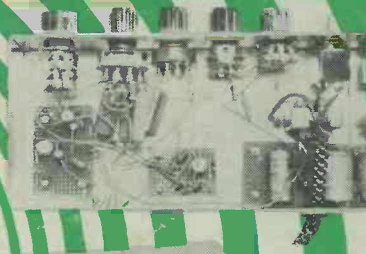
RADIO & ELECTRONICS CONSTRUCTOR

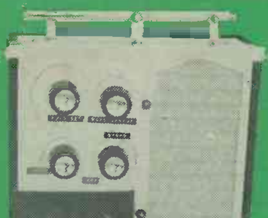
DECEMBER 1975

30p

WIEN BRIDGE AUDIO SIGNAL GENERATOR



Continuously variable range from 7·5Hz to 75kHz.



THE 'DRACHMA'

S.W. & V.H.F. PORTABLE

PART 1 (2 PARTS)

ALSO FEATURED

'IN SITU' TRANSISTOR CHECKER

RADIO & ELECTRONICS CONSTRUCTOR

DECEMBER 1975
Volume 29 No. 5

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Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that such queries cannot be answered over the telephone; they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

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CONTENTS

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JANUARY ISSUE WILL BE PUBLISHED ON 2nd JANUARY

COMPONENTS

HOBBYIST - PROFESSIONAL - DOMESTIC - SURPLUS - INDUSTRIAL
JUST A FEW OF OUR BARGAINS ARE LISTED BELOW - SEND STAMPED ADDRESSED ENVELOPE FOR A QUOTE ON OTHER REQUIREMENTS. PAY US A VISIT. OVER 90% OF STOCK BELOW QUANTITY WHOLESALE PRICE. RETURN POSTAL SERVICE UNLESS CHEQUE.

Goods sent at customer's risk, unless sufficient payment for insurance included (2p per £1 Min 7p) British Isles only.

VALVE BASES

Printed circuit B9A – B7G 2p
Chassis B7 – B9G – B7G 4p
Shrouded chassis B7G – B9A .. 6p
B8A – B9A chassis – B12A tube .. 6p

TO3 or TO66 Mica Washer .. 2p
18 volt 4 amp charger, bridge rectifier 50p
GC10/4B £3.00

Speaker, 6" x 4", 5 ohm, ideal for car radio etc. £1

TAG STRIP – 6 way **3p**
9 way **5p** Single **1p**

VHF Radio Tuner Head Takes ECC 85 80p

Telescopic aerial
Closed 9½", open 38½"
Fitted right angle TV plug, **50p**

1¼ glass fuses— 250 m/a or 3 amp (box of 12) 18p
3" tape spools **8p** 1 Terryclips chrome finish 4p
Brand new Boxed 6K7G **25p** 1.5m, log edge pot .. 8p
PVC or metal clip on M.E.S. bulb holder 5p
Geared Knob, Inner to Outer Ratio 8:1 .. .. .. 60p
Bulgin, 5mm Jack plug and switched socket (pair) 30p
12 volt solenoid and plunger 30p
250 RPM 50 c/s locked frequency miniature mains motor .. 50p
200 OHM coil, 2¼" long, hollow centre 10p
Belling Lee white plastic surface coax outlet Box 30p
R.S. 12 way standard plug and shell 20p

SWITCHES

Pole	Way	Type	
4	2	Sub. Min. Slide	18p
6	2	Slide	20p
4	2	Lever Slide	15p
2	2	Slide	12p
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

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

RESISTORS

⅛–¼–½ 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 2¼" x 2½" **£1.50**

1½ METER AUDIO LEAD

5 pin din plug 180° both ends 80p
3 pin din to open end, 1½yd twin screened lead 35p

POTS

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

COMPUTER AND AUDIO BOARDS

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** + **75p** post and packing
7lb for **£1.75** + **£1** post and packing

Skeleton Presets
Slider, horizontal or vertical standard or submin. 5p

Clear Plastic Boxes
For component storage or projects, sliding lid. 1¾" x 1½" x 1" 10p

THERMISTORS

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

KNOBS

SILVER METAL PUSH ON WITH POINTER, OR WHITE PLASTIC, GRUB SCREW WITH POINTER AND SILVER CENTRE 8p EACH.
1" DIAM. WITH 1½" SKIRT SPUN ALUMINIUM GRUB SCREW FIXING, ¼" 30p EACH.

ZM1162A INDICATOR TUBE

0-9 Inline End View. Rectangular Envelope 170V 2·5M/A £1.50

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
Mains or 12v d.p.c.o. heavy duty octal **60p**

RESETTABLE COUNTER

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

Boxed GEC KT88 valve £2

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

JAP 4 gang min. sealed tuning condensers New 25p
Ex-eqpt. 2 or 4 gang 15p

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.

CONNECTOR STRIP

Belling Lee L1469, 4 way polythene. 3p each

Strong grey plastic box same design as die cast ali 4⅜" x 2⅜" x 1¼" 40p

1" or 1⅜" or ¾" CAN CLIPS .. 2p

MAINS DROPPERS

36+79 ohm 15p
66+66+158 ohm, 66+66+137 ohm
17+14+6 ohm, 266+14+193 ohm 20p
50+40+1k5 ohm
285+575+148+35 ohm } 30p
25+35+97+59+30 ohm

5¼" x 2¾" Speaker, ex-equipment 3 ohm 30p
2 Amp Suppression Choke 5p
3 x 2½ x $\frac{1}{16}$" } **PAXOLINE** .. 2p
4⅝ x ½ x ⅛", ... 2 for 1p
220K & 100 ohm 3 watt resistors .. 4p
VALVE RETAINER CLIP, adjustable 2p

OUTPUT TRANSFORMERS

Sub-miniature Transistor Type .. 25p
Valve type, centre tapped or straight 40p

THE RADIO SHACK

161 ST. JOHNS HILL, BATTERSEA, LONDON S.W.11
Open 10 a.m. till 7 p.m. Monday to Saturday – Also Sunday afternoons
Terms: Payment with order Telephone: 01-223 5016

12 volt 250M/A or 6 volt ½A Transformers £1
Whiteley Stentorian 3 ohm constant impedance volume control way below trade at 80p
Drive Cord 1p per yd.

SEMICONDUCTORS

Full spec. marked by Mullard, etc. Many other types in stock.

AC107	12p	BC179B	11p	BF180/1/2/3	20p
AC128	5p	BC184C	9p	BF184/5	15p
AC176	9p	BC186/7	13p	BF194/5/6/7	5p
ACY28	18p	BC213L/214B	9p	BF194A/195C/200	10p
AD149	40p	BC261B	10p	BF258/262/263	24p
AD161/2 matched pr.	69p	BC327	12p	BF336	25p
AF116	12p	BC328	10p	BFS28 Dual Mosfet	92p
AF124/6/7	20p	BC337/8	12p	BFW10/11 F.E.T.	26p
AF139/178/180/181	30p	BC547/558A	7p	BFW30	£1.35
AF239	20p	BC548/557	9p	BFW57/58	20p
ASY27/73	25p	BCX32/36	12p	BFX12	20p
BC107A or B	9p	BCY40	60p	BFX29/30/84/88	16p
BC107/8/9	6p	BCY70/1/2	9p	BFX89	35p
BC108A/B/109B/C	10p	BD112/3/5/6	40p	BFY50/1/2	12p
BC147/8/9	6p	BD131/2/3/5/7/9	30p	BFY90	50p
BC147A/B	8p	BD201/2/3/4	£1.00	BR101 } Programmable Unj Junction	30p
BC148A/B, 9B/C/S	8p	BD232/4/5	46p	BRY39 } Programmable Unj Junction	31p
BC157/8/9	6p	BDX77	£1.40	BRY56 } Programmable Unj Junction	34p
BC158A/B	11p	BF115	12p	BSV64	40p
BC159B/C, 157A	11p	BF167/173	15p	BSV79/80 F.E.T.s	£1
BC178A/B	12p	BF178/9	20p	BSV81 Mosfet	90p

BSX20/21	13p
BSY40	28p
BU105-01	93p
CV7042 (OC41 OC44, ASY63)	7p
GET111	40p
OC35	32½p
ON222	30p
TIP30	43p
TIP3055	50p
TIS88A FET	23p
ZTX300	8p
ZTX341	15p
2N393/MA393	30p
2N706	8p
2N929	14p
2N987	35p
2N1507/2219	17p
2N2401/2412/2483	25p
2N2904/5/6/7	13p
2N2907A	15p
2N3053	13p
2N3054/3055 (or equiv)	35p
2N3133	18p
2N3704	10p
2N4037	35p
2N5036	60p
2SA141/2/360	31p
2SB135/6/457	20p
40250	60p

OTHER DIODES

1N916	6p
1N4148	1·5p
BA145/148	12p
Centercel	10p
BZY61	10p
BB103/110 Varicap	18p
BA182	18p
OA5/7/10	10p
BZY88 Up to 33 volt	6p
BZX61 11 volt	16p
BR100 Diac.	19p

INTEGRATED CIRCUITS

TAA700	£2.95
741 8 pin d.i.l. op. Amp	18p
TAD100 AMRF	£1.00
CA3001 R. F. Amp	£1.00
TAA300 1wt Amp	£1.25
NE555v Timer	42p
TAA550 Y or G	31p
TAA263 Amp	65p
7400/2/10/20/30	13p
7404	14p
7414	45p
7438/74/86	27p
7483	80p
LM300, 2-20 volt	50p
74154	£1.44

BRIDGE RECTIFIERS

Amp	Volt			Amp	Volt		
½	1,600	BYX10	30p	2	30	LT120 type	30p
1	140	OSH01-200	20p	0.6	110	EC433	15p
1.4	42	BY164	28p	5	400	Texas	75p

THYRISTORS

Amp	Volt		
1	240	BTX18-200	50p
1	400	BTX18-300	65p
1	240	BTX30-200	40p
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	£8.00
30	1000	28T10 (Less Nut)	£3.00

RECTIFIERS

	Amp	Volt	
IN4004	1	400	3p
IN4005	1	600 }	4p
IN4006	1	800 }	4p
IN4007	1	1,000 }	4p
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	£1.00
BYX46-400*	15	400	£1.50
BYX46-500*	15	500	£1.75
BYX46-600*	15	600	£2.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
BYX52-1200	40	1,200	£2.50

Avalanche type

TRIACS

Amp	Volt		
6	400	Plastic	74p
25	900	BTX94-900	£4.00
25	1200	BTX94-1200	£6.00

12-0-12 50M/A Min. Txfmr. 90p

Pair of LA2407 Ferrox cores with adjuster 25p

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

DLI Pal Delayline 50p

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

BPX40	65p
BPX42	£1.00
BPY10	£1.00
(VOLTIAC)	
BPY68 }	£1.00
BPY69 }	£1.00
BPY77 }	£1.00
Diodes	

Photo transistor

BPX29	£1.00
OCP71	30p

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

.3" red 7 segment L.E.D. 14 D.I.L. 0-9 + D.P. display 1.9v, 10m/a segment 65p

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
Holders or pads 50p per 100

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 } 9p
Speaker din switched }
3.5mm Switched Socket }

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	7p	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

U.E.C.L. 10 way pin socket 2B606001R10 10p

U.E.C.L. 20 way pin socket B260800A1R20 20p

3.5mm STEREO PLUG Metal screened 35p

Philips electronic engineer kits add on series E1004 £1.00 each

RG4-1250 Mercury vapour rectifier £5.00

SOLDER
Multicore - 2½p foot

ENAM. COPPER WIRE

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

GARRARD
GCS23T or GP93/1 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 10p

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

SMALL ORDERS, ENCLOSE SUITABLE STAMPED ADDRESSED ENVELOPE
LARGE ORDERS, ADD SUFFICIENT FOR POSTAGE, INSURANCE, ETC.
TOTAL GOODS PLUS CARRIAGE, ADD V.A.T.

MAIL ORDER CUSTOMERS ONLY ADD 8% V.A.T.

WILMSLOW AUDIO

THE Firm for speakers!

SPEAKERS

Baker Group 25, 3, 8 or 15 ohm	£8.64
Baker Group 35, 3, 8 or 15 ohm	£10.25
Baker Group 50/12, 8 or 15 ohm	£14.00
Baker Deluxe 12", 8 or 15 ohm	£13.75
Baker Major 3, 8 or 15 ohm	£11.87
Baker Superb 8 or 15 ohm	£18.12
Baker Regent 8 or 15 ohm	£10.00
Baker Auditorium 12"	£16.25
Celestion PST8 (for Unilex)	£3.75
Celestion G12H 8 or 15 ohm	£15.95
Celestion G12M 8 or 15 ohm	£12.95
Celestion G15C 8 or 15 ohm	£26.95
Celestion G18C 8 or 15 ohm	£34.50
Celestion MH1000 8 or 15 ohm	£13.50
EMI 13 x 8, 150 d/cone, 8 ohm	£2.94
EMI 13 x 8 type 350, 8 or 15 ohm	£9.56
EMI 13 x 8.25 watt bass	£9.00
EMI 5" 14A/730 mid-range 8 ohm	£3.50
EMI 6½" 93850 4 or 8 ohm	£2.90
EMI 8 x 5, cer. mag. 8 ohm	£1.87
EMI 8 x 5, 10 watt, d/c roll/s 8 ohm	£3.95
EMI 10 x 6 93870 8 ohm	£2.69
EMI 14" x 9" base, 8 ohm	£13.25
Elac 9 x 5, 59RM109 15 ohm, 59RM114 8 ohm	£3.44
Elac 6½" d/cone, roll surr. 8 ohm	£4.06
Elac 6½" d/cone 8 ohm	£3.12
Elac TW4 4" tweeter	£1.75
Elac 10" 10RM239 d/c 8 ohm	£3.12
Elac 8" 3 ohm	£2.87
Eagle Crossover 3, 8 or 16 ohm	£1.75
Eagle CT5 cone tweeter 8 ohm	£2.06
Eagle CT10 tweeter 8 or 16 ohm	£3.00
Eagle DT33 dome tweeter 8 ohm	£6.31
Eagle FF5 3 way crossover	£3.62
Eagle SN75 crossover with tw. contro	£4.69
Eagle FF28 multicell, horn	£9.00
Eagle HT15 horn tw. 16 ohm	£4.40
Eagle HT21 horn tw. 8 ohm	£6.81
Eagle MHT10 horn tw. 8 ohm	£4.44
Eagle FR4 4" full range	£6.12
Eagle FR65 6½" full range	£9.62
Eagle FR8 8" full range	£12 31
Fane Pop 15 watt 12"	£5.25
Fane Pop 25T 30 watt 12"	£7.50
Fane Pop watt 12"	£12.00
Fane Pop 55 12" 60 watt	£13.95
Fane Pop 60 watt 15"	£17.25
Fane Pop 100 watt 18"	£25.95

SPEAKERS

Fane Crescendo 12A 8 or 15 ohm	£34.50
Fane Crescendo 12B 8 or 15 ohm	£36.50
Fané Crescendo 15, 8 or 15 ohm	£47.50
Fane Crescendo 18, 8 or 15 ohm	£62.95
Fane 910 horn	£14.95
Fane 920 horn	£33.95
Fane 152/12a 15" 15 ohm	£16.00
Fane 801T 8" d/cone roll surr.	£9.95
Fane 808T 8" d/cone	£3.95
Fane 807T 8" d/cone roll surr.	£5.75
Goodmans 8P 8 or 15 ohm	£5.50
Goodsmans 10P 8 or 15 ohm	£5.80
Goodmans 12P 8 or 15 ohm	£13.95
Goodmans 12P–D 8 or 15 ohm	£16.95
Goodmans 12P–G 8 or 15 ohm	£15.95
Goodman 12AX 100 watt 8 or 15 ohm	£36.50
Goodsmans 15AX 100 watt 8 or 15 ohm	£40.25
Goodsmans 15P 8 or 15 ohm	£21.00
Goodmans 18P 8 or 15 ohm	£36.00
Goodmans Hifax 750	£16.00
Goodmans Axent 100 tweeter & crossover	£8.44
Goodmans Audiom 100, 15 ohm	£13.90
Goodmans Axiom 401, 8 or 15 ohm	£20.00
Goodsmans Twinaxiom 8" 8 or 15 ohm	£10.14
Goodsmans Twinaxiom 10" 8 or 15 ohm	£10 75
Gauss 12" full range 8 ohm	£73.00
Gauss 12" Bass 8 ohm	£73.00
Gauss 15" full range 8 ohm	£83.00
Gauss 15" Bass 8 ohm	£83.00
Gauss 18" full range 8 ohm	£110.00
Gauss 18" Bass 8 ohm	£110.00

All the above Gauss (American) speakers are fitted with 4½" voice coils and can handle 200 watts RMS.

Kef T27	£6.06
Kef T15	£6.94
Kef B110	£8.37
Kef B200	£9.50
Kef B139	£16.95
Kef DN8	£2.31
Kef DN12	£5.99
Kef DN13	£4.50
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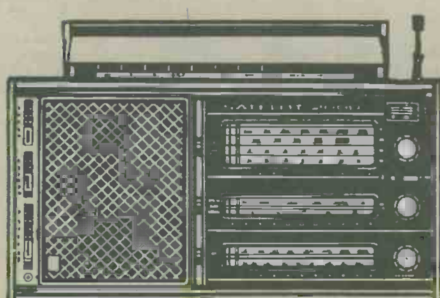

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AC125	0·18	C111E	0·51	AF139	0·31	ST141	0·18	BF178	0·31
AC126	0·18	C400	0·31	AF178	0·51	TIP29	0·44	BF179	0·31
AC127	0·19	C407	0·26	AF179	0·51	TIP30	0·52	BF180	0·31
AC128	0·19	C424	0·26	AF180	0·51	TIP31A	0·56	BF181	0·31
AC132	0·15	C425	0·51	AF181	0·51	TIP32A	0·68	BF182	0·41
AC134	0·15	C426	0·36	AF186	0·51	TIP41A	0·68	BF183	0·41
AC137	0·15	C428	0·20	AF239	0·38	TIP42A	0·81	BF184	0·26
AC141	0·19	C441	0·31	AL102	0·68	TI843	0·31*	BF185	0·31
AC141K	0·30	C442	0·31	AL103	0·68	UT46	0·28*	BF187	0·28
AC142	0·19	C444	0·36	ASY26	0·26	ZN414	1·11	BF188	0·41
AC142K	0·26	C450	0·22	ASY27	0·31	2G301	0·19	BF194	0·12
AC151	0·16	MAT100	0·19	ASY28	0·26	2G302	0·19	BF195	0·12
AC154	0·20	MAT101	0·20	ASY29	0·26	2G303	0·19	BF196	0·15
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AC178	0·29	OC20	0·65	BC107	0·08	2N3053	0·18	BF272	0·81
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AC181K	0·30	OC26	0·30	BD138	0·51	2N3392	0·15	BFX84	0·22
AC187	0·22	OC28	0·51	BD139	0·56	2N3393	0·15	BFX85	0·31
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AC188	0·22	OC35	0·43	BD155	0·81	2N3395	0·18	BFX87	0·25
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ACY18	0·20	OC42	0·25	BD177	0·67	2N3404	0·29	BFY51	0·20
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ACY20	0·20	2N929	0·21	BD179	0·71	2N3414	0·16	2G309	0·37
ACY21	0·20	2N930	0·21	BD180	0·71	2N3415	0·16	2G339	0·20
ACY22	0·17	2N1131	0·20	BD185	0·67	2N3416	0·29	2G339A	0·17
ACY27	0·19	2N1132	0·22	BD186	0·67	2N3417	0·29	2G344	0·19
ACY28	0·19	2N1302	0·15	BD187	0·71	2N3525	0·77*	2G345	0·17
ACY29	0·36	2N1303	0·15	BD188	0·71	2N3614	0·69	2G371	0·17
ACY30	0·29	2N1304	0·18	BD189	0·77	2N3615	0·76	2G371B	0·12
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ACY34	0·21	2N1306	0·21	BD195	0·87	2N3646	0·09	2G374	0·18
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BC207	0·11	2N2220	0·22	BF125	0·46	2N3905	0·29	2N697	0·14
BC208	0·11	2N2221	0·20	BF127	0·51	2N3906	0·28	2N698	0·25
BC209	0·12	2N2222	0·20	BF152	0·56	2N4058	0·12	2N699	0·36
BC212L	0·13	2N2368	0·18	BF153	0·46	2N4059	0·10	2N706	0·08
BC213L	0·13	2N2369	0·15	BF154	0·46	2N4060	0·12	2N706A	0·09
BC214L	0·17	2N2369A	0·15	BF155	0·71	BC113	0·10	2N708	0·12
BC225	0·26	2N2411	0·25	BF156	0·49	BC114	0·16	2N711	0·31
BC226	0·36	2N2412	0·25	BF157	0·56	BC115	0·16	2N717	0·36
BC301	0·28	2N2646	0·48	BF158	0·56	BC116	0·16	2N718	0·25
BC302	0·25	2N2711	0·21	BF159	0·61	BC117	0·19	2N718A	0·51
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BCY31	0·27	2N2905A	0·21	OC44	0·16	BC132	0·12	2N4061	0·12
BCY32	0·31	2N2906	0·16	OC45	0·13	BC134	0·19	2N4062	0·12
BCY33	0·22	2N2906A	0·19	OC70	0·10	BC135	0·12	2N4284	0·18
BCY34	0·26	2N2907	0·20	OC71	0·10	BC136	0·16	2N4285	0·18
BCY70	0·15	2N2907A	0·22	OC72	0·15	BC137	0·16	2N4286	0·18
BCY71	0·20	2N2923	0·15	OC74	0·15	BC139	0·41	2N4287	0·18
BCY72	0·15	2N2924	0·15	OC75	0·16	BC140	0·31	2N4288	0·18
BCZ10	0·20	2N2925	0·15	OC76	0·16	BC141	0·31	2N4289	0·18
BCZ11	0·26	ACY35	0·21	OC77	0·26	BC142	0·31	2N4290	0·18
BCZ12	0·26	ACY36	0·29	OC81	0·16	BC143	0·31	2N4291	0·18
BD115	0·63	ACY40	0·18	OC81D	0·16	BC145	0·46	2N4292	0·18
BD116	0·81	ACY41	0·19	OC82	0·16	BC147	0·10	2N4293	0·18
BD121	0·61	ACY44	0·36	OC82D	0·16	BC148	0·10	2N5172	0·12
BD123	0·67	AD130	0·39	OC83	0·20	BC149	0·12	2N5194	0·56
BD124	0·70	AD140	0·49	OC139	0·20	BC150	0·19	2N5294	0·56
BD131	0·51	AD142	0·49	OC140	0·20	BC151	0·20	2N5296	0·56
BD132	0·61	AD143	0·39	OC169	0·26	BC152	0·18	2N5457	0·32
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7442	0·69	0·66	0·59	74107	0·41	0·39	0·37	74194	£1·20	£1·16	£1·11
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7444	£1·11	£1·06	£1·02	74111	0·83	0·81	0·78	74196	£1·11	£1·06	£1·02
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BP932	0·15	0·14	0·13	BP945	0·28	0·26	0·23	BP9093	0·42	0·40	0·38
BP933	0·15	0·14	0·13	BP946	0·14	0·13	0·12	BP9094	0·42	0·40	0·38
BP935	0·15	0·14	0·13	BP948	0·28	0·26	0·23	BP9097	0·42	0·40	0·38
BP936	0·15	0·14	0·13	BP951	0·65	0·60	0·56	BP9099	0·42	0·40	0·38

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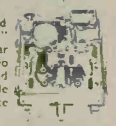

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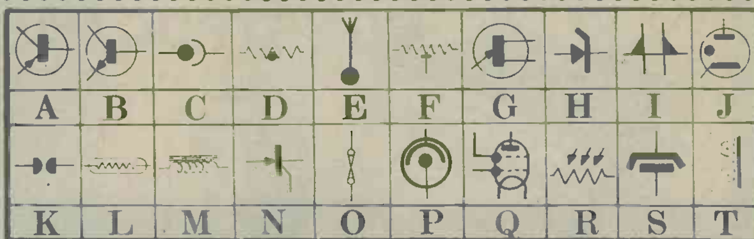

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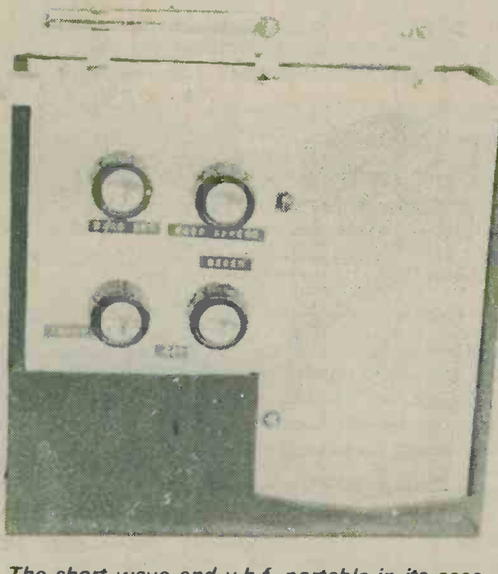
THE 'DRACHMA' S.W. AND V.H.F. PORTABLE — Part 1

This receiver covers the short wave band from 5.5 to 22MHz and the v.h.f. band from 75 to 105MHz. The ingenious reflex circuit allows reception of both a.m. and f.m. signals. Circuit operation and the first steps in construction are described this month, and the constructional information will be completed in next month's concluding article.



