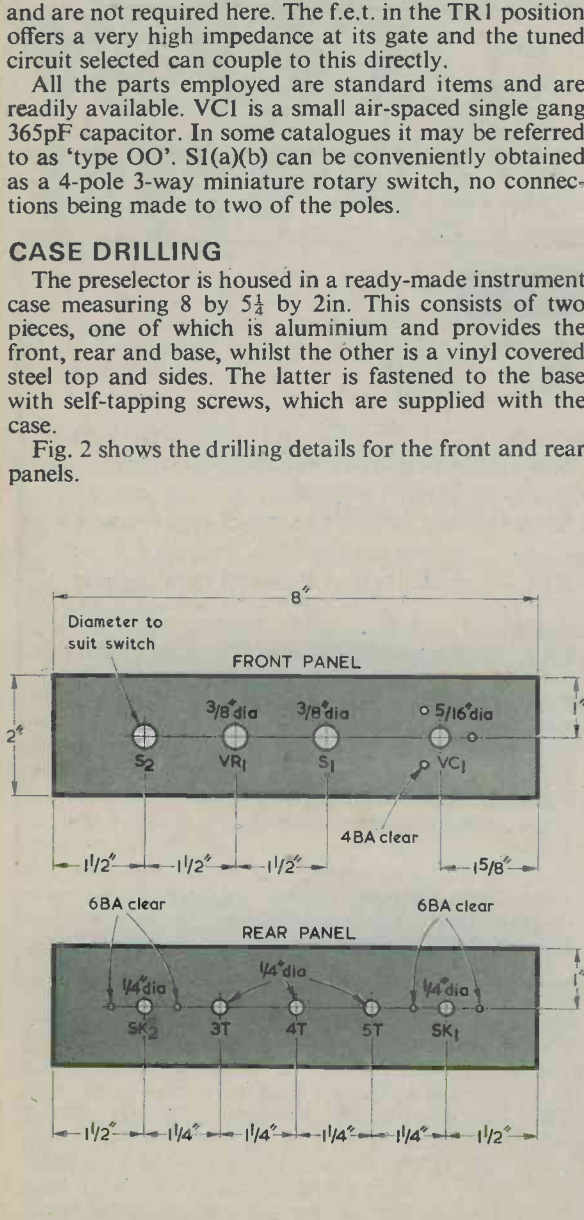
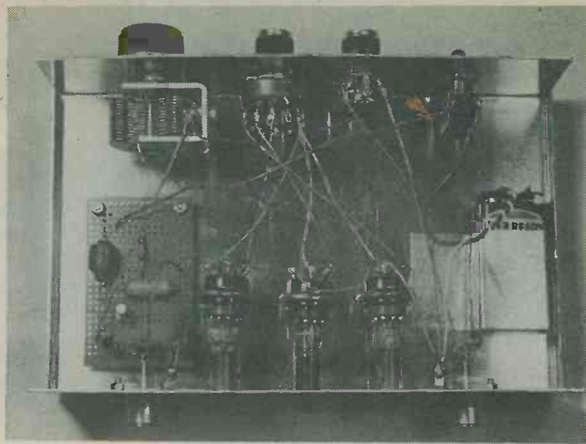


Fig. 2. Drilling details for the front and rear panels



The layout of components inside the case

Three countersunk 4BA clear holes are required in the front panel for VC1. Their positions can be marked out by pressing a piece of paper against the front plate of the capacitor and then using this as a template. When VC1 is later mounted (after all drilling has been carried out) it is held with three short countersunk 4BA bolts passing through these holes into the three tapped 4BA holes in its front panel. The bolt ends must not pass beyond the inside surface of the capacitor front plate as they may then damage the fixed or moving vanes of the capacitor. Spacing washers are required on these bolts also between the rear of the front panel and the capacitor front plate to provide spacing of ⅛in. or more, thereby giving clearance for the front ball race of the capacitor.

SK1 and SK2 are standard coaxial sockets, and the 6BA clear mounting holes for these may be marked out with the aid of the sockets themselves. When these are later mounted, a solder tag is fitted under the 6BA securing nut of each which is nearer the centre of the rear panel.

Two 6BA clear holes are required in the base for the component panel shown in Fig. 4, and these may be marked out with the aid of the panel itself. The panel will take up the position, close to SK2, which is shown in the photograph of the internal layout. The photograph also illustrates a small aluminium bracket which holds the battery in place. Two suitably positioned 6BA clear holes may next be drilled for this. When the 6BA bolts are later fitted to these four holes, their heads will be below the cabinet base. Finally, four holes should be drilled near the base corners for four rubber feet.

WIRING

The drilling is now complete and the four rubber feet, VC1 and the components shown in Fig. 3 may be fitted. The spindles of VR1 and S1(a)(b) should be cut to a suitable length before they are mounted on the chassis. The three Denco coils are secured by plastic nuts which pass over threaded sections on their formers. These plastic nuts should be taken to 'finger tightness' only, as the plastic thread could otherwise be sheared. The coils should have the orientation shown in Fig. 3, i.e. pins 1 and 9 should be towards SK2.

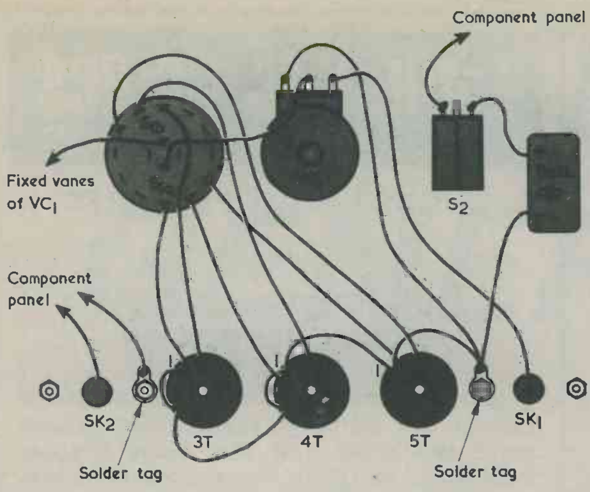


Fig. 3. Chassis wiring. For convenience, all components are drawn in a single plane

It is possible to solder leads direct to the pins of the three Denco coils, but this is liable to lead to deformation of the plastic formers due to the heat from the soldering iron. It is recommended instead that B9A valveholders be fitted over the coil pins and connections made to the valveholder tags.

Fig 3 illustrates the chassis wiring, with all the components shown in a single plane for ease of presentation. Before wiring up to switch S1(a)(b) confirm with an ohmmeter or continuity tester the three outer tags corresponding to each centre tag used. The relative positioning of the centre and outer tags may differ, with some switches, from that shown in the diagram. All wiring should be kept reasonably short. The chassis connection to VC1 moving vanes is automatically provided by its mounting to the front panel, and a wiring connection to its fixed vanes tag is all that is necessary.

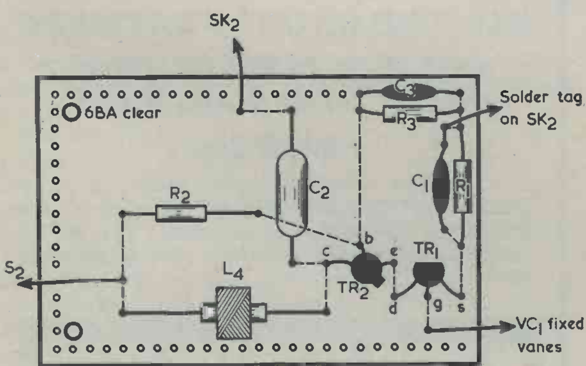


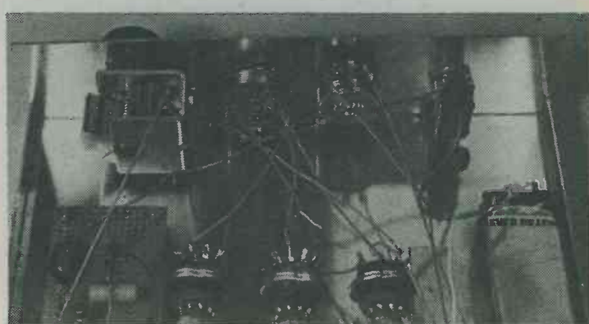
Fig. 4. Component layout and wiring on the perforated panel

COMPONENT PANEL

The two transistors and their immediate components are wired up on a plain perforated panel, of 0.1in. matrix, having 16 by 25 holes. The component layout and underside wiring on this panel are shown in Fig. 4.

The panel cannot be purchased with the size shown, and it has to be cut out from a larger perforated board. After this, the two 6BA clear mounting holes are drilled out. (In practice, this process will be carried out at an early stage in construction to enable the corresponding 6BA clear holes in the cabinet base to be marked out.) The components are mounted in the positions indicated with their lead-outs bent over at right angles underneath the panel. The lead-outs are cut to length and soldered together to form the circuit. The underside wiring is represented by the broken lines in the diagram.

Four leads leave the panel to connect to S2, VC1 fixed vanes, the centre connector of SK2, and the chassis tag at this socket. Flexible insulated wires should be fitted here cut to a suitable length by putting the panel temporarily in position on the cabinet base, and then having their ends stripped for connection. The panel is next mounted by means of two ½in. 6BA bolts with two extra nuts, or spacing washers, on each to hold the panel a little way off the base. This method of mounting should be adequate to provide reliable clearance but if it is felt that additional protection against short-circuits to the underside wiring is required a piece of thin s.r.b.p. ('Paxolin') sheet having the same dimensions as the panel can be secured underneath it and directly against the cabinet base. The four insulated leads from the panel may then be soldered to the appropriate circuit points.



Connections to the coils are made by way of B9A valveholders fitted over the coil pins

There is a space for the battery on the side opposite the component panel. A small piece of aluminium sheet may be bent to form a simple bracket which will hold the battery in position, and this bracket is secured to the cabinet base at the two 6BA clear holes drilled earlier.

When wiring has been completed it should be carefully checked over. The battery may then be fitted under its bracket and connected into circuit. The preselector is then ready for use.

NOTES ON USE

The preselector is coupled to the short wave receiver by a coaxial cable in the manner described earlier. It is desirable to keep this cable as short as is reasonably possible in order to minimise losses. The aerial connects to the centre connector of SK1.

Operation of the controls is very simple. S1(a)(b) selects the desired range. In its extreme anticlockwise position it switches in the 3T coil, giving a coverage of about 1.65 to 5.5MHz (182 to 55 metres). The central position of S1(a)(b) selects the 4T coil, providing a range of approximately 5 to 15.5MHz (60 to 19.4 metres), and the fully clockwise position brings in the 5T coil, with a range of about 10.5 to 32.5MHz (28.5 to 9.2 metres). The cores of the three coils are fully screwed in, so that the ends of the threaded brass stems are flush with the ends of the formers.

VC1 is the tuning control and is adjusted to peak the wanted signal. It will need to be adjusted slightly every time the main tuning on the receiver is altered. Preselector tuning is quite sharp because of the negligible loading on its tuned circuit which results from an f.e.t. input stage. A slow motion drive for VC1 is not necessary, however, provided it is fitted with a reasonably large knob.

The rear of the preselector, showing the two coaxial sockets and the three plastic coil securing nuts

It is very important to ensure that VR1 is not advanced any further than is necessary to provide an adequate signal for the receiver. If VR1 is left in the maximum position all the time with a t.r.f. receiver the detector may be overloaded with most signals, and audio quality and even selectivity may be impaired. With a superhet, excessive signal output from the preselector can cause a substantial increase in cross-modulation, thereby causing the increased overall gain to offer little benefit. VR1 must be kept at a *low* level setting with most signals if the preselector is to give optimum performance.

The main advantage of using a unit such as this is the improvement in r.f. selectivity it offers. When propagation conditions are poor and signal strengths are very low, then it is possible to take advantage of the full additional gain afforded by the preselector. It is essential to bear these points in mind and to operate the preselector accordingly to obtain the maximum benefit from it. ■

POCKET R.F. GENERATOR

By T. Sutherns

A simple single frequency crystal oscillator with low impedance output.

WHILST ONE CANNOT DENY THAT A WIDE BAND variable frequency signal generator is of tremendous help to the constructor, one has to use it a great deal if its expense is to be justified. For the experimenter who will only need an r.f. source once in a while something cheaper is obviously required. The circuit to be described is extremely cheap, and is crystal controlled and almost infallible. By selecting appropriate crystals a wide range of frequencies may be covered, limited only by the high frequency performance of the transistor and the construction techniques employed. Frequencies offered by most fundamental crystals should be obtainable with little difficulty. The prototype was operated mainly at frequencies around 8MHz.

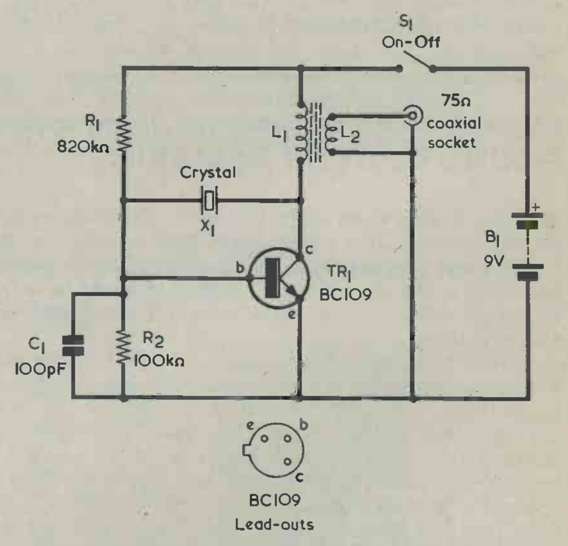
THE CIRCUIT

As can be seen from the accompanying diagram the circuit is very simple. It is basically a Pierce-Colpitts oscillator, with C1 and X1 forming the capacitive tap across the collector load, L1. R1 and R2 provide bias for the transistor. An extra winding is added to L1 to give a low impedance output.

The two resistors may be 10% types rated at $\frac{1}{10}$ to $\frac{1}{4}$ watt. C1 is silvered mica. Its precise value is not critical, but 100pF provides a good starting off figure for the more experimentally minded. TR1 is a BC109. A BF194 has also been tried and gives similar results. The crystal can be a surplus type of the required frequency or a brand new one. In either case the crystal should work in this circuit if it works at all.

L1 is a Repanco type CH1 2.5mH r.f. choke. L2 is an output coupling winding consisting of 40 turns of 34 s.w.g. enamelled copper wire or similar scramble wound on top of the choke coil. The coupling winding works satisfactorily into an impedance of 75Ω.

The battery can be an Ever Ready type PP3 or equivalent.

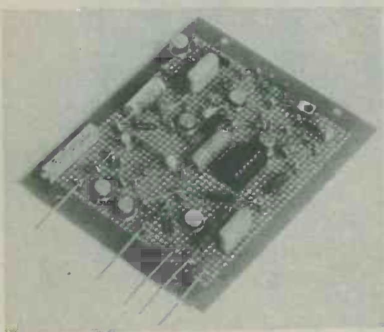


The pocket r.f. generator consists of a Pierce-Colpitts oscillator, and provides a low impedance unmodulated signal at crystal frequency

The author's circuit provides an output of 250mV peak-to-peak and second and third harmonics appear to be negligibly low. Current consumption from the 9 volt battery is very low, being about 0.25mA only. The whole unit complete with battery can be assembled in a small plastic or metal case, with the crystal socket, the on-off switch and the coaxial output socket mounted on the front panel. If a metal case is used, this is made common with the negative supply rail. ■

NEWS . . . . AND .

LOW-COST RE-USABLE CIRCUIT ASSEMBLY KIT



Lektrokit Ltd. – the well known Reading-based supplier to the electronics industry of professional quality modular racking and chassis systems, instrument cases, prototype hardware and the like – have just announced the availability of their low cost re-usable Circuit Assembly Kit No. 13 that will prove of as much interest to home constructors and amateur designers as it will to professional design and development engineers.

Their new kit, which is simple to assemble and quick to dismantle, comprises five plain double-sided circuit boards (the same type LK–141 that Lektrokit supply to industry) together with 500 standard pre-tinned brass solder pins. At £4 a kit, plus V.A.T., it represents a real saving over the cost of having to buy the items individually.

The re-usable circuit boards are made of SRBP (synthetic resin bonded paper) and measure 4¾ by 4 in. They are perforated with 0.052 in. diameter holes on the international 0.1 in. matrix and are thus ideally suitable for link wiring and mounting standard components on either side, thus allowing single or double sided p.c.b. arrangements. 24-way edge connector adaptors (type LK-2241/2261) at 0.15 in., and 0.1 in. pitch are available for use with the kit.

The kit will prove of particular value for prototype work as well as for final circuit construction, and will doubtless also arouse great interest in schools, technical colleges, polytechnics, universities and other educational/training establishments.

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EMI VIDICONS USED IN CCTV SYSTEM AT THE ROUND CHURCH CAMBRIDGE

In these days when many churches are reporting falling attendances, it is refreshing to hear of one that has such a large congregation, that to allow them to participate fully in the services the Church authorities have had to install a closed circuit television link combined to a sound system.

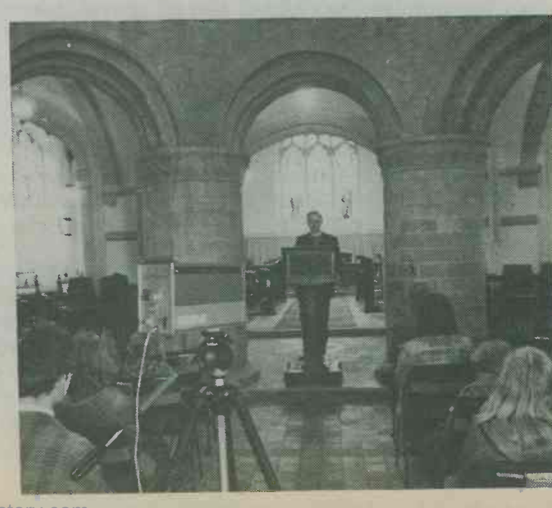
This is what has happened at the Holy Sepulchre Church – the Round Church – near St. John's College, Cambridge. During his 20 years as incumbent the vicar, Canon Mark Ruston M.A., has built up his student congregation to the point where an overflow has had to be accommodated in the church hall across the road.

Canon Ruston's Parochial Church Council is fortunate that the Hon.-Secretary, Mr. J. H. Hinton, was technically qualified to be able to install and operate the system. Since the equipment was installed, the church council has purchased two specially selected replacement vidicon camera tubes from the Electron Tube Division of EMI Electronics Ltd., Blyth Road, Hayes, Middlesex. This has enabled the camera to be used in the low light levels which prevail in this ancient church.

The original single camera set-up has proved so successful during its first year of operation that a second camera is being considered. Mr. Hinton was impressed with the advice and technical assistance he received from EMI after purchasing a relatively inexpensive tube. The company does, in fact, sell large quantities of vidicon tubes, coils and associated components to individuals.

Mr. Hinton, who believes that there is scope for more co-operation between churches on such matters, stressed the importance of utilising technical ability and training, to help churches take full advantage of modern technology in spreading their message. He said that the atmosphere of the service "comes over well" giving the overflow congregation the feeling of "being there."

The church of the Holy Sepulchre is one of only four remaining ancient Round Churches in England. It was originally built around 1130 AD, although many alterations have taken place over the centuries.



. . . COMMENT

V.A.T.

We have received from Mr. Alan Sproxton, the well known director of Home Radio (Components) Ltd., copy of a letter he, as representative of a group of 25 businessmen who retail electronic components, has sent to his M.P.

The letter sets out the difficulties of implementing the legislation for a multiple V.A.T. system, where electronic suppliers are concerned. Home Radio state, for example, that they stock more than 6,000 different small electronic components which now carry 3 different rates of V.A.T. In addition, on many items, they say they cannot obtain a reliable definition of the rate of V.A.T. to apply.

We trust that readers will understand the great difficulties faced by electronic component retailers when pricing components.

SPECIAL DIRECT SUPPLY

Only very occasionally do we sell books not published by ourselves. When we do so, it is because we feel the book concerned is of particular value to those of our readers interested in the subject dealt with.

Such a book is Tower's International Transistor Selector, reviewed last month in Recent Publications. A full page advertisement for the book, together with a coupon which may be used if desired, appears in our advertisement pages.

SCOTCH RECORDING TAPE USED BY BIRMINGHAM'S COMMERCIAL RADIO STATION

What's long, green and heard all over the Midlands? The answer is Scotch 262 recording tape, a distinctive pea-green coloured magnetic tape which has been adopted for all its recording requirements by Birmingham's commercial radio station, BRMB.

BRMB Radio's chief engineer Dave Wood emphasised that live radio with its local immediacy was the goal aimed for by BRMB, but, he said, "you can't get away from tape and the tape you use must not only perform well, but consistently well". Scotch 262 was evaluated initially by the studio manager and the effect was immediate. "Now I prefer it to any other tape in the building".

B.A.R.T.G. 1975 CONVENTION

The British Amateur Radio Teleprinter Group's Annual Convention was held again this year at Meopham, Kent; a venue which has proved itself to be eminently suitable, and there was again a good attendance.

Several changes in the programme were made this year, the 'lecturettes' in the afternoon were increased and they ranged in topics from "Getting Started on RTTY" to the latest decisions taken at Region 1IARU Conference at Warsaw, on Amateur RTTY Standards– such matters as teleprinter speeds, AFSK Standards, etc.

The usual sales stands offered plenty of scope for bargain hunters, those with "auto-heads" in their RTTY stations, but who had no facilities for cutting their own tapes, were well catered for by a group running a "tape factory". Instead of a "live station" this year, there was a 'closed-circuit' RTTY demonstration which probably gave a better demonstration to visitors.

Altogether a very enjoyable occasion.

"He said the fellow he's bringing for you is a real switched-on type!"