The short wave and v.h.f. portable in its case. The telescopic aerial is fitted to the three clips at the top to function as a carrying handle

By
Sir Douglas Hall, K.C.M.G.

This receiver was designed by the author for use by him while on a visit to a rather distant country where local stations operate on v.h.f., and where the short wave bands from about 22MHz to about 5.5MHz are required for listening to the B.B.C. and other European broadcast stations. The receiver covers both these ranges, and switching between short waves and v.h.f. is carried out automatically by the short wave bandset control. When v.h.f. is selected the coverage is about 75 to 105MHz, and either a.m. or f.m. signals may be received.

CIRCUIT DESCRIPTION

The circuit appears in Fig. 1. With S1 in the position shown, the short wave bands will be received. The signal is picked up on a telescopic aerial and is applied via VC1 to the emitter of TR1, which functions as a common base amplifier. The amplified signal at TR1 collector appears across the r.f. choke L3 and then passes through C2 and C3 to L1 (which is air cored and has a very low inductance) and L2, which is the permeability tuned short wave coil. Coarse tuning of L2 is achieved by varying the position of a ferrite road within it, and the relevant control forms the band setter. Fine tuning is carried out by VC2, which acts as a band spreader.

The signal across the tuned circuit is applied to the base of TR2. This, functioning as a common collector device, causes a current amplified signal to appear across D1, which provides detection. The detected a.f. signal is now amplified by TR2, working this time in the common base configuration. Regular readers will recognise the author's "Spontaflex" arrangement for TR2 and its associated components. The amplified a.f. signal at TR2 collector is built up across R3 and is fed back to TR1, which acts now as a common emitter audio frequency amplifier. Because of the

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relatively high value of R3, TR1 requires negative feedback to increase its input base impedance. This negative feedback is given because R1 in its emitter circuit is not bypassed. Despite the feedback, quite a useful degree of amplification is provided by TR1 due to the high output load offered by the primary of T1.

If the band set control is adjusted so that the ferrite rod is completely removed from L2, S1 is automatically switched over to v.h.f. This removes L2 and C2 from the circuit, allowing L1 and VC2 to form the v.h.f. tuned circuit, with coupling from L3 being given by C3 only.

Positive feedback to provide reaction for a.m. reception, or synchronous oscillation for f.m. reception, is given by a Colpitts configuration, with VC3, VC4 and VC5 providing the requisite capacitive tap. VC3 is ganged to the band set control to provide consistent reaction over the whole of the short wave band, and its capacitance decreases as the ferrite rod is taken out of coil L2. The method by which regeneration is controlled is new. In addition to giving very smooth operation, it allows increased efficiency to be obtained.

As has been pointed out, TR2 acts as a common collector device at radio frequencies, whereupon its base input impedance is equal to its emitter load impedance multiplied by its current amplification factor. But at audio frequencies TR2 functions as a common base amplifier, and in this configuration it will give greatest a.f. gain when the emitter load impedance is as low as possible and the collector output load impedance is as high as possible. If, however, too high a value of resistor were employed in the collector circuit of TR2, the current in the transistor would be so restricted as to make it function as a negative feedback detector rather than as an efficient reflex amplifier. Also, if a low impedance diode were chosen to keep the audio input impedance low, there could be a refusal on the part of the transistor to oscillate at the higher radio frequencies because of the consequent damping of the tuned circuit connected to its base.

With medium and long wave designs, the solution to these problems consists of employing a Darlington pair of transistors followed by a low impedance diode. The very high current gain of the Darlington pair then ensures that the damping of the tuned circuit at the input base is very small. But it is difficult in practice to make a Darlington pair work satisfactorily at higher frequencies, and in any case most low impedance diodes are inefficient at these frequencies. In the present design a normal high impedance diode is employed, and it is connected in a circuit which allows a controlled forward current to flow through it in addition to the emitter current of TR2. As the additional forward current increases the impedance of the diode reduces. When the additional current is low the diode has a high impedance and the damping of the tuned circuit at TR2 base is small, allowing the circuit to os-

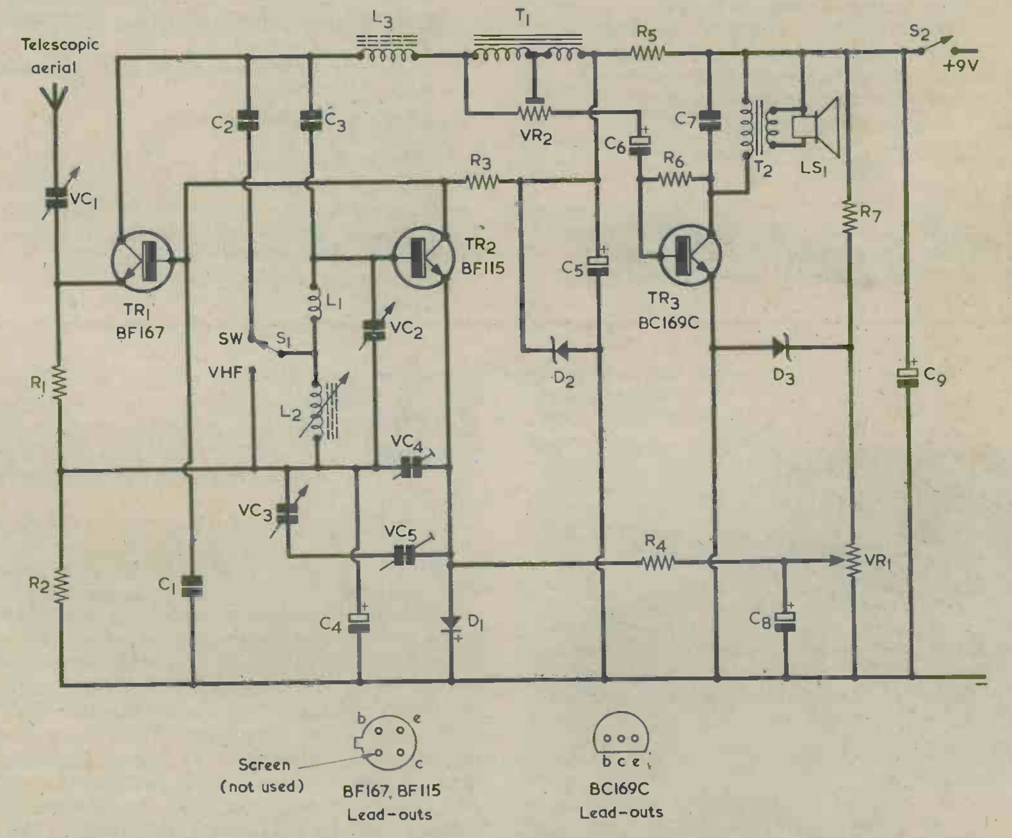


Fig. 1. The circuit of the short wave — v.h.f. portable. The connections to the two transformers are indicated in the wiring diagram, to be published in next month's issue

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)
- R1 180Ω
- R2 1kΩ
- R3 47kΩ
- R4 2.2kΩ
- R5 680Ω
- R6 470kΩ
- R7 2.7kΩ
- VR1 10kΩ potentiometer, linear, with switch S2, type P20 (Electrovalue)
- VR2 22kΩ pre-set potentiometer, skeleton

Capacitors
- C1 470pF silvered mica or ceramic
- C2 6.8pF silvered mica or ceramic
- C3 3.3pF silvered mica
- C4 100μF electrolytic, tantalum or aluminium, 2.5 V Wkg.
- C5 100μF electrolytic, 10 V Wkg.
- C6 4.7μF electrolytic, tantalum or aluminium, 10 V Wkg.
- C7 0.047μF plastic foil
- C8 2.2μF electrolytic, tantalum or aluminium, 10 V Wkg.
- C9 1,000μF electrolytic, 10 V Wkg.
- VC1 100pF variable, 'Dilecon' (Jackson)
- VC2 15pF variable, type C804 (Jackson)
- VC3 50pF variable, type C804 (Jackson)
- VC4 20pF trimmer, mica
- VC5 140pF trimmer, mica

Inductors
- L1 see text
- L2 see text
- L3 2.5mH r.f. choke type CH1 (Repanco)
- T1 Driver transformer type LT44 (Eagle)
- T2 Output transformer type LT700 (Eagle)

Semiconductors
- TR1 BF167
- TR2 BF115
- TR3 BC169C
- D1 OA90
- D2 zener diode, 6.8V, 250 or 400mW
- D3 zener diode, 2.7, 3.0 or 3.3V, 250 or 400mW

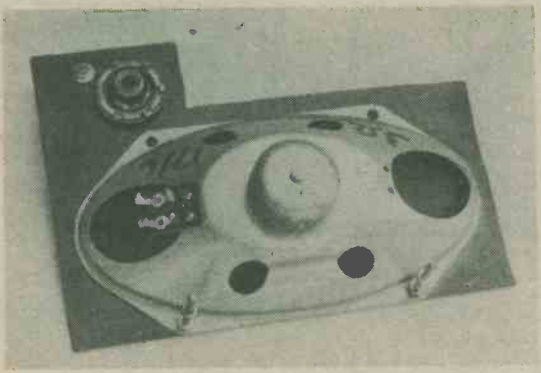
Switches
- S1 see text
- S2 part of VR1

Speaker
- LS1 3Ω speaker, 7 x 3⅝in.

Aerial
- Telescopic aerial type TA10 (Eagle)

Battery
- 9 volt battery type PP9 or equivalent

Miscellaneous
- 18-way tagboard, "Standard" (R.S. Components)
- Ferrite rod, 4 x ⅜in. dia. (see text)
- Ball drive type 4511/F (Jackson)
- 3 brackets type LK-2311 (Lektrokit)
- 3 spring clips type LK-2721 (Lektrokit)
- 1¾in. tuning drive drum type 4028 (Jackson-Home Radio)
- 2 spindle extenders type 4827 (Jackson - Home Radio)
- 24 s.w.g. enamelled wire
- Nylon drive cord
- Elastic (See text)
- Speaker fabric
- 2 screw hooks
- Plywood, hardboard, Formica or s.r.b.p.
- Fablon or Contact
- Bolts, nuts washers, etc.



The loudspeaker panel with the ball drive fitted

cillate. If the additional current is increased it will reach a level where the reduced impedance of the diode causes sufficient damping of the tuned circuit for oscillation to cease. Under this condition, also, a high level of audio frequency amplification will be provided by TR2.

The additional forward current for the diode is controlled by VR1, which in consequence becomes the reaction control for the receiver. The current from VR1 slider is limited by series resistor R4, whilst the voltage across the potentiometer is stabilized by zener diode D3. The method of reaction control used here should not be confused with that employed by the author in three recent designs where oscillation was produced by *increasing* the current through a silicon diode to lower its impedance. With the present design oscillation is produced by *decreasing* the current through a germanium diode to raise its impedance.

Another zener diode, D2, stabilizes the collector supply for both TR1 and TR2. Thus, in the interests of tuning stability the reflex stages have a supply of constant voltage, this being especially important for the reception of v.h.f. signals.

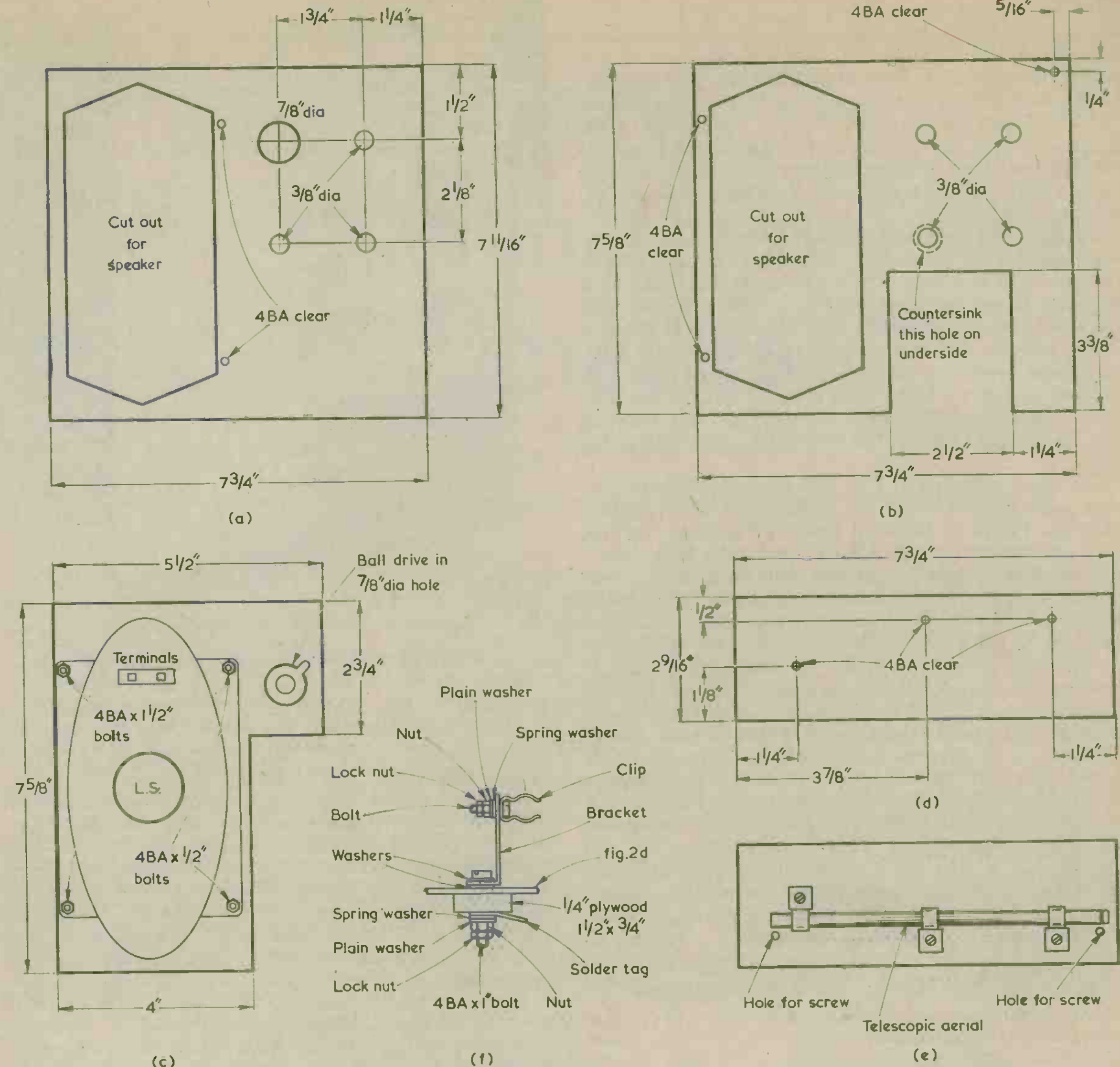


Fig. 2(a). Rear view of the front panel of the receiver
(b). The rear of the component panel
(c). The speaker panel, also seen from the rear
(d). The top of the receiver, viewed from the underside
(e). The three bracket-clips mounted on the other side of the top piece
(f). Detail of the centre bracket-clip

The audio output from TR1 is transformer coupled by T1 to TR3. The section of VR2 track between its slider and L3 helps to equalise the collector load of TR1 through the audio spectrum and prevents any tendency to threshold howling. The remaining section of VR2 track keeps radio frequency currents away from TR3. R5 and C5 are decoupling components for the reflex stages. C9 is the usual large-value capacitor scross the power supply.

The output transistor, TR3, couples to the speaker via output transformer T2. The value of R6 is chosen so that, with typical transistors, TR3 will pass about 10mA collector current.

No difficulties should be experienced in obtaining the parts required for the receiver. If any component requires special comment this will be given when it is referred to in the constructional details which now follow.

CONSTRUCTION

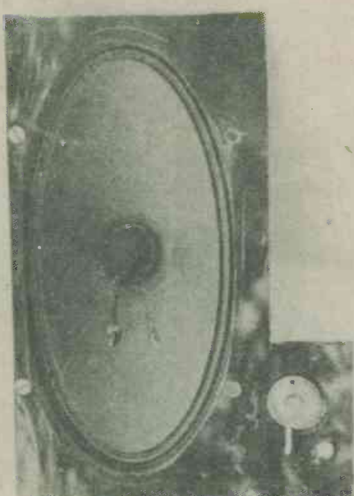
Construction may be started by cutting out and drilling the various sections which together make up the "chassis" of the receiver. These parts are fitted together as described in next month's concluding article and any queries concerning the purpose of some of the holes, etc., will be cleared up then.

The section in Fig. 2(a) will be the visible front of the receiver. It should consist of s.r.b.p. ("Paxolin") or Formica $\frac{1}{16}$in. thick and, after it has been completed, covered with Fablon or Contact. The speaker is not fitted directly to this section but is mounted on Fig. 2(c) which will be fitted directly behind Fig. 2(a). In consequence the cut-out for the speaker in Fig. 2(a) will be backed by speaker fabric sandwiched between the two parts. At the time being, drill out the three $\frac{3}{8}$in. and the $\frac{7}{8}$in. holes only.

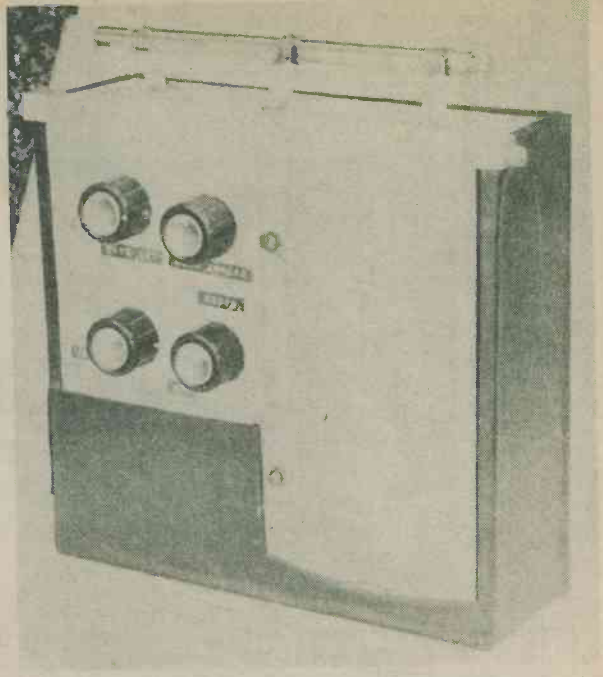
Section 2(b) is made of $\frac{1}{4}$in. plywood, and will be fitted spaced off behind Fig. 2(c) by about $\frac{3}{8}$in. Mark out and drill the four $\frac{3}{8}$in. holes using Fig. 2(a) as a template to ensure that they coincide with the $\frac{3}{8}$in. and $\frac{7}{8}$in. holes in the latter. The lower ends of the two pieces are at the same level when they are later assembled, leaving a gap above Fig. 2(b) of $\frac{1}{16}$in. The speaker aperture in Fig. 2(b) may be left for the moment. The 4BA clear hold at the top right hand corner may be drilled but not the remaining two 4BA clear holes.

The speaker panel of Fig. 2(c) should be about $\frac{1}{8}$in. thick and may consist of hardboard or a similar material. When it is fitted behind Fig. 2(a) the left hand and bottom edges will be level with each other. Cut out the speaker aperture and four 4BA clear mounting holes for the speaker, positioning these to suit the particular speaker employed. The speaker is specified in the Components List as 7 by 3$\frac{5}{8}$in. This size is sometimes advertised by retailers, and it is possible also that some speakers with nominal dimensions of 7 by 4in. will actually have a width of 3$\frac{5}{8}$in. although this point cannot be guaranteeed. Alternatively a 7 by 3in. speaker could be used, and this should be more than adequately narrow for the present design. Using Fig. 2(c) as a template, drill out the two 4BA clear holes in Fig. 2(a) and the remaining two 4BA clear holes in Fig. 2(b). The aperture for the speaker in Fig. 2(b) can also be cut out, remembering that this is to provide clearance for the speaker frame. The speaker aperture in Fig. 2(a) may also be cut out. The speaker is not fitted at this stage.

The epicyclic slow-motion drive is fitted to Fig. 2(c) as shown, and this requires a $\frac{7}{8}$in. hole matching the



The other side of the loudspeaker panel



Another view of the completed receiver

$\frac{7}{8}$in. hole in Fig. 2(a). The latter may be used as a template for positioning the hole in Fig. 2(c). Also required in Fig. 2(c) is a 6BA clear hole for a bolt to secure the anchor lug of the drive.

Fig. 2(d) shows the piece which forms the top of the receiver from the underside and this consists of $\frac{1}{16}$in. s.r.b.p. or Formica. Fig. 2(e) shows this from the top with the three bracket-clips for the telescopic aerial fitted. The aerial is clipped into all three when it is used as a carrying handle for the receiver. When it is employed as an aerial its lower end is fitted to the *central* clip, which is arranged so that the aerial may be set to point in any direction.

This central bracket-clip is shown in Fig. 2(f) and consists of one Lektrokit bracket LK-2311 and one Lektrokit spring clip LK-2721. Both these items are available from Home Radio in packets of ten. Although it is not assembled until later Fig. 2(f) shows, for information, the arrangement of washers and nuts which are used to enable the bracket and clip to be rotated to any desired position. The 4BA bolt which passes through Fig. 2(d) is 1in. long, and it will be noted that there is a solder tag underneath for connection to the aerial. The two end bracket-clips are the same as Fig. 2(f) except that each clip is secured to each bracket by a bolt and nut only, as also is each bracket to Fig. 2(d). The rotatable facility is not required with these end bracket-clips. The two small holes for screws in Fig. 2(e) are drilled later. Since its upper surface is visible this piece is covered with Fablon before the bracket-clips are fitted.

Fig. 2(f) also shows a piece of plywood measuring 1$\frac{1}{2}$ by $\frac{3}{4}$in. This is cut out later.

NEXT MONTH

Constructional details will be completed in next month's concluding article. The full Components List is given in this issue but it should be pointed out that details concerning some of the parts will be published next month.

(To be concluded)

SUGGESTED CIRCUIT 301

'In situ' transistor checker

By G. A. French

The device to be described in this article is intended for testing small signal amplifying transistors without removing them from the circuits in which they are wired. It operates by temporarily increasing the base current of the transistor and checking that there is a corresponding increase in collector current. The checker is intended only for testing small signal amplifying bipolar transistors in battery operated radio receivers and a.f. equipment. It may not be employed for checking output transistors nor may it be used for testing transistors in mains-driven equipment, where the higher voltages that are present may cause damage to the transistor being checked.

Despite these limitations the circuit is still of quite considerable use, and it has the advantage of extreme simplicity. It is capable of checking both n.p.n. and p.n.p. transistors without polarity switching. When employed for checking transistors on a printed circuit board, the process of applying the test prods requires a little more concentration than is needed for such operations as taking voltage measurements with two test prods.

SERIES RESISTANCE

The transistor checker functions by reason of the fact that in virtually all battery operated small signal amplifying stages there is resistance in series with the transistor emitter, the transistor collector or both. Fig. 1(a) illustrates a standard transistor bias circuit, in which it is assumed that the collector load is an i.f. transformer winding, which will have negligible d.c. resistance. As can be seen, the biasing circuit includes a resistor in series with the emitter.

An i.f. amplifier stage of the type shown in Fig. 1(a) will probably have further resistance in the collector circuit, this being given by a decoupling resistor, as illustrated in Fig. 1(b).

If the transistor is an a.f. amplifier with a resistive collector load, the resistance of the load will add to any emitter bias and decoupling resistance that may be present. If the transistor is a driver coupling directly to the bases of the output transistors, as in Fig. 1(c), no harm will result if the driver transistor is caused to pass a high collector current, as its collector is, in any case, intended to take the output transistor emitters nearly to the lower supply rail on the appropriate half-cycles of signal.

Fig. 1(d) shows a driver transistor with the primary of a driver transformer appearing between the collector and the upper supply rail. The latter may connect directly to the battery of the equipment without any series decoupling resistor. The resistance of the driver transformer primary will be low and the only relatively large resistance in circuit is given by the bias resistor between the emitter and the lower supply rail. In all normal instances the value of the bias resistor will be sufficiently high to allow the transistor checker to be employed.

It is extremely unlikely that a circuit of the type shown in Fig. 1(e) will be encountered in commercially designed equipment. Here, the supply rails connect direct to the battery without any series decoupling resistance, and there is no significant resistance in either the emitter or the collector circuits. If an attempt were made to check transistor operation by increasing its base current the transistor, particularly if it had a high current gain, could dissipate excessive power and be damaged. Fortunately, the first step in carrying out the transistor check automatically reveals the existence of a circuit condition such as that shown in Fig. 1(e), and the check is not then continued. The low resistance load in the diagram could be a driver transformer primary or an r.f. or i.f. coil. Since it is improbable that a commercial design would include a stage in which the transistor has no series protective resistance, the load could very well consist of an acceptable load which has, due to a fault condition, become short-circuited.

BASE CURRENT

The transistor check consists of connecting a sensitive voltmeter across the emitter and collector of the transistor being checked and then applying a 47KΩ resistor between the collector and the base. If the transistor is in working order its collector current will increase whereupon, due to the series resistance in its circuit, the voltage between the emitter and collector will drop. This voltage drop will be indicated by the voltmeter. The amount of voltage drop will depend on the gain of the transistor, the level of resistance in its emitter and collector circuits and the standing current in the base bias potential divider when this is of the type shown in Fig. 1(a). In some instances, a driver transistor in a circuit of the type shown in Fig. 1(c) may not exhibit a significant drop in emitter-collector voltage when the base current increases due to d.c. negative feedback in the circuit. The transistor checker may not, in consequence, be as effective with this particular circuit as it is with the others discussed.

Making the arbitrary assumption that the transistor being checked should not be made to pass more than 20mA when the 47kΩ resistor is applied between its collector and its base, the series resistance in its emitter and collector circuits should not be less, for the circuits of Figs. 1(a), (b) and (d), than 600Ω with equipment supplied by a 12 volt battery, 450 Ω with a 9 volt battery, and 300 Ω with a 6 volt battery. The required levels of resistance should be found in standard battery operated equipment. In practice there is a further margin of protection against excessive collector current because the extra base current passed by the 47kΩ resistor is derived from

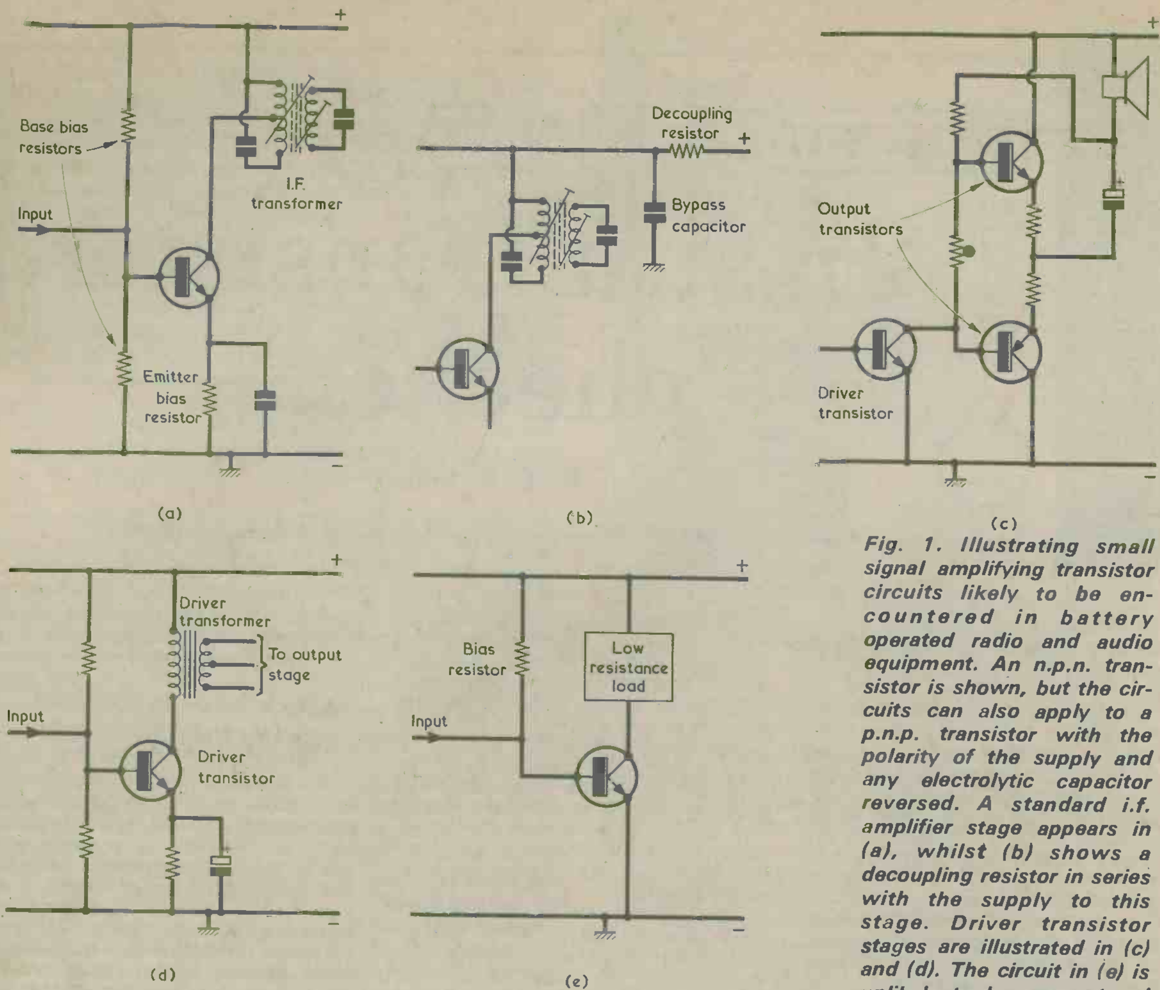


Fig. 1. Illustrating small signal amplifying transistor circuits likely to be encountered in battery operated radio and audio equipment. An n.p.n. transistor is shown, but the circuits can also apply to a p.n.p. transistor with the polarity of the supply and any electrolytic capacitor reversed. A standard i.f. amplifier stage appears in (a), whilst (b) shows a decoupling resistor in series with the supply to this stage. Driver transistor stages are illustrated in (c) and (d). The circuit in (e) is unlikely to be encountered in commercial equipment except under fault conditions

the transistor collector. As collector voltage falls so does the extra base current.

The circuit of the transistor checker is shown in Fig. 2. Two contacts of the test prods connect to the emitter and collector of the transistor being checked and the voltage across these is measured by the voltmeter given by M1, R3, R4, R5 and R6. The base test prod is then applied to the base of the transistor whereupon, if this is serviceable, the voltage reading will fall.

When the transistor being checked is an n.p.n. type the emitter-collector prods are applied as shown in Fig. 3(a). Applying the base test prod causes the 47kΩ resistor, R1, to be connected between collector and base. The remaining 47kΩ resistor, R2, connects between base and emitter, and the current which flows in it is negligibly low because the voltage across it will only be that existing across the base-emitter junction. This will be about 0.6 volt for a silicon transistor and about 0.2 volt for a germanium transistor.

A p.n.p. transistor is checked in the manner illustrated in Fig. 3(b). This

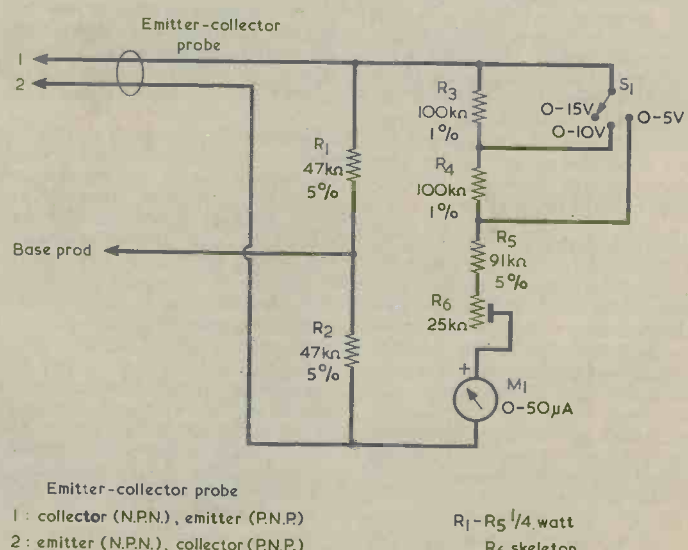
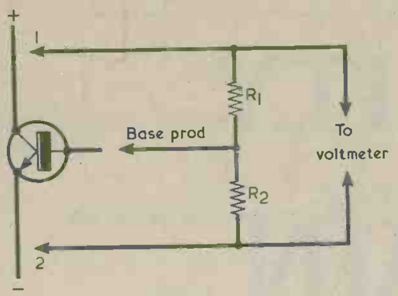
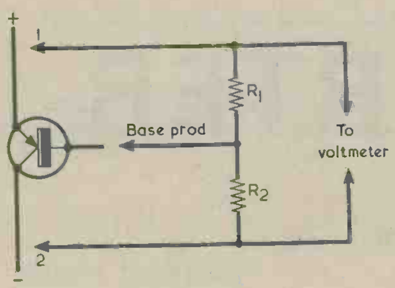


Fig. 2. The circuit of the transistor checker



(a)



(b)

Fig. 3(a). The transistor checker is applied to an n.p.n. transistor in the manner shown here (b). Method of connection to a p.n.p. transistor

time it is R2 which appears between the collector and the base, whilst R1 is now connected between the base and the emitter. It will be apparent that it is not necessary to know whether the transistor being checked is p.n.p. or n.p.n., or even to know its lead-out layout. The collector-emitter prods are simply applied to the two lead-outs which cause the voltmeter to give the highest forward reading. The base prod is then applied to the remaining lead-out.

TEST PROBES

A little ingenuity is called for in making up the collector-emitter probe as this requires two prods in the one assembly and has to be home constructed. The general requirement is illustrated in Fig. 4(a) where the prod tip spacing of $\frac{1}{4}$ in. should enable connection to be readily made to the appropriate copper sections of a printed circuit board. If the two prods can be sprung in the same way as the contacts in a bayonet lamp socket are sprung, use of the probe will be considerably eased as it will not then have to be held at exactly the correct angle to the printed circuit board.

An alternative approach towards making up the two-prod probe is suggested in Fig. 4(b). This requires flat springy metal strips which could be cut from the negative contact of a 4.5 volt torch battery, and it is held at a small angle to the printed circuit board. The base prod is, of course, a standard single contact test prod.

The voltmeter section of the unit can be switched by S1 to read 0-5 volts, 0-10 volts or 0-15 volts. R3 and R4 are both 1% 100kΩ resistors, whilst R5 is a 5% resistor in series with the pre-set potentiometer R6. The latter is adjusted so that the total resistance given by R5, R6 and the internal resistance of the meter is also 100kΩ. A simple method of setting up R6 consists of connecting the negative terminal of the meter and the junction of R5 and R4 to a 4.5 volt battery, as in Fig. 5. Also connected to the battery is

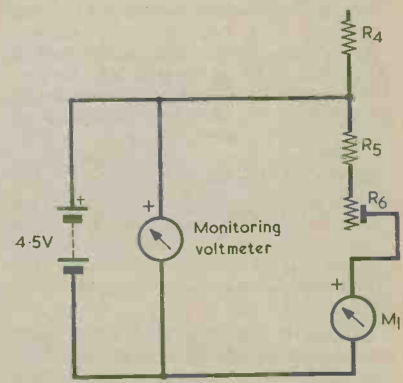


Fig. 5. R6 can be set up with the aid of a 4.5 volt battery and an external voltmeter

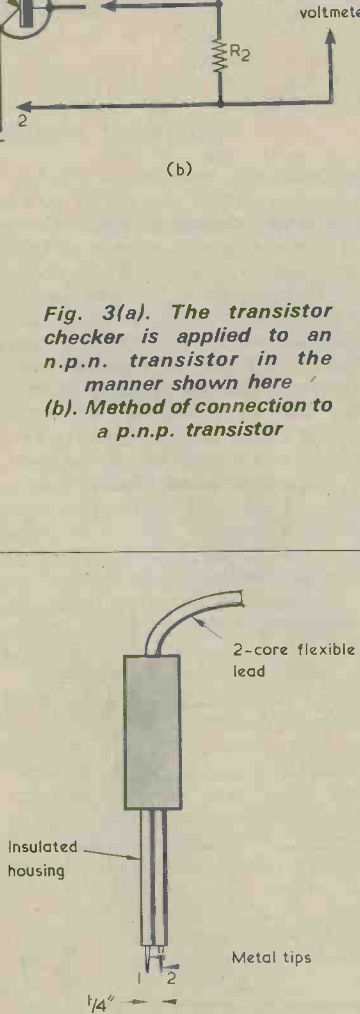
a separate voltmeter. R6 is then adjusted so that meter M1 gives the same reading as the monitoring voltmeter.

The resistors required for the unit may be assembled in a small wooden or plastic box with meter M1 and range switch S1 mounted on the front panel. Flexible leads passing through holes at one side can then connect to the prods.

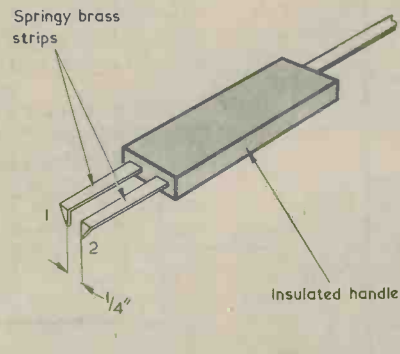
Before the transistor checker is employed, the voltage of the battery supplying the equipment to be tested should be measured with the equipment switched on. S1 is set to a suitable range and the emitter-collector prods applied to the emitter and collector of the transistor being checked. If the lead-outs are not known, the prods are applied to the two lead-outs which give the highest forward voltage reading in the meter, as was just mentioned.

Should the emitter-collector voltage be equal to or very nearly equal to battery voltage, no further tests are carried out with the transistor checker and the following possibilities then exist. First, the transistor stage may be in a circuit condition of the type shown in Fig. 1(e), in which case applying the base test prod could damage the transistor. Second, the transistor could be receiving no base bias and a fault should be looked for in the base bias circuit. Third, the transistor could have gone open-circuit. These possibilities can be examined using normal fault-finding techniques.

If the voltage across the transistor is very low, say between 1.5 and 1 volt, a fault condition probably exists, causing the transistor to draw too much



(a)



(b)

Fig. 4(a). Basic requirements for the emitter-collector probe (b). An alternative construction for the probe which may be simple to assemble current. Possible causes are a reduction in resistance in the emitter bias circuit due, perhaps, to a short-circuited emitter bypass capacitor or an open-circuit or high value in the lower resistor of the base potential divider when this is of the type shown in Fig. 1(a). A further possibility is that the series collector resistance has gone high in value. These points should be checked before proceeding further. The reduction in voltage across the collector and emitter when the base prod is applied will be less pronounced, or even hardly noticeable, when there is a very low voltage across the transistor. Although rather unlikely, the transistor itself could be causing the low voltage condition.

Should the voltage across the transistor be lower than 1 volt, the same fault conditions as in the previous case can exist and it is more probable that the transistor itself is causing the trouble.

When it is found that the voltage across the transistor is in excess of 1.5 volts and is at least a volt or more lower than battery voltage then the base prod may be applied. With a serviceable transistor the voltage across the collector and emitter will fall, proving that the transistor is giving correct transistor operation and can therefore be considered in working order.

With germanium transistors whose emitters connect directly to the lower supply rail, as in Fig. 1(c), it may be difficult to initially find the two lead-outs which give the highest forward voltage in the meter, as the voltage between collector and base will be very nearly the same as the voltage between collector and emitter. The simple solution here is to first check with the emitter-collector probe connected to one pair of lead-outs and the base prod applied to the remaining lead-out. If this does not give the desired drop in voltage then the emitter-collector probe is connected to the other possible pair of lead-outs and the test repeated.

S1 can, of course, be switched to a lower range if the initial voltage found across the emitter and collector warrants this.

Connecting the base prod to the transistor base will cause additional current from the emitter and collector circuits to pass through the appropriate 47kΩ resistor, R1 or R2. Where there is a high series emitter and collector resistance, this fact could, of itself, cause a small drop in voltmeter reading. If such an effect is suspected the magnitude of the drop due to the 47kΩ resistor on its own can be checked by temporarily applying the base prod to the emitter, whereupon a similar voltage drop will be given. In most instances the voltage drop due to current in the 47kΩ resistor will be negligibly low, and the voltage drop due to correct transistor operation will be considerably higher and much more noticeable. ■

UNITY GAIN INVERTER

By J. R. Davies

Comments on a basic circuit configuration.

Occasionally, an a.f. amplifier design requires that a unity gain phase inverter be inserted in a signal chain. A possible instance occurs when a speaker is driven by a full bridge amplifier as in Fig. 1. This arrangement provides a voltage swing at the speaker which is twice that available from a single amplifier. With a single amplifier the peak positive or negative voltage swing at the speaker is nearly half the supply potential; with the bridge arrangement the peak voltage swing is nearly the full supply potential.

A unity gain phase inverter is inserted at the input to one of the amplifiers to ensure that the two amplifier outputs are in anti-phase.

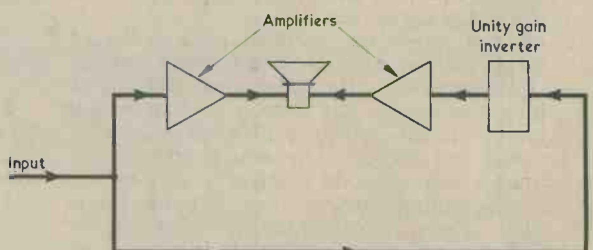


Fig. 1. A full bridge amplifying arrangement. The two individual amplifiers have identical characteristics

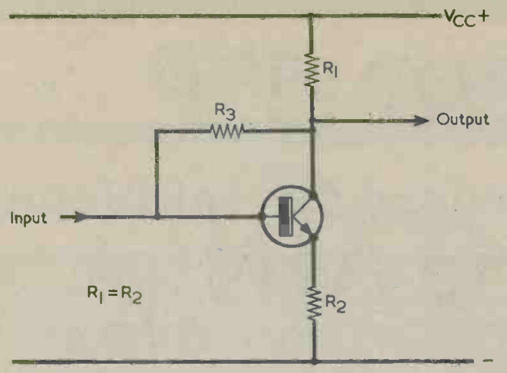
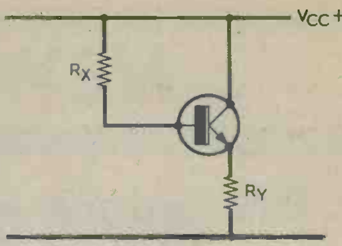


Fig. 2. The unity gain inverter circuit. For clarity, input and output coupling capacitors are omitted

Fig. 3. A transistor configuration which is used to demonstrate the relationship between base bias and emitter load resistors



PHASE INVERTER

A very simple but effective phase inverter is shown in Fig. 2. There is nothing new about this circuit but some comments concerning its operation may be of interest to constructors. Resistors R1 and R2 have equal values. Bias resistor R3 has a value which, ideally, causes the emitter to be at 0.25Vcc and the collector to be at 0.75Vcc under quiescent conditions. The circuit functions by reason of the fact that, when the transistor has a reasonably high current gain, the collector current can be assumed to be equal to the emitter current.