LOW COST ELECTRONIC VOLTMETER

By G. A. French

Suggested Circuit 296

Integrated circuits are at their most advantageous when they carry out a function with a minimum of external discrete components. A typical example of what can be achieved here is given by the use of a 741 operational amplifier as a voltage follower, in which configuration the output is connected directly to the inverting input. The device then offers a low impedance output voltage which is very nearly equal to the voltage at its high impedance non-inverting input, and the only other connections which need to be made to the i.c. are the positive and negative supplies. The difference between the output and input voltages is the very small offset voltage given in the particular operational amplifier employed

This month's 'Suggested Circuit' is for a very simple electronic voltmeter incorporating two 741 voltage followers. Voltage readings are given on an inexpensive 0-1mA meter movement, and the input resistance of the voltmeter is 1MΩ per volt.

VOLTMETER CIRCUIT

The circuit of the electronic voltmeter appears in Fig. 1, and the first of the two voltage followers to be considered is IC1. The voltage to be measured is applied to its non-inverting input by way of the emitter follower TR1. There is a fixed voltage drop of around 0.6 volt across the base and emitter of TR1, with the result that the output of IC1 is negative of the voltage at TR1 base by about 0.6 volt and its own, much smaller, offset voltage.

Although the input resistance at the non-inverting input of IC1 is high, being typically 2MΩ, it is not high enough to act as a voltage input point for a simple electronic voltmeter. The addition of TR1 offers, at the transistor base, an exceptionally high input resistance, and this is more than adequate for the present application. The i.c. non-inverting input point looks into the base of an n.p.n. emitter follower inside the integrated circuit, with the result that the input current to the i.c., although very small, flows in the required direction to permit emitter follower operation in TR1. It is feasible that the required very high input resistance at TR1 base will not be realised if a transistor passing exceptionally large leakage current is employed here. However, the author has had considerable experience of very high input resistance emitter follower circuits incorporating silicon planar transistors, such as the BC107 in the present circuit, and has yet to find an input transistor which did not give a satisfactory performance. Naturally, the transistor employed should be one of reputable manufacture which is properly marked up with the manufacturer's type number. A 'reject' or 're-brand' must not be used.

The voltmeter circuit is powered by two 6 volt batteries in series, and a connection is taken from the central voltage point between the batteries to the negative test terminal. The positive test terminal connects to the arm of the Range switch, S1. The 0–1 volt range is selected when this switch is at position 1, and the voltage at the positive test terminal is then applied direct to the base of TR1. Setting S1 to positions 2, 3 and 4 selects the voltage ranges indicated in the diagram, with R3, R2 and R1 functioning as voltmeter multipliers. Negligible current is consumed by the base of TR1 whereupon the multiplier resistors merely require values which meet the requirement of 1MΩ per volt. Thus, when S1 is set to position 3, one-tenth of the voltage across R2, R3 and R4 is applied to the base of TR1, and the range selected is 0–10 volts.

I.C. OUTPUT

The output of IC1 couples to the components R5, VR1 and M1. These form an internal voltmeter having a full-scale deflection of 1 volt. Since the output of IC1 is negative of the base of TR1 by a fixed voltage, the negative end of the internal voltmeter has to be returned to a point which is similarly negative of the negative test terminal, and this point is provided at the output of a second voltage follower, IC2. The potential of IC2 output is controlled by the potentiometer VR2 which, in consequence, becomes a Set Zero control. One of the useful attributes of an i.c. voltage follower is well exemplified by IC2. If the negative terminal of M1 were returned to the slider of a simple potentiometer connected across the supply rails, the standing current in that potentiometer would need to be well in excess of the f.s.d. value of the meter and this would cause a heavy drain on the supply. When the voltage follower circuit is used the only current drain is about 0.15 mA in R6, VR2 and R7, plus a current of some 1 to 2mA in the integrated circuit.

The internal voltmeter is set up to give an f.s.d. reading of 1 volt by adjusting VR1. This adjustment is carried out after the electronic voltmeter has been assembled.

To ensure complete isolation of the batteries when the voltmeter is not required, the on-off switch consists of the double pole component, S2(a)(b). This can be a standard d.p.s.t. toggle switch.

The pin numbering shown for the two integrated circuits is that corres-

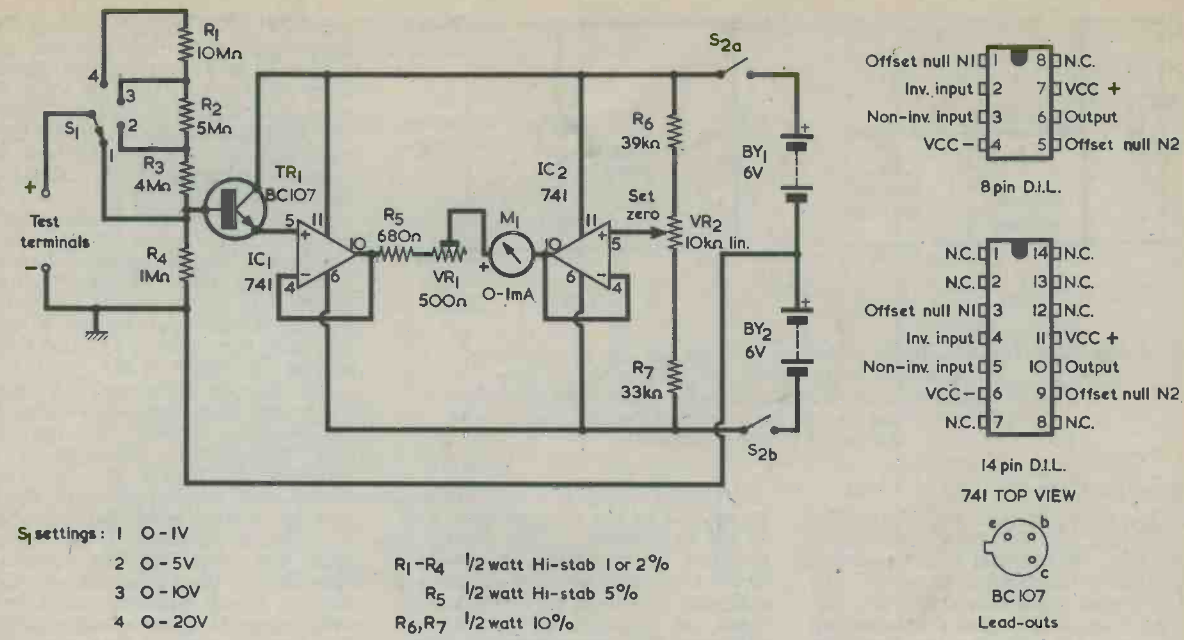


Fig. 1. The complete circuit of the electronic voltmeter

ponding to the 14 pin version of the 741. The 8 pin package can alternatively be employed, and the inset diagrams give pin allocations for both versions of the device. No connections are made to the offset null pins.

Turning next to the component types, VR1 can be a small pre-set skeleton potentiometer, whilst VR2 is a standard carbon track potentiometer. VR2 is mounted on the front panel of the assembled electronic voltmeter in company with S1, S2(a)(b), the two test terminals and, of course, meter M1. The two 6 volt batteries may be Ever Ready type PP1, or can be made up of 1.5 volt HP7 cells in series.

The input resistors R1 to R4 should be close tolerance types, preferably with a tolerance on value of 1%. Unfortunately, close tolerance resistors with values much above 1MΩ are not readily available and it will probably be necessary to employ two or more close tolerance resistors in series to make up R1, R2 and R3. Readers with access to accurate resistance measuring instruments may be able to select the values required from wider tolerance resistors. The problem of obtaining the requisite voltage multiplier resistors is unavoidable in any voltmeter having a very high input resistance, and it is for this reason that the present design restricts the highest voltage reading to 20 volts.

If a lower input resistance can be accepted it becomes possible to have a top voltage range of say 0–100 volts, and the provision of suitable multiplier resistors is eased somewhat. Alternative range switching circuits with sensitivities of 200kΩ per volt and 100kΩ per volt are shown in Figs. 2(a) and (b) respectively. These use a 5 way rotary switch instead of the 4 way rotary switch employed for S1 in Fig. 1.

Should the unit be assembled in a metal case, the case can be common with the negative test terminal, as indicated by the chassis symbol in Fig. 1.

It will be helpful to wire up VR2 such that its slider travels towards R7 as the potentiometer knob is turned clockwise. Clockwise rotation of the knob then corresponds with a forward movement of the meter needle, providing a psychological linkage between the adjustment and its effect.

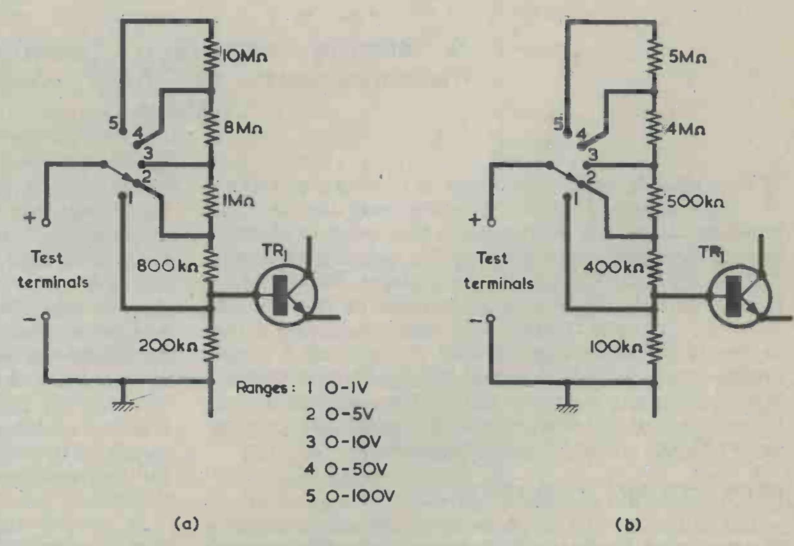


Fig. 2(a). Alternative multiplier resistor values for an input resistance of 200kΩ per volt
(b). An input circuit of 100kΩ per volt, offering the same voltage ranges as in (a). The resistors in both input circuits should be ½ watt high stability types

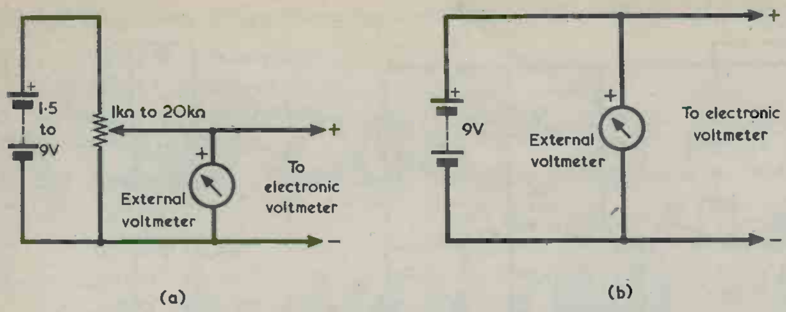


Fig. 3(a). The electronic voltmeter can be set up by applying a voltage of 1 volt to it in the manner shown here
(b). Alternatively a 9 volt battery may be applied, the electronic voltmeter being set up for a reading corresponding with that in the external voltmeter

SETTING UP

The setting up process is carried out when the unit has been constructed. Initially, VR1 should be set to insert maximum resistance into circuit. The instrument is then switched on, and VR2 is adjusted to give a zero reading in meter M1 with the test terminals short-circuited.

A known voltage of 1 volt may next be applied to the test terminals with S1 set to position 1. This voltage is obtained by connecting a potentiometer across a battery and adjusting it such that a voltage of 1 volt is provided, as indicated by an external voltmeter. The arrangement is shown in Fig. 3(a). VR1 is adjusted until meter M1 gives an f.s.d. reading. The known voltage is then removed and the setting of VR2 re-checked. Should it be necessary to readjust VR2, the test voltage should be applied a second time and VR1 finally set up for f.s.d. reading in M1. There is no need for further adjustment to VR1, which is then at its final setting.

An alternative test voltage source can consist of a 9 volt battery with a monitoring voltmeter connected across it, as in Fig. 3(b). This time S1 is set to the 0–10 volt range. If the actual voltage of the 9 volt battery is, say, 9.2 volts, then VR1 is adjusted for a reading of 0.92mA in M1.

The author's prototype circuit gave stable operation and adjustments to the Set Zero control were required very infrequently. Although it is preferable to adjust the Set Zero control with the test terminals short-circuited it was found that there was no difference in results if the adjustment was made with the terminals open-circuit. The current drawn from the two 6 volt batteries was 2.5mA when meter M1 gave a zero reading, and rose to about 3.2mA with M1 at full-scale deflection. ■

HIGH VALUE OHMMETER

By F. G. Lloyd

A simple approach towards the measurement of high resistance values

The average multi-testmeter is capable of carrying out many useful measurements but in most instances it has one shortcoming, this being an inability to give clear resistance readings for values above some 500kΩ. Ironically, it is resistors above 500kΩ which are the more liable to go high in value or open-circuit.

After a spate of trouble with resistors having values in this range, the writer decided to make up a robust knock-about unit which would be capable of measuring high resistances. It was found that a compromise had to be reached between simplicity and cost, and the design finally adopted is described here.

MEASURING RESISTANCE

The simplest way of measuring resistance consists of applying a known voltage across the resistance and measuring the current flowing through it. This method can be employed to measure high value resistances by either providing a very sensitive current reading meter, a high applied voltage, or a combination of the two.

It was felt that a current reading meter having a full-scale deflection of 50μA represented a reasonable sensitivity for general work. This f.s.d. figure has the advantage that many testmeters incorporate a 0–50μA current range and could be employed with the resistance measuring unit, thereby saving the cost of a separate 0–50μA meter movement. A transistor or i.c. op-amp current amplifier could be employed with the meter to enable lower currents to be measured, but this would introduce complications which the writer was trying to avoid. He decided instead to use the 0–50μA meter as it stood with a high applied voltage across the resistance being measured. The nominal voltage required by the unit is 45 volts, and the use of this voltage certainly results in a very simple and reliable design.

It can be argued that the provision of a 45 volt supply represents a relatively heavy initial outlay. On the other hand, there is the fact that if the unit is used only infrequently the battery life will be very long, approaching the shelf life. Should the unit be used extensively the batteries will naturally be exhausted correspondingly earlier, but they will at least have been earning their keep. The 45 volts may be provided

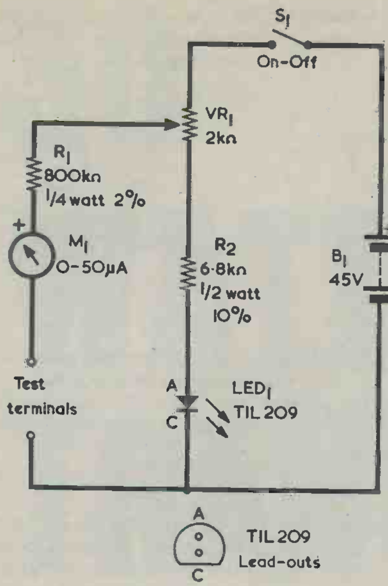


Fig. 1. The circuit of the high-value ohmmeter. Cost may be reduced by employing a testmeter switched to read 50µA f.s.d. for M1

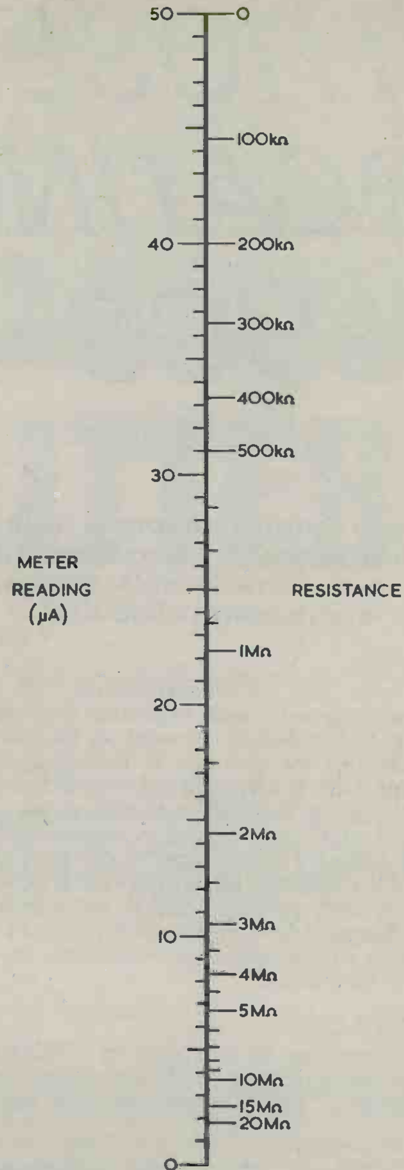


Fig. 2. Chart showing current readings and corresponding test resistance values

by five 9 volt batteries in series, and they need to be replaced when the voltage across each falls to around 8 volts. The batteries could then be used in, say, a transistor radio until they were finally exhausted. Many experimenters have a bench supply offering outputs of up to 30 volts or more. Such a supply, in series with one or two 9 volt batteries, as required, could power the resistance measuring unit.

The circuit of the unit appears in Fig. 1. When S1 is closed the 45 volt supply is applied to VR1, R2 and LED1, causing the l.e.d. to light up and indicate that the unit is switched on. VR1 is a set-zero control and its slider couples to R1, a close tolerance 800kΩ resistor. This, in turn, connects via the 0–50µA meter to the upper test terminal.

OPERATION

To use the unit, S1 is closed and the test terminals are temporarily short-circuited. VR1 is next adjusted for an f.s.d. reading in the meter. The voltage between the slider of VR1 and the lower supply rail will then be 40 volts. The test terminals may next be connected to the resistance to be measured whereupon its value can be found with the aid of the chart reproduced in Fig. 2. As is to be expected, 800kΩ appears at the current mid-point in the chart, and it will be noted that readings up to 10MΩ can be resolved, with useful indications up to 20MΩ.

VR1 may be a carbon track potentiometer. It can alternatively have a value of 2.2kΩ or 2.5kΩ if either of these are more readily available. Should difficulty be experienced in obtaining any of these values in a carbon track potentiometer a small wire-wound component may be employed instead. If a single close-tolerance resistor of 800kΩ cannot be obtained for R1, two separate close-tolerance resistors in series may be used. Suitable preferred values would be, say, 120kΩ and 680kΩ, 240kΩ and 560kΩ or 330kΩ and 470kΩ.

The unit can be made up in a small case with S1, VR1 and the test terminals on the front panel. If a 0–50µA meter is to be made integral with the unit this may also be mounted on the front panel. Should a testmeter switched to read 0–50µA be employed instead, two terminals may be provided to which it can connect. The current drawn from the 45 volt battery when S1 is closed is about 5mA, this flowing mainly through VR1, R2 and LED1. In the author's unit the 45 volt supply was obtained from five PP3 batteries. ■

THOSE LOCATING LUGS

By R. Desmond

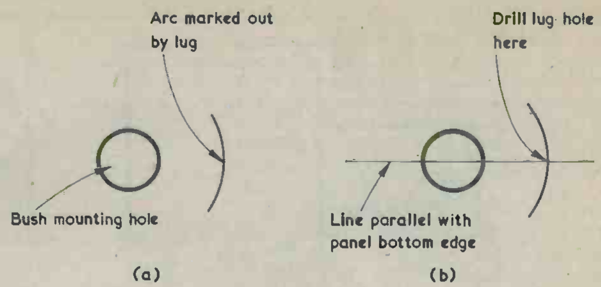


Fig. 2(a) Marking out an arc on the panel with the aid of the locating lug
(b) If desired, the lug and mounting hole centres can be on a horizontal line

Drilling an additional panel hole for a potentiometer or rotary switch can result in a considerable increase in equipment reliability

When you buy a potentiometer or rotary switch you will almost invariably find that it has a locating lug projecting forward at the front. The purpose of this locating lug is to ensure that the potentiometer or switch cannot be rotated if there is any slackening of the bush mounting nut securing it to the panel on which it is fitted. A ham-handed person operating a loosely secured control can turn its whole body, thereby twisting the wiring which connects to the control and possibly causing damage to components connected to it. Rotary switches and potentiometers fitted with switches are particularly susceptible to a fate of this nature.

LOCATING LUG

The problem can be overcome by drilling a small hole in the panel through which the locating lug of the potentiometer or rotary switch can pass. See Fig. 1.

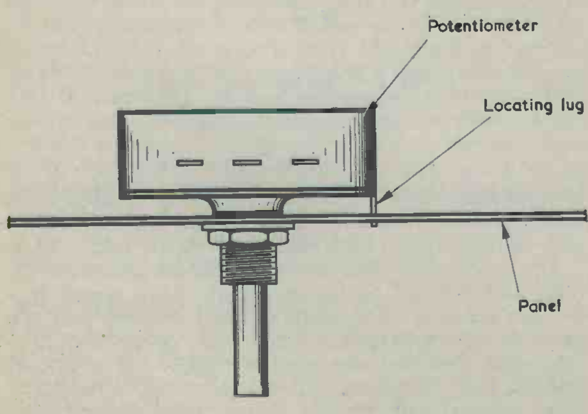


Fig. 1. When fitting a potentiometer or rotary switch the locating lug should pass through a hole in the panel

The hole diameter needs to be equal to or just slightly larger than the width of the lug. When the control is mounted it will then be impossible to accidentally rotate its body if the bush mounting nut works loose. The provision of panel holes or slots to take the locating lugs of rotary controls is common practice in manufactured electronic equipment.

The distance between the bush centre and the locating lug varies with different makes and models of potentiometer and rotary switch, whereupon it is necessary to mark out the locating lug hole on the panel with the aid of the control itself.

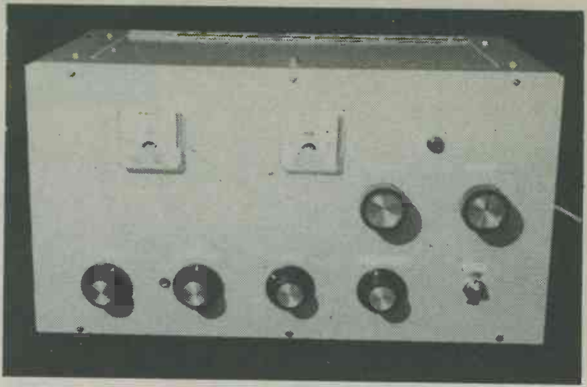
First, drill out the bush hole for the control, this in most instances being $\frac{3}{8}$in. in diameter. Then remove the mounting nut and shake-proof washer from the control, pass its bush through the hole just drilled and position it so that its tags appear in the approximate position desired. Next, push the control forward so that its locating lug is against the panel surface and turn its body through about 20° of rotation in both directions.