If an input signal takes the base of the transistor positive, emitter follower action causes the emitter to go positive by the same amount. The emitter current increases and so also, by an equal amount, does the collector current. Since R1 and R2 have equal values the increased voltage now appearing across R1 will be the same as the increased voltage across R2. Thus, taking the base of the transistor positive causes the collector of the transistor to go negative by an equal amount.

The converse will also hold true. If the transistor base is taken negative, the emitter and collector suffer an equivalent excursion, with the collector going positive. In consequence, the circuit carries out the function of a unity gain inverter.

Assuming the quiescent emitter and collector voltages just mentioned and ignoring forward voltage drops in the transistor, the peak negative input voltage which the circuit can handle is that which takes the emitter to the negative rail, with no current flowing in either R1 and R2. The peak positive input voltage is that which takes the emitter to very nearly half the supply voltage, whereupon the collector is only very slightly positive of the emitter. Under these conditions, the maximum peak-to-peak input voltage is half the supply potential. In practice, it would be wise to assume that the maximum useful peak-to-peak input voltage is about 75% of half the supply voltage. This will take in tolerances on value in R1 and R2, and gain spread in the transistor. Normally, the circuit would be run at much lower input voltages.

BIAS RESISTOR

The optimum value for the bias resistor, R3, can be readily calculated. In an earlier article, "Finding Bias Resistance Values" which appeared in the June 1973 issue of *Radio & Electronics Constructor,* the author showed that when a transistor is connected up as illustrated in Fig. 3 the emitter will be at around half the supply voltage when the value of resistor RX is equal to the value of the emitter load resistor RY multiplied by a "central" figure in the hFE gain spread of the transistor. This "central" figure is one-third of the way up from the lower figure in the gain spread. If the transistor is a BC107 it has an hFE spread of 110 to 450. The difference between these figures is 340, and one-third of 340 is, for the level of accuracy required here, 110. So, with a BC107 a suitable value for RX in Fig. 3 is 110 plus 110, or 220 times the value of RY.

With the inverter circuit of Fig. 2 it is required that, under quiescent conditions, the emitter be at one-third instead of one-half of collector potential, so that twice the voltage dropped across R2 is dropped across R3. In consequence, the value required in R3 of Fig. 2 is twice the value calculated for RX of Fig. 3.

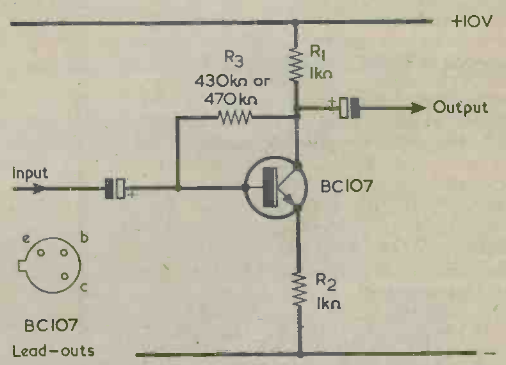


Fig. 4. A practical unity gain inverter. The input and output coupling capacitors have values suitable for the frequencies to be handled

Fig. 4 shows a practical unity gain inverter circuit. R1 and R2 have been arbitrarily given values of 1kΩ, which means that the quiescent current flowing in these resistors is approximately 2.5mA. The transistor is a BC107 and the value required in R3 is 1kΩ multiplied by 440 (double the multiplier required with a BC107 in the Fig. 3 circuit). In practice a 430kΩ or 470kΩ resistor would be suitable.

In addition to its use as a unity gain inverter, the circuit of Figs. 2 and 4 may also be employed as a phase splitter, outputs being taken from the emitter and collector. The signal voltages at these points are equal in amplitude and opposite in phase. ■

NEWS . . . AND .

CBM launch scientific standard for calculators

CBM Business Machines Limited recently announced the launch of a comprehensive range of three new hand-held calculators designed to create a meaningful standard for all scientific calculator users. The complete range utilise CBM's own integrated circuit design capability with the use of their own exclusive chips in every model.

The models are priced at £29.95, £39,95 and £49.95 excluding V.A.T. After the initial launch it is planned to build the entire range at CBM's British factory in Eaglescliffe, near Stockton, and export throughout Europe.

A special feature of this CBM range is that these machines all calculate to 14 digits and include at least 8 digits in the mantissa, plus two in the exponent. This provides a degree of accuracy considerably greater than most other calculators on the market. Two independent memories are included throughout the range as well as parenthesis on all three models. In addition to all the usual trig, log and power functions, these models have "Exponent shift keys". When depressed, these keys will shift the decimal point of the mantissa, as the exponent is simultaneously increased or decreased to the required power. Special features also included on these models are mean and standard deviation for statistical work, plus polar to rectangular coordinate conversions.

CBM Business Machines Limited operate from offices at 446 Bath Road, Slough, Bucks, and a factory at Eaglescliffe. Together with associated companies in Germany, France and Switzerland, they serve the whole European market.

EF.10X electronic air purifier

With present day pollution reaching alarmingly high levels, the EF.10X electronic air purifier has been developed to provide the ultimate in efficient and economical air cleaning. Ideal for homes and offices alike, it provides a high rate of purification.

Even with continuous 24 hours operation, running costs are less than for a 60 watt light bulb.

Heat loss is reduced as the same room air is recycled, e.g. the air in a room of 2,500 cu.ft. is filtered 7 times per hour. This eliminates the need to open windows for ventilation, during the winter.

The whole unit measures only approx. 21in. long x 12in. high and 10in. deep, with a rich rosewood finished front panel surrounded by a robust black satinised metal case. Weighing only 34 lbs., it can be carried (see special carrying handle) from room to room as required and placed on a shelf or table — the only installation required is to fit a 13 amp plug.

Normal, stale polluted room air is drawn in at the back of the unit by a quiet but powerful suction fan, and forced through four individual internal filters, each scientifically designed to remove a certain size range of particle.

Price: £168.75 including VAT. Stockists: Harrods, Heals and Selfridges, or direct from Humidifier Sales Ltd., 21 Napier Road, Bromley, Kent BR2 9JA.

. . . COMMENT

New radio telescope to see stars born?

Jodrell Bank radio astronomy centre is to have yet another radio telescope aerial dish, costing about £2m, it was reported on BBC World Service.

The new aerial will be used to listen to radio sources both in our own galaxy and way outside it, with a particular hope that the astronomers will be able to eavesdrop, so to speak, on the moments when a star is being born in the depths of the heavens.

The Jodrell Bank radio astronomers will use the new dish aerial as part of a system involving their existing aerials. The new dish will be 25m in diameter, and sited some 100 km away from the Jodrell Bank headquarters at a place called Knockin, on the border between England and Wales.

The dish of a radio telescope aerial gives an enormous magnification of the very weak signals from outer space, but Jodrell's technique with the new dish, as it is with others spaced away from the main centre, will be to use it to form what's called an interferemeter.

This involves using two or more widely-spaced small aerials, just tens of metres across, as if they were parts of a much bigger aerial, a hundred or more kilometres across. This does not make the aerials magnify as well as a real big aerial would do, but it does have a different and even more valuable effect.

The bigger an aerial, the finer the detail it can see — small aerials give fuzzy pictures, and big ones sharp pictures. The effect of combining the signals from two or more wide spaced small aerials in this way is to produce an extremely detailed picture, showing very small things clearly, and giving very exact information on the positions of radio sources so that they can be correlated with pictures from optical telescopes.

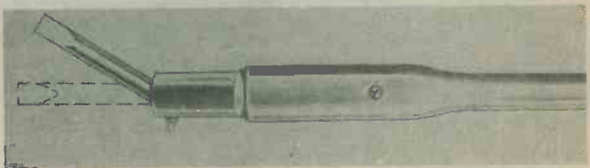
Swiss S.W. service 40 years old

In 1934, the Swiss community in Quito, the capital of Ecuador, asked the Swiss Broadcasting Corporation (SBC) to broadcast a radio programme to South America in honour of August 1st, the Swiss National Day. SBC, fascinated by this pioneering idea, acted on the request, and on August 1st, 1935 a Swiss broadcast was transmitted to Latin America by short wave over the transmitters of the League of Nations in Geneva, which had kindly agreed to provide facilities for this historic event.

The broadcast was such a striking success that in autumn 1935, SBC began a regular service of programmes for listeners abroad, mainly intended for Swiss citizens living in North and South America.

At the end of the 1930s, SBC finally acquired its own short-wave centre, situated at Schwarzenburg, near the capital, Berne.

Adjustable bit for Solon soldering iron



Alternative positions of the bit

A significant modification has been made to the 65-watt Solon soldering iron. Flexibility in use has been improved by the introduction of an adjustable pencil bit.

The new model gives choice of a straight or angled bit. The simple turn of a screw enables the angle of the bit to be adjusted for use in near-inaccessible parts, or to aid visibility.

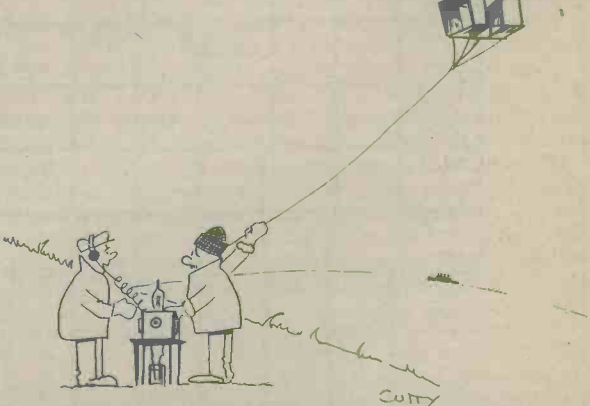
The 65-watt iron is now obtainable with three types of bit: adjustable-angle pencil, straight pencil and and oval tapered. All parts are replaceable and obtainable as spares.

The iron is ideal for general workshop or household use, the two types of pencil bit being especially suitable for wiring connections and similar light work.

COVER PRICE INCREASE

We regret that, because of rising costs, commencing with the next issue the cover price of *Radio & Electronics Constructor* will be increased to 35p.

Annual Subscriptions will be £5.00 per annum, and for copies sent to U.S.A. and Canada the cost will be $11.00, all inclusive of postage.



"It's a message from some guy in England calls himself Marconi — and says 'Compliments of the Season to all Radio & Electronics Constructor *readers'."*

TOUCH TUNING CONTROL

By J. B. Dance

Details of an MOS integrated circuit which allows television receiver channels to be selected by touch buttons or by a remote switch.

Most television receivers employ one of the conventional mechanically switched push-button types of tuner unit for programme selection. An alternative system is available for both colour and monochrome receivers which involves the use of a touch tuning system incorporating a specially designed integrated circuit.

THE ETT6016

The Hughes ETT6016 MOS touch tuner is a 16 pin dual-in-line integrated circuit. It provides facilities for selecting any programme from up to six signals and for indicating the selected channel by means of a neon bulb.

The very high input resistance of the MOS circuit enables it to detect the impedance of a person's finger placed across the two contacts of a sense plate, and it then carries out the channel switching according to the particular set of contacts which are touched.

The same integrated circuit can also be employed in a remote control circuit which causes it to switch through the various channels successively until the required one is reached.

CIRCUIT

A typical ETT6016 circuit is shown in Fig. 1. The device operates from a 33 volt supply, this being normally the supply used to control the varicap tuning

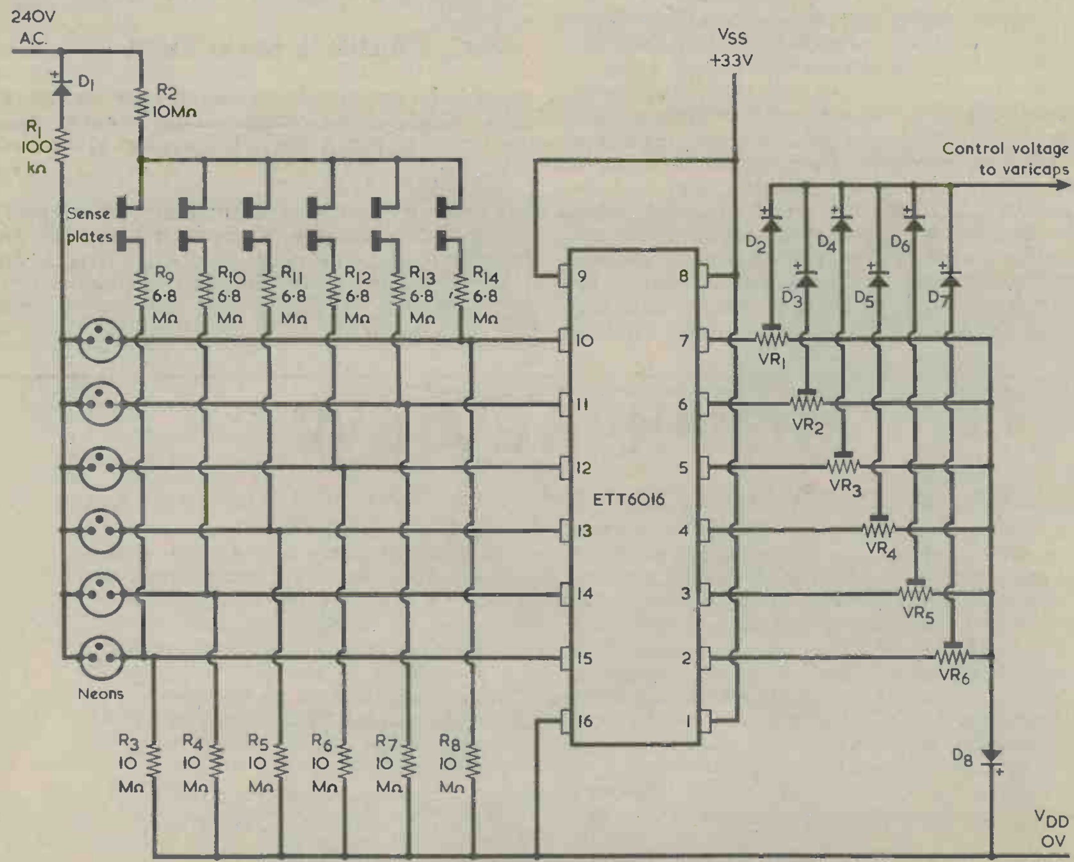


Fig. 1. Typical circuit for an ETT6016 tuning system

capacitors. If this supply is positive, V_{SS} is 33 volts positive and V_{DD} is zero volts, as in Fig. 1. Alternatively, a negative supply can be used in which case V_{SS} is zero volts and V_{DD} is 33 volts negative.

Pins 10 to 15 of the ETT6016 are the "sense inputs" which detect the current flowing through the finger of the operator; they also control the neon bulbs. Pins 2 to 7 provide the voltage outputs to the varicap tuning capacitors.

The 10MΩ resistors R3 to R8 determine the impedance of the sense input circuits. One side of each touch plate is connected via one of the resistors R9 to R14 to the corresponding sense input, and the other side via a 10MΩ protective resistor, R2, to the 50Hz mains or alternatively to a positive supply of a similar voltage.

The sensitivity of the switching system is determined by the value of the resistors R3 to R8 and the value of the alternating voltage at the upper end of R2.

SWITCHING

When the potential between the sense input and V_{DD} reaches 15 volts (equivalent to a current of 1.5μA through the finger touching the plate) the channel concerned will be latched on and all of the others switched off. The potential of the chosen sense input is switched by a low impedance MOS switch to the value V_{SS} and the corresponding neon will glow.

The alternating mains voltage is rectified by diode D1. The use of a half-wave rectified unsmoothed supply to drive the neons minimises the voltage appearing across the MOS circuit during turn-off.

Potentiometers VR1 to VR6 are set so that each one provides the voltage required by the varicap diode in the tuner unit to tune to the corresponding programme.

Diodes D2 to D7 isolate each channel from the others. D8 is a temperature compensation diode which matches the diodes D2 to D7.

STEPPING SYSTEM

In the circuit of Fig. 1, pin 9 is held at a potential equal to V_{SS}. If a negative-going pulse (relative to V_{SS}) is applied to pin 9 for a period of between 100μS and 1mS, the operating channel will be changed by one step so that the next channel comes into use.

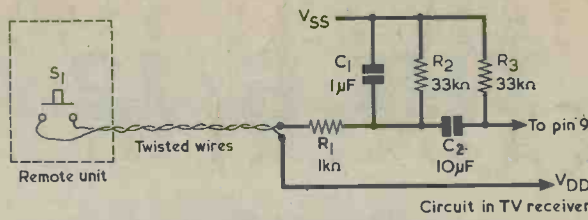


Fig. 2. Remote tuning using the ETT6016. Channels are selected in succession by closing the switch in the remote unit

The remote control system shown in Fig. 2 may be employed using a 2-wire link (with twisted wires) and a single switch, S1, in the remote control unit.

The components R1 and C1 act as a filter which removes any spurious pulses due to contact bounce at S1. R2 of Fig. 2 discharges C1 between the channel stepping operations.

The value of C2 determines the length of the pulse applied to pin 9 of the integrated circuit; this capacitor is discharged by R3. The suggested values of 1uF and 10μF for C1 and C2 of Fig. 2 may be varied somewhat, depending on the amount and type of contact bounce at the switch contacts.

INITIAL CHANNEL SELECTION

If a 1μF capacitor is connected between one sense input and V_{SS}, the corresponding channel will be selected when the power is first applied to the circuit. This requires that a steady d.c. sense voltage supply be employed.

Further information and an applications report are available from Hughes Microelectronics Ltd., 12-18 Queens Road, Weybridge, Surrey. Circuits which employ only one touch contact per channel can be used with the ETT6016, but the double contact system shown in Fig. 1 is more reliable.

BOOK REVIEW

A GUIDE TO AMATEUR RADIO, 16th Edition. By Pat Hawker, G3VA. 112 pages, 250 x 185mm. (9¾ x 7¼in.) Published by Radio Society of Great Britain. Price 90p.

One wonders how many British amateur transmitters made their first steps in the direction of their licences with the aid of this well-known publication. Now in its 16th edition, it continues to offer excellent practical advice on passing the licence examinations. And, as always, it gives helpful information on many other aspects of the hobby.

This latest edition has been extensively revised and enlarged to take in latest trends, with particular attention to s.s.b. techniques and semiconductor applications. An entirely new chapter on amateur radio equipment includes a survey of over 160 commercial receivers, transmitters and transceivers. Also provided are full constructional details of two simple transistor receivers and a phone-c.w. transmitter.

A Guide To Amateur Radio is virtually a must for anybody entering the field of amateur radio transmission. It can, if necessary, be obtained direct from Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE, for £1.14 post paid.

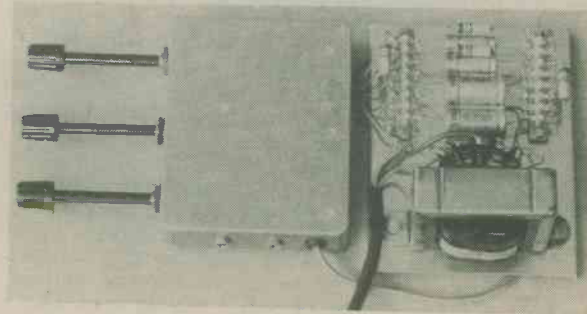
THE 6/12 AMPLIFIER

Part 2

by J. T. Neill

6 watt continuous, 12 watt peak

The circuit operation of this amplifier was described in last month's issue. In this concluding article details are given of construction and setting up.



In last month's issue we completed our examination of the circuit functioning of the "6/12" amplifier and its power supply. Also given was the complete Components List for the amplifier and power supply. We next deal with constructional details.

CONSTRUCTION

Leads from the power supply to the amplifier can be up to 18in. in length; there are in fact six of them in all. This total is made up of two positive rails, two negative rails and two earth returns. One of the earth lines (E1 in Figs. 2 and 6, both published last month) is the return from the loudspeaker and the other (E2) is the return from the remainder of the circuitry. This separation of earth lines is necessary to eliminate unwanted coupling between stages arising from large output signal currents flowing in the same impedance as earth currents to earlier stages. Distortion, or even oscillation, can be caused if only one earth return is used. The two earth lines are brought together on the power supply, close to the transformer secondary centre tap, which is firmly bonded to the mains earth.

As the photographs and specification which appeared last month indicate, the "6/12" is very compact. All but the power supply is contained in a robust die-cast box, as specified in the Components List. The two input sockets are on one short side and the output socket on the other. All three controls are on one long side, which means that the internal strengthening rib in the centre of that side will have to be removed. Such a task is easily carried out by means of a *small* cold chisel, followed by filing. Ensure throughout the operation that the box is firmly held in a vice.

The power leads enter through a hole and grommet as shown and terminate at the 6-way tagstrip mounted close to one side of the box. This tagstrip is readily visible in the photograph of the amplifier interior.

The jack sockets are of the insulated variety, with their earth connections insulated from the chassis. The earth return for the output is taken to one tag on the 6-way tagstrip and thence to the earth point on the power supply, via a separate lead as already described. Earth returns from the two signal input sockets are made by joining them together and connecting them to chassis using a solder tag under one of the fixing nuts for the tagstrip. This point is also the chassis connection for the remainder of the circuitry and is taken back to the main earth point on the power supply via the second earth lead.

Both output transistors are bolted to the flat of the box, using a mica washer as insulation between the box and collector. The collector is connected internally to the metal pad visible on one large side of the device. If available, use some silicone grease, or other heat sink compound, on either side of the mica washer. Do not overtighten the nut and bolt used for fixing.

The output transistors have the outlet connections given in the main circuit diagram of Fig. 2. Note that the centre lead is the collector. Both output collectors are joined together, and the output transistors are mounted sufficiently close to each other for this to be done without further wiring. The safety resistor R21 is then used to take the ouput signal to the appropriate jack socket.

VEROBOARD ASSEMBLY

Most of the remaining circuitry is contained on a piece of 0.15in. pitch Veroboard having 23 holes by 13 strips. The layout used in the prototype is given in Fig. 7, and it is strongly recommended that this be followed. In particular, note that D1 and D2 are so positioned on the board that they lie close to TR2 and TR4 for a measure of temperature compensation, as described earlier. No connection is made to pin 5 of either integrated circuit, and this lead is left clear of the board in both cases.

The Veroboard is mounted on the bottom of the box using two 6BA screws and nuts. For insulation between the box and copper strips on the board, each screw is first held in place with a 6BA nylon nut. A piece of thick cardboard, the same size as the board and with two holes capable of passing over the nylon nuts, is then so positioned that when the Veroboard is dropped into place no contact is possible with the box. The nylon nuts are then in contact with the copper side of the board. Metal nuts may be used on the component side.

Resistors R1, R2 and R3 are wired directly on the input sockets, while some of the resistors and capacitors associated with the tone controls are mounted between VR1, VR2, VR3 and the component board. These are illustrated in Fig. 7. The three potentiometers take up the same relative positions on the die-cast box side as in Fig. 7, i.e. VR3 is in the centre, VR1 is at the input socket end and VR2 is at the output socket end.

All connections to the board, both for components and for other wiring, are made to the correct size Veropins; these are inserted from the copper side and then soldered in place. It will be noted that C7 and R8 in Fig. 7 connect to a Veropin fitted to what is otherwise an isolated copper strip. This Veropin is merely used as an anchor point for the two components and serves no other function.

Detailed construction of the power supply will depend to some extent on the physical sizes of the components used. The layout is in no way critical and can be adjusted to suit individual circumstances. In the prototype a piece of aluminium sheet measuring $5\frac{1}{4}$ by $4\frac{3}{4}$in., with each long side bent down at right angles

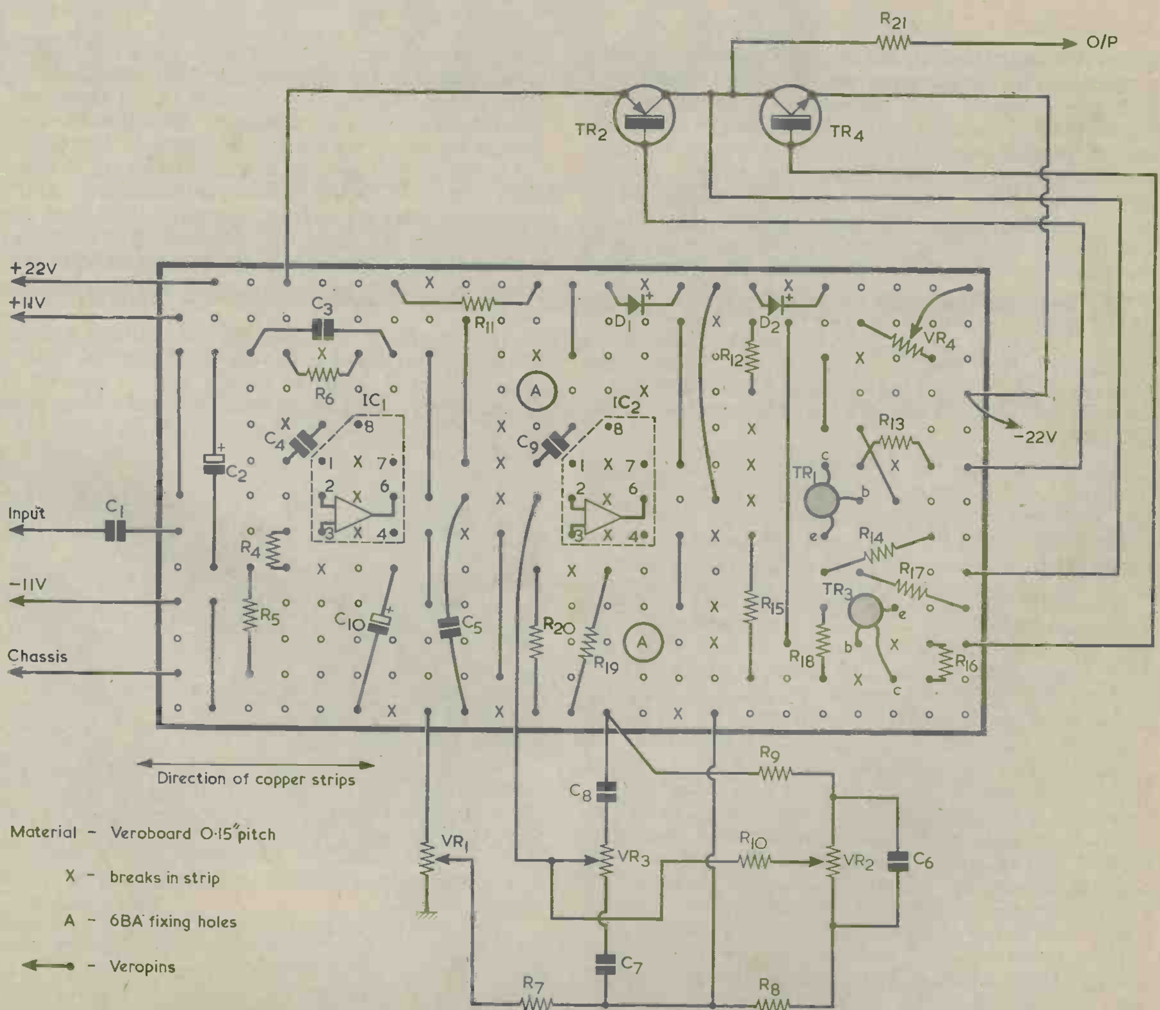


Fig. 7. The component side of the Veroboard panel on which most of the parts are assembled

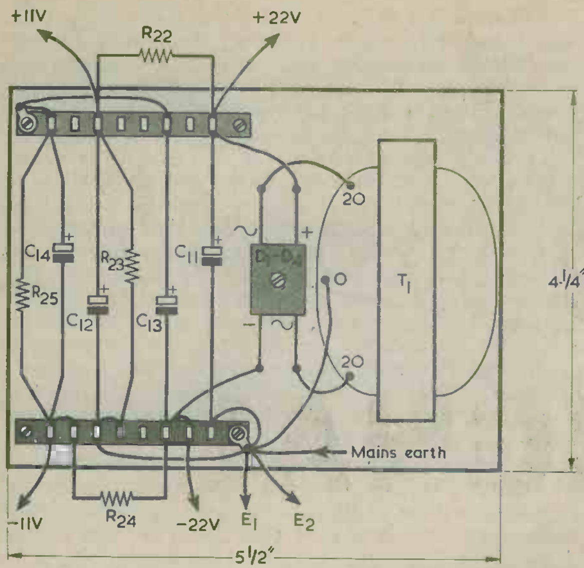


Fig. 8. A suitable layout for the power supply components

about ¼in. from the edge for strength, was employed as a chassis. The transformer was mounted at one end, and the resistors and capacitors located on two tagstrips fixed parallel to the chassis longer sides. The bridge rectifier was a 100 volt 2 amp type in a plastic encapsulation and was fitted, by a bolt passing through its central fixing hole, near the middle of the power supply chassis. The earth point for the E1, E2 leads was a solder tag under a screw securing one of the tagstrips. The mains earth and the transformer secondary centre-tap also connected to this point.

The general layout of the power supply is shown in Fig. 8. This does not include the connections of the mains live and neutral wires to the transformer primary. For 240 volt mains these should connect to the zero volt and 245 volt primary taps, and *not* to the 225 volt tap.

Before connecting the power supply to the amplifier, check its output voltages. Off load, they should be about 30 volts positive and negative and 15 volts positive and negative.

TESTING

When all wiring is complete set VR4 to insert minimum resistance, i.e. fully anti-clockwise. This will result in minimum current through TR2 and TR4. Insert a current reading meter in series with the positive supply to the output stage; a multi-range testmeter set to its highest current range for safety will suffice. Do not connect a load to the amplifier at this stage. Switch on and rapidly note the current reading. It should be about 10mA, ignoring any initial switch-on surge. If it is greater than about 20mA, switch off at once; a fault is probably present and should be located and rectified before proceeding further. With all in order, set the testmeter to a suitable range and slowly increase VR4 until a reading of about 15mA is given; this is the output stage standing current.

If an audio oscillator and oscilloscope are available, inject a 1kHz signal of appropriate level at either input and monitor the output waveform. Set the amplifier gain about half-way and then adjust the oscillator to give about 1 volt peak-to-peak output signal. Connect an 8Ω load, which may be either a loudspeaker or a dummy load. At the output level present, about 16mW, there should be no crossover (or other) distortion. If crossover distortion is seen it should be cured by a *slight* increase in the setting of VR4, which will give an increased current in the output stage. Without the audio oscillator and oscilloscope it would be best to keep to the 15mA quiescent current. If subsequent listening tests at low levels indicate the possibility of crossover distortion an increase in the setting of VR4, again *slight* only, may be made.

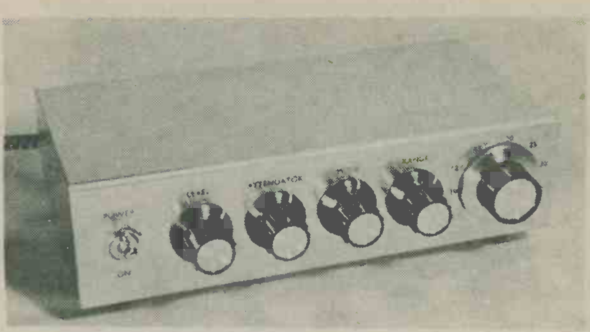
Next measure the standing d.c. voltage present at the output terminal with respect to chassis, both with and without a load. It should not be greater than about 30mV. If it is, a fault is most likely present which either prevents the negative feedback at d.c. from being 100% effective over the tone control and output stage, or a standing d.c. voltage is present at the volume control slider. It is important not to have a large standing d.c. voltage at the output since no coupling capacitor is employed in series with the loudspeaker, nor is one necessary in normal use.

Full power testing can then be carried out. A continuous output power of 6 watts in 8Ω should be available with bursts of 12 watts possible for short periods. These power levels correspond to 6.9 volts r.m.s. and 9.8 volts r.m.s. respectively. Readers who are using a 15Ω speaker or who do not have the requisite test equipment may omit this last test.

Finally, how best to mount the amplifier? Being so small and totally enclosed, room can readily be found for it in most record player plinths in such a position that there is easy access to the three controls. A little more care is called for in locating the power supply but since it is remotely situated no great trouble should arise.

The question of loudspeakers and their enclosures is, as most constructors realise, a subject on its own. In this case, personal choice and cost will largely determine what to use; but be sure that the unit is of a suitable impedance and can handle the power required. ■

WIEN BRIDGE AUDIO SIGNAL GENERATOR



By R. A. Penfold

Offering a continuously variable range from 7.5Hz to 75kHz, this mains powered audio signal generator employs an ingenious method of automatic gain control for its op-amp sine wave oscillator. A second op-amp provides an alternative square wave output.

This audio signal generator is of modern design and incorporates two high gain operational amplifiers. The circuit is based on the popular 748 integrated circuit, and the very high gain of this device allows an extremely pure sine wave output to be obtained. A square wave output is also available. Frequency coverage is continuously variable from less than 7.5Hz to more than 75kHz. There are four ranges and the coverage in each is shown in the accompany table.

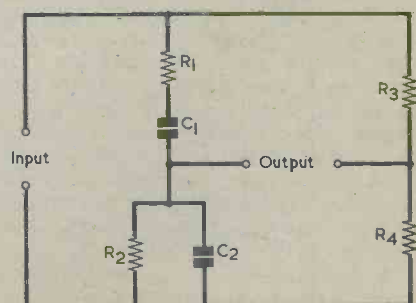
The basic signal output level is approximately 1 volt peak-to-peak on both sine and square wave outputs. A 3-position attenuator provides further output amplitudes of 100mV and 10mV peak-to-peak, and a continuously variable attenuator of the volume control type is also included in the circuit.

A quite compact design has been achieved, and the prototype has outside dimensions of 8 by 4 by 2in., excluding feet and control knobs. The generator is mains powered.

WIEN BRIDGE

The signal generator incorporates a Wien bridge oscillator. The basic circuit diagram of the Wien bridge is shown in Fig. 1. In practical versions of the bridge, R1 is almost invariably equal to R2 and C1 to C2. The operating frequency of the bridge is then given by the equation included in the diagram.

At this operating frequency there is no phase shift between the input and output of the circuit, whereas some degree of phase shift occurs at all other frequencies. In a Wien bridge oscillator the bridge is connected between the input and output of an amplifier having a voltage gain of 3 times or more, the gain being necessary to compensate for the losses in the



$$f = \frac{1}{2\pi R_1 C_1}$$

Fig. 1. A basic Wien bridge circuit

bridge circuit. The amplifier must also have its input and output terminals in phase, so that it is positive feedback that is supplied by the bridge.

Fig. 2 shows how an operational amplifier can be incorporated into a Wien bridge oscillator. The Wien bridge network is connected between the output and non-inverting input of the amplifier, and R3 and R4 are not required here as the input impedance of the amplifier is extremely high.

For a pure sine wave output the overall amplifier gain must be just sufficient to maintain oscillation. Otherwise, the Wien network will permit sufficient feedback for oscillation to occur at frequencies other than the central frequency of operation, and this would result in distortion of the output waveform.

In an operational amplifier circuit the gain of the amplifier can be controlled by a potential divider connected between the output and the inverting input. This is given in Fig. 2 by R5 and R6. Theoretically it would seem possible to give these two resistors fixed values which would provide just the right degree of gain, but such an approach is not feasible in a practical circuit. In order to maintain the amplifier gain at just the correct level over a wide range of frequencies it is necessary to resort to some form of automatic gain control.

PRACTICAL CIRCUIT

The full circuit diagram of the audio signal generator is shown in Fig. 3. IC1 is used in the Wein bridge oscillator, and R1, R3 and VR1(a)(b) are the resistors of the Wien bridge oscillator. As VR1(a)(b) enables the two resistive elements of the network to be varied in value it also enables the operating frequency to be varied. By switching the capacitive values (C1 to C8) in the network, four ranges are covered.

The automatic gain control action required to just maintain oscillation is provided by TR1. This is a field effect transistor, and at low applied voltages the drain to source terminals present what is effectively an ordinary resistor, the value of which can be controlled by varying the gate to source voltage. When the gate has the same potential as the source, the drain to source resistance is only a few tens or hundreds of ohms.

The voltage gain of IC1 is equal to the sum of R13,

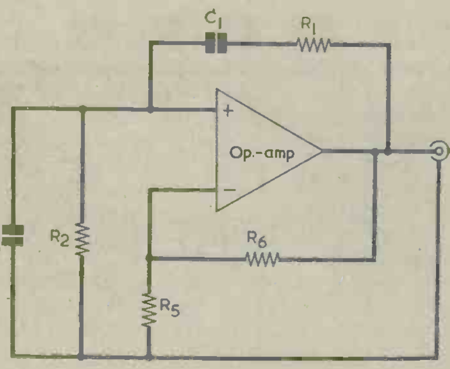


Fig. 2. A Wien bridge oscillator incorporating an operational amplifier

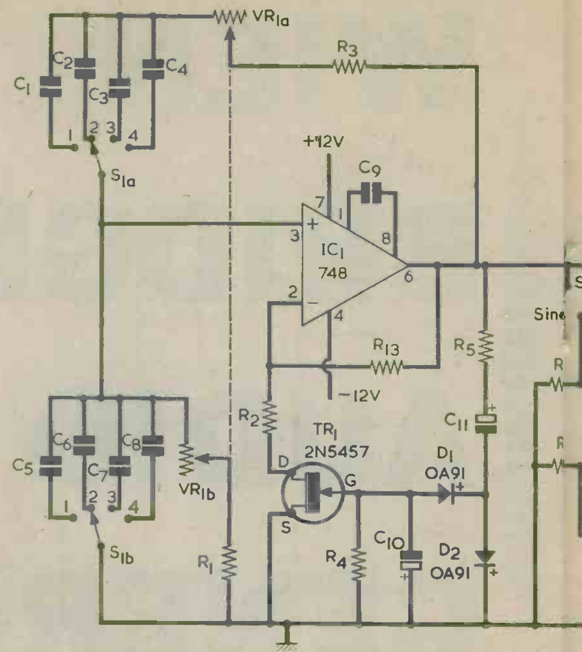


Fig. 3. The circuit of the Wien bridge audio sig

COMPON

Resistors
(All fixed values miniature ¼ watt 5%)
R1 680Ω
R2 27kΩ
R3 680Ω
R4 220kΩ
R5 390Ω
R6 1kΩ
R7 56Ω
R8 100kΩ
R9 680Ω
R10 6.2kΩ
R11 620Ω
R12 68Ω
R13 68kΩ
VR1 10kΩ + 10kΩ dual gang potentiometer, carbon linear
VR2 1kΩ potentiometer, carbon linear

Capacitors
C1 2.2μF plastic foil
C2 0.22μF plastic foil
C3 0.022μF plastic foil
C4 0.0022μF plastic foil
C5 2.2μF plastic foil
C6 0.22μF plastic foil
C7 0.022μF plastic foil
C8 0.0022μF plastic foil
C9 10pF ceramic
C10 25μF electrolytic, 10 V Wkg.
C11 10μF electrolytic, 25 V Wkg.
C12 1.8pF silvered mica (see text)
C13 1,000μF electrolytic, 16 V Wkg.
C14 1,000μF electrolytic, 16 V Wkg.

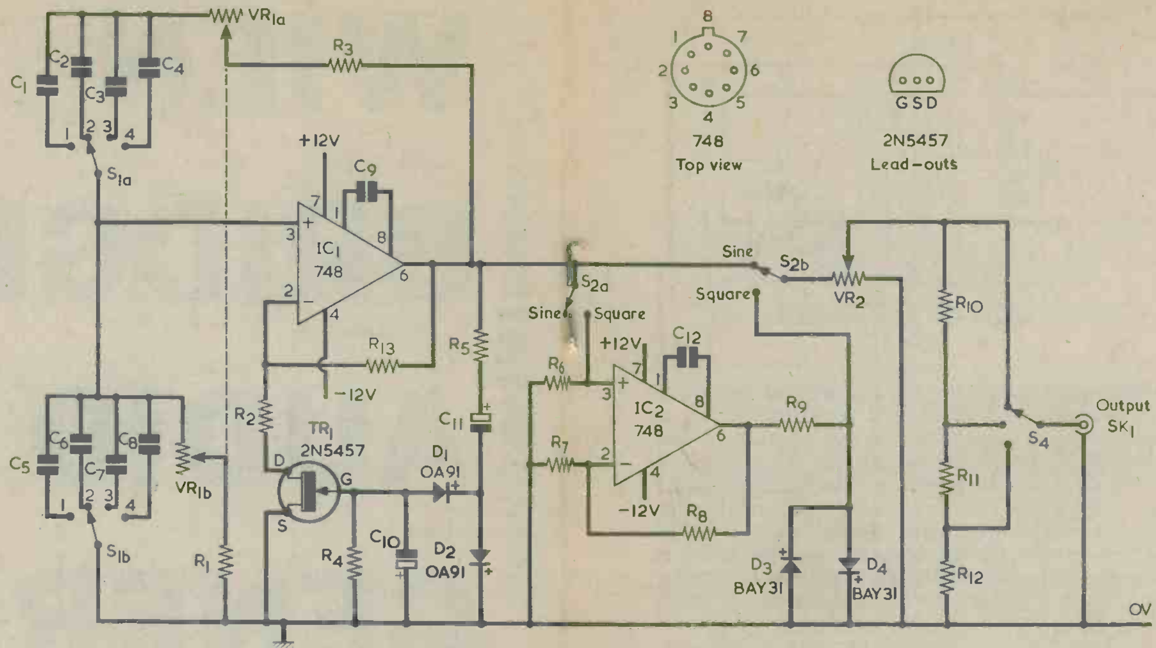


Fig. 3. The circuit of the Wien bridge audio signal generator less the power supply section

COMPONENTS

Resistors
(All fixed values miniature ¼ watt 5%)
R1 680Ω
R2 27kΩ
R3 680Ω
R4 220kΩ
R5 390Ω
R6 1kΩ
R7 56Ω
R8 100kΩ
R9 680Ω
R10 6.2kΩ
R11 620Ω
R12 68Ω
R13 68kΩ
VR1 10kΩ + 10kΩ dual gang potentiometer, carbon linear
VR2 1kΩ potentiometer, carbon linear

Capacitors
C1 2.2μF plastic foil
C2 0.22μF plastic foil
C3 0.022μF plastic foil
C4 0.0022μF plastic foil
C5 2.2μF plastic foil
C6 0.22μF plastic foil
C7 0.022μF plastic foil
C8 0.0022μF plastic foil
C9 10pF ceramic
C10 25μF electrolytic, 10 V Wkg.
C11 10μF electrolytic, 25 V Wkg.
C12 1.8pF silvered mica (see text)
C13 1,000μF electrolytic, 16 V Wkg.
C14 1,000μF electrolytic, 16 V Wkg.

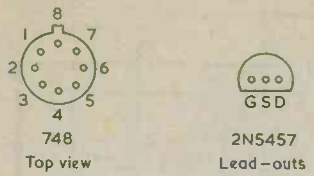
Transformer
T1 Miniature mains transformer, secondary 9-0-9V at 100mA (see text)

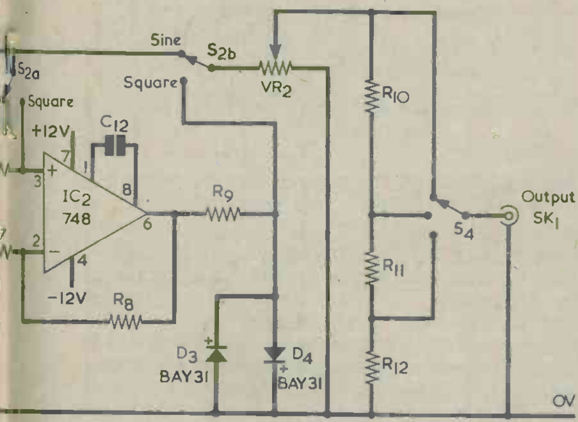
Semiconductors
IC1 748 in round TO5 encapsulation
IC2 748 in round TO5 encapsulation
TR1 2N5457
D1 OA91
D2 OA91
D3 BAY31
D4 BAY31
D5-D8 1N4002

Switches
S1 2-pole 4-way rotary (see text)
S2 2-pole 2-way rotary (see text)
S3 d.p.s.t. toggle
S4 1-pole 3-way rotary (see text)

Socket
SK1 Flush fitting coaxial socket

Miscellaneous
Chassis, 8 x 4 x 2in. 16 s.w.g. aluminium, with base plate (see text)
5 knobs
4 rubber feet
Veroboard, 0.1in. matrix
Plain Veroboard, 0.15in. matrix
Veropins for 0.1in. Veroboard
Mains lead and plug





signal generator less the power supply section

ONENTS

Transformer
T1 Miniature mains transformer, secondary 9-0-9V at 100mA (see text)

Semiconductors
IC1 748 in round TO5 encapsulation
IC2 748 in round TO5 encapsulation
TR1 2N5457
D1 OA91
D2 OA91
D3 BAY31
D4 BAY31
D5-D8 1N4002

Switches
S1 2-pole 4-way rotary (see text)
S2 2-pole 2-way rotary (see text)
S3 d.p.s.t. toggle
S4 1-pole 3-way rotary (see text)

Socket
SK1 Flush fitting coaxial socket

Miscellaneous
Chassis, 8 x 4 x 2in. 16 s.w.g. aluminium, with base plate (see text)
5 knobs
4 rubber feet
Veroboard, 0.1in. matrix
Plain Veroboard, 0.15in. matrix
Veropins for 0.1in. Veroboard
Mains lead and plug

TABLE

Signal Generator Frequency Ranges

Range	Frequency Coverage
1	7.5 – 75Hz
2	75 – 750Hz
3	750Hz – 7.5kHz
4	7.5 – 75kHz

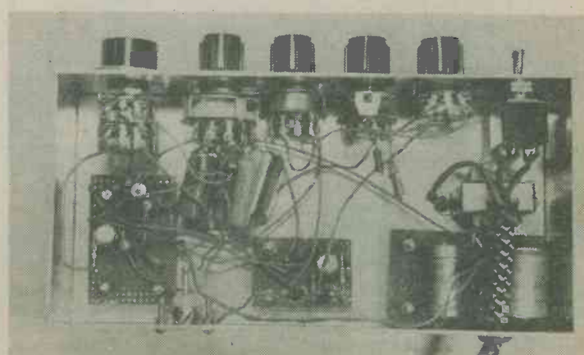
R2 and the drain to source resistance of TR1 divided by the sum of R2 and the drain to source resistance of TR1. With TR1 gate at the same potential as its source, this gain will obviously be well in excess of 3, and the circuit will initially oscillate violently. A proportion of the output of the i.c. is fed via R5 and C11 to a voltage doubler rectifier and smoothing circuit consisting of D1, D2 and C10. These produce a negative voltage at TR1 gate which is proportional to the amplitude of oscillation. The negative bias has the effect of increasing the drain to source resistance of TR1, and so it reduces the gain of the amplifier as well. As the amplifier gain reduces so also does the amplitude of the oscillation and thus the negative bias on the gate of TR1, and a point of equilibrium is reached at which the circuit is just gently oscillating.