MARKED OUT ARC

Remove the control and examine the panel. The locating lug will have marked out an arc as indicated in Fig. 2(a), this having just the correct radius from the centre of the $\frac{3}{8}$in. bush mounting hole. The locating lug hole can be drilled at any point along this arc. For reasons of neatness it will frequently be desirable for the locating lug hole to be on a horizontal line which also passes through the centre of the bush mounting hole, and this is particularly the case with potentiometers, whose tags will then project accurately above or below the potentiometer body. All that is then necessary is to draw a line parallel with the panel bottom or top edge through the bush mounting hole centre and the locating lug arc, as indicated in Fig. 2(b). The locating lug hole is then drilled at the point where the two lines intersect.

It is preferable that the rear surface of the panel be marked out since the arc will not then be visible from the front and will in any case be covered by the component body itself. If the marking out has to be carried out on the front of the panel (because, say, it is difficult to drill the hole from the rear) the arc should be marked out as lightly as possible, so that it may be later cleaned off. Alternatively, it can be covered by the knob which is fitted to the control. ■

30 WATT TRANSMITTER

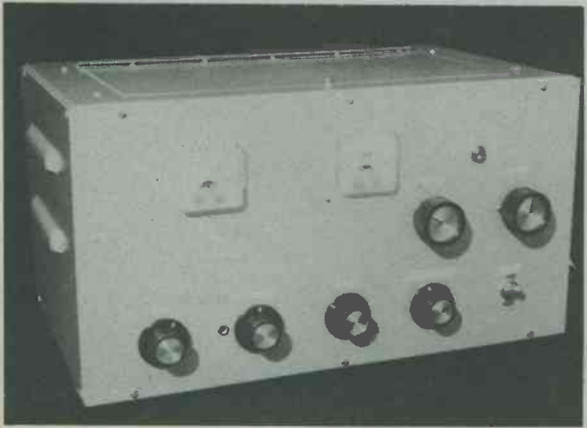


Part 1

by F. G. Rayer

Primarily intended for operation on the 10 metre band of 28 to 29.7MHz, this transmitter will also operate, with modified coils, on the higher wavelength amateur bands up to 160 metres. The description of its construction will be completed in a concluding article in next month's issue

Continuing our series on 28MHz amateur band equipment



The completed 30 watt transmitter housed in its metal case

THOUGH THIS TRANSMITTER WAS ORIGINALLY BUILT TO use in conjunction with the other 10 metre equipments so far described in this series it lends itself well to operation on other bands, where it has been employed with equal success. The other equipments described are for 10 metres only and the 10 metre band is generally sufficiently unoccupied to be excellent for local contacts (although it can also of course be used for occasional long-distance working, dependent on conditions). But it is realised that some operators may have more interest in a lower frequency band, and the transmitter will give a very satisfactory performance on 80 metres or even 160 metres if wanted (the latter with reduced input to conform with licence conditions) as well as on 40, 20 and 15 metres.

The transmitter is a single unit, requiring only the addition of a microphone, aerial and a.c. mains supply. Any receiver covering the frequencies used can be employed for reception purposes, an extension control circuit from the transmitter giving complete control of the station.

The circuit is shown in two parts – the r.f. section and the modulator. The r.f. section is given in Fig. 1, and a few points may be dealt with so that its working is clear.

COMPONENTS

Resistors
(All fixed values ¼ watt 10% unless otherwise stated)

R1	47kΩ ½ watt
R2	33kΩ 1 watt
R3	10kΩ 5 watt
R4	22kΩ ½ watt
R5	47Ω 1 watt
R6	22kΩ 3 watt
R7	5.6kΩ 10 watt
R8	47kΩ 1 watt
R9	47kΩ 1 watt
R10	1MΩ
R11	1.2MΩ
R12	270kΩ
R13	1.2kΩ
R14	3.3kΩ
R15	220kΩ
R16	33kΩ ½ watt
R17	1MΩ
R18	100kΩ 5%
R19	100kΩ 5%
R20	3.3kΩ
R21	33kΩ 5%
R22	33kΩ 5%
R23	220kΩ 5%
R24	220kΩ 5%
R25	240Ω 1 watt
R26	1kΩ 3 watt
R27	100Ω 2 watt
R28	100Ω 2 watt
VR1	1MΩ potentiometer, log track

Capacitors

C1	22pF silvered mica (see text)
C2	0.01μF disc ceramic, 150 V. Wkg.
C3	0.01μF disc ceramic, 500 V. Wkg.
C4	0.02μF disc ceramic, 250 V. Wkg.
C5	100pF silvered mica
C6	0.05μF disc ceramic, 150 V. Wkg.
C7	2,000pF disc ceramic, 750 V. Wkg.
C8	2,000pF disc ceramic, 1kV. Wkg.
C9	0.01μF disc ceramic, 150 V. Wkg.
C10	0.01μF disc ceramic, 150 V. Wkg.
C11	2,000pF disc ceramic, 1kV. Wkg.
C12	32μF electrolytic, 350 V. Wkg.
C13	32μF electrolytic, 350 V. Wkg.
C14	47pF silvered mica
C15	50μF electrolytic, 6 V. Wkg.
C16	8μF electrolytic, 350 V. Wkg.
C17	0.25μF plastic foil, 350 V. Wkg.
C18	0.01μF plastic foil, 350 V. Wkg.
C19	50μF electrolytic, 6 V. Wkg.
C20	0.01μF plastic foil, 350 V. Wkg.
C21	0.01μF plastic foil, 350 V. Wkg.
C22	0.01μF plastic foil, 350 V. Wkg.
C23	50μF electrolytic, 50 V. Wkg.
C24	0.01μF plastic foil, 600 V. Wkg.
C25	0.01μF plastic foil, 600 V. Wkg.
C26	16μF electrolytic, 450 V. Wkg.
C27	32μF electrolytic, 450 V. Wkg.
TC1	10 or 12pF trimmer, concentric (see text)
VC1	250pF variable, Type C804 (Jackson Bros.)
VC2	250pF variable type C12, 0.024in. air-gap (Jackson Bros. – see text)
VC3,4	518+518pF variable, 2-gang Type L (Jackson Bros. – see text)

Inductors

L1	oscillator anode coil (see text)
L2	p.a. tank coil (see text)
L3	pick-up loop (see text)
L4	anti-parasitic choke (see text)
L5	10H smoothing choke, 85mA, (Home Radio) or similar
RFC1	2.6mH r.f. choke Type RFC5 (Denco)
RFC2	2.6mH r.f. choke, 250 mA, Type RFC9A (Denco)
T1	modulation transformer, Type 747 (see text)
T2	mains transformer, secondaries 250-0-250V 150mA, 6.3V 2A (see text)
T3	mains transformer, secondaries 250-0-250V 100mA, 6.3V 2A (see text)

Valves

V1	5763
V2	6146
V3	6BR7
V4	ECC83 or 12AX7
V5	EL84
V6	EL84

Diodes

D1–D4	silicon rectifiers, 1A 1kV p.i.v., 1N4007 or similar
D5, D6	silicon rectifiers, 1A 800V p.i.v., 1N4006 or similar

Switches

S1	4-pole 4-way rotary, 2 wafers
S2	2-pole 3-way rotary
S3	s.p.s.t. toggle

Fuse

F1	250mA cartridge fuse and holder

Meters

M1	0–5MA moving-coil
M2	0–150mA moving-coil (see text)

Crystals

X1, 2	7MHz or 14MHz crystals (see text)

Miscellaneous

Bulb, 6V 0.1A or 0.15A, and panel mounting holder
3 B9A skirted valveholders, with screening cans
2 B9A valveholders, plain
1 octal valveholder
2 crystal sockets (see text)
3 coaxial sockets (see text)
3-core mains lead with plug and 3A fuse
2-way external control socket

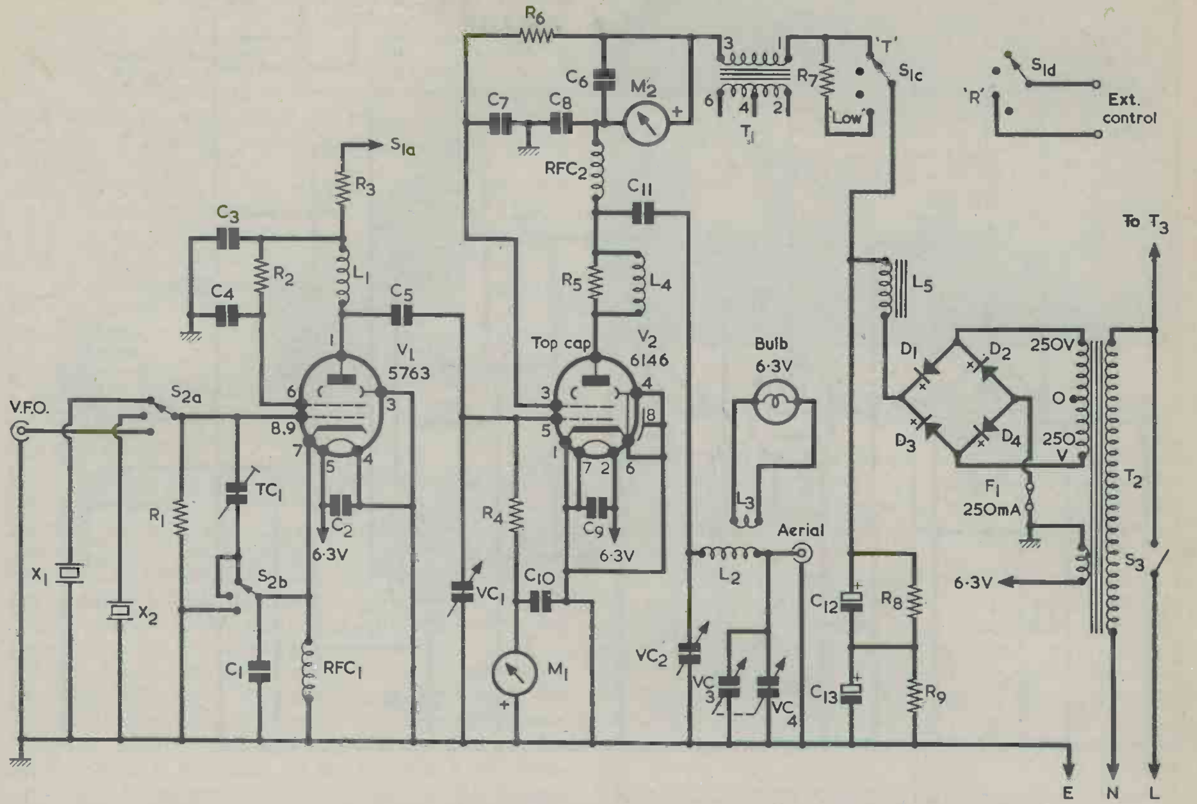
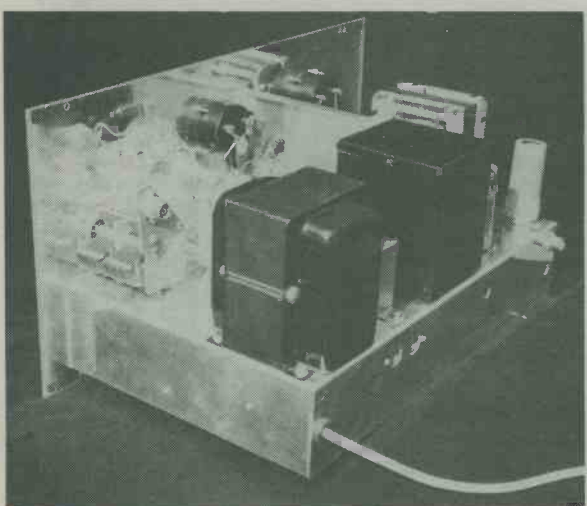


Fig. 1. The circuit of the r.f. section of the 30 watt transmitter. V1 is the crystal oscillator and V2 the power amplifier



A three-quarter side view, illustrating the solid construction of the transmitter

CRYSTAL OSCILLATOR

In terms of frequency, the 10 metre band, at 28 to 29.7MHz, is very much wider than the other amateur bands from 15 to 160 metres. For this reason, crystal control is practical, and greatly simplifies construction. V1 in Fig. 1 is the oscillator, and switch S2(a), with the two crystals X1 and X2, selects alternative channels in the band. S2(a)(b) is a 2-pole 3-way switch, and in the third position S2(b) short-circuits RFC1 and disconnects TC1, so that a variable frequency oscillator may be plugged into the v.f.o. socket. The use of a v.f.o. is of course purely optional on any band employed.

V1 provides an output at a harmonic of the crystal frequency, so X1 and X2 may be 14MHz band or 7MHz band crystals. Adequate drive for the power amplifier V2, was easily obtained with any 14MHz or 7MHz crystals, the output from V1 being at twice or four times the crystal frequency.

V1 anode coil, L1, is tuned by VC1 to the required output frequency. VC1 allows grid current for V2, as shown by meter M1, to be adjusted. Grid current is run at about 2mA, which gives 44 volts bias across R4.

Switch S1(a), which appears in the modulator circuit of Fig. 2, allows h.t. to be applied to V1 only, and VC1 is always adjusted for a suitable grid current before switching on the power amplifier, V2. This procedure also allows the frequency which will be used to be found on the receiver.

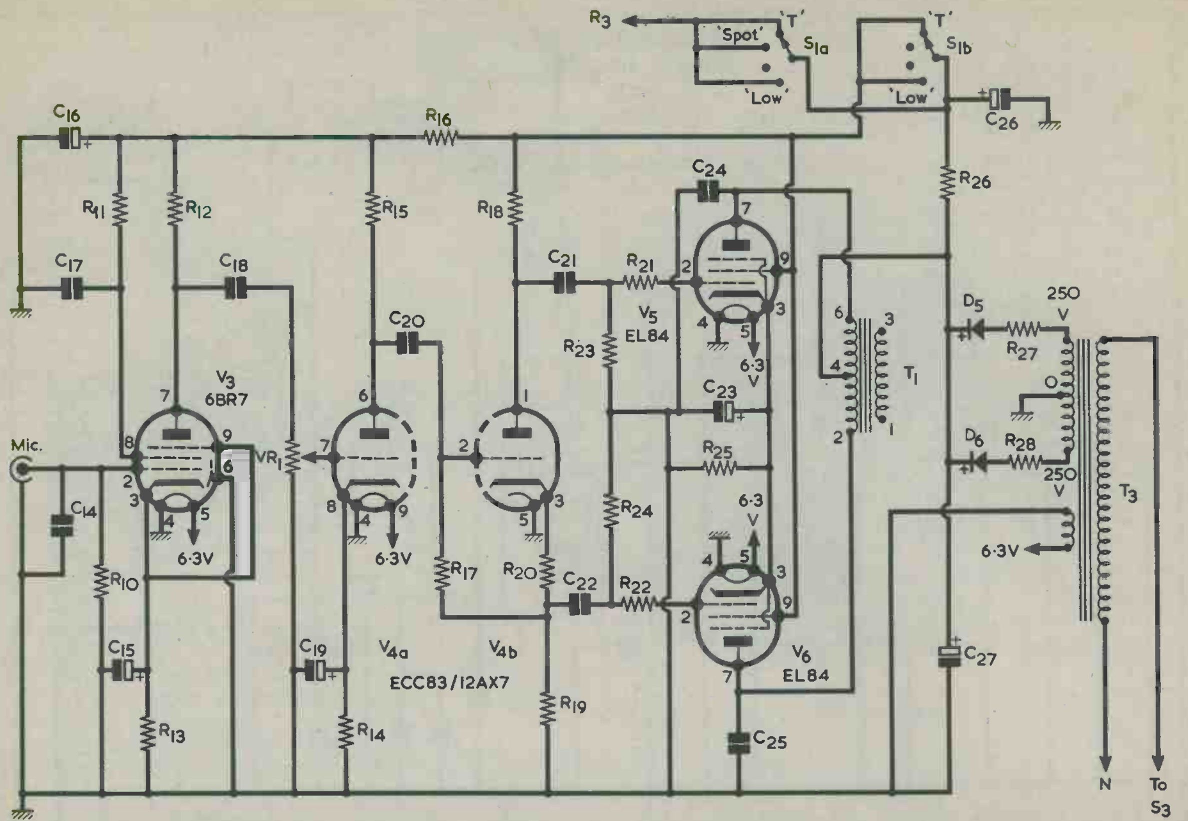


Fig. 2. The modulator section of the transmitter. For ease of circuit presentation, T1 appears both in this diagram and in Fig. 1

POWER AMPLIFIER

The power amplifier, V2, receives approximately 400 volts h.t., and is run with an input of 70mA to 80mA, or 28 to 32 watts. Anode current is monitored by M2. R5 and the parallel anti-parasitic choke allow stable operation on any frequency. VC2, with L2 and VC3,4 form a pi network which allows the transmitter to feed a dipole, ground plane, or any other conventional single-band or multi-band aerial.

The mains transformer, T2, supplies h.t. for V2 only. This transformer has a 250–0–250 volt 150mA secondary and would normally supply a rectified voltage of about 250 at 150mA. However, the transformer has the full 500 volt secondary applied to a bridge rectifier and choke input filter in Fig. 1, whereupon a rectified voltage of approximately 400 volts appears across the smoothing capacitors, C12 and C13. The fact that approximately double the output voltage and half the output current is obtained results in the same power loading as would be given with a full-wave rectifier giving 250 volts at 150mA. It was found that, with the choke input providing about 400 volts only, the transformer can be run for lengthy periods at 80 to 90mA without any sign of overheating whatever. The use of T2 obviates any need for a high voltage transformer. The transformer employed by the author was a Parmeko type P.2931, which is not now in production and may be difficult to obtain. However, any other mains transformer offering the same h.t. and heater voltages and currents may be employed, although it may of course have a different construction and slightly different dimensions. C12 and C13 in series provide smoothing, and R8 and R9 are connected across them to equalise voltage and act as bleed resistors.

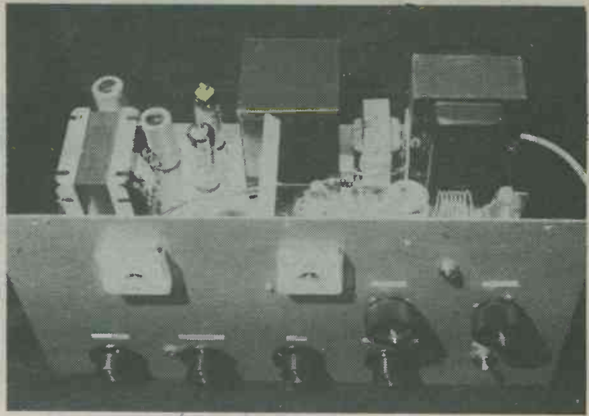
S1(c) applies h.t. to the p.a. at 'T' (Transmit). For ease of initial adjustment when changing bands or aerial, S1(c) has a 'Low' position which enables h.t. to be applied to V2 via R7. This allows tuning up at reduced power, with no danger of damaging V2.

L3 is a loop near L2 and connects to a panel lamp. The loop draws a little r.f. power and the lamp acts as an indicator. This arrangement can assist in tuning, and it shows that the usual r.f. power is being produced. Switch S1(d) closes the external control terminals in the 'R' (Receive) position, thereby switching on the receiver.

or operating a relay to do this and transfer the aerial, if preferred.

T1 is the modulation transformer and a suitable component for this can be obtained from Garex Electronics, 7 Norvic Road, Marsworth, Tring, Herts., HP23 4LS. This transformer is ideal for the modulator and p.a. valves employed, and in terms of efficiency the circuit is fully up to standard and gives a potent signal. For ease of circuit presentation, the modulation transformer is also included in Fig. 2.

Two components which require mention are the variable capacitors specified for VC2 and VC3,4. VC3,4 can be any non-miniature 2-gang receiver type component with a value of around 500pF each section. VC2, and the capacitor specified for VC3,4, may be ordered direct from the manufacturers, Jackson Brothers (London) Ltd., Kingsway, Waddon, Croydon, CR9 4DG. It will be noted that meter M2 is specified as 0–150mA. If desired, a 0–100mA meter may be employed here instead.



Looking down on the chassis from the front

MODULATOR

The circuit of the modulator appears in Fig. 2. The input is provided by a crystal microphone and this couples to the low noise high gain amplifier, V3. VR1 is the audio level control, and is followed by the double-triode V4. The first section of this valve, V4(a), functions as an amplifier and the second, V4(b), as a phase-splitter. Additional h.t. smoothing and decoupling for V3 and V4(a) are provided by C16 and R16.

V5 and V6 are the push-pull modulators, operating with about 280 volts at the anodes and 250 volts at the screen-grids. Fig. 2 also shows the switching operations carried out by S1(a) and S1(b). H.T. is present on the output anodes at all times. In the 'T' and 'Low' positions, S1(b) completes the h.t. circuit for the output screen-grids and for V3 and V4. S1(a) provides h.t. for the transmitter oscillator, V1, at all positions except 'R'. The h.t. supply is obtained from T3, with R27 and R28 acting as rectifier surge limiters. R26 and C26 give additional smoothing.

The modulation transformer, T1, has already been mentioned. The winding between terminals 2 and 6 is for an anode-to-anode load of 8kΩ with terminal 4 being the centre-tap. The winding between terminals 3 and 1 can work into a modulating impedance of 3kΩ to 8kΩ. The overall modulator circuit has always brought reports of very satisfactory speech quality, with freedom from hum and other defects, and the gain is easily sufficient for any crystal microphone.

The mains transformer, T3, gives the secondary voltages and currents quoted in the Components List, and that used by the author had dimensions which caused it to take up some 2½ to 3in. of chassis space. If a transformer offering a somewhat higher voltage is used, the values of R27 and R28, or of R26, can be increased accordingly.