This a.g.c. action, together with the large amount of negative feedback around the i.c., produces an extremely pure sine wave output. The negative feedback also provides the circuit with a low output impedance.

The a.g.c. action also plays the important role of maintaining the output signal amplitude of IC1 at a constant level.

C9 is a compensating capacitor, and is necessary to prevent IC1 from becoming unstable.

Capacitors C1 to C8 should preferably have a tolerance of 5% or less. Capacitors having wider tolerances will work in the circuit and can be used with some loss in frequency calibration accuracy. It may be noted here that Mullard type 296 polyester capacitors, available in $0.0022\mu F$, $0.022\mu F$ and $0.22\mu F$, have tolerance on value of 10%.



Looking down into the case of the signal generator. This view shows the positioning of the three circuit boards

SQUARE WAVE OUTPUT

Switch S2(a)(b) selects sine or square wave output. When it is in the sine wave position, the output of IC1 is coupled to the output socket by way of the attenuator network. When S2(a)(b) is in the square wave position the output of IC2 is connected to the attenuator network, and the output of IC1 is connected to the non-inverting input of IC2.

As we have already seen, the voltage gain of an operational amplifier can be determined by two resistors coupling back to the inverting input, and these are R7 and R8 in the case of IC2. They cause IC2 to have a voltage gain of about 1,800 times. Obviously, the output of IC1 will only need to swing a few millivolts positive or negative to send the output of IC2 fully positive or negative. The sine wave input signal to IC2 therefore produces an almost square wave signal of about 20 volts peak-to-peak at its output.

This amplitude is far larger than is required and so the signal is fed to a simple clipping circuit consisting of R9, D3 and D4. The diodes are silicon types, and they become conductive at forward voltages a little in excess of 0.5 volt, thereby clipping the signal at about plus and minus 0.5 volt. This provides a square wave output of about 1 volt peak-to-peak, which is about the same as the output level from the sine wave generator. The clipping circuit also improves the shape of the output waveform.

If desired, the rise time of the square wave can be improved slightly by experimentally reducing the value of C12. Care must be taken not to reduce the value of this component to a level which results in IC2 becoming unstable.

The two i.c.'s employed for IC1 and IC2 are type 748 in the round TO5 (or TO99) encapsulation. These are available from several suppliers.

POWER SUPPLY

Fig. 4 shows the circuit of the power supply section. To those unfamiliar with operational amplifier circuitry this may look a little unusual, but it really only consists of two ordinary full-wave rectifier and smoothing circuits. D6, D7 and C13 provide a supply which is positive of the central earth point while D5, D8 and C14 provide a supply which is negative of this central point. Equal positive and negative supplies are thus provided.

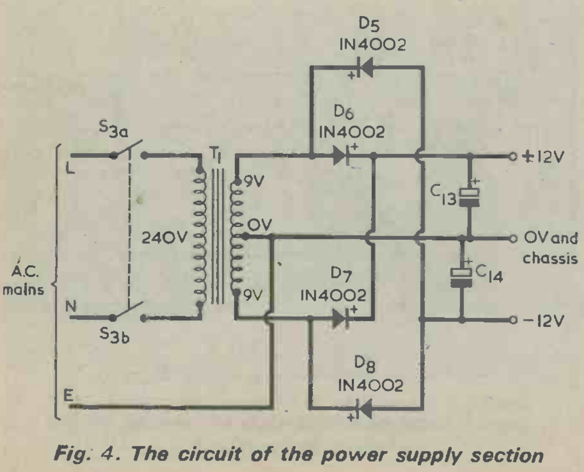


Fig. 4. The circuit of the power supply section

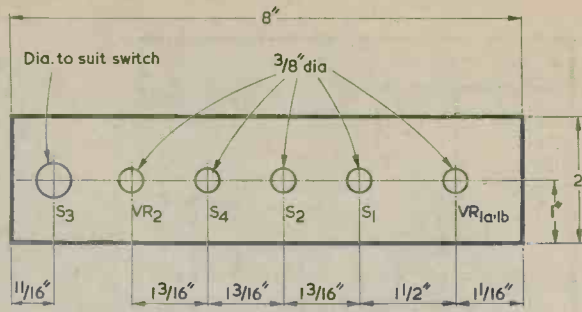


Fig. 5. Drilling details and control layout on the front panel

The ripple content on the supply section output is higher than would normally be permissible for a signal generator, but this does not matter here as one of the advantages of using operational amplifiers is their ability to reject the ripple on their supply lines.

In the prototype, T1 was a miniature mains transformer having a secondary rated at 9-0-9 volts at 100mA. If necessary, a transformer having a 9-0-9 volt secondary rated at a higher current may be employed. For instance, Home Radio list a transformer offering 9-0-9 volts at 300mA.

THE CASE

A suitable housing for the generator consists of an 8 by 4 by 2in. 16 s.w.g. aluminium chassis with base plate, and this may be obtained from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2. One of the 8 by 2in. sides is used as the front panel, and the baseplate is used as the lid. The baseplate is a tight push fit into the chassis, and should be secured in place with four small self-tapping screws.

The layout of controls on the front panel, together with drilling requirements, is shown in Fig. 5. This is quite straightforward. The approximate layout of the main components and the three component panels inside the case can be seen by referring to the accompanying photographs. Precise positioning is not essential, but the components and panels should be sensibly placed so that the generator can be wired up easily. Also required are four holes near the corners of the case bottom to take mounting bolts for rubber feet, and holes in the rear panel for the mains lead and the output socket.

CONSTRUCTION

The electrical construction begins with the wiring of the power supply section. The rectifiers and smoothing capacitors are mounted on a plain Veroboard panel of 0.15in. matrix. The layout and wiring on this are shown in Fig. 6. Start construction by cutting out a panel having 16 by 10 holes, and then make the two 6BA clearance mounting holes using a No. 31 drill.

Next mount the components in the positions shown in Fig. 6 and connect up their lead-outs on the underside of the panel. The underside wiring is represented by the broken lines in the diagram. The mounting holes for the panel and for T1 can then be drilled in the bottom of the case. The panel is wired up to T1 secondary before being finally mounted in position. Three 7in. leads are fitted to the panel for the 12 volt positive and negative outputs and the zero volt output. These will later connect to the sine wave oscillator panel.

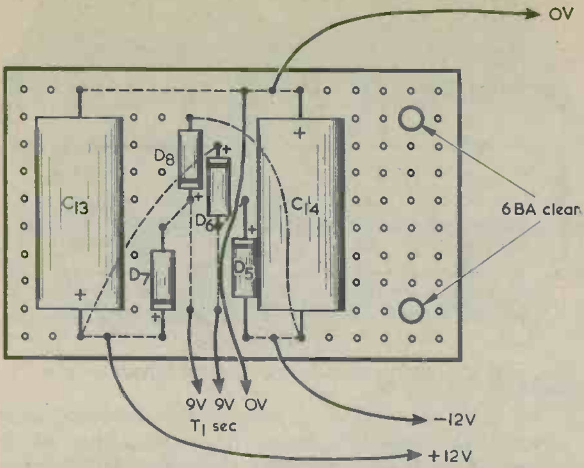


Fig. 6. The power supply components are assembled on a piece of plain perforated board

Use extra nuts over the mounting bolts for the power supply panel so that the wiring on the underside of the panel is spaced clear of the case bottom. To complete the power supply section, wire up S3 to the transformer primary and the mains lead. It is essential that the hole in the rear panel of the case for the mains lead be fitted with a grommet. Also the case must be connected to the mains earth. This is accomplished by connecting the earth wire of the mains lead to a solder tag under a mounting nut for T1.

SINE WAVE PANEL

The sine wave oscillator and squarer circuits are assembled on separate boards. The component layout of the sine wave oscillator panel is shown in Fig. 7. This employs a piece of 0.1in. matrix Veroboard having 21 strips by 14 holes.

When a board of the appropriate size has been cut out and the two mounting holes have been drilled, all the components can be soldered into circuit. There are no breaks in the copper strips on this board. 0.1in. Veropins are fitted at the points where external leads will connect to the panel.

The board is mounted on the base of the case, behind VR1(a)(b) and with the TR1 end nearer the front. It is spaced off the bottom of the case in the same way as was the power supply panel. External connections are then completed.

In order to reduce the number of interconnecting leads, R10 to R12 are mounted on S4, and C1 to C8 are mounted on S1(a)(b). The controls are wired up to conform with the circuit diagram given in Fig. 3. The 2-gang potentiometer VR1(a)(b) is wired up such that the resistance each section inserts into circuit reduces as the spindle is turned clockwise. S1(a)(b) is a 3-pole 4-way switch with only 2 of the poles used. S2(a)(b) is a 2-pole 2-way rotary switch. In the prototype a 3-pole 4-way switch with adjustable end stop set to give 2 ways was employed, but a standard 2-pole 2-way rotary switch could be used instead. The switch fitted in the S4 position was a 4-pole 3-way component with only one pole used.

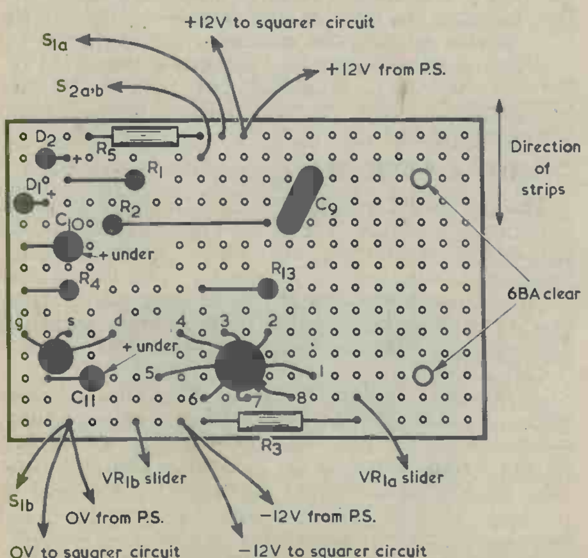


Fig. 7. The component side of the sine wave oscillator panel

SQUARE WAVE PANEL

The squarer circuitry is assembled on a second Veroboard of 0.1in. matrix. This has 11 strips by 16 holes, and its component layout is shown in Fig. 8. It is constructed and wired into circuit in the same way as the sine wave generator panel, and it should be noted that it has six breaks in the copper strips. It is fitted to the bottom of the case near the rear, with the 6BA clear mounting holes nearer the sine wave oscillator panel.

After a final thorough check of the wiring has been completed, the unit is finished and is ready for its initial testing. It is advisable to make a comprehensive check of the control functions to test for possible errors in the control wiring.

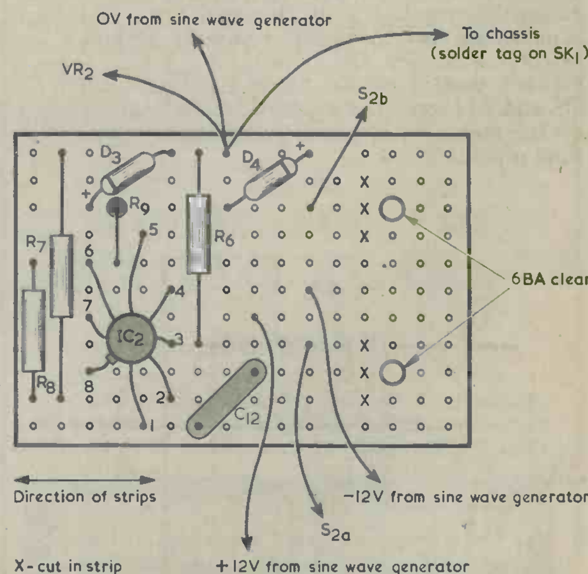


Fig. 8. Component layout and wiring on the square wave panel

A view from the rear, illustrating the positions of the output socket and the mains lead entry point

CALIBRATION

In order to provide an accurately calibrated scale around the control knob of VR1(a)(b), either an oscilloscope with an accurately calibrated timebase or an oscilloscope and an accurately calibrated signal generator are required. Some form of audio frequency meter could alternatively be used, if available.

It is more than likely that the constructor will not have access to such equipment, whereupon the scale reproduced full-size in Fig. 9 can be traced and used instead. This will indicate approximate output frequencies.

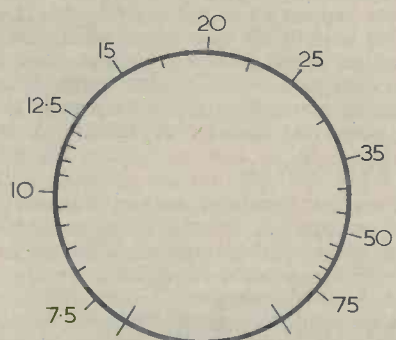


Fig. 9. If frequency calibration equipment is not available the scale shown here can be used to provide approximate calibration for VR1(a)(b). The scale is reproduced full size and may be traced

The generator can be calibrated against an oscilloscope timebase by connecting its output to the Y input of the oscilloscope. With sync switched out the timebase and signal generator will be operating on the same frequency when a stable trace displaying one complete cycle is present on the screen of the oscilloscope.

Calibration against a second signal generator with the aid of an oscilloscope is possible, using the Lissajous figure method.

If the constructor has a musical ear it is even possible to calibrate the unit against a second generator by listening to the output of both and adjusting them to produce the same note. A similar process can be used to calibrate the unit against a musical instrument, except that here the signal generator is adjusted to produce the same note as is played on the instrument and then a table is consulted to establish the frequency of the note. A table showing the frequencies of concert pitch notes was published in the October 1973 issue of *Radio & Electronics Constructor.* ■

CHOOSING THE RIGHT BATTERY

By Vivian Capel

There is usually one battery which is best suited for a particular application. This article demonstrates how the correct battery can be chosen, bearing in mind discharge current, size and economy.

One of the features of transistor circuits is that, being operated at low voltage, they can conveniently be battery powered, and so the majority of commercial products as well as home constructed designs use batteries. The snag is that there seem to be so many battery types and sizes that the constructor in particular can be at a loss as to the best type to choose. The user of commercially built equipment has at least the guidance of the equipment maker, and the size of battery is fixed by the dimensions of the battery compartment, but even here there is a choice of several types.

CELL TYPES

In order to make a knowledgeable choice for the particular piece of equipment we need to power, we should know something of the construction of the various types and how they work. The two main divisions of battery cells are primary cells and secondary cells. Typical secondary cells are those used in car batteries that can be recharged; they are especially suited to provide heavy discharges for sustained periods. Primary cells would be quickly exhausted under such conditions and their use would be very uneconomical.

A familiar sight, the PP9 9 volt battery is the most popular in the Ever Ready range of layer cell types (Photographs courtesy The Ever Ready Company [Great Britain] Limited)

There are several types of secondary cell, but the most common and efficient to date is the familiar lead-acid variety. Disadvantages are weight and the presence of corrosive sulphuric acid which could escape through the necessary air vents if the cell is tipped over. In the early days of battery valve radios, Varley dry and jelly-acid types were popular to overcome the latter problem.

Although not usually considered rechargeable, it is possible to charge primary torch cells to a limited extent, and with escalating costs this appears to be an increasingly attractive prospect. However, charging efficiency is low and the number of recharges limited. Attempted recharging of layer cells, which are also of the primary type, is not recommended.

The modern dry battery is based on the Leclanche cell. In its simplest form the cell employs a zinc negative electrode and a carbon positive electrode immersed in a solution of ammonium chloride, known commonly as sal-ammoniac. A potential difference of about 1.5 volts is produced by the chemical reaction which eats the zinc away in the process, and also liberates bubbles of hydrogen gas. These bubbles form around the carbon and effectively insulate it by preventing contact with the solution, and thus the action of the cell is inhibited. The cell is then said to be polarised, and it must be rested to allow the gas to clear away before it can be used again.

Polarisation is one of the main problems with this type of cell as it restricts the amount of continuous current it can give. The effect is minimised by introducing a chemical such as manganese dioxide as a depolarising agent. This has a strong affinity for hydrogen, and the reaction is for one of its oxygen atoms to combine with a pair of hydrogen atoms to form a molecule of water, leaving manganese oxide in its place. Thus the hydrogen is removed and the only adverse effect is slight dilution of the electrolyte by the generated water. The chemical action, though, takes time, and it is still possible for the cell to become polarised by hydrogen being liberated faster than it can be disposed of if the discharge current is too heavy. So, the effectiveness of the depolariser sets the maximum limit for continuous discharge current.

In a round dry cell the negative electrode is form-

Five 1.5 volt alkaline manganese cells in the Ever Ready range. Of these the most popular are the MN1400, MN1500 and MN2400

ed by a zinc case which contains the electrolyte in the form of paste. With modern cells the zinc is usually surrounded by a steel outer shell to protect equipment from corrosive leakage if a battery is retained after it is exhausted. The positive electrode takes the form of a carbon rod in the centre, around which is packed the depolariser. Between this and the case is a porous container which holds the electrolyte.

SIZES AND RATINGS

Although many different sized Leclanche-type dry cells are made, the voltage remains the same. The reason for this can be appreciated if we consider a large cell to be the same as a small one except for greater surface areas of the electrodes. The large cell may be regarded as two or more small ones connected in parallel, which according to basic theory would give the same voltage but higher current. Thus multi-cell batteries, in which cells are series connected, always have nominal voltages which are multiples of 1.5 volts, such as 4.5 volts, 6 volts, 9 volts and 12 volts.

It follows, then, that the cell size determines the current it will deliver for a specified time. For small cells a suitable unit of capacity is the miliamp-hour, and at first sight it could appear that a 1,000mAH cell will give 1,000mA for 1 hour, 100mA for 10 hours, 10mA for 100 hours, or any other discharge level in proportion. In practice, though, various factors make the time-discharge relationship non-linear, so that in our example the discharge time at 1,000mA would probably be much less than 1 hour, while at 10mA it could be greater than 100 hours. Generally, the heavier the discharge the less the proportional time. The milliamp-hour capacity is therefore specified at one particular rate of discharge or length of time. At other discharge rates the time will be only roughly proportional, and only then if the discharge does not vary too greatly from that specified.

Another factor is whether the discharge is continuous or intermittent. The more intermittent it is the longer the proportionate life, so that a cell which may give 100mA for 5 hours continuous could give the same current for 10 hours if discharged for say half an hour a day, or even longer for half an hour a week. Short usage and long rests give long life, which is why testmeter and doorbell batteries usually last for considerable periods. Makers rarely quote mAH capacity figures and, considering the factors that can influence cell life so considerably, this is understandable.

TORCH CELLS

Capacity, then, is governed by size, which also affects the maximum continuous current before the cell polarises and the maximum discharge for economical use. Although intended for use in torches, the standard round cells can be used with transistor equipment to give 6 or 9 volts by employing a plastic container or battery holder which houses four or six cells in series. Starting with the largest and using Ever Ready type numbers, the round cells are SP2, SP11, U12 and U16. There are also the two-cell No. 8 torch battery and the No. 800 cycle lamp battery.

Comparing the capacity with cost we find that (at the time of writing) the U12 is about two-thirds the cost of the SP2, yet has only about one-seventh the capacity. The SP11 is only marginally cheaper than the SP2, and has less than half its capacity. From this it can be seen that the larger the cell the more economical it is, and the SP2 is without doubt the best value for moderate discharges in this range of torch cells. Its size and weight could be a disadvantage in small equipment and for low discharges would be unnecessarily large. Normally though it is well worth making room for if possible, but if space is restricted use the SP11 size. The U12 is uneconomical for supplying transistor equipment, and this size should only be used where space is very much at a premium or the discharge currently is very low. (See also the later comments concerning highpower cells.) The U16 is more uneconomical for transistor supply purposes and should be ignored except for sub-miniature extra-low discharge applications.

Polarisation is an important factor where continuous operation is concerned. Working from his own and a colleague's experiences with these cells, the author suggests the following approximate maximum continuous currents which the cells will deliver without resting: SP2, 150mA; SP11, 70mA; and U12, 25mA. Higher currents can be obtained for short periods because the cells are in fact intended for use in torches where the discharge is usually of the order of 300mA.

HIGH POWER CELLS

Some applications require high discharge levels for long periods. Battery tape recorders are an example in which the motor can take between 100mA and 300mA, and would soon cause standard cells, especially the smaller ones, to be polarised.

For this and other applications where motors are involved, the high power range has been developed. The

The High Power 1.5 volt cells type HP2, HP11 and HP7. These are particularly recommended for motorised applications where relatively high discharge currents exist

The PP3 layer type battery together with a newcomer, the PP3-P battery. The latter, which is not dealt with in this article, is distinguishable by its gold jacket and gives up to 30% more life in transistor radio applications than does the standard PP3

chemical formula and construction is slightly different, very thin paper separators are used and also a high grade manganese depolariser. This gives fast depolarising and so allows higher maximum continuous currents. These cells are the same size as the standard cells type SP2, SP11 and U12, and can be fitted in their place. Starting with the largest and again using Ever Ready type numbers, they are HP2, HP11 and HP7.

To illustrate the difference between high power and standard cells, it is found that an SP2 will run for about 18 minutes at a current of 500mA before polarising, whereas the HP2 will run at the same current for approximately 3¼ hours. At the time of writing they cost about one and a half times more, except the HP7 which is only slightly dearer than the U12. In view of this and also the low capacity of the U12 cell, it is recommended that the HP7 be used for all transistor supply applications in place of the U12. With the other sizes it is, in the author's opinion, uneconomical to use high power cells in place of standard cells for intermittent or low current uses because the overall capacity is about the same and so there is no advantage.