Switch S3 is the main on-off switch for both T2 and T3. Solid-state circuitry is not very practicable at the power level used in the r.f. section unless considerable care is exercised. In consequence, valves are preferred, and the types required are robust and easily obtained. No stage in either the r.f. or modulator section is run at maximum ratings, so there is some latitude in the voltages found. The EL84's can be run up to 300 volts for anode and screen-grid, giving 17 watts output, whilst the 6146 may run up to 112mA at 600 volts. Thus, the transmitter is operating at well under these ratings.

NEXT MONTH

Constructional details will be given in the next article in the series, and this article will conclude the description of the transmitter. The final article in the overall series on 28MHz equipment will appear in the succeeding issue, and it will deal with 10 metre aerials.

The Components List accompanying the present article lists the electronic parts required for the transmitter. Some of the items which are indicated as 'see text' will be dealt with in the next article, and this will also clear up other outstanding points concerning the components. A second Components List, covering the chassis, case and other hardware, will be given next month.

(To be continued)

BACK NUMBERS

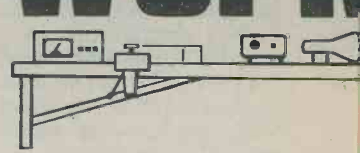
For the benefit of new readers we would draw attention to our back number service.

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 8p postage.

Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.

We regret that we are unable to supply photo copies of articles where an issue is not available. Libraries and members of local radio clubs can often be very helpful where an issue is not available for sale.

500 mw work



An inexpensive general purpose a.f. amplifier which will be particularly useful for experimental, testing and servicing work

THIS PIECE OF EQUIPMENT WAS ORIGINALLY DESIGNED as a test instrument for use in the electronics workshop. There are numerous occasions when an amplifier of this type is needed for such functions as a.f. signal tracing in faulty audio equipment, and it has also proved very useful when checking newly constructed tuners, receivers and signal generators.

The amplifier has an input sensitivity of approximately 50mV for full output, and the input impedance is of the order of 200kΩ. The noise level is very low at –66dB with the input open-circuit.

Although the basic circuit configuration used in the output stage is not particularly modern, a large amount of negative feedback is employed and enables a level of distortion to be given which is lower than that of many more up-to-date circuits.

The unit is housed in an attractive home-made aluminium case which has dimensions of about 6 by 2 by 6in. The unit is powered from an internal 9 volt battery type PP7. Quiescent current is about 4.5mA, but this increases to peaks of over 100mA when the Class B output stage is used at full power.

A simple top-cut tone control is incorporated in the design.

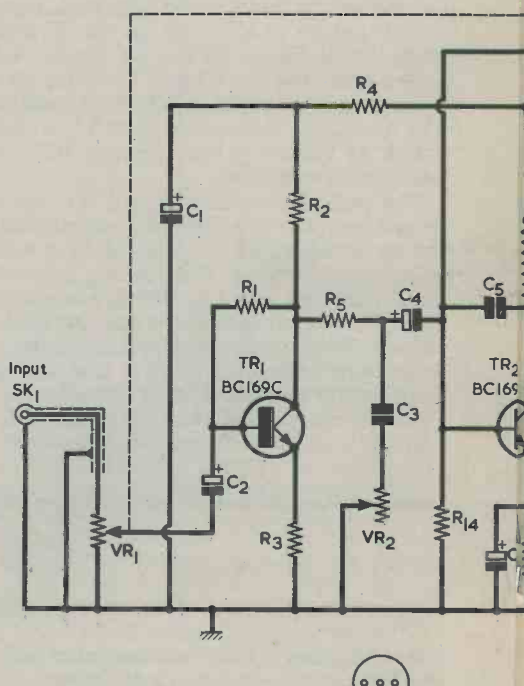


Fig. 1. The circuit of the 500mW a.f. amplifier. A lat and otp

mw workshop am

An inexpensive general purpose a.f. amplifier which will be particularly useful for experimental, testing and servicing work

By R. A. Penfold

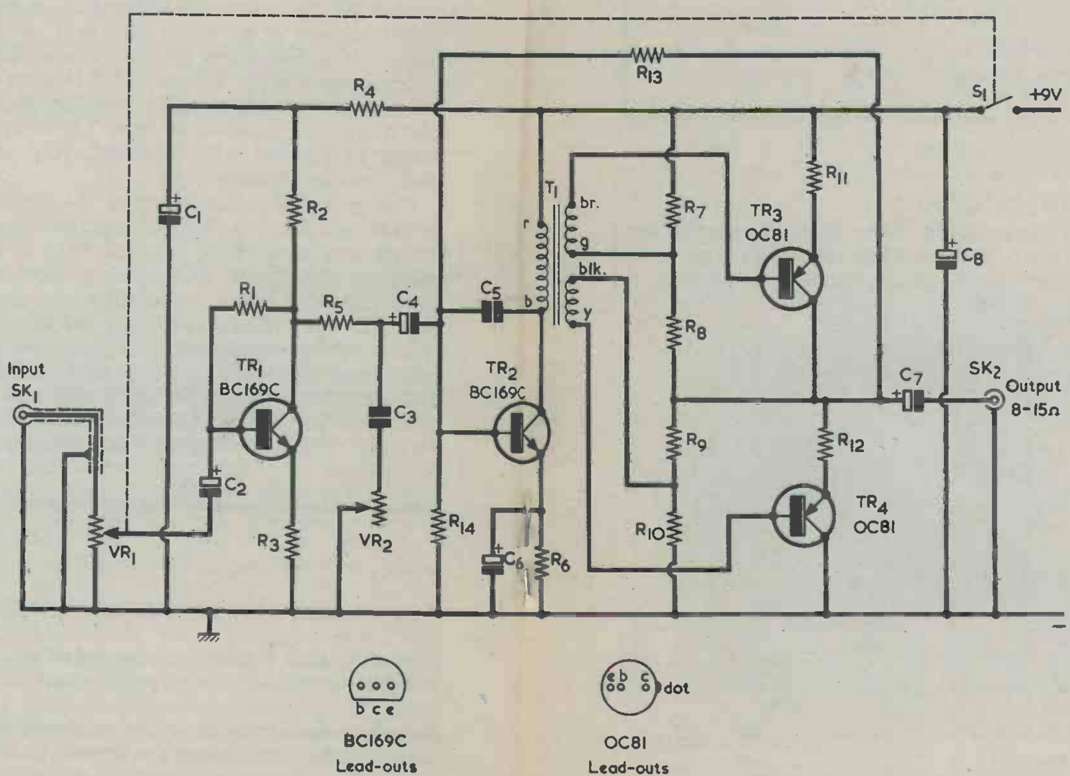
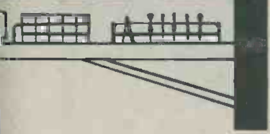
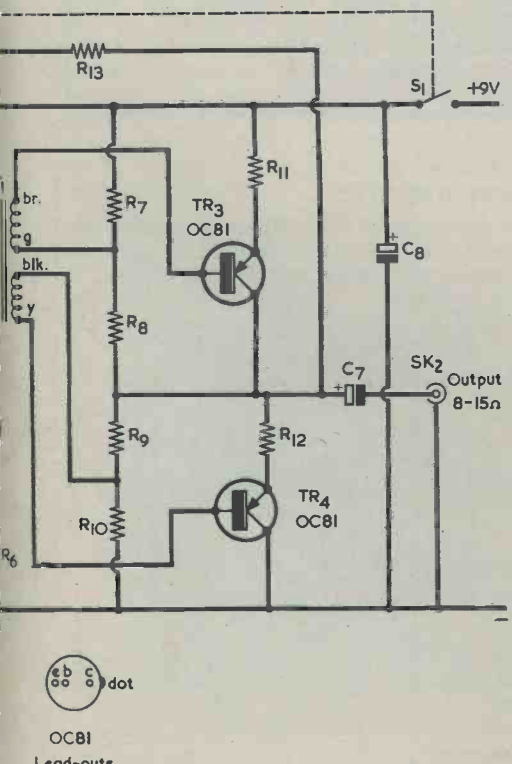


Fig. 1. The circuit of the 500mW a.f. amplifier. A relatively high level of feedback is applied over the driver and output stages

shop amplifier



By R. A. Penfold



vely high level of feedback is applied over the driver t stages

CIRCUIT OPERATION

The full circuit of the amplifier is given in Fig. 1. VR1 is the volume control, and the input signal is coupled from the slider of this to the base of TR1 via the d.c. blocking capacitor C2. TR1 operates as a low noise common emitter input stage with R1 as its base bias resistor and R2 as its collector load resistor. The unbypassed emitter resistor, R3, provides negative feedback and has the effect of reducing noise and distortion as well as boosting the input impedance of the amplifier. These features are achieved at the expense of some voltage gain.

A top-cut tone control is given by R5, C3 and VR2. C3 offers a reactance which reduces as frequency increases, whereupon it provides a relatively high level of attentuation to the higher audio frequencies when VR2 slider is at the upper end of its track. This attenuation reduces as VR2 inserts more and more resistance, and is almost completely absent when VR2 slider is at the lower end of its track. The signal from the tone control is passed to the base of driver transistor TR2 via C4.

The collector of TR2 couples into the primary of the transformer T1. Base bias for this transistor is provided by R13 and R14 and, since R13 connects to the amplifier output, this resistor also provides negative feedback over both the output and driver stages. The feedback level is high and results in a correspondingly low voltage gain and distortion level in the driver and output stages.

Resistor R6, bypassed by C6, provides the emitter bias for TR2. C5 reduces the response of TR2 at high frequencies, and thus improves stability.

T1 has two secondary windings, one coupling to TR3 and the other to TR4. The signal feeds to these two transistors are in antiphase, so that TR3 produces the positive output half-cycles of signal whilst TR4 produces the negative half-cycles. A quiescent bias is provided by the potential divider R7, R8, R9 and R10, resulting in the output transistors both passing a small collector current in the absence of signal. This quiescent bias prevents the appearance of crossover distortion. Both transistors function as common emitter amplifiers.

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)

R1	1.8MΩ
R2	5.6kΩ
R3	470Ω
R4	820Ω
R5	2.2kΩ
R6	820Ω
R7	100Ω
R8	2.7kΩ
R9	100Ω
R10	2.7kΩ
R11	1Ω
R12	1Ω
R13	27kΩ
R14	10kΩ
VR1	500kΩ potentiometer, log, with switch S1
VR2	5kΩ potentiometer, linear

Capacitors

C1	100μF electrolytic, 10V. Wkg.
C2	1μF electrolytic, 10V. Wkg.
C3	0.47μF plastic foil, type C280 (Mullard)
C4	10μF electrolytic, 10V. Wkg.
C5	560pF polystyrene or silvered mica, side wires
C6	100μF electrolytic, 6V. Wkg.
C7	400μF electrolytic, 10V. Wkg.
C8	100μF electrolytic, 10V. Wkg.

Transformer

T1	Driver transformer type TT47 (Repanco)

Transistors

TR1	BC169C
TR2	BC169C
TR3	OC81 (see text)
TR4	OC81 (see text)

Sockets

SK1	3.5mm jack socket
SK2	3.5mm jack socket

Switch

S1	d.p.s.t. toggle, part of VR1

Battery
9 volt battery type PP7 (Ever Ready)

Miscellaneous
2 knobs
Battery connector
Plain Veroboard, 0.15in. matrix, $3\frac{3}{4} \times 2\frac{1}{2}$in.
20 s.w.g. aluminium sheet
4 rubber feet
Flexible screened wire
Connecting wire, solder, etc.

Increasing base current in TR3 causes its collector current to increase and the collector to go positive. Increasing base current in TR4 similarly causes its collector current to increase, but the effect this time is that the base and emitter, which couples to the speaker, are drawn negative. The transistors offer a high current gain and the output impedance is sufficiently low to drive an 8Ω speaker via C7. Resistors R11 and R12 are included in circuit to limit current in the output transistors and thereby prevent thermal runaway. The output may also be coupled to a 15Ω speaker, whereupon the output power is slightly reduced. Speaker impedances lower than 8Ω must on no account be employed.

Theoretically, TR3 and TR4 should be a matched pair. Readers with access to component retailers may be able to have a pair of matched transistors selected for a small fee, although such a service is not advertised by the larger mail order houses. However, since there is a high level of feedback in the driver and output stages, satisfactory operation should be obtained with unmatched transistors. The writer checked this point experimentally by replacing one of the OC81's with an AC128 having quite a different gain and could detect no noticeable effect on performance at all.

S1 is the on-off switch for the amplifier and is ganged with volume control VR1. C1, R4 and C8 are supply decoupling components.

CASE CONSTRUCTION

The case is home-made from 20 s.w.g. aluminium sheet, and details of the two parts required are given in Fig. 2. A commercially made metal case of similar

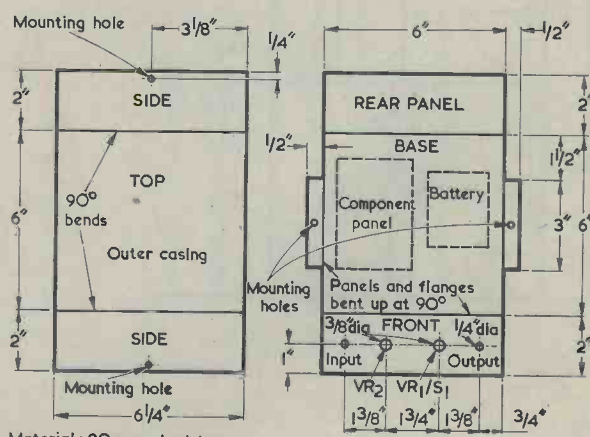


Fig. 2. The dimensions of the two pieces which make up the amplifier case. The manner in which they fit together is described in the text

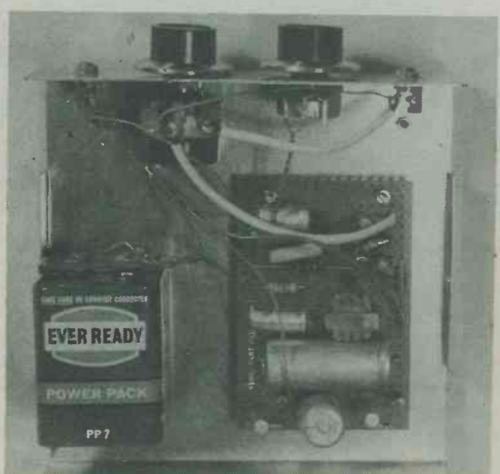
dimensions could be used, if preferred, as the size is not critical provided the components and battery can be accommodated.

One section of the case, as shown in Fig. 2, is the piece of aluminium which forms the rear panel, base and front panel. This is made from a single piece of metal measuring 10 by 7 in. It is cut to the shape shown in Fig. 2 and then the front and rear panels are bent upwards with the aid of a vice and two wooden blocks. The two $\frac{1}{2}$in. side flanges are similarly bent upwards.

The holes in the front panel are next drilled out. Both the input and output of the amplifier are taken to 3.5mm jack sockets, and these usually require $\frac{1}{4}$in. diameter holes. The holes for VR1/S1 and VR2 are $\frac{3}{8}$in. diameter. Four holes to take screws securing rubber feet may next be drilled at the base corners. The holes for these are not shown in Fig. 2. Later, two further holes will be drilled in the base for the screws which secure the component panel.

The item which forms the top and two sides, or the cover, is also shown in Fig. 2. This is made from a 10 by $6\frac{1}{4}$in. piece of aluminium. The two mounting holes in the sides are drilled clearance size for small self-tapping screws. The metal is next bent at the lines indicated to form the top and two sides. This item is then fitted over the first piece so that the sides pass over the $\frac{1}{2}$in. flanges. The front of the cover projects forwards over the front panel by a small amount in the manner illustrated in the photographs. Using the cover as a template, the positions of the two mounting holes in the $\frac{1}{2}$in. flanges are next marked out, and these are drilled tapping size for the self-tapping screws. When the amplifier is finally assembled, the cover will be secured in place by two self-tapping screws passed through the two sets of mounting holes.

The appearance of the completed amplifier is enhanced if the two bends in the cover are given a slight radius, as indicated in the photographs, instead of being bent abruptly. The corresponding top corners of the rear and front panels are slightly rounded off to suit.



The use of a perforated component board allows most of the parts to be assembled as a complete module

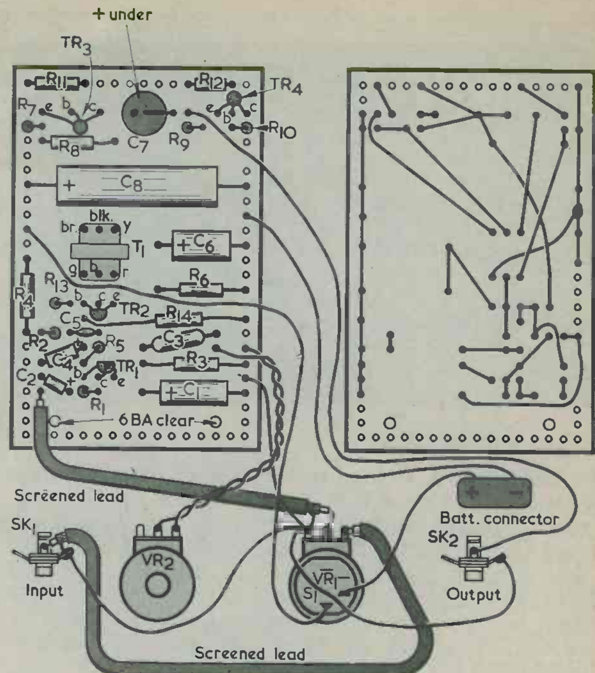


Fig. 3. Component layout and wiring of the amplifier. For convenience of presentation the front panel controls and sockets are shown in the same plane as the component board. The positions of the controls and sockets can be readily ascertained from the photographs of the interior of the amplifier

COMPONENT PANEL

All the amplifier components with the exception of the controls and the jack sockets are assembled on a piece of plain (i.e. with no copper strips) Veroboard of 0.15in. matrix measuring $3\frac{3}{4}$ by $2\frac{1}{2}$in. This is a standard size in which the board is sold. Fig. 3 illustrates the component layout on the board as well as the underside wiring. It also shows all the other wiring of the unit. Looking at the front panel from the front of the amplifier, the input jack is to the left.

Initially, the two 6 B.A. clear mounting holes are drilled in the Veroboard in the positions shown. The board is then used to mark out the corresponding 6 B.A. clear holes in the base of the case, and these are also drilled out. The components are then fitted to the Veroboard and wired up as shown. Wiring on the board is quite straightforward, and sleeving should be placed over any leads which cross over or are very close to other leads. In most cases the component lead-outs will themselves be long enough to make the appropriate connections. Where this is not the case the lead-outs may be extended by soldering on tinned copper wire of around 22 s.w.g.

The input screened lead has only its centre wire connected to the board. No connection is made to the braiding at this end. Ensure that all wiring under the board is reasonably flat and does not project downwards by an excessive amount. Leads to the controls and the output jack can be made a little longer than is required at this stage.

The controls and jack sockets as seen from the rear

The board is secured to the base of the aluminium case by two 1 in. 6 B.A. bolts, with the heads underneath. Spacing washers or additional 6 B.A. nuts are used on the bolts to keep the underside of the board well clear of the base surface. If desired, additional protection against short-circuits to the aluminium base may be provided by mounting a second piece of s.r.b.p. ('Paxolin') of about the same dimensions underneath the board and immediately above the base.

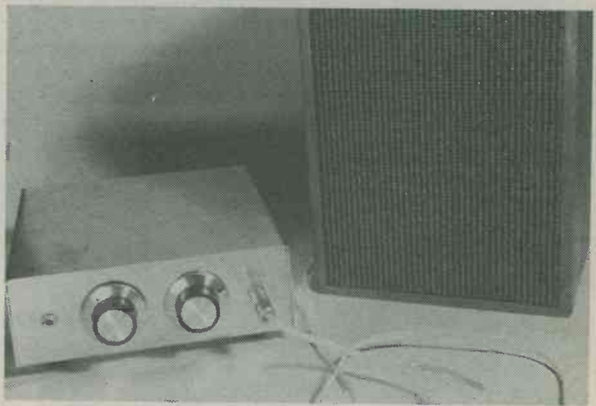
Connections to the front panel components may then be carried out, the leads from the board being shortened as necessary. The amplifier picks up its chassis connection from the mounting bushes of the input and output jack sockets; if necessary, the appropriate socket tag may be located with the aid of an ohmmeter or continuity tester. An ohmmeter or continuity tester may also be employed to determine the requisite tags on S1, of which only one pole is used. Tag positioning on some switches may differ from that shown in Fig. 3.

There is plenty of space for the battery alongside the component board. A piece of foam rubber is glued to the underside of the case top above the battery, so that the battery is held firmly in place when the cover is fitted.

USING THE AMPLIFIER

After the amplifier has been completed, a testmeter switched to a high current range should be inserted in series with the positive supply lead and the amplifier switched on. If the testmeter indicates that it is safe to do so, the amplifier is switched off, a lower current range selected in the meter and the amplifier switched on once more. The quiescent current drawn by the amplifier should be around 4.5mA. If the current reading is considerably different from this figure the amplifier must be switched off at once and the wiring re-checked.

As already mentioned, the amplifier may be coupled to an 8Ω or 15Ω speaker but must not be used with a speaker having an impedance lower than 8Ω. Speakers of impedance higher than 15Ω can be employed if the consequent loss in output power can be tolerated. The prototype is employed with an Eagle 4in. 8Ω speaker type FR.4 mounted in a home-made cabinet, and the combination gives very good results.



The amplifier in use in conjunction with an external loudspeaker

A word of warning is necessary concerning the output jack socket to which the speaker connects. With some types of 3.5mm. jack plug and socket it is possible to momentarily short-circuit the socket contacts during the process of inserting or removing the plug. In consequence, the speaker plug should not be inserted or removed when the amplifier is switched on and handling a signal, as excessive current might then flow in the output transistors and cause them to be damaged.

To avoid stray pick-up of mains hum and similar effects, the input connection to the input jack plug should be made by way of screened wire, the braiding of this being soldered to the plug contact which connects to the amplifier chassis. ■

REGENERATIVE OVERLOAD TRIP

An add-on circuit which cuts off a d.c. supply whenever the current drawn exceeds a preselected value.