ALKALINE MANGANESE CELLS

Alkaline manganese cells are quite different from the standard or high power cells. Potassium hydroxide is used as the electrolyte, and compressed manganese dioxide forms the positive electrode instead of a carbon rod, and it thus serves as its own depolariser. The voltage is the same at 1.5 volts, but the cell capacity is some five times greater than the standard unit. It can be even higher than that at heavy discharge currents, which as we have seen reduce standard cell capacity considerably, because alkaline cells are specially suited to continuous heavy discharges. Additionally they have a long shelf life, a low internal resistance and are not affected by extremes of temperature.

The Ever Ready type numbers, again starting from the largest torch equivalent size, are MN-1300, MN-1400 and MN-1500. There is also the MN-2400 which is equivalent in size to the U16. At the time of writing, cost is about three times higher than the standard cells except for the MN-1300 which is about five times that of the SP2. There is then a cost advantage except for the large size which just breaks even. Capacity figures in mAH are quoted for these cells, being 10,000mAH for the MN-1300, 5,000mAH for the MN-1400, 1,500mAH for the MN-1500 and 750mAH for the MN-2400.

LAYER-TYPE BATTERIES

These are made up of rectangular Leclanche sections instead of the usual cylindrical cells. They are particularly suited for supplying low to medium current transistor circuits. The 9 volt pack is the most common but 6 volt batteries are also available. Again working from experience, the author suggests the following approximate maximum continuous currents for five of the most common types: PP3, 10mA; PP6, 25mA; PP7, 35mA; PP9, 65mA; and PP10, 150mA. As with the torch cells, the cost-capacity ratio improves as the size increases, so it pays to use the largest that can be accommodated unless the discharge current is to be very low. The PP3 is the least economical and is best used only for miniature low current applications. On the other hand, the PP10 is both large and costly and is not very convenient unless large currents are required.

MERCURY CELLS

Mercury cells use zinc as the negative electrode and potassium hydroxide as the electrolyte, as in the alkaline cells, but the positive electrode consists of compressed graphite and mercuric oxide. Off load the terminal voltage is usually 1.35 volts dropping to 1.2 volts with the rated load. Unlike other types of cell, the voltage remains at a steady level throughout the whole of its life, then drops rapidly below 1 volt when it is exhausted. This is a useful feature where a constant voltage is required. Other features are low internal resistance to the end of its life, no polarisation effects and hence no need for rest periods.

In comparison with the alkaline cells, mercury cells have about 1½ to 2 times the capacity at about twice the cost, so there is little economic advantage. Apart from the small hearing aid type of battery, there are no equivalents to the standard torch sizes.

Probably the most useful versions of the mercury cell for electronic applications are the "button" types, which range from about 8 to 16mm. in diameter with heights of only 3 to 5mm. Capacities of up to 350mAH can be obtained, which is very useful for subminiature low voltage low discharge applications such as electronic watches, tie microphones and hearing aids.

SUMMARY

It can be seen that the large variety of batteries is not as bewildering as at first it may appear, since each type has its own applications. We can summarise these as follows. For a supply of 9 volts at less than 100mA intermittent, one of the layer-type batteries is most suitable, normally the largest that can be accommodated. A pack of round cells can be employed for a 6 volt or 9 volt supply, using standard torch types for 150mA continuous or less, or for larger intermittent currents. For continuous currents of 200mA upward the high power versions should be used, but not for short duration use. For longest life and best economy at medium to high discharges, intermittent or continuous, use alkaline manganese cells. As with the layer type, use the largest round cell that can be fitted to the equipment for the sake of economy, and avoid the smallest ones for all except very small current applications. Employ mercury cells for low voltage sub-miniature uses.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT   *Frequencies* = kHz

Now is the time for broadcast band Dxers to listen for those elusive signals from the East and Far East on the Tropical Bands. In the last issue, mention was made of several such stations that could be logged by the newcomer to the hobby and in this edition more transmissions from this area of the world are listed.

An easy one to start with would be Kabul, Afghanistan, on **4775.** Listen from around 1500 onwards, or, if conditions are good, from 1400 to 1430 when the programme language is English. Kabul radiates the Home Service 1 from 0128 to 0830 and from 1430 to 1730; the Foreign Service is radiated from 1300 to 1430 and the power is 100kW.

Next, try Tibet. Transmissions from Lhasa may be heard on **4035** from 1400 onwards till 1545 when radiating the Home Service in Tibetan providing good conditions prevail. Lhasa may also be heard from 1600 to 1800 when relaying the Radio Peking Hindi Service. Whilst around this area of the dial, try for Huhehot, Inner Mongolia, on **4068.** Listen from 1400 to 1500 when it is relaying Radio Peking's Mongolian Service.

A more difficult one would be Rangoon, Burma, on **4725.** The schedule is from 1100 to 1415 and the power is 50kW, listen from 1400.

Radio Bangkok, Thailand, on **4830** will provide quite a challenge to most Dxers, the channel is a difficult one owing to commercial QRM. The schedule of this one is from 2300 to 1600 and the power is 10kW, listen from around 1430.

Then there is Ulan Bator, Mongolia, on **5053.** To log this one, listen at 2155 when the station opens the evening transmission (evening to us here in the UK but morning to the Mongolians).

CURRENT SCHEDULES

● GHANA

"Radio Ghana — the Voice of the Revolution", Accra, operates two Domestic Services as follows — GBC-1 on **3350** from 0530 to 0805, 1600 to 2305 from Mondays to Fridays; from 0530 to 0900, 1600 to 2305 on Saturdays and Sundays. On **4915** from 0530 to 0805, 1200 to 2305 Mondays to Fridays; from 0530 to 2305 on Saturdays and Sundays. On **5990** from 1200 to 1600. Mondays to Fridays and from 0900 to 1600 Saturdays and Sundays. Programmes are in English and various local dialects.

GBC-2 on **3366** from 0530 to 0805, 1600 to 2305 Mondays to Fridays, from 0530 to 0900 and from 1600 to 2305 on Saturdays and Sundays. On **4980** from 0530 to 0805, 1155 to 2305 Mondays to Fridays; from 0530 to 2305 Saturdays and Sundays. On **7295** from 1200 to 1600 Mondays to Fridays, from 0900 to 1600 Saturdays and Sundays. All programmes are in English.

● ZAMBIA

Zambia Broadcasting Services, Lusaka, has an External Service which operates on Sundays from 0550 to 0715 and from 1050 to 1215 on **11880** and **17895.** From 1650 to 2000 on **6060, 6165, 7235** and on **9580.** Sign-on during weekdays is at 1550 on the latter four channels and sign-off is at 2100 Mondays to Thursdays, 2045 on Fridays and at 2030 on Saturdays.

● LIBYA

The "Radio of the Popular Revolution from the Libyan Arab Republic", Tripoli, has a Domestic Service, in Arabic, from 0400 to 2200 on **6185.**

● IRAQ

"The Broadcasting Service of the Iraqi Republic", Baghdad, has a main programme in Arabic on various channels from 0228 through to 2315. Listen from 1000 through to 2300 on **6168, 7180, 11785** and on **17770.** The "Voice of the Masses" programme in Arabic is from 0220 through to 2320 on **7225,** on **3952** from 1600 to 1930. The Kurdish programme is from 0258 to 0855 and from 1230 to 2200 on **3243** and **6030.** The Syriac transmission is from 1500 to 1630 on **3195,** the Turkmen programme from 0900 to 1225 on **3243** and on **6030.**

●NIGERIA

The Nigerian Broadcasting Corporation, Lagos, operates a Domestic Service from 0430 sign-on to 2305 sign-off as follows — from 0430 to 1000 and from 1500 to 2305 on **4990;** from 0700 to 1630 on **7255,** most of the programmes being in English.

● MALAYSIA

Radia Malaysia, Penang, on **4985,** is scheduled from 0930 to 1630, from 2230 to 0130 (Sundays through to 1630) and from 0530 to 0630 (Saturdays through to 1630).

●INDONESIA

RRI Jakarta on **4805** nominal (often measured by us on **4804.5**) operates from 1000 to 1600 and from 2200 to 0100, radiating the Programme Nasional.

RRI Medan on **4764** should also be listened for at this time of the year, schedule is from 1000 to 1600.

● LIBERIA

ELWA, Monrovia, on **4770** has a Home Service in English from 0600 to 0815 and from 1530 to 1800 from Mondays to Fridays inclusive. Saturdays from 0600 to 1800, Sundays from 0700 to 1800 and daily from 1900 to 2300. Programmes in West African vernaculars are broadcast daily from 1800 to 1900.

● AFGHANISTAN

Kabul on **4775** radiates the Home Service 1 in Pushto and Dari from 0128 to 0830, from 1430 to 1730 and the Foreign Service from 1300 to 1430 (in English from 1400 to 1430.)

AROUND THE DIAL

Several interesting transmissions have been logged on the 90 metre band, they are listed here in frequency order for the convenience of those who like to explore this part of the spectrum.

● 90 METRE BAND

3200 PLA Fukien, China, talk in Chinese apparently illustrated with short excerpts of Chinese music at 1859 GMT.

3330 Peshewar, Pakistan, radiating their appealing interval signal consisting of a few bars of local music repeated, at 1613. The afternoon/evening schedule of this one is from 1415 to 1810 but has been observed closing as late as 1900 on some occasions. The power is 10kW.

3396 Kaduna, Nigeria, light music Palm Court style with announcements in English at 1834. The evening schedule is from 1630 to 2305 and the power 10kW. From November to April however Gwelo, Rhodesia, operates on this channel with a 100kW transmitter and it is therefore unlikely that the station you will now hear on this channel is, in fact, Kaduna!

3400 Rawalpindi, Pakistan, OM with a talk in dialect in the West Pakistan Home Service which operates from November to February from 1415 to 1620 and from March to October from 1700 to 1800. The power is 10kW and can also be heard in parallel on **4835**. Logged at 1613.

3450 Peking, China, a talk in Chinese in the Home Service 1 followed by a rousing choral rendition of a marching song at 2023. Schedule is from 1000 to 1735 and from 2000 to 2200, also in parallel on **4905**.

3886 Praia, Cape Verde Is., guitar music with songs and announcements by YL at 1955. This one is listed on **3883** but has, in fact, been on a measured **3886** when observed by us over the past few months. Radio Clube Cabo Verde has an evening schedule from 2000 to 2400 and the power is 5kW.

● 75 METRE BAND

3917.5 Seoul, South Korea, womens choir, local music, OM announcer in local dialect in Home Service 1, at 2040. Seoul operates on this channel from 2000 to 1700, the power is 5kW and, like many 75 metre band channels, is a difficult one owing to the commercial QRM. Several weeks of 'watching' produced this logging.

3925 Delhi, India, OM with a talk in vernacular in the Home Service programme. Schedule of this well-reported transmitter is from 1330 to 1735, listen for the newscasts in English at 1430, 1530 and at 17.30. Logged at 1607 and the power is 10kW.

HERE AND THERE

● CHINA

A Radio Peking channel not often reported is that of **4460**, logged at 2030 when radiating a programme of local music in the Home Service 1. Schedule on this channel is from 1130 to 1735 and from 2000 to 2330.

● NORTH KOREA

Pyongyang on a measured 6589.5 at 2016, YL with song in Korean, local music, choral songs. This is the Domestic Service, schedule is from 1500 to 1800 and from 2000 to 0830, this being listed as **6600**. The service is also radiated in parallel on **6288.5** (measured), listed **6290** and also on **11350** (measured and found correct!).

● CLANDESTINE

Voice of the Thai People on a measured **9422.5** at 1535, OM with harangue in Thai, military music followed by YL with a further harangue. The transmitter is thought to be operating from North Vietnam.

● SOUTH YEMEN

Aden on **11770**, OM with a talk in Arabic in the "Voice of the Omani Revolution" programme arranged by the Popular Front for the liberation of Oman. The schedule of this transmission is from 1600 to 1700.

60 METRE BAND

● TANZANIA

Dar-es-Salaam on **5050** at 1932, YL with song in a programme of local pops, all vocals in Swahili. This 20kW transmitter operates the National Service from 0300 to 0700 and the Commercial Service from 1400 to 2015.

● PERU

Radio Atlantida, Iquitos, on **4790** at 0420, typical Andean songs and Altiplano music, identification by OM at 0431. Transmission schedule commences at 0900 and closes, on occasions, at 0600 but the actual sign-off time is extremely variable, even being sometimes noted with a 24-hour transmission period. The power is 1kW.

Radio Samaren, Iquitos, on **4815** at 0433, guitar music, songs in Spanish, announcements by OM, identification at 0445 as "Radio Samaren". The schedule of this one is also variable but in general operates from 1100 to 0500 (sometimes heard as late as 0600). The power is 1kW but beware, has been reported identifying as "Voz de la Revolucion Peruana".

Radio Andina, Huancayo, on **4966**, Andean music with plaintive song by YL. This 1kW transmitter operates from 1100 to a variable 0600 (heard as late as 0900 on occasions). Logged at 0457.

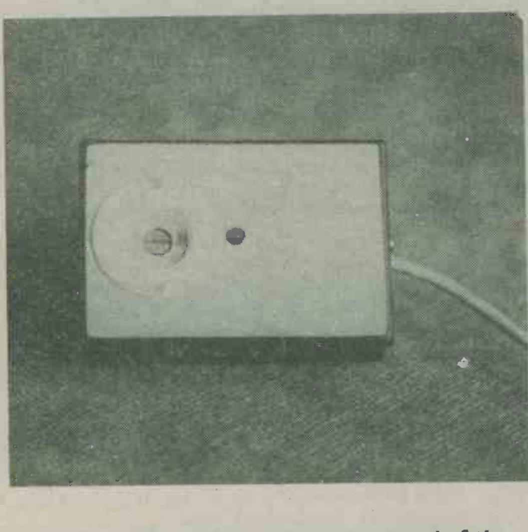
Radio Huancavelica, Huancavelica, on **4885** at 0441, songs in Spanish, guitar, announcements and identification at 0445. Schedule 1100 to 0500, power 1kW.

TOUCH SWITCH

By

S. V. Essex

This switch is actuated by touching a contact pad mounted on its front panel. An internal J-K flip-flop allows the controlled circuit to be successively turned on and off at each touch of the finger.



The only parts visible on the front panel of the switch are the touch contact assembly and the light-emitting diode which indicates that the internal relay is energised

This article describes a touch switch which is capable of switching lights or electrical appliances on and off by successive applications of a finger to a pair of metal contacts. It can be used to replace a conventional on-off switch, either as a novelty or where a switch is required which can be operated with very little force or vibration. The touch switch can be built into a wall as a permanent feature or it may be built as a free-standing unit (as was the prototype) if it is inconvenient to incorporate it into the piece of equipment with which it is to be used. Leaving the touch switch permanently connected to the mains is not expensive in terms of electricity costs, as the unit consumes less than 1 watt.

CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 1. As can be seen from this, the two touch switch contacts form a break in the circuit between R13 and the positive side of the reservoir capacitor C1. Thus, when these contacts are bridged by placing a finger across them a current will flow through the skin resistance of the finger and through R13. A voltage is then produced across R14 and R15, and this voltage is applied to the base of TR5.

TR5, TR4 and TR3 form a Schmitt trigger, which acts in the following manner. When there is no voltage applied to the base of TR5 this transistor does not pass any collector current, and in consequence no current flows through the base-emitter junction of TR4. Since TR4 is thus unbiased, it does not pass any collector current and its collector takes up a high potential. A proportion of the voltage at the collector of TR4 is applied to the base of TR3 via the potential divider formed by R8 and R10. As a result, TR3 is biased on, causing a voltage to be developed across R9, which is common to the emitter circuits of both TR3 and TR4.

If a voltage is applied to the base of TR5 which is greater than the voltage across R9 plus the base-emitter voltages of TR5 and TR4, TR5 starts to pass collector current, thereby biasing TR4 on. When this occurs the collector voltage of TR4 falls, reducing the bias current applied to TR3. This in turn reduces the collector current of TR3 and lowers the voltage developed across R9, thereby biasing TR4 even further on. The resistor values are chosen to ensure that a regenerative action occurs, so that when the voltage applied to the base of TR5 exceeds a certain level the circuit very quickly changes over from one state (TR4 off and TR3 on) to the other state (TR4 on and TR3 off).

When TR3 turns off, TR2 is biased on. Thus, the "clock" input of the integrated circuit is grounded by TR2 whenever the touch switch contacts are touched. The 7472 flip-flop, IC1, is one of the 74 series of t.t.l. integrated circuits, and is used here because it is cheaper than a flip-flop composed of discrete components. It also simplifies the construction of the touch switch and saves space. The 7472 i.c. is described as a "J-K master-slave flip-flop" and was designed for much more complex circuit applications than the use it is put to here; in consequence most of the input terminals are left unused.

The internal circuitry of the integrated circuit is complicated and it is best to consider it as a circuit "block". There are two output terminals, these being designated Q and not-Q (i.e. Q with a bar over it). One of these is at a high potential and the other is at a low potential. When the "clock" input is grounded, the

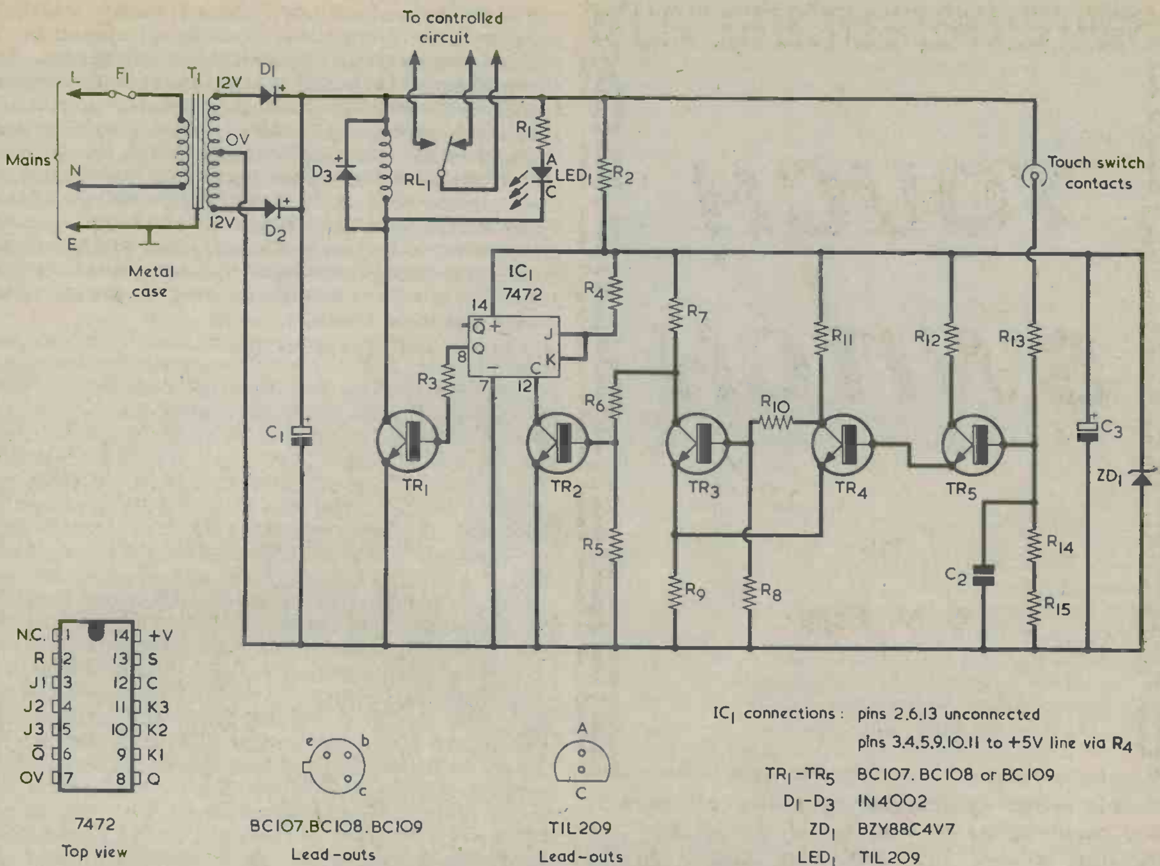


Fig. 1. The circuit diagram for the touch switch

COMPONENTS

Resistors
(all ¼ watt 10% unless otherwise stated)
R1 1.2kΩ
R2 560Ω ½ watt
R3 10kΩ
R4 1kΩ
R5 10kΩ
R6 33kΩ
R7 6.8kΩ
R8 18kΩ
R9 2.2kΩ
R10 22kΩ
R11 10kΩ
R12 100kΩ
R13 1MΩ
R14 10MΩ
R15 10MΩ

Capacitors
C1 220 or 250µF electrolytic, 25V Wkg.
C2 0.022µF, type C280 (Mullard)
C3 500µF electrolytic, 6V Wkg.

Transformer
T1 Mains transformer, secondary 12-0-12V at 50mA, 'Sub-Miniature Mains Transformer, 12V Type' (R.S. Components)

Semiconductors
TR1-TR5 BC107, BC108 or BC109
IC1 7472
D1-D3 1N4002
ZD1 BZY88C4V7
LED1 TIL209 (with mounting bush)

Relay
RL1 'Miniature Open P.C. Relay', 12V, 1,640Ω coil, type 913 (R.S. Components)

Fuse
F1 50mA cartridge, 20mm, with chassis-mounting fuseholder

Miscellaneous
Aluminium box type AB9, 4 x 2¾ x 1½in.
Plug and socket assembly type P360 (Bulgin)
Recess plate (see text)
Veroboard 0.1in. matrix, 21 strips by 14 holes
I.C. holder, 14 way d.i.l.
S.R.B.P.
Mains lead and grommet
4 rubber feet
2 cable clamps
Formica
Nuts, bolts, washers, etc.

output that was high goes low and the output that was low goes high. In other words, the two outputs change state every time the touch switch contacts are touched. The Q output terminal is connected to TR1 base via R3, so that when Q goes high TR1 is biased on and energises the relay in its collector circuit. Since the Q terminal changes state every time the contacts are touched, the first touch will energise the relay (assuming it was released initially) and the relay will remain energised until the contacts are touched again, whereupon it will release.

The external circuit which is to be switched is connected to the relay contacts. For safety reasons there is no connection between the relay contact circuit and the circuitry of the touch switch.

Diode D3 is connected across the relay winding to suppress the high back-e.m.f. generated when the current flowing through the winding is cut off. A light-emitting diode, in series with a resistor, is also connected across the relay winding; this indicates when the relay is energised. If the l.e.d. were omitted there would be no way of knowing whether power was being supplied to a piece of equipment, and this could be dangerous if a fault developed in the equipment which prevented it from working. If, for instance, the touch switch was connected to an ordinary light bulb and the bulb failed, without the l.e.d. indication it would be impossible to know if the bulb socket was live or not.