By R. J. Caborn

THIS OVERLOAD TRIP CIRCUIT CAN BE CONNECTED TO the ouput of a d.c. power supply, and it may be pre-set to act at any current from 100 to 400mA. The basic switching device, a power transistor, remains conductive until the trip current is reached whereupon it turns off abruptly. The circuit can only be brought back to its previous state by disconnecting the excessive load. The trip circuit causes the voltage available from the d.c. supply to be reduced by about 1 volt, and it gives a very small degradation of the voltage regulation. The d.c. supply can have any output voltage up to some 30 volts.

TRIP CIRCUIT

The trip circuit is shown in Fig. 1. For convenience of presentation the negative rail appears at the top in this diagram, and it will be helpful to remember that a turned-on silicon transistor has its base about 0.6 volt above the emitter and its collector about 0.3 volt above the emitter. Both the transistors in the trip circuit are silicon types.

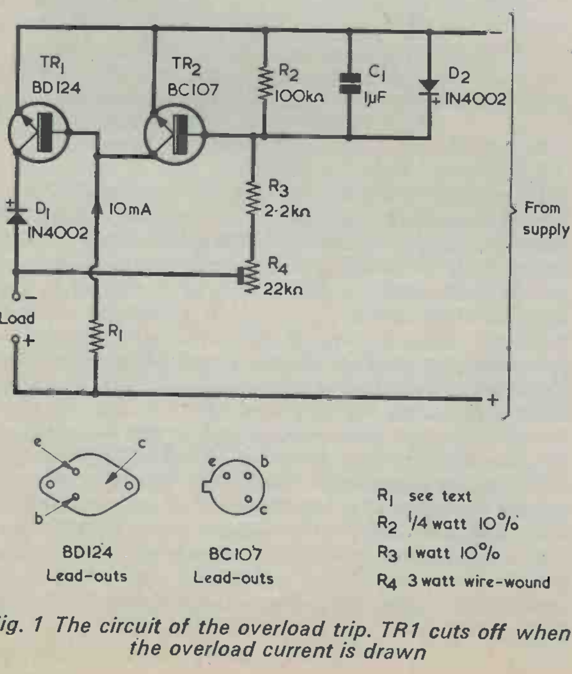


Fig. 1 The circuit of the overload trip. TR1 cuts off when the overload current is drawn

If, with no load connected, the d.c. supply is applied, a current of about 10mA flows into the base of TR1. This is sufficient to make TR1 conductive, whereupon a voltage is available at the negative load terminal which is about 0.9 volt positive of that on the negative rail. This voltage is the sum of those dropped across TR1 and the forward biased silicon diode D1.

The trip current level is adjusted by pre-set potentiometer R4. Let us say that this has been previously adjusted so that the circuit trips at 300mA.

A load is now connected across the load terminals and this could initially draw a current of around 100mA. Most of this current flows through TR1 and D1, whilst a small fraction flows in R4, R3, R2 and the base-emitter junction of TR1. If we now cause the load current to slowly increase the current flowing in the base-emitter junction of TR2 will also increase, although at a much lower rate. When the load current reaches the trip level of 300mA, the current flowing in the base-emitter junction of TR2 is sufficiently high for its collector to take the base of TR1 slightly negative. In consequence TR1 collector goes slightly positive, with the result that the current in the base-emitter junction of TR2 increases. Its collector takes the base of TR1 further negative, the collector of TR1 goes increasingly more positive and the situation is soon reached where TR1 is completely cut off and TR2 is fully conductive. If signal polarities from the base of TR2 to the collector of TR1 are traced through it will be seen that the action which causes the two transistors to change states is regenerative, and that the combined gain of the two transistors appears in the regenerative loop. In practice, the turn-off in TR1 when the trip current level is reached is very abrupt. So long as the load is connected, TR1 remains cut off, and the only current in the load will be that which flows through R4, R3, R2 and the base-emitter junction of TR2. For most normal settings of R4 this current will be of the order of milliamps only. If the load is disconnected, the two transistors revert to their previous states, with TR1 on and TR2 off.

VOLTAGE DROP

It was just stated that as load current increases so does the current flowing in the base-emitter junction of TR2. This statement assumes that the voltage across the conducting TR1 and D1 increases with increasing load current and such is indeed the case. The voltage dropped across these two components increases by about 0.1

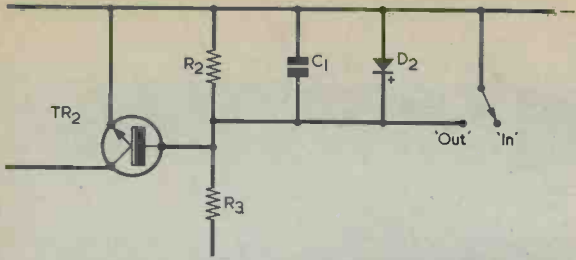


Fig. 2. An additional switch allows the trip facility to be cut out if desired. It also enables a high value electrolytic capacitor connected across the load to become charged without tripping the circuit

to 0.15 volt for each 100mA rise in load current. The consequent increase in base current in TR2, although small, is still sufficient to trigger the circuit. When R4 has been set to a particular current trip value, the short-term repeatability at that current value is in practice very good. Long-term repeatability should be nearly as good although there may be slight shifts in tripping current due to changes in ambient temperature.

The function of capacitor C1 is to slightly slow the voltage rise at TR2 base if loads which are near the tripping level are suddenly applied to the load terminals. Without C1, the abrupt connection of such loads may cause the transistors to trip.

If, as is probable, a high value electrolytic capacitor is connected across the load terminals, the charging current to this component can trip the circuit on switch-on. Should this occur an additional switch can be connected into circuit, as shown in Fig. 2. When this switch is set to 'Out', TR2 is cut off and the high value capacitor is then able to charge via TR1 and D1. The added switch can also be set to the 'Out' position when it is desired to use the circuit without the current trip facility. When the circuit has tripped and the load is disconnected, the switch may also be set to the 'Out' position to charge the high value electrolytic capacitor once more.

Returning to Fig. 1, the value of R1 should be such that about 10mA flows into the base of TR1. For a supply voltage of 10 volts R1 may be 1kΩ ½ watt, for 20 volts it may be 2kΩ ½ watt, and for 30 volts it may be 2.7kΩ ½ watt. Intermediate resistance values may be employed for intermediate supply voltages. If TR1 is an exceptionally low gain specimen and it is desired to have the circuit trip at currents approaching 400mA it may be necessary to increase TR1 base current by employing a slightly lower value for R1.

R4 should be a wire-wound potentiometer for two reasons. First, it is possible for currents approaching 15mA (with a 30 volt supply) to flow through its track if it is accidentally set to insert very low resistance when the circuit is tripped. Second, the setting of this potentiometer is a little critical and a wire-wound potentiometer will maintain its adjusted resistance value more reliably than will a carbon track potentiometer. The potentiometer is shown as 22kΩ in Fig. 1, but it may alternatively be 20kΩ or 25kΩ if it is easier to obtain these values.

TR1 is specified as a power transistor since it has to pass relatively high surge currents when there is a large value electrolytic capacitor across the load terminals. Its average dissipation is quite small and it does not need to be mounted on a heat sink.

Diode D2 ensures that a high reverse voltage cannot be applied to the base-emitter junction of TR2 after switch-off when a high value capacitor is connected across the load terminals. It is reverse biased during normal operation and has no other effect on circuit functioning.

The circuit is set up by adjusting R4 to trip the circuit when the desired maximum load current is being drawn. For ease of explanation, a theoretical means of drawing the load current for the setting-up process is illustrated in Fig. 3(a), in which RX is a current limiting resistor, RY is a variable resistor and the meter is a multi-testmeter switched to read 0–500mA (or to read a suitable alternative f.s.d. current if a 0–500mA range is not provided). R4 of Fig. 1 and RY of Fig. 3(a) are both set to insert maximum resistance into circuit, then the power supply is switched on. RY is then adjusted until the desired trip current is indicated by the meter. The resistance inserted by R4 is next slowly reduced until the circuit trips. The power supply is then switched off, RY returned to insert maximum resistance and the supply switched on again. The resistance inserted by RY is slowly reduced until the circuit trips once more. If the circuit trips at a slightly different current from the desired one, a very small adjustment is made to R4 and the process repeated. After several runs of this nature it should be possible to bring R4 precisely to the desired setting.

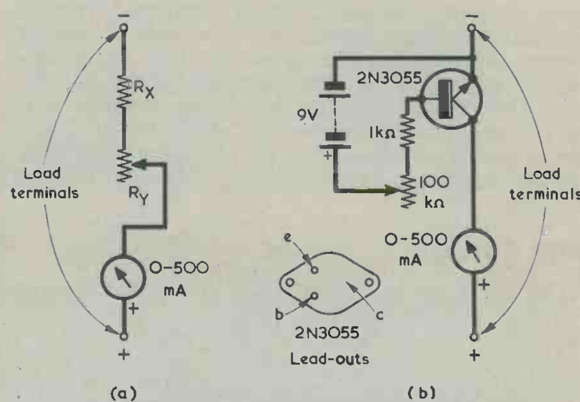


Fig. 3 (a). A variable load for setting up the trip circuit can consist of a fixed and a variable resistor in series
(b). In practice, it will be difficult to obtain a suitable variable resistor for the load shown in (a). An alternative variable load incorporating a power transistor is shown here

In practice it will be unlikely for the constructor to have access to a suitable potentiometer for the RY position in Fig. 3(a) since this is called upon to carry current of the order of hundreds of milliamps. A practical alternative adjustable load is shown in Fig. 3(b), in which the load current is drawn by a power transistor such as the 2N3055. Initially, the 100kΩ potentiometer in Fig. 3(b) is set to insert maximum resistance. Reducing its resistance then has the same effect as reducing the resistance of RY in Fig. 3(a) and the setting-up procedure carries on in the same way as was described for Fig. 3(a). The 2N3055 will need to be mounted on a heat sink whose size depends upon the voltage and current it has to handle. A heat sink about 4 in. square should be adequate for most requirements.

If a high value electrolytic capacitor is to be connected across the load terminals, this should be wired into circuit after the setting-up procedure has been completed. ■

TESTING TRANSFORMER TEMPERATURE

How to measure temperature rise in components wound with copper wire

By E. Higgins

ARE YOU WORRIED ABOUT THE TEMPERATURE AT WHICH the mains transformer in your latest pet circuit is running? There is a simple means of checking operating temperature in any inductive component which is wound with copper wire, and all that is required is a means of measuring resistance with reasonable accuracy. The method can be employed with mains transformers, modulation transformers, smoothing chokes, TV line output transformers and any other wound components handling relatively high power levels. It is, indeed, a standard procedure employed in the R. and D. laboratories of set-makers and component manufacturers.

TEMPERATURE COEFFICIENT

To find running temperature, first measure the resistance of the winding, or one of the windings, in the inductive component whilst it is cool and is at ambient temperature. Next, connect the component up in its circuit and let it operate for a period until it has reached its final running temperature. Then, disconnect the component from its circuit and quickly measure the resistance of the winding once more. This will have increased because copper wire has a positive temperature coefficient of resistance, and the percentage increase will indicate the temperature of the copper wire above ambient.

The temperature coefficient of annealed copper wire is 0.0039 per °C. So, if the resistance has increased by 3.9% the temperature rise is 10°C. Should the resistance have gone up by 39% the temperature rise will be the unsafe figure of 100°C. Intermediate increases in resistance correspond to intermediate rises in temperature. A thermometer is desirable to give a measure of ambient temperature before starting the test but it is not needed for any other purpose.

The accompanying table shows resistance increase and the corresponding temperature rise above ambient for temperature increases up to 103°C. The temperature figures are given to the nearest whole number, whereupon a 4% (not 3.9%) resistance increase is shown as corresponding to a temperature above ambient of 10°C. To take an example, assume that a transformer winding, when cold, has a resistance of 40Ω and that this rises to 44Ω when the wire is hot. The resistance increase is 10% and so the temperature rise above ambient is 26°C. If the ambient temperature were 20°C the winding wire, when hot, would be running at 46°C.

TABLE

Wire Resistance Increase (%)	Temperature Above Ambient (°C)
1	3
2	5
3	8
4	10
5	13
6	15
7	18
8	21
9	23
10	26
11	28
12	31
13	33
14	36
15	38
16	41
18	46
20	51
25	64
30	77
35	90
40	103

Speaking in very general terms, the wire temperature in well designed impregnated transformers and chokes can run up to a maximum of 100°C. Don't forget that the temperature found by the resistance measurement technique is above ambient temperature. Ambient temperature in a hot environment, e.g. in a crowded chassis on a very hot day, may well run up to 45°C, which leaves 55°C safe winding temperature increase in hand. Allowing a safety margin of 10°C gives a maximum practical increase above ambient of 45°C. However, even when these safeguards are taken into account, it is still wise to keep winding temperature rises to below some 35°C for really long life and reliability. ■

INTEGRATED CIRCUIT SUPERHET

By R. A. Penfold

Part 2.

In this concluding article details are given of the wiring, assembly and alignment of the receiver. Also described is the construction of the optional add-on audio output stage which enables the receiver to be coupled to a speaker

THE ARTICLE IN LAST MONTH'S ISSUE COMPLETED THE examination of the receiver circuit and its mode of operation. Also described was the work involved in making up the chassis, front panel and other metal parts. The next processes in construction are assembly and wiring up.

MIXER WIRING

All the controls, sockets and valveholders may now be mounted on the front panel and chassis. The two 6 B.A. securing screws for the tuning drive should be short types with round heads. Valveholders should have the pin orientation shown in Fig. 6. A solder tag is secured under both mounting nuts of L1 and L3 valveholders, and a further tag is held under one of the mounting nuts of L2 valveholder.

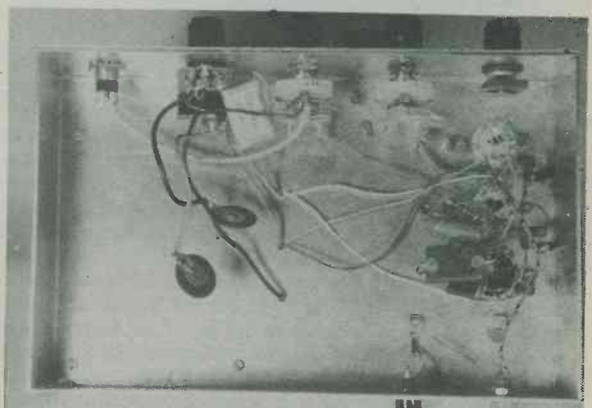
VC6 is specified in the Components List (published last month) as Jackson type C804, but the capacitor employed in the prototype was a different type of the same capacitance. The Jackson capacitor should just clear the tags of the valveholder for L1. If necessary, these tags may be bent down a little and the outer end of the valveholder centre spigot (if fitted) cut away. It may be found more convenient to fit VC6 after the wiring to the valveholder has been completed.

Before finally fitting the 3-gang capacitor in position an insulated lead about 3in. long is soldered to each of the three lower fixed vane tags. These leads are then passed through the three chassis holes under the capacitor frame. A solder tag is secured under the rear mounting nut for the capacitor.

The aerial input and mixer-oscillator stages are then wired as in Fig. 6. Here, all leads should be kept short and direct. The padding capacitors, C6, C7 and C8, are shown away from L3 valveholder for clarity; in practice they connect to the appropriate valveholder tags by short leads. Some of the valveholder tags to which no coil connections are made are used as anchor tags.

There are four connections from the component panel to the mixer-oscillator circuit, these being two connections from IFT2, a positive supply from R16, and the a.g.c. connection. These wires are taken from the component panel to the points shown in Fig. 6 at a later stage, after the component panel has been assembled and mounted.

Two leads are shown passing from the moving vanes tag of VC5 to VR1 and JK1. The lead to VR1 connects to the tag at the minimum volume end of its track. The lead to JK1 connects to the jack socket contact corresponding with the sleeve of the jack plug. This last lead is only needed if the jack socket is of the insulated type. Should the jack socket be of the non-insulated type it will take up its chassis connection via its mounting bush and nut.



The components below the chassis with the battery and its bracket

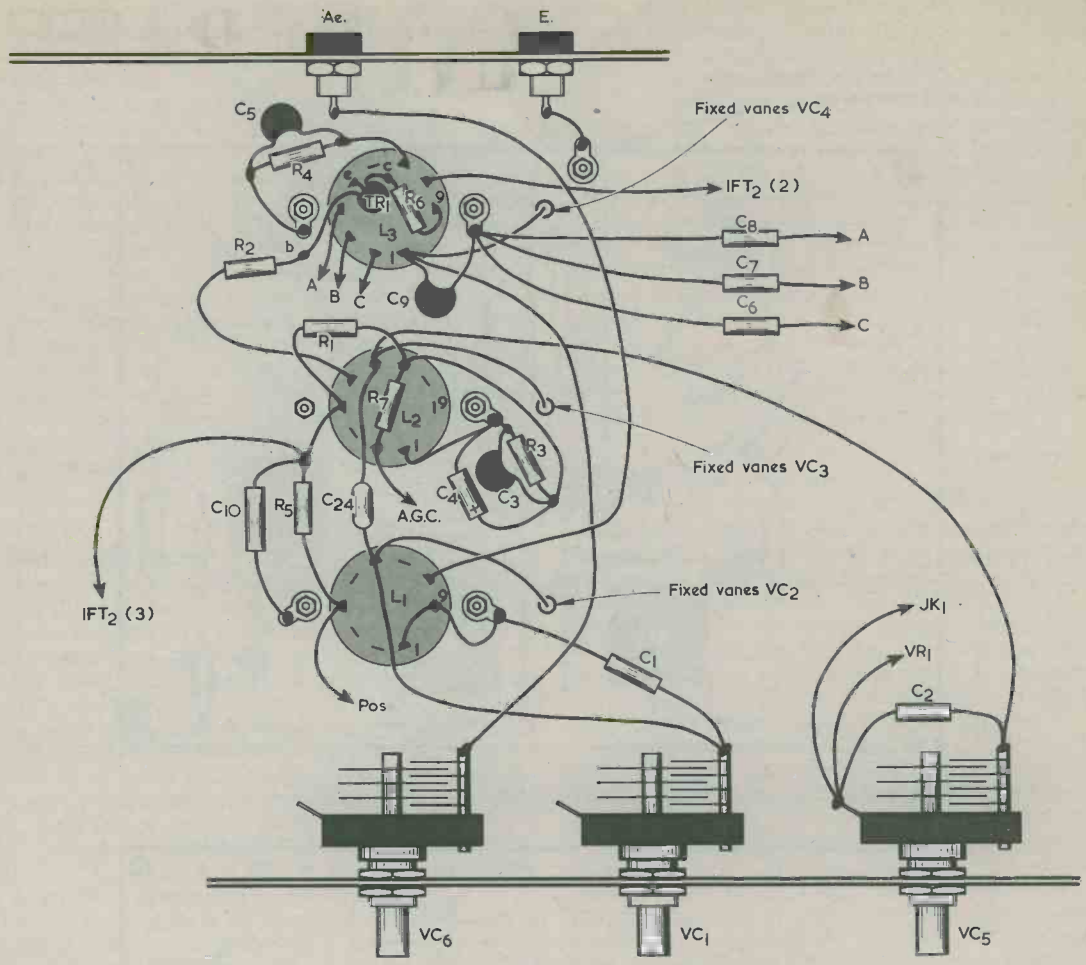


Fig. 6. The wiring of the aerial and mixer-oscillator stages. The moving vanes of VC6, VC1 and VC5 connect to chassis via their mounting bushes

COMPONENT PANEL

The component panel has already been cut out and has had its four mounting holes drilled. It now needs to be prepared to take the components and wiring shown in Fig. 7. The diagram shows the panel full size, and it may be traced so that the various holes can be accurately located. This point does not, however, apply to the i.f. transformers, whose positions are shown in outline only. The positions of the tag and lug mounting holes are marked out with the aid of the leaflet provided with each transformer. Central holes to allow core adjustment are needed also for IFT2 and IFT3. The holes for the component lead-outs should be $\frac{3}{64}$in. diameter.

When the board has been drilled, mount the i.f. transformers, the integrated circuit, R11, R12 and C17. Then wire up five insulated leads on the panel underside as shown by the broken lines in the upper view. Next, mount and connect the rest of the components and the two link wires on the component side of the board. These link wires are also insulated.

Non-insulated wiring on the panel underside is shown in the lower view in Fig. 7. The edge 'A-A' is identified in both views to assist in locating the wiring positions. In most instances the component lead-outs will be long enough to make the various interconnections but, where necessary, they may be extended by lengths of 22 s.w.g. tinned copper wire. Note that some chassis connections are made via the i.f. transformer mounting lugs.

Finally, add thin flexible insulated wires for the connections to external components and to the mixer-oscillator stage. These leads are made longer than will be required, and are cut down to the correct length when their remote ends are connected. Note that C19 is not on the panel but is soldered to VR1 at the tag connecting to the maximum volume end of its track.

Next, fit the panel in position on the chassis, with IFT3 nearer the front of the receiver, using four 6 B.A. bolts and nuts. Spacing washers or extra nuts are fitted to ensure that the panel underside wiring is well clear of

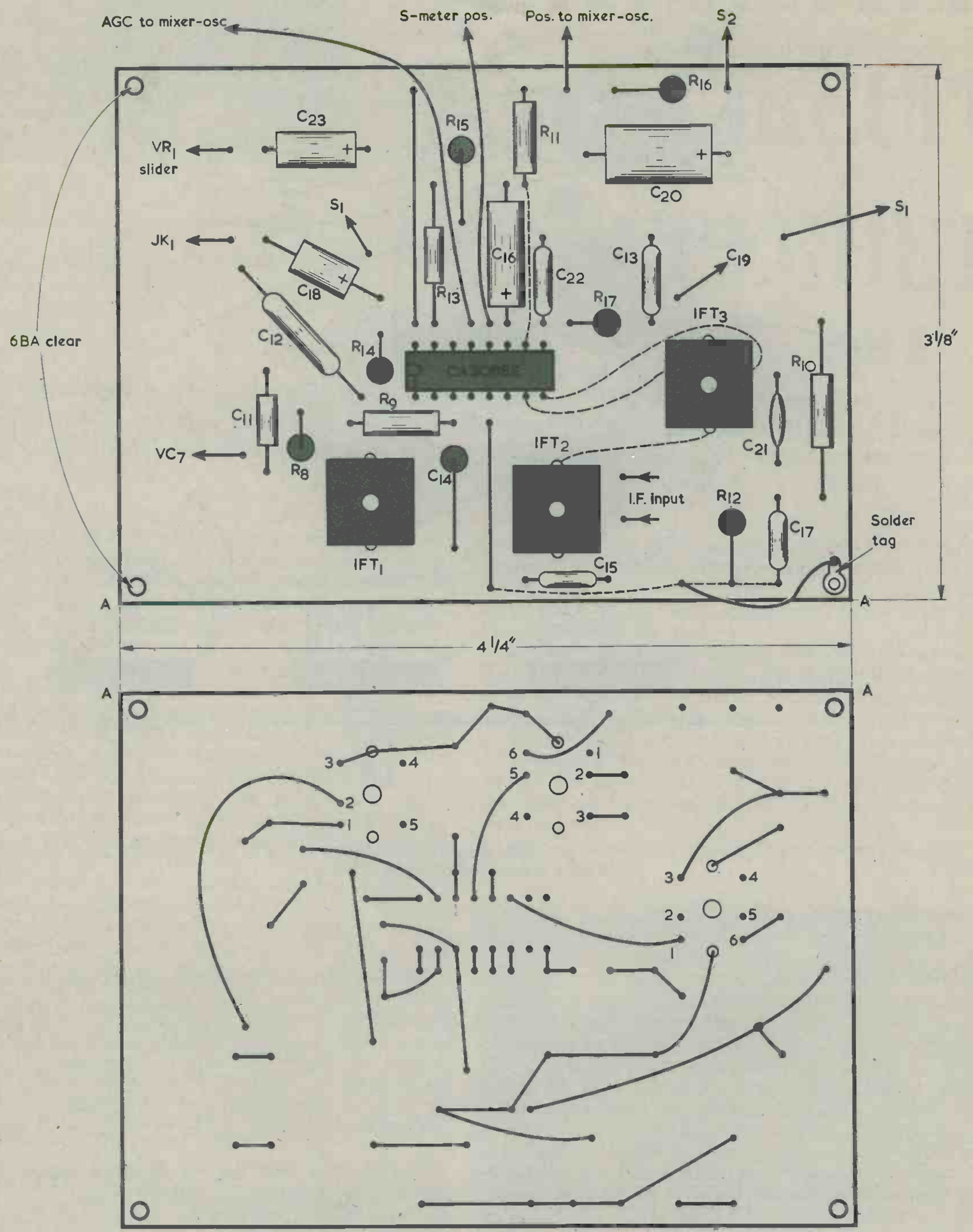


Fig. 7. Drilling and wiring details for the i.c. component panel. This is reproduced full size and the diagram may be traced

the chassis surface. The free ends of the flexible leads may then be connected to the external points, being shortened as necessary. Later, however, the panel has to be dismounted and positioned on its side for alignment purposes, and the flexible leads should be given sufficient length to enable this to be done.

Two of the leads from the panel connect to S1. This is simply a single pole 2-way rotary switch and its only requirement is that it is small in size so that it does not interfere with the coil in the L1 position. A suitable component would be the 'butterfly type' switch Type A retailed by Henry's Radio, Ltd. The author used a midget 3-pole 4-way switch with adjustable end stop in the prototype. The lead from the component panel to S2 connects to one tag of this switch. The remaining switch tag connects to the positive battery connector. The lead to the S-meter couples to the positive terminal of this component. Its negative terminal connects to chassis via a solder tag under one of its mounting nuts.

The negative battery connector is coupled to VR1 at the tag connecting to the minimum volume end of its track.

AERIAL AND EARTH

As with any short-wave receiver, an efficient aerial is essential if the set is to be used for serious listening. A good indoor aerial will provide reception of a reasonable number of stations, and quite acceptable results can be obtained with such an aerial. If possible, though, an outdoor aerial consisting of about 50 to 100 ft. of good quality aerial wire should be used, this being positioned high enough to be clear of buildings and other obstructions. With an aerial of this nature the receiver should provide excellent world-wide reception.

If a short indoor aerial is to be used permanently, it will probably be beneficial to make the aerial connection to pin 6 of L1 instead of pin 8. This will provide a very worthwhile increase in signal strength.

An earth connection is by no means necessary, and is only really likely to be of benefit if the constructor is interested in medium wave Dx, or in the 160 and 80 metre amateur bands. At these frequencies an earth connection will produce a very noticeable increase in signal strength.

ALIGNMENT

As was just mentioned, it is necessary to temporarily dismount the component panel and turn it on its side to enable the i.f. circuits to be aligned. A chassis connection to the panel can be made via a short piece of wire.

Insert the Range 2 coils (Blue coil at the front, Yellow in the middle and Red at the rear), connect an aerial and headphones and switch on. Set VC1, VC5 and VC6 to about half maximum capacitance. The i.f. transformers are pre-aligned at the factory and their cores should be sufficiently near the final settings required to give quite good i.f. sensitivity. Adjusting the main tuning control should allow reception of a few stations. The three plug-in coils are supplied with their cores screwed right in. The cores should be adjusted so that about $\frac{3}{8}$in. of the threaded brass stem protrudes from the top of each former.

Tune to a station at a setting of about 50 on the tuning dial and adjust the cores of L1, and then L2, to obtain a peak reading in the S-meter.

I.F. transformers IFT2 and IFT3 are adjusted next with the receiver carefully tuned to a station which is not prone to fading. Each i.f. transformer has two cores, one reached from above and the other reached from below. They should only be adjusted with a proper trimming tool, and the Denco trimming tool type TT5 is suitable.

First adjust the upper core of IFT3 and then its lower core, following with the upper and lower cores of IFT2 in that order. Repeat the procedure several times to ensure that the alignment is at its optimum. All these adjustments are for maximum reading in the S-meter.

Switch off, remount the component panel on the chassis and then switch on again. Set VC7 to approximately half maximum capacitance and accurately tune in a weak station. Switch on the b.f.o. and adjust the core of IFT1 for a whistle or heterodyne if one is not already present. Adjust the core of IFT1 for the lowest possible note.

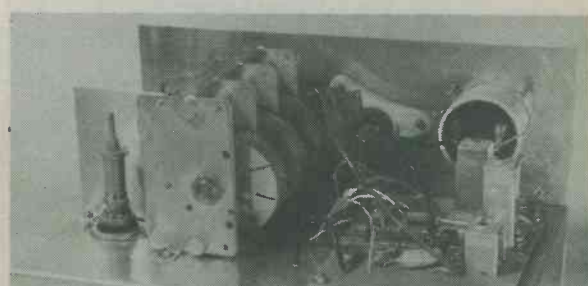
Switch the b.f.o. off. Next, plug in the Range 3 and Range 4 coils in turn, adopting the same procedure for setting up their cores as was used on Range 2.

OPERATING NOTES

If the main interest is in the short-wave broadcast bands then Range 4 will be the range of principal interest, since most of the popular broadcast bands are included in its coverage. For amateur band listening, Range 3 covers the 160 and 80 metre bands whilst Range 4 includes the 40 and 20 metre bands, the latter being in general the best for Dx reception. Range 2 provides medium wave reception and may be employed for medium wave Dx or, with the optional add-on a.f. output stage, normal entertainment listening.

On short waves always keep VC1 and VC5 adjusted for peak signal strength when receiving a.m. signals. The S-meter can be used as a tuning meter here.

The b.f.o. is switched in for s.s.b. and c.w. (morse) reception. For best results on s.s.b. the a.f. gain control should be turned to maximum and VC5 adjusted to peak the signal. VC1 can also be peaked on weak signals, but with stronger ones it must be backed off slightly. This is necessary as b.f.o. injection has been kept low to prevent the formation of an a.g.c. voltage which would reduce sensitivity. Strong s.s.b. signals can therefore easily swamp the b.f.o., resulting in a poor quality audio signal.



Rear view of the receiver, showing the i.c. component panel in position

C.W. signals are peaked in the same way as a.m. signals, and the b.f.o. frequency control is adjusted to give a comfortable audio beat note.

If the S-meter should be found to be too sensitive, as could occur due to spread in the i.c. and component tolerances, a small value resistor may be inserted in series with it. The value can be found by experiment and will probably be of the order of 33Ω. The resistor can be inserted between the negative terminal of the meter and the chassis tag, in place of the wire currently fitted.

ADD-ON OUTPUT STAGE

The receiver, as described so far, has an output which is only suitable for high impedance headphones or any other medium to high impedance load. This output is relatively quite high, and a very simple output stage offering quite low voltage gain can be readily added for driving a speaker. The receiver can still be used with high impedance headphones when required, these now being plugged into the output from the add-on audio stage.

The addition of the output stage enables an external 25Ω speaker to be driven up to a maximum r.m.s. output of about 300mW.

The circuit of the output stage is given in Fig. 8. Four transistors are used, two (TR1 and TR2) as a Darlington pair driver and two (TR3 and TR4) as emitter follower output transistors.

The a.f. output of the i.c. from C18 is applied to the base of TR1 via R1 in the diagram. This transistor attenuates any i.f. signal that may still be present in the i.c. output and ensures overall stability. TR1 and TR2 provide a high level of amplification and couple into the bases of TR3 and TR4. These operate in a standard Class B configuration with TR3 amplifying positive half-cycles and TR4 negative half-cycles. R5 is adjusted to allow a small quiescent current to flow, thereby avoiding crossover distortion. The output emitters couple to the speaker by way of C2.

R3 and R2 form a potential divider which, at d.c., allows the output emitters to take up approximately half the supply potential under quiescent conditions. At a.c. these resistors appear in a negative feedback network comprising R3 and R2, the latter being in parallel, via R1, with the impedance at the a.f. output of the integrated circuit. A voltage gain of the order of 8 to 10 times is thereby given.

Capacitor C1 is the supply decoupling capacitor for the output stage. The accompanying Components List shows the parts required for the stage.

ASSEMBLY

The amplifier components are assembled on a piece of plain Veroboard of 0.15in. matrix having 16 holes by 16 holes. The component and wiring sides of this board are shown in Fig. 9.

First cut out the board and then drill the two 6 B.A. clear mounting holes. The components are fitted and wired as illustrated. As with Fig. 7, one edge of the board is marked 'A-A' to enable the wiring to be followed more readily.

An L-shaped bracket having the same width as the board is made up from 18 s.w.g. aluminium sheet, and it secures the board to the chassis rear next to the earth socket in the manner shown in the photograph of the chassis underside. The board takes up its chassis

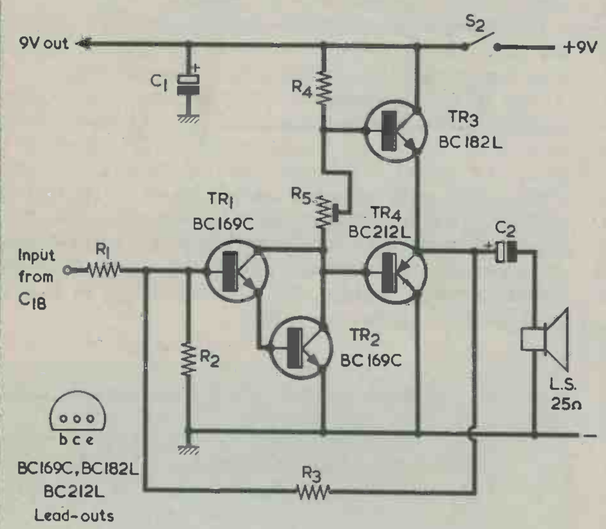


Fig. 8. The circuit of the optional audio outpu stage

Resistors
(All fixed values ¼ watt 5%)

R1	1.8kΩ
R2	5.6kΩ
R3	18kΩ
R4	1kΩ
R5	1kΩ preset potentiometer, standard skeleton, horizontal

Capacitors

C1	100μF electrolytic, 10 V. Wkg.
C2	100μF electrolytic, 10 V. Wkg.

Transistors

TR1	BC169C
TR2	BC169C
TR3	BC182L
TR4	BC212L

Miscellaneous
25Ω speaker
3.5mm. jack plug
Plain Veroboard panel, 0.15in. matrix, 16 holes by 16 holes
18 s.w.g. aluminium for mounting bracket

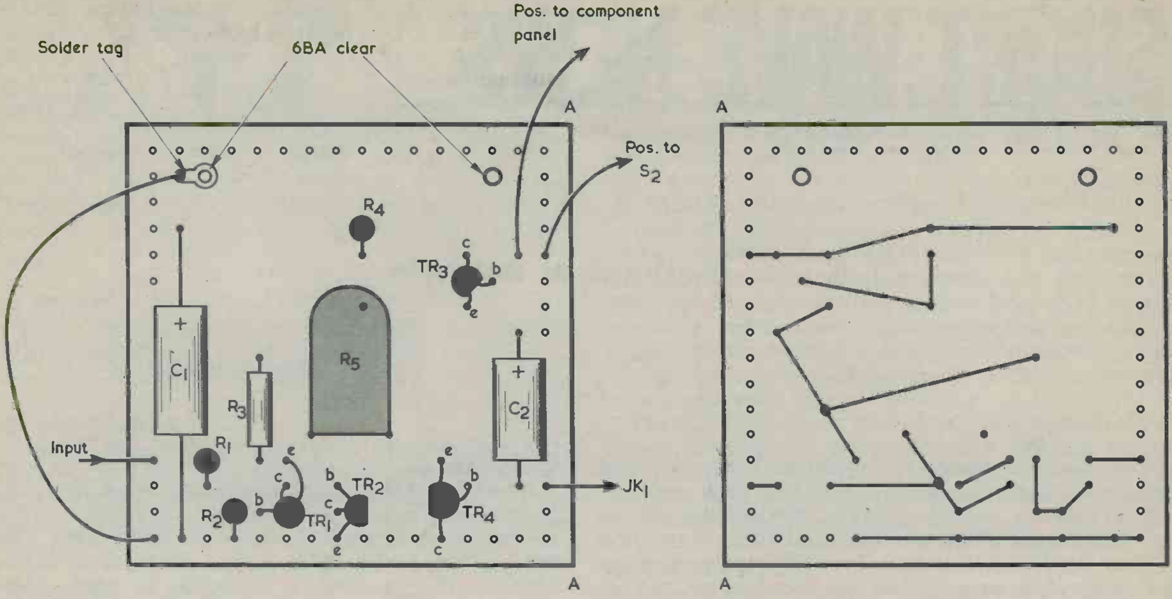
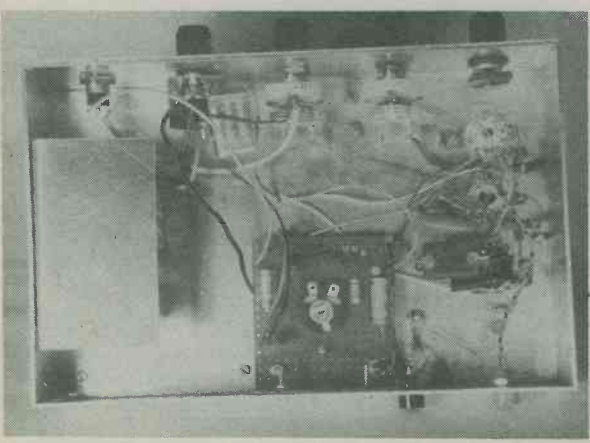


Fig. 9. The component and wiring sides of the audio output stage board

connection by means of a solder tag at one of the mounting holes. This is bolted to the bracket which, in turn, is bolted to the chassis.



How the add-on audio output stage is mounted underneath the chassis

The receiver wiring has to be modified slightly to bring the audio stage into circuit. The lead from C18 on the i.c. board to JK1 is unsoldered at JK1 and taken to the input of the audio board. A lead from the negative side of C2 on the audio board is connected to JK1 in place of the lead just removed.

The positive supply lead from the i.c. panel to S2 is disconnected at S2 and connected to the positive rail on the audio board. Another lead from this positive rail is then taken to S2.

The final process required is that of setting up R5 on the audio board for the correct quiescent current in the two output transistors. Set R5 to give minimum resistance between the two output transistor bases by turning its slider fully clockwise. Insert a multimeter switched to read 20 to 50mA f.s.d. in the positive supply lead from the battery. Put the receiver a.f. gain control to its minimum setting.

Switch the receiver on and observe the meter. This should indicate a current flow of about 10 to 15mA. Slowly adjust R5 to insert increasing resistance between the output transistor bases until the meter reading increases by 2.5mA. The meter can then be removed, and the set is once more ready for use.

With the add-on output stage incorporated, a 25Ω speaker may be plugged into JK1. So also may the high impedance headphones, which will now offer a higher volume of sound. Normally, the a.f. gain of the receiver will need to be at a lower setting than before when headphones are plugged in. ■

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times=GMT *Frequencies*=kHz

Clandestine transmitters come and go, they rise in the firmament, blaze like super novas and then ignominiously fizzle out, leaving a black hole where they once so brilliantly shone. Recent military and political events in the Far and Middle East have had their repercussions on the short wave scene and in the deceased column we must list our old friend the "Voice of Iraqi Kurdistan". With Iranian support the Kurds had resisted inclusion into the Iraqi state and had, from time to time, operated the transmitter whose precise location was never detected. The site has now been found, it was underground and well camouflaged near Darband in the mountains of Northern Iraq. The equipment had been smashed by the Kurds.

Then we have the demise of the clandestine "Voice of the National United Front of Cambodia" which, towards the end of the siege of Phnom-Penh, greatly increased the total hours of transmission time but has not been heard since late April and the occupation of the capital by the Kmere Rouge. The Phnom-Penh domestic service which abruptly ceased transmissions in mid-April returned to the air later with the identification "Here is Phnom-Penh, the broadcasting station of the National United Front of Cambodia Radio."

In the births column we have the "Voice of Chilean Resistance" which is to be heard daily from 2330 to 2400 on 7145 via the facilities of Radio Algiers and the Chilean resistance movement resident in Algeria.

CURRENT SCHEDULES

● PORTUGAL

Radio Portugal, "Emissora Nacional", Lisbon, presents an External Service in English to Europe from 2030 to 2100 on **6025** and **9740**. Other transmissions in English are as follows – from 0230 to 0300 and from 0430 to 0500 to USA and Canada (East and West Coast) on **6025** and **11935**; from 1400 to 1430 to India on **17895** and **21495**; from 1600 to 1630 to the Middle East on **17895** and **21495**; from 1800 to 1900 to East and West Africa on **11875** and **21495**.

● DOMINICAN REPUBLIC

"Radio-Television Dominican Onda Internacional", Santo Domingo, operates an External Service in English from 2145 to 2200 on **9505** consisting of both home and world news.

● ISRAEL

The Israel Broadcasting Authority, Jerusalem, offers programmes in English as follows – from 0500 to 0515 to Europe and North America on **5900, 7395, 9009, 9815, 11700, 11960, 12025** and on **15240**; from 1130 to 1200 to Europe and N. America on **9009, 11960, 12025, 15240** and on **21590**; from 1830 to 1845 to the Middle East (relay of Arab World Service) on **5915**; from 2000 to 2055 to Europe, North America and Africa on **7395, 9009, 9630, 9730, 9815, 11960, 12025** and on **15240**.

● TANZANIA

"Radio Tanzania", Dar-es-Salaam, has a Home Service in Swahili from 0300 to 0700 on **4825** and **5050**; from 0700 to 2110 on **7165** and **9550** (also from 1600 to 2110 on **4825**). The Commercial Service operates from 0300 to 0500 on **4785**; from 0900 to 1100 on **7280** and **9530** and from 1400 to 2015 on **5050**.

● TUNISIA

The Tunisian Home Service, all programmes in Arabic, can be heard from sign-on at 0458 to sign-off at 2200 on **11970** and **15225**.

● INDONESIA

Radio Republik Indonesia currently radiates the National Programme from 1000 to 1600 and from 2200 to 0100 on **4805, 6045** and on **11720**; from 0500 to 0930 on **6045, 7270** and on **11720**.

● PORTUGAL

An External Service from Lisbon is that in Portuguese to Portuguese workers resident in European countries from 1200 to 1300 and from 1730 to 1800 over the "Radio Trans-Europa" transmitter at Sines on **6115**.

● SOUTH AFRICA

"'Radio RSA' – The Voice of South Africa", Johannesburg, presents an External Service in English as follows – from 0300 to 0425 to East and Central Africa and the Middle East on **3995, 4875, 5980** and on **7270**; from 0615 to 0705 to West Africa on **11900, 15220** and on **17780**; from 1000 to 1045 to South, North and East Africa on **11970** and **15220**; from 1100 to 1200 to Central and East Africa on **11900, 15220** and on **21535**; from 1300 to 1550 to Central and East Africa on **11900** (to 1456), **15220** and on **21535**; from 1600 to 1650 to East Africa and the Middle East on **7270, 11900** and on **15175**; from 2100 to 2150 to West Africa and Europe on **4875, 5980, 7270** and on **11900**; from 2230 to 2320 to North America on **5980, 9525, 9695** and on **11900.**

● CANADA
Radio Canada International, Sackville, has re-arranged the morning broadcast in English directed to Africa and the transmissions are now of 20 minutes duration; from 0620 to 0640, 0700 to 0720 and from 0740 to 0800 on **7155** and **9685** via BBC transmitters at Daventry and on **7290, 9605** and **17820** via the Malta relay.

● SPAIN
Radio Nacional Espana, Madrid, has replaced the **9620** frequency with that of **9505** for the broadcast in Spanish to Europe from 1000 to 2030.

● AUSTRALIA
Radio Australia's programme in English directed to the U.K. and Europe may be heard from 0645 to 0745 on **9570** and on **11765**, the newscast being at 0715, the latter being repeated from 0815 to 0830 suitably updated.

● SOUTH VIETNAM
Saigon Radio domestic service is reportedly (BBC Monitoring Service) adhering to the following schedule – from 0700 to 1600 and from 2200 to 0400 on **4877, 6165, 7175, 7245, 9620** and on **9755.** Identification in Vietnamese is "This is the liberated Saigon Broadcasting Radio – the Voice of the Saigon-Gia Dinh people broadcasting from Saigon".

AROUND THE DIAL
Some of the transmissions recently logged by us which may possibly interest other listeners are listed monthly under this heading.

● CLANDESTINE
Azad Kashmir is still currently using the **3383** channel and was logged at 1822 when signing-off with their interminably long choral anthem with a surprisingly high signal strength.

● MOZAMBIQUE
Lourenco Marques is often to be heard here in the U.K. on the 90m band channels of **3210** and **3265.** The former frequency was entered in the logbook at 1803, at which time a programme of guitar music with announcements by male and female announcers in Portuguese was heard; the latter channel at 1748 with a programme of Afrikaans pops. The schedule of the **3210** transmitter is from 0400 to 0600 and from 1500 to 2210, that of the **3265** transmitter being from 1630 to 0400.

RCM Beira can be heard on **3235**, being listed here at 1742 with country and western music records. Schedule is from 1500 to 1830.

● COLOMBIA
Radio Catatumbo, Ocana, at 0202 on a measured **4768.5,** OM with identification, commercials and then programme of local pop records. This one is listed on **4765** and has a schedule from 1000 to 0400.

● HONDURAS
HRPL3 Radio Progreso, El Progreso, at 0212 on **4920,** OM with clear identification, songs in Spanish, local music. Schedule is from 1100 to 0500.

● COSTA RICA
TIHB Radio Capital, San Jose, at 0205 on **4832,** lively pop songs in Spanish, identification at 0214. TIHB has a 24 hour schedule and, although listed as a 1kW transmitter, is often one of the best signals on the 60m band, especially around 0200.

● PERU
OAX8F Radio Atlantida, Iquitos, at 0300 on a measured **4790** (listed **4785**) with full identification, commercials, local announcements and local music. This one has been drifting around from **4785** to **4790** for some time and was logged earlier this year on **4788** on several occasions. The schedule is from 0900 to 0455 but has been reportedly signing-off on Sundays at 0400 and weekdays as late as 0600.

OAX2S Radio Jaen, Jaen, at 0220 on **5005,** OM with songs in Spanish, announcements but no positive identification at 0230 (tentative logging). The observed schedule of this **250** watt transmitter is from 1045 to 1250 and from 0000 to 0400.

● BRASIL
ZYK28 Radio Olinda, Pernambuco, at 0230 on **3375,** full identification, announcements, local pops. Schedule is from 0800 to 0325 but reportedly heard as late as 0400 on occasions.

● ECUADOR
HCWE1 Radio Nacional Espejo, Quito, at 0251 on **4679,** OM with full identification, local music and songs in Spanish. Schedule is of 24 hour duration.

● VENEZUELA
YVRA Radio Monogas, Maturin, at 0235 on **3325,** local pops, OM in Spanish with announcements and commercials. This one is a relatively easy-to-log Latin American on the 90m band, the power is 5kW and the schedule is from 1000 to 0400 but has been heard signing-off as late as 0540. Sometimes also identifies as "Voz de Matarin", which all helps towards the fun and games!

● AUSTRALIA
ABC Brisbane as early as 1910 (rather surprisingly) on **4920,** OM with announcements in a record programme including such popular hits as "Puppet on a String" etc., with full identification and a newscast, including both world and local news at 1930.

● KENYA
Nairobi at 1853 on **4804,** OM with a talk in English about the developing countries of Africa. This one is not all that easy to log and from practical experience has been found to 'vanish' from the scene for long periods at a time. This channel carries the Home Service in English and the schedule is from 0255 (Sundays 0355) to 0630 and from 1300 to 2010 (Saturdays 2110) and the power is 5kW.

● NIGERIA
NBC Kaduna, logged at 1826 on **3396,** light orchestral music programme. This is the North Central State Programme and the schedule is from 0430 to 0705 and from 1630 to 2305, the power is 10kW.

In your workshop

This month Smithy the Serviceman returns to the subject of operational amplifiers. He discusses the internal circuitry of the 741 op-amp and then deals with offset null adjustments and basic negative feedback circuits

"But dash it all, Smithy," wheedled Dick, "you *promised*."

Exasperated, the Serviceman clattered his soldering iron down on its rest.

"Am I ever," he snorted, "going to get any peace from you today?"

"But you *promised*," repeated Dick. "In our last technical session you started telling me about operational amplifiers and you then described the 709 op-amp."

"Well?"

"You next said that you'd give me some more gen on op-amps, including the 741, at a later date."

"So?"

"Well, this is the later date! It's ages since you discussed the 709 and I'm getting more and more agog with curiosity about these op-amps."

741 OP-AMP

"Perhaps," said Smithy with heavy sarcasm, "it may have escaped your notice that, since the last time, we've both of us been up to our ears in work. Neither of us have had time to even think of op-amps."

"All the more reason," argued Dick, "for us to take a little time out and deal with something which doesn't have to do with regular servicing."

Smithy mopped his brow and considered Dick's suggestion. It was certainly very tempting. The two of them had been under exceptionally heavy pressure of work since he had expounded on the functioning of the 709 operational amplifier, and they had been gradually getting more and more on each other's nerves. He suddenly reached a decision, switched off the television chassis on his bench and pushed it back.

"Oh, all right then," he stated. "It won't do us any harm to have a short break from routine servicing work, provided that it *is* a short break. I'll get out my data book on linear integrated circuits."

As Smithy walked over to the filing cabinet his delighted assistant brought his stool over and perched himself alongside Smithy's bench. Smithy returned with a bulky manufacturer's data book and placed it on his bench.

"Now, let me quickly recap on what I said last time," he remarked, as he settled himself on his own stool. "I told you that two of the most popular op-amps which are available these days are the 709 and the 741. We then went through the internal circuit of the 709 and saw that an offset voltage has to be applied to the input terminals if the op-amp output is to be at earth potential."

"That earth potential," chimed in Dick, "being mid-way between the positive and negative supply rails."

"Correct," confirmed Smithy. "We saw also that with the 709 we require two external capacitive feedback loops to provide frequency compensation. These loops give high frequency attentuation and ensure that the op-amp is kept stable despite it's exceptionally high voltage gain."

"And that gain," said Dick with satisfaction, "was no less than 45,000 times typical. That's what I *call* a voltage gain!"

"Indeed," concurred Smithy. "Well, in a few moments we'll press on and take a look at the 741 op-amp, which is an improvement on the 709, but before we do that I want to discuss some of the disadvantages of the 709. The first of these is the necessity of having to add the external frequency compensating components. Ideally, an integrated circuit should have all its essential parts neatly tucked away inside it, so that all you have to connect up to it are a power supply and the input and output circuits. There are two further disadvantages with the 709 which I didn't mention last time. One of these is that the 709 is liable to 'latch up', or stick at an extreme positive or negative output level, if both its inputs are taken too far away from earth potential. And the other is that the output stage can burn out if too much current is drawn from it due to, say, an accidental short-circuit. Because of this last factor it is normally desirable to insert a current limiting resistor between the output pin of the 709 and the output circuit into which it feeds, and this means yet another external discrete component."

"I see," said Dick thoughtfully. "Do you get any of these disadvantages with the 741 op-amp?"

"All these snags," stated Smithy. "are completely absent with the 741. The 741 doesn't require external compensating components. it doesn't latch up and its output is short-circuit proof."

"Blimey," said Dick. "That *is* an improvement. If the 741 is so good, why is it that there are so many 709's knocking around?"

"Partly because the 709 is still a jolly good op-amp," replied Smithy. "It can give an excellent performance if you don't mind adding the extra external components it needs and if you treat it with a little care. Also, if the external frequency compensating capacitors are given very low values it can be made to operate at frequencies higher than the 741. So a 709 may be a better choice than a 741 for high frequency applications. And having said all that, let's now get down to the 741. First of all, we'll take a look at its

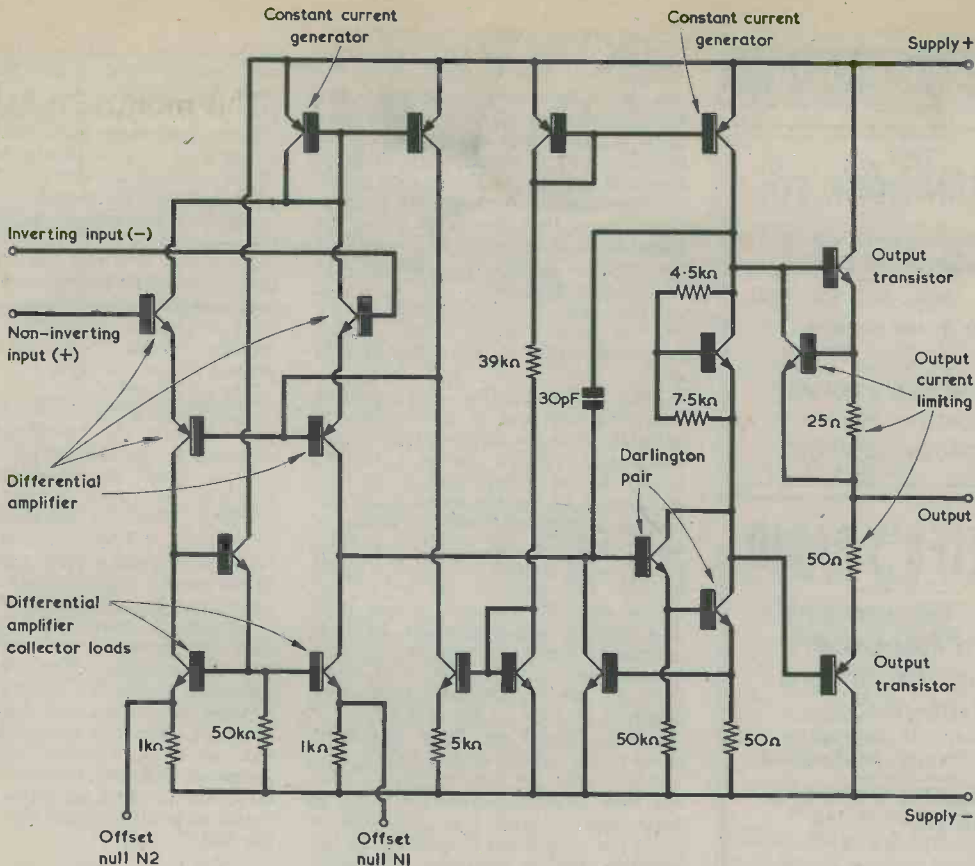


Fig. 1. The internal circuitry of the 741 operational amplifier

internal circuitry."

Smithy opened the data book and pointed to a diagram giving the internal circuit of the 741 operational amplifier. (Fig. 1).

"Dear, oh dear," sighed Dick. "This has got more transistors in it than the 709."

"True, true," agreed Smithy. "Even so, it's still fairly easy to find your way around the circuit. We'll start off with the differential amplifier to which the inverting and non-inverting inputs are applied. In the 709 the differential amplifier consists of two transistors with a constant current generator between their common emitter connection and the negative supply rail. The differential amplifier is the other way round in the 741 and what is effectively a constant current source couples the differential amplifier transistors to the *positive* supply rail. Also, the two single differential amplifier transistors in the 709 are replaced in the 741 by two *pairs* of transistors. For instance, the non-inverting input goes to the base of an n.p.n. transistor whose emitter couples to the emitter of the p.n.p. transistor immediately below it. That's one of the pairs. The inverting input goes to another n.p.n. transistor with a p.n.p. transistor immediately below it, and that's the second of the differential amplifier pairs."

"The collectors of the p.n.p. transistors," remarked Dick, "connect to the collectors of two n.p.n. transistors whose emitters go to the negative rail via 1kΩ resistors. What do those bottom two transistors do?"

"They act as high value collector load resistors for the p.n.p. transistors," stated Smithy. "As I said last time, it's often easier to add a transistor to an integrated circuit than it is to add a resistor."

"The emitters of those bottom two transistors," went on Dick, staring closely at the circuit, "are taken out to two pins marked 'Offset Null'. What are those pins for, Smithy?"

"They enable an external circuit to be applied which cancels out the offset input voltage," replied Smithy. "But forget about those two pins for the moment and just assume that nothing is connected to them."

DARLINGTON PAIR

"Righty-ho," said Dick obligingly. "In the 709 the output from the differential amplifier is taken from the collector of the right-hand transistor and fed to a Darlington pair."

"The same sort of thing happens with the 741," said Smithy. "There is a direct connection from the collector of the right-hand p.n.p. transistor to the input base of a Darlington pair. This Darlington pair then feeds the bases of the emitter follower output transistors directly, current from the positive rail for the Darlington pair collectors being supplied via a second constant current generator."

"I notice," remarked Dick, "that the two output transistor bases aren't connected directly together, as they are in the 709. There's a transistor with 45kΩ and 7.5kΩ biasing resistors between them. Will this transistor keep the output transistors turned on all the time?"

"It will," confirmed Smithy. "And so you don't get crossover distortion, as you do with the 709. Now, let's have a quick look at signal polarity as a signal goes through the amplifier. If we start at the inverting input, the signal at the collector of the p.n.p. transistor in the inverting input pair is in phase with the signal at the input, because that signal has gone through what are effectively an emitter follower and a grounded base transistor. The signal is then inverted by the Darlington pair before it hits the output stage. So the inversion given by the Darlington pair provides the inversion needed by the inverting input."

"This circuit," said Dick cheerfully, "seems to be a lot easier than the 709 one. Now, how about a signal at the non-inverting input? This will obviously be inverted once by the differential amplifier and it will then be inverted a second time by the Darlington pair."

"Very good," commended Smithy. "And those two inversions bring the signal back to its initial phase, so that the op-amp output is in phase with its non-inverting input."

"You said that the output of the 741 is short-circuit proof," Dick reminded Smithy. "How is that arrived at?"

"If," replied Smithy, "the output is fully negative and is short-circuited to earth or to the positive supply rail, the current which flows is mainly limited by the 50Ω resistor in the output circuit. If, on the other hand, the output is short-circuited to earth or to the negative rail when it is fully positive, the output current is limited by the 25Ω resistor in the output circuit and the transistor whose base and emitter are connected to that resistor. There's a very crafty little circuit here and, to explain it more fully, I'll identify the three transistors involved as TRA, TRB and TRC."

Smithy added the three identifications to the circuit. (Fig. 2.)

"Now let's say," he went on, "that the base of output transistor TRB is fully positive and that the current from the output pin to earth or to the negative rail is gradually increased. As soon as the increasing current in the 25Ω resistor reaches about 25mA a voltage of around 0.6 volt appears across it. This turns on TRC, whereupon some of the relatively low constant current from TRA starts to flow in the output. If the potential on the output pin is taken further negative,

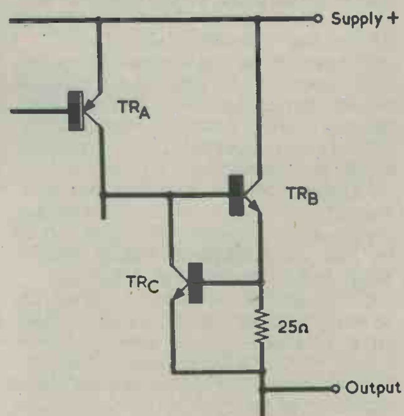


Fig. 2. Detail illustrating the functioning of the positive output current limiting section of the 741

the collector of TRA is correspondingly pulled negative by TRC, whereupon the base voltage of TRB falls also. In consequence the only current that can flow in the output is the 25mA in the 25Ω resistor plus a proportion of the constant current from TRA."

"Stap me," exclaimed Dick. "That *is* neat. Well, you've explained the short-circuit proof bit, Smithy. Now tell me how it is that the 741 doesn't need external frequency compensation components."

"I should tell you that?" snorted Smithy. "Dash it all, the reason is staring you in the face."

"Is it? Where?"

"Look at the input of the Darlington pair. What's the component which connects to the first base?"

Dick stared closely at the circuit. Suddenly, the truth dawned.

"Why, there's a capacitor there!" he gasped. "Stone me, Smithy, somebody's smuggled a dirty great 30 puff capacitor in amongst all the transistors and the resistors!"

"Exactly," agreed Smithy. "And that dirty great 30 puff capacitor, as you call it, couples effectively from the collectors of the Darlington pair back to their input base, and it provides all the high frequency compensation that the op-amp requires. Getting a capacitor diffused into an integrated circuit is no mean feat, and this is the major step which raises the 741 above the 709."

OFFSET NULL

"This 741 op-amp," said Dick enthusiastically, "certainly packs in some neat schemes. The only bit you haven't explained so far are those two offset null pins. Can you carry on to them next, Smithy."

"Okey-doke," replied Smithy obligingly. "However, I think that the best thing for me to do here will be to deal with the three most common methods of obtaining offset null with both the 741 *and* the 709."

"For a start," commented Dick, "you could tell me what 'offset null' means!"

"Fair enough," replied Smithy. "Well, 'offset null' describes the process by means of which you cancel out the offset input voltage and bring the op-amp output to earth level. Let's get my pad over."

Smithy drew his note-pad towards him and sketched out a circuit. (Fig. 3(a).)

"Here's a simple method of getting offset null," he continued. "I've drawn the op-amp in the usual manner as a triangle on its side with the output appearing at the apex. The op-amp I've shown here can be a 741 or, if the external frequency compensating components are added, a 709. The inverting input of the amplifier connects to earth via a resistor which in practice could be part of the op-amp negative feedback circuit. The non-inverting input connects to the slider of a pre-set

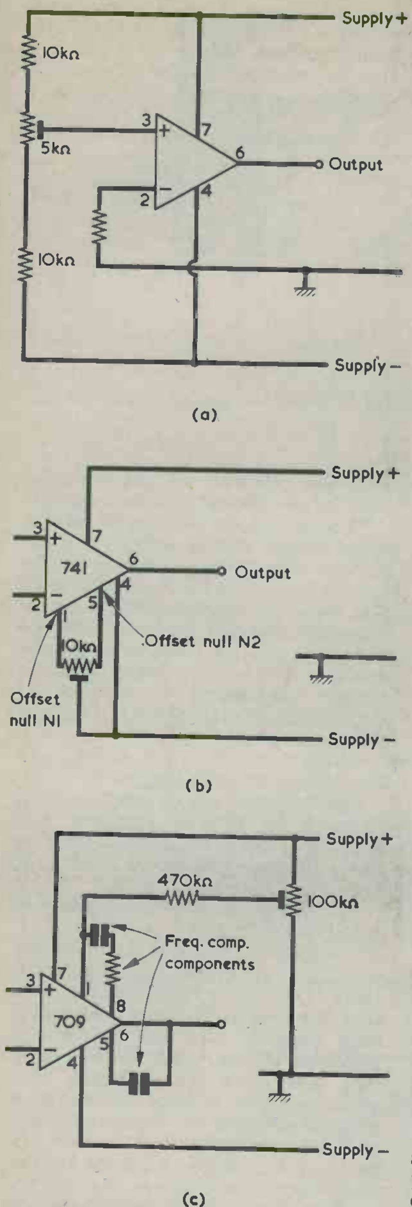


Fig. 3(a). A simple means of obtaining null offset. Pin numbers shown here and in subsequent diagrams apply to the 8 pin version of the 709 or 741
(b). External offset null circuit for the 741 op-amp
(c). A null offset control circuit suitable for the 709

pot which sits between two equal value fixed resistors. I've given the pot and the resistors values which are typical of what you'll find in practical circuits. All you have to do with this circuit is adjust the pot until the output of the op-amp is at earth potential. This approach can also be used to cancel out the offset voltage when the inverting input is returned to a potential which is positive or negative of earth. It might be necessary then, of course, to alter the fixed resistor values so that the pot slider can be brought up to the voltage at the inverting input."

"That method," said Dick critically, "doesn't actually cancel out the offset voltage at all, does it? You'll still have the offset voltage existing between the two inputs after you've set up the pot."

Smithy shot a surprised glance at his assistant.

"Hey, you're bright today."

Dick beamed.

"I have my moments," he responded cheerfully. "Behind this lofty brow of mine throbs a dynamic and powerful brain which has never yet been exercised to the full."

"Humph," grunted Smithy. "Well, your comment is certainly correct. The method I've shown for obtaining an offset null is only used when you're interested in input signals at the inverting input and it doesn't matter if the voltage at the non-inverting input is a little removed from that at the inverting input. Incidentally, if you use this circuit with a 741 there's no need to make any connections to its two offset null pins. You simply leave them open-circuit."

"I've just had another great thought."

"This is getting worrying. What is it this time?"

"Well," said Dick, "we know that op-amps have fantastically high voltage gains. Because of this high gain, won't there have to be a very critical setting of the pot to bring the op-amp output to earth potential?"

"Blimey, you really *are* with it! And you're perfectly right again, too. When the op-amp is employed without an external negative feedback circuit the setting up of the pot in that circuit is extremely critical. When, however, the feedback circuit is added, the overall gain is reduced, normally, to something between unity and some 200 times according to circuit requirements. The pot adjustment is then very much less critical. For simplicity, I didn't put a feedback circuit in my diagram, but I'll be showing you how such a circuit works shortly."

Smithy proceeded to sketch out a second circuit. (Fig. 3(b).)

"Now," he stated, "when it's required that the op-amp output be at earth potential when both the inputs are at the same potential, it's necessary to start making null adjustments to the internal circuitry of the op-amp. If this is a 741 you connect an external 10kΩ pot between the two null points and couple the pot slider to the negative supply rail as I've shown here. As you can see, adjusting this pot varies the collector loads for the 741 differential amplifier. Okay?"

"Sure. What do you do if it's a 709?"

"There's a neat approach here," said Smithy, "which is recommended

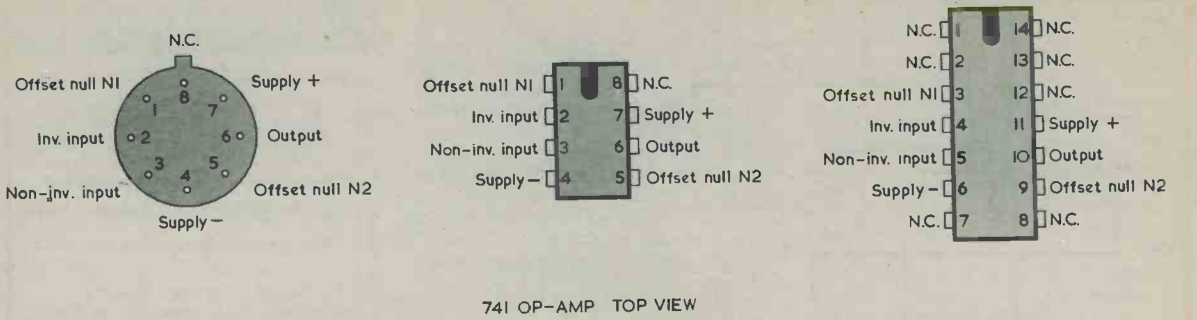


Fig. 4. Pin layouts for the 741 in its three most readily available packages

by R.S. Components. Here's the idea."

Smithy drew a third offset null adjustment circuit. (Fig. 3(c).)

"You saw the internal circuit of the 709 during our last session," he stated. "The 470kΩ resistor I've shown here couples to the internal frequency compensating pin which happens to connect, inside the i.c., to the collector of the inverting input transistor in the differential amplifier. Adjusting the 100kΩ pot in the null circuit thus varies the effective collector load for that transistor."

741 PARAMETERS

Smithy turned a page in the data book on his bench and showed his assistant some of the characteristics of the 741 operational amplifier.

"The 741," remarked Dick, "has a higher typical voltage gain than the 709. According to this book, it's 200,000 times."

"It also has a higher maximum input voltage swing," said Smithy, "as well as a higher maximum dissipation figure. Like the 709, it's available in the round 8-lead TO99 can as well as in 8 pin dual-in-line and 14 pin dual-in-line packages. The supply, input and output pins are also the same as for the 709. The three 709 pins which are employed for frequency compensation appear, in the 741, as two null offset pins and one 'no connection' pin."

Smithy pointed to the pin layout diagrams for the 741 in the data book. (Fig. 4.)

"It's funny," remarked Dick, "how pin layout diagrams for i.c.'s are always top views with the pins pointing away from you, whilst lead layout diagrams for transistors are always the other way round with the leads pointing towards you."

"Like the beefburger," commented Smithy, shrugging his shoulders, "that's one of the little mysteries of life. Let's examine some typical feedback circuits next."

Smithy drew out a further circuit. (Fig. 5(a).)

"This," he continued, "is pretty well the classic resistive feedback circuit for an op-amp. The amplifier used may be a 741. It could also be a 709, in which case you'd need to add the external frequency compensating components and use the alternative offset null circuit I showed you. Also, with a 709 it's customary to insert a 51Ω resistor between the output and the load, at the point I've marked with a cross."

"Let's stick with the 741," said Dick, "it makes things less complicated."

"All right," responded Smithy. "From now on all the circuits I'll show you will use the 741, although they could alternatively employ the 709 if the appropriate external components are fitted. Now, there are two resistors in the present circuit which are marked R1 and R2. R2 is the feedback resistor and R1 is a resistor in series with the input signal source. It is assumed that the latter has an internal resistance of zero. Now, the overall voltage gain in the circuit is equal to R2 divided by R1."

"That seems pretty obvious," commented Dick. "Let's say that R2 divided by R1 is 5. Then, if the input goes positive by 1 volt the output will swing negative by 5 volts. Despite the very high gain of the op-amp, the output can't swing negative by more than 5 volts because this would then shift the potential of the inverting input by an impossibly high amount."

"You've got the idea," said Smithy approvingly. "There will in practice be very tiny shifts in voltage at the inverting input but these will be so small that they can be completely ignored. The inverting input can in consequence be looked upon as a 'virtual earth' and this fact can be very useful in some circuit calculations. Incidentally, if R2 is equal to R1 the overall voltage gain is unity."

"What sort of supply voltages do you need in a circuit like this?"

"The two rails can be anything from about 6 to 15 volts positive and negative of earth. Neither rail must be above the maximum figure of 18 volts positive or negative of earth."

"What sort of values do you require in the two resistors?"

"Normally," said Smithy, "you try to keep them above 1kΩ and below 1MΩ. There's no hard and fast rule here but resistance values above 1kΩ keep currents nice and low whilst resistance values below 1MΩ ensure that you don't get problems with offset current or pick-up of mains hum or static voltages and things like that. A qualifying factor here is that R1 provides the input resistance of the overall amplifying circuit. Now, here's another circuit. This one allows the input to be fed to the non-inverting input."

Smithy drew a further circuit (Fig. 5(b).)

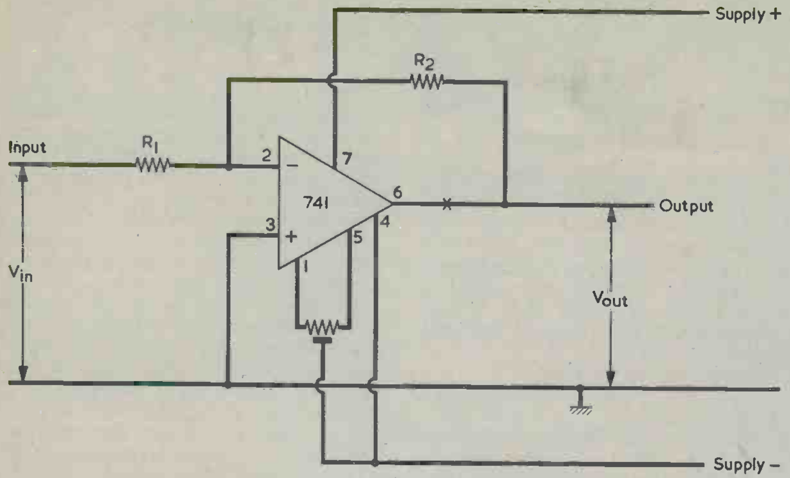
"Hallo," remarked Dick. "The voltage gain isn't equal to R2 divided by R1 this time."

"No, it isn't," agreed Smithy. "The voltage fed back to the inverting input is equal to the output voltage multiplied by R1 over the sum of R1 and R2. Which is, of course, what you'd expect with a simple potential divider like this. The voltage gain is the reciprocal of the fraction of the output voltage that's fed back and so it's equal to the sum of R1 and R2 divided by R1."

"Wait a minute," said Dick frowning. "Let's try this out with an actual figure. Suppose the voltage across

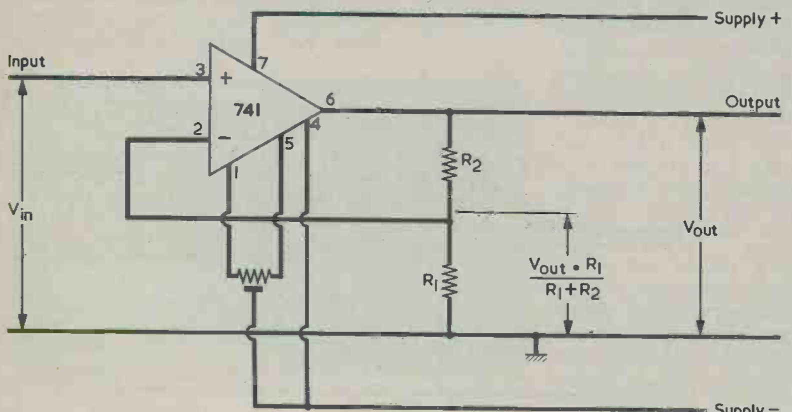
TABLE
741 – Principal Parameters

Supply voltage (VS+ and VS–)	18V max.
Supply current (VS=15V)	1.7mA typical
Input voltage range, either input	±13V typical
Duration of output short-circuit	Unlimited
Input offset voltage	1mV typical
Maximum p–p output swing	28V typical
Large signal voltage gain	200,000 typical
Input resistance	2MΩ typical
Total power dissipation (below 55°C ambient)	500mW max.



$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1}$$

(a)



$$\frac{V_{out}}{V_{in}} = \frac{R_1 + R_2}{R_1}$$

(b)

Fig. 5(a). A standard op-amp voltage amplifier circuit with controlled gain. A 741 with an external null offset circuit is assumed

(b).. Another standard op-amp circuit with resistive feedback. This time the input is applied to the non-inverting input

R1 is one-fifth of the output voltage. The output voltage will then swing positive by 5 volts when the input goes positive by 1 volt, because there will then be 1 volt feedback going back to the inverting input. Why, of course, it all figures!"

"Satisfied?"

"Yes, definitely. Have you got any more feedback circuits, Smithy?"

Smithy sketched out another circuit. (Fig. 6(a).)

"Here's another amplifier which gives unity gain," he remarked. "The output is connected direct to the inverting input. This time we don't bother about an offset null circuit or the earth point and we employ just a positive and negative supply rail. What we have here is a voltage follower and the output voltage is almost exactly equal to the input voltage, the only difference being the uncancelled offset input voltage. You *could* cancel out the offset voltage by adding an external offset null potentiometer circuit but for most applications it isn't worth going to the bother."

"What's the advantage of the circuit?"

"It offers a high impedance input and a low impedance output," said Smithy. "The supply voltage can be between 12 and 15 volts. Now, let's put a resistor in between the output and the inverting input."

Smithy added the resistor. (Fig. 6 (b).)

"What does that do?" asked Dick.

"Nothing in particular," grinned Smithy. "The current flowing through the resistor to the inverting input will only be a fraction of a microamp so, provided the value of the resistor is not too high, say lower than 470kΩ, the circuit will still act as an accurate voltage follower."

Dick scratched his head.

"Then why," he asked, "have you added the resistor?"

"Because," said Smithy, "it allows me to take the next step of putting in another resistor, together with two resistors which hold the non-inverting input at a central potential between the supply rails. Also, the input now goes to the inverting input." (Fig. 6 (c).)

"Blimey," said Dick. "It looks as though you've got a feedback amplifier just like the first one you showed me."

"That's right," chuckled Smithy. "This amplifier will give a voltage gain equal to R2 divided by R1, just as before. As there isn't a reference earth point, the circuit is probably better employed for a.c. and not for d.c. amplification, whereupon it's necessary to put in input and output coupling capacitors."

With a flourish, Smithy added the two capacitors. (Fig. 6(d).)

"There you are," he said. "This is the circuit of a jolly useful fixed gain a.c. amplifier which only requires two supply rails, either of which can be at earth potential."

INTEGRATING CIRCUIT

"You said last time," stated Dick, "that if you put a capacitor between the output and the inverting input of the op-amp, an input square wave becames changed to an output triangular wave."

Smith glanced at his watch.

"You've certainly got a good memory," he remarked wryly. "Okay then, but this will have to be our very last look at op-amps. Here's what you get if you have a capacitor between the output and the inverting input."

Smithy drew out the circuit. (Fig. 7).

"This is general theory," he went on, "so I'm only showing the two amplifier inputs, the output and an earth point. Now, when the square wave takes the inverting input positive the amplifier output tries to go negative. But the left hand plate of the capacitor takes the inverting input negative also. As a result, the output can go negative at a slow rate only, as the capacitor gradually charges. The opposite happens when the square wave takes the inverting input negative, and the consequence is that you get a triangular wave at the output of the op-amp. The effective value of the capacitor is the actual value multiplied by the voltage gain of the op-amp."

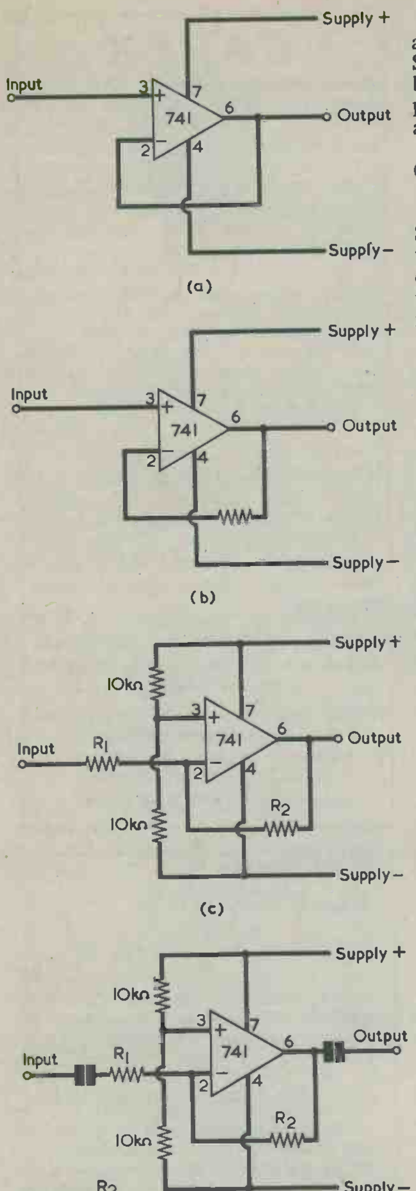
"That circuit," commented Dick confidently, "must be one which would have been quite impossible before integrated circuits appeared on the scene."

"I've got news for you," chuckled Smithy. "The circuit I've just described is a Miller integrator, and it can employ *any* type of voltage amplifier including a valve. Do you know when the Miller integrating effect first saw the light of day?"

"Fairly recently?"

"Believe it or not," said Smithy, "the Miller effect was originally described as long ago as 1919!"

And with this demonstration that some basics of electronics are not as new as we fondly imagine, Smithy resolutely closed the discussion and returned to the television receiver whose repair had been so rudely interrupted by his avidly curious assistant. ■



$$V_{gain} = \frac{R_2}{R_1}$$

Fig. 6(a). The simple circuit required for a voltage follower
(b). The circuit still functions as a voltage follower if a resistor is inserted between the output and the inverting input
(c). If the non-inverting input is coupled to a fixed potential and a resistor is inserted in series with the inverting input, a fixed gain amplifier results
(d). With input and output coupling capacitors added, the circuit becomes a useful a.c. amplifier

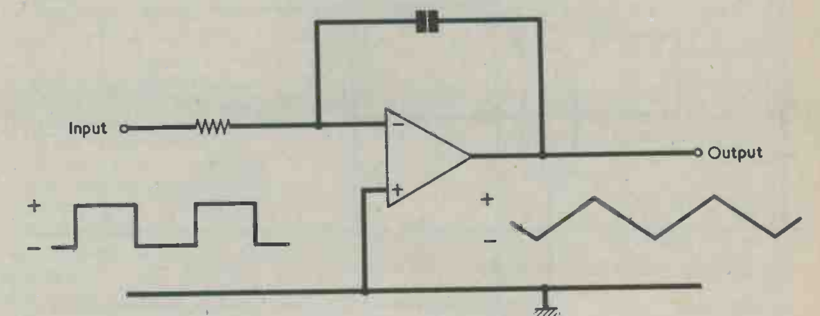


Fig. 7. A basic Miller integrator. A square wave at the input produces a triangular wave at the output

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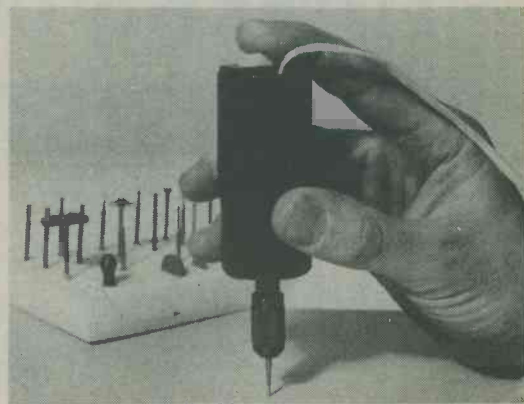

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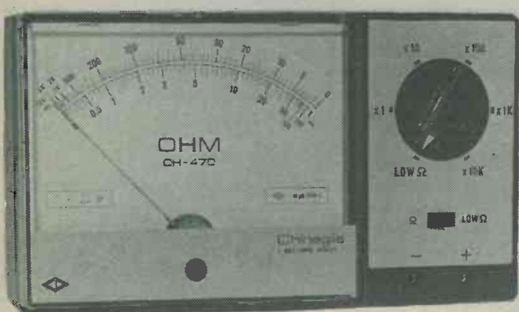

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For further information please contact: Chinaglia (U.K.) Ltd., 19 Mulberry Walk, London SW3 6DZ.

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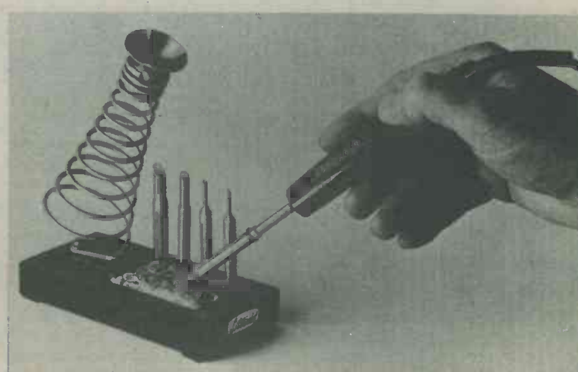

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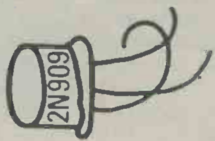

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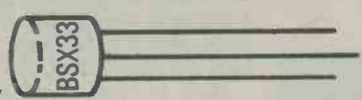

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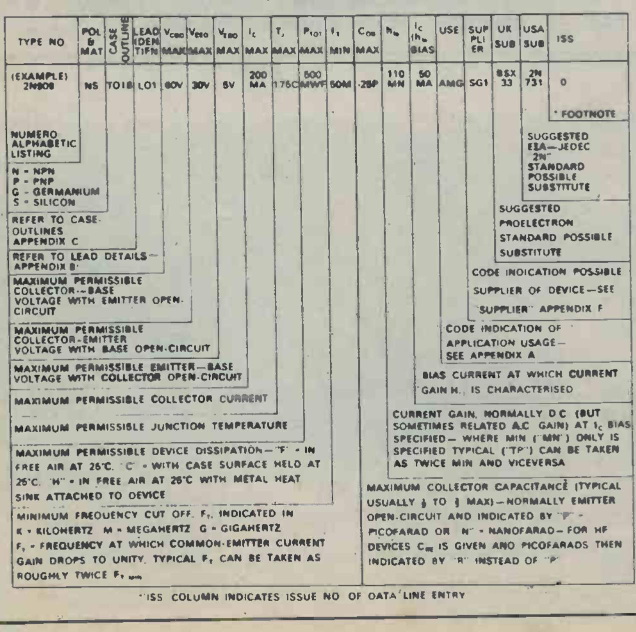

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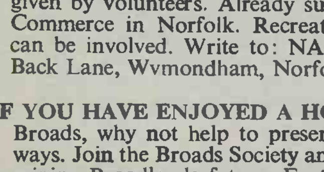

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A Wien bridge oscillator has series C and R from amplifier output to non-inverting input and parallel C and R from non-inverting input to earth. If both C's and R's are equal, $f = 1/2\pi CR$. The table shows worked values of R against C and frequency. Thus, f is 400Hz when C is 0.01μF and R is 40kΩ

Frequency	500pF	1,000pF	2,000pF	5,000pF	0.01μF	0.02μF	0.05μF	0.1μF	0.2μF	0.5μF
50Hz	6.4MΩ	3.2MΩ	1.6MΩ	640kΩ	320kΩ	160kΩ	64kΩ	32kΩ	16kΩ	6.4kΩ
100Hz	3.2MΩ	1.6MΩ	800kΩ	320kΩ	160kΩ	80kΩ	32kΩ	16kΩ	8kΩ	3.2kΩ
150Hz	2.1MΩ	1.1MΩ	530kΩ	210kΩ	110kΩ	53kΩ	21kΩ	11kΩ	5.3kΩ	2.1kΩ
200Hz	1.6MΩ	800kΩ	400kΩ	160kΩ	80kΩ	40kΩ	16kΩ	8kΩ	4kΩ	1.6kΩ
300Hz	1.1MΩ	530kΩ	270kΩ	110kΩ	53kΩ	27kΩ	11kΩ	5.3kΩ	2.7kΩ	1.1kΩ
400Hz	800kΩ	400kΩ	200kΩ	80kΩ	40kΩ	20kΩ	8kΩ	4kΩ	2kΩ	800Ω
500Hz	640kΩ	320kΩ	160kΩ	64kΩ	32kΩ	16kΩ	6.4kΩ	3.2kΩ	1.6kΩ	640Ω
750Hz	420kΩ	210kΩ	110kΩ	42kΩ	21kΩ	11kΩ	4.2kΩ	2.1kΩ	1.1kΩ	420Ω
1,000Hz	320kΩ	160kΩ	80kΩ	32kΩ	16kΩ	8kΩ	3.2kΩ	1.6kΩ	800Ω	320Ω
2,000Hz	160kΩ	80kΩ	40kΩ	16kΩ	8kΩ	4kΩ	1.6kΩ	800Ω	400Ω	160Ω
3,000Hz	110kΩ	53kΩ	27kΩ	11kΩ	5.3kΩ	2.7kΩ	1.1kΩ	530Ω	270Ω	110Ω
4,000Hz	80kΩ	40kΩ	20kΩ	8kΩ	4kΩ	2kΩ	800Ω	400Ω	200Ω	80Ω
5,000Hz	64kΩ	32kΩ	16kΩ	6.4kΩ	3.2kΩ	1.6kΩ	640Ω	320Ω	160Ω	64Ω
7,500Hz	42kΩ	21kΩ	11kΩ	4.2kΩ	2.1kΩ	1.1kΩ	420Ω	210Ω	110Ω	42Ω
10,000Hz	32kΩ	16kΩ	8kΩ	3.2kΩ	1.6kΩ	800Ω	320Ω	160Ω	80Ω	32Ω

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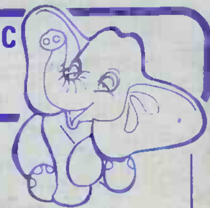

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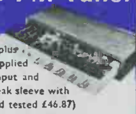

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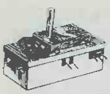

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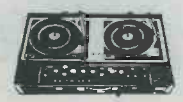

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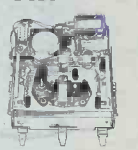

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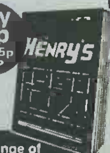

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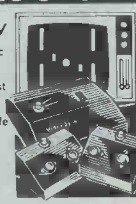

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