The power supply for the touch switch is obtained by means of mains transformer T1 and rectifiers D1 and D2. C1 smooths the resultant voltage. The nominal 5 volt supply for the flip-flop and the Schmitt trigger is obtained via resistor R2, and is stabilized and decoupled by zener diode ZD1 and C3 respectively.

C2 is connected across the two high value resistors R14 and R15 to remove any alternating voltages which could appear at the base of TR5, and it thus prevents instability. R13 limits the maximum base current of TR5 to a low value. The maximum current that could pass through the finger of the person operating the switch is less than 15μA.

COMPONENTS

The Components List gives details of the transformer and relay used in the prototype. The relay specified has s.p.d.t. contacts rated at 5 amps at 250 volts a.c. The prototype used an integrated circuit holder to mount the flip-flop; this makes it easier to connect the i.c. into circuit and eliminates the possibility of its being damaged by excessive heat during soldering.

The transistors can be any member of the BC107, BC108, BC109 family. The mains fuse is rated at 50mA, although the actual rating is not important as long as it is not more than 500mA. A 20mm. type was used in the prototype to save space.

The aluminium box type AB9 is available from several suppliers including Home Radio and Electrovalue. Details of the parts employed for the touch contacts are given in the constructional information.

CONSTRUCTION

The touch switch contacts can be either integral with the aluminium box, as in the prototype, or they can be situated some distance away and connected to the rest of the circuitry with wires. These should not be excessively long as there may then be unwanted signal pick-up, which could affect the operation of the touch switch.

The contacts can be made in a number of ways, and the author of this article tried several alternatives before settling on the method of construction finally employed. Two brass strips taken from old batteries worked well but tarnished rapidly. A piece of Veroboard with alternate copper strips interconnected also worked well at first. However, when a damp finger was applied across the strips some moisture was transferred to the insulating material and formed a conductive path that stopped the switch from working until the moisture had evaporated, a process which sometimes took several minutes.

The method of construction finally adopted is shown in Fig. 2. This uses a recess plate intended for mounting a jack socket, and which is available both from Home Radio and Electrovalue. The hole at the bottom of this is about $\frac{7}{16}$in. in diameter, and around this there is a round flat "ledge" which is about $\frac{3}{4}$in. across. A round piece of aluminium with a diameter of $\frac{3}{4}$in. and having a $\frac{3}{8}$in. hole in its centre is placed on this ledge and forms one of the touch contacts (it does not matter which one). The aluminium piece can be made by drilling a $\frac{3}{8}$in. hole in a piece of aluminium sheet, this hole then being used as the centre for a $\frac{3}{4}$in. chassis punch. This will punch out a bent piece of aluminium. The aluminium is then flattened in a vice and any slight imperfections are cleared with emery cloth. Rubbing lightly over the surface with the emery cloth will also give a matt finish and improve the appearance of the aluminium. The piece fits into the bottom of the recess plate and is secured by two 6BA countersunk screws. These also secure, below the recess plate, a round piece of s.r.b.p. ("Paxolin") which has a diameter of about 1in. A 2BA cheese-head screw, whose head forms the centre touch contact, is fitted to the centre of the s.r.b.p. piece. The s.r.b.p.

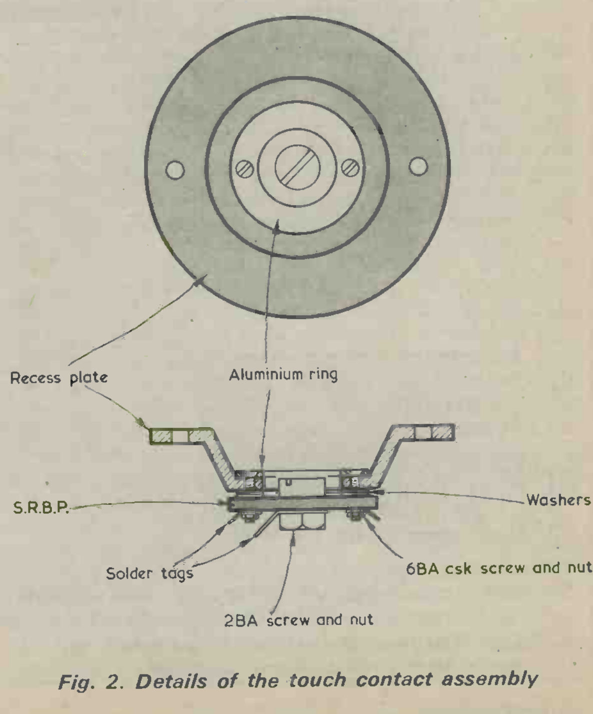


Fig. 2. Details of the touch contact assembly

item is spaced off from the bottom of the recess plate by washers on the 6BA bolts so that the top of the 2BA screw is just a little lower than the surrounding aluminium ring. The finger's natural curvature will then bridge the two contacts without the finger needing to be pressed hard. All screws used in this assembly should be nickel or chromium plated to prevent tarnishing. Their lower ends should not protrude excessively below their nuts.

Because there is nothing but air between the two contacts at the level where the finger touches them, this contact design eliminates the drawback which was evident with the Veroboard. The recess plate requires a $1\frac{1}{8}$in. hole in the surface to which it is mounted and this can be made with an Octal valveholder chassis punch. If the recess plate is fitted in the same box as the remainder of the components, as occurs with the prototype, great care *must* be taken to ensure that all parts of the contact assembly and its connections are well clear of the circuitry, including in particular the mains connections to the transformer and the relay contacts. It should be mentioned here that the metal frame of the relay specified is common with its moving contact. When a metal box is used it must be connected to the mains earth.

Because, as just stated, the relay frame is common with its moving contact, it cannot be bolted direct to the metal box. It requires an insulated mounting and this is provided by the s.r.b.p. piece shown in Fig. 3. The relay is secured to this by means of two short 8BA bolts and nuts, with the bolt heads underneath. The s.r.b.p. piece is then in turn secured to the case with 6BA bolts and nuts. Spacing washers are fitted on the 6BA bolts to ensure that the 8BA bolt heads are well clear of the inside surface of the case. The tags of the relay should be well below the undersurface of the case top when this is fitted. If necessary, they can be cut down slightly.

METALWORK

The aluminium box may next be prepared, but it will be found helpful to first drill the two 6BA clear holes in the Veroboard, as indicated in Fig. 5. The board may then be employed as a template in ensuring precise positioning of the corresponding holes in the box. The s.r.b.p. item of Fig. 3 may be similarly employed as a template when marking out its securing holes. Before drilling any holes in the box, the layout diagram of Fig. 6 and the photograph of the box interior should be studied to obtain a general idea of component layout.

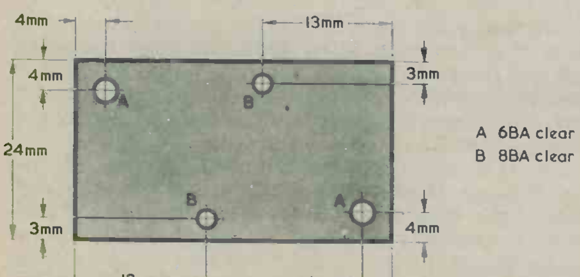
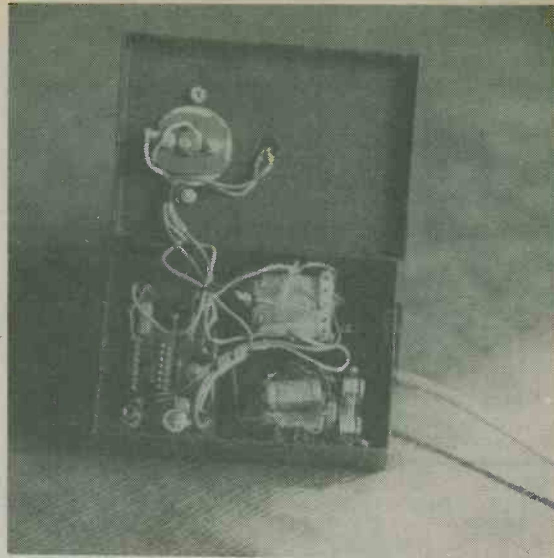


Fig. 3. The relay is mounted on an insulating plate having the dimensions shown here



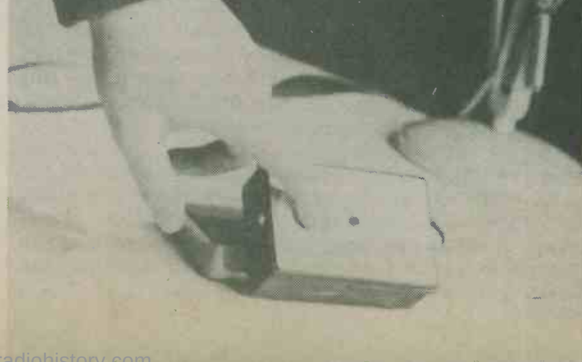
The components and Veroboard assembly inside the metal box. As is explained in the text, the touch contact bolts, with advantage, be orientated through 90°.

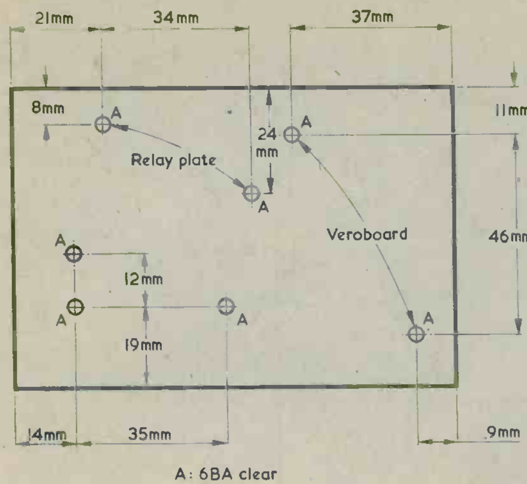
Fig. 4(a) shows the holes required in the base of the box as seen from below. The mounting holes for the Veroboard and the relay insulated mounting plate are indicated. The remaining three holes are for the mains transformer and the mains lead clamp. Also required are four holes for rubber feet. These are not shown in the diagram.

Fig. 4(b) shows the holes required in the top, as seen from above. The recess plate requires two 6BA clearance holes, but these are not indicated. In the photograph of the box interior, it will be seen that a line drawn through the 6BA bolts of the touch contact assembly runs parallel to the length of the box. An increase in clearance from the relay is given by having the line drawn through the 6BA bolts run parallel to the width of the box, and this is recommended. The two 6BA clear holes in the box top for the recess plate can then be marked out, using the recess plate as a template. The other hole in the lid is for the l.e.d. and this should have a diameter to suit the mounting bush employed.

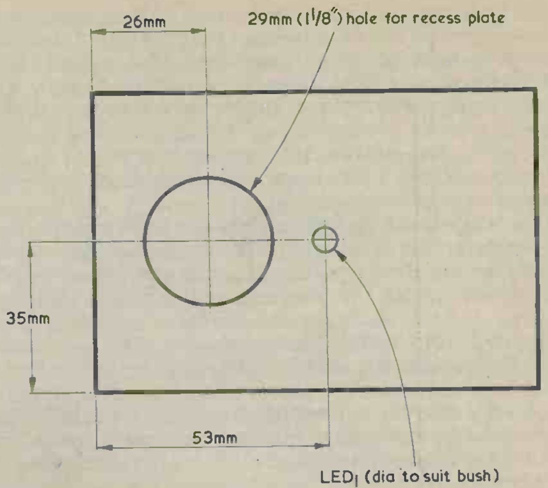
Only one short side requires holes and these are shown in Fig. 4(c). The large hole is for the panel-mounting section of the P360 plug and socket assembly, and the smaller hole is for the grommet through which the mains lead passes. A hole slightly larger than $\frac{1}{4}$in. diameter may be made here if necessary.

The touch switch in use. Here, it is controlling a small table lamp

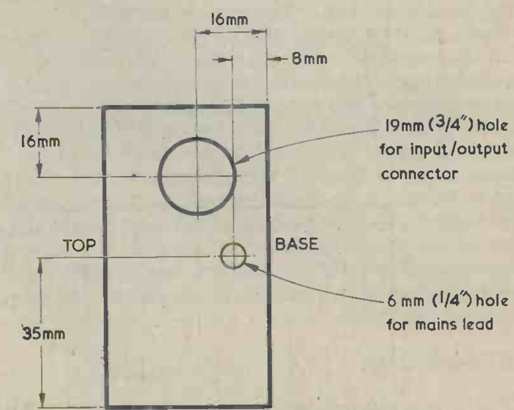




(a)



(b)



(c)

Fig. 4(a). Drilling details for the box base, as seen from below (b). The holes required in the top for the light-emitting diode and the touch contact assembly (c). Two holes are needed in the short side through which the mains lead passes

VEROBOARD

The component and copper sides of the Veroboard are shown in Fig. 5. This will already have its 6BA clear mounting holes drilled, and the next process is to cut the copper strips at the points indicated. The components may then be soldered in place. Note that R14 and R15 are connected together by a "mid-air joint" off the board. An integrated circuit holder is soldered to the Veroboard, the i.c. being fitted into this after all soldering is completed. No force should be used when inserting the i.c. as the pins are easily bent.

Flying leads of thin insulated flexible wire leave the board at the points indicated to connect to external components. These leads can be fairly long at this stage, being cut to the required length later. Leads to the l.e.d. and touch contacts need, however, to be long enough to allow the top to be held alongside the box when the box is open. These leads may be held by a clamp under one of the nuts securing the recess plate. The light-emitting diode mounting bush is first pressed into the hole provided and then the diode is gently pushed into place. Care must be taken not to bend the l.e.d. lead-out wires too close to the body, and the connections to it should be kept clear of the case and of each other.

The assembled Veroboard is mounted on the case bottom with 6BA nuts and bolts, spacing washers being fitted over the bolts to space the Veroboard away from the inner surface of the case. The mains transformer is secured in the position indicated in Fig. 6, the fuseholder being held under one of its mounting nuts. A solder tag is fitted under the other mounting nut and the earth wire of the mains lead is soldered to this, thus earthing the transformer core and the metal box. The mains lead is secured inside the case by the clamp shown.

D1, D2 and C1 are mounted on top of the transformer. Diode D3 is wired across the relay coil tags. Take care to ensure that all three diodes are wired in correctly. Damage will result if any diode is connected wrong way round. The three contact tags of the relay are wired to the three pins of the P360 plug.

As a final point, a piece of Formica was glued to the top of the box with the prototype. This enhances its appearance and provides a surface around the touch contacts which is easy to clean.

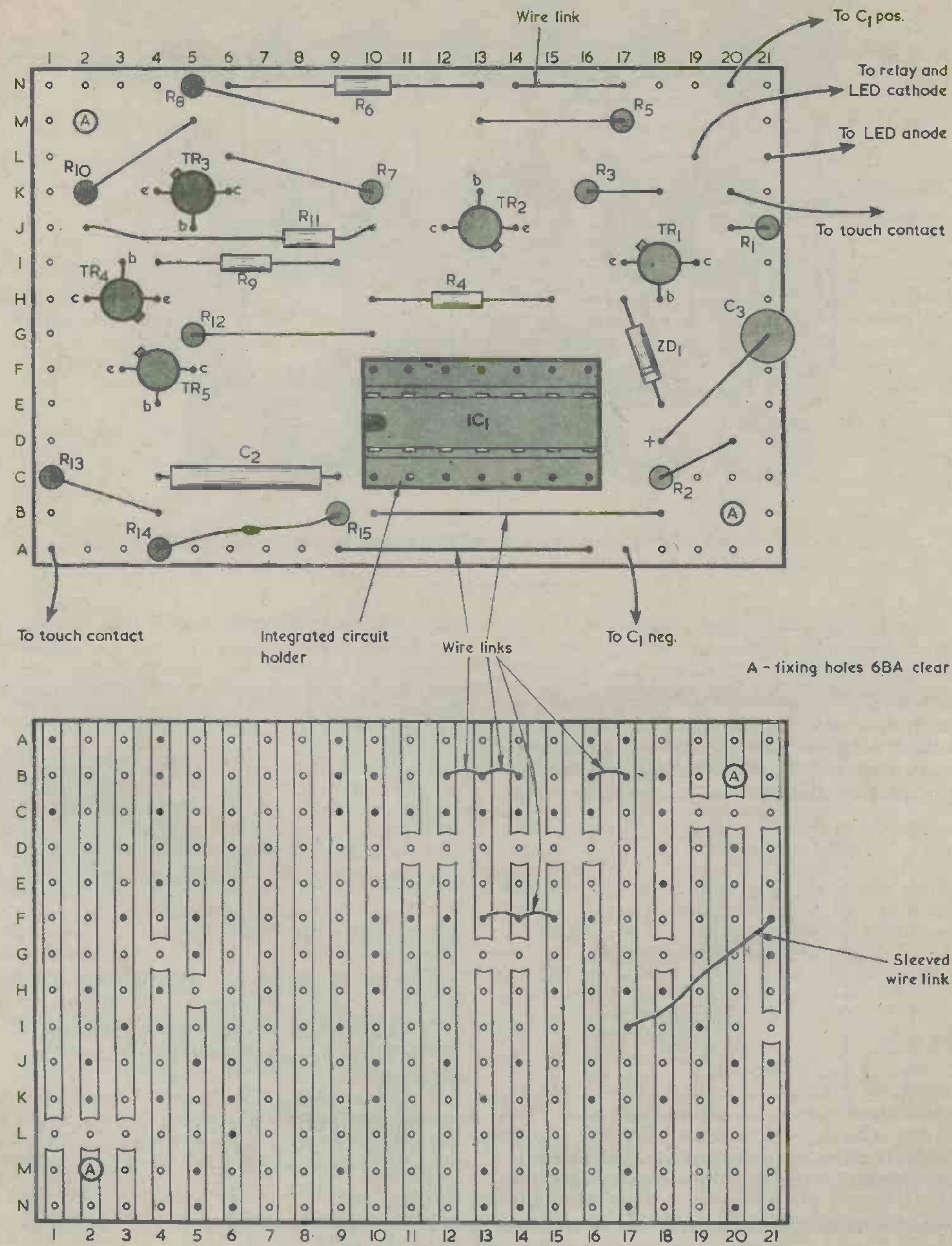


Fig. 5. Component and copper sides of the Veroboard assembly

SENSITIVITY

The prototype touch switch was extremely sensitive and would operate if the resistance presented to the contacts was as high as 30MΩ It was found that young people needed only the lightest of touches to operate the switch, whilst older people had to press the contacts harder due to their higher skin resistance.

A quirk of the circuit is that the relay energises for a split second when the touch switch is first supplied with power. This is not bothersome, in fact it is quite useful as it supplies a click to confirm that the circuit has indeed been turned on. Also, the relay clicks when the power to the circuit is removed.

Although no steps have been taken to ensure that the touch switch always starts with the relay de-

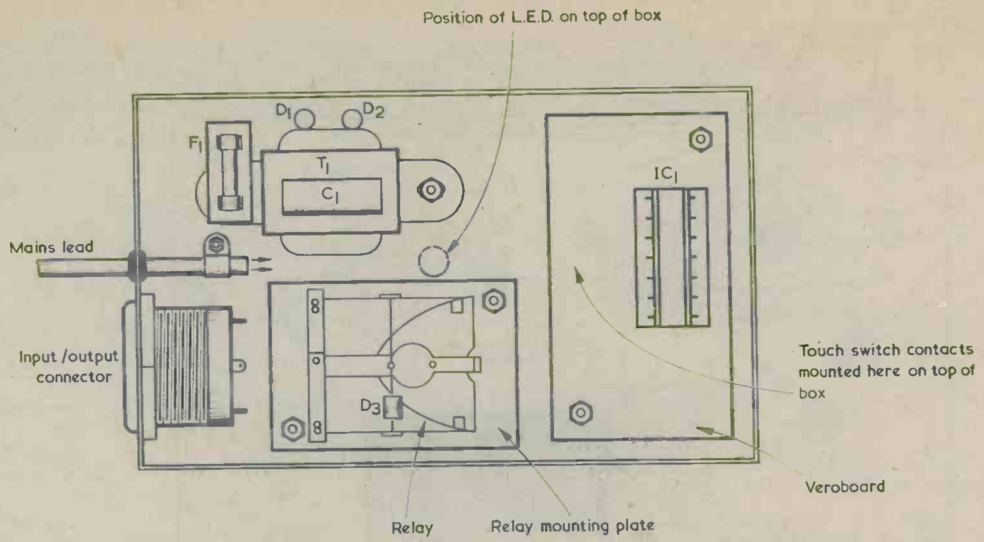


Fig. 6. The layout of the various parts of the touch switch in its aluminium box

energised (apart from the brief instant just mentioned) the prototype has always done so, even when several different integrated circuits have been tried. If an i.c. is employed that habitually starts off in the state where Q is high, and if this is considered undesirable, the resistor R3 could be connected to the non-Q output. One would expect that the i.c. would start off in one state for 50% of the time, and in the other state for the other 50%, but this does not (luckily) seem to happen.

In simple switching arrangements the connections to the relay contacts should be made such that the circuit is fail-safe; i.e. if a fault develops in the touch switch and the relay de-energises, no power is applied to the appliance being switched. This will then also be the case if the power supply to the touch switch fails.

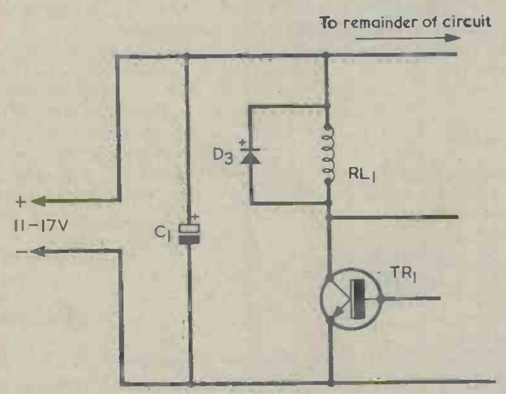


Fig. 7. The touch switch can operate from a low direct voltage by applying this direct to C1

BATTERY OPERATION

The touch switch can be operated from a 12 volt battery supply as shown in Fig. 7. Here, the transformer and rectifiers D1 and D2 are omitted, and the supply connects directly to C1. This makes operation feasible in a car, or where the touch switch needs to be independent of the mains supply. The circuit will work with any power supply voltage between 11 and 17 volts provided the voltage is fairly stable. It is important to ensure that the supply polarity is correct.

BACK NUMBERS

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

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

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.

RADIO TOPICS

By Recorder

Metrication in dimensions isn't of course a great problem and the millimetres and centimetres gradually creep up on us, to be absorbed gently into the body electronic. Not without a bit of indigestion, though.

Take integrated circuits for a start. When the first dual-in-line i.c.'s appeared, someone had the nice standardising idea of having the pins spaced out at 0.1in. intervals, with the two lines of pins separated by 0.3in. What, on the face of it, could be more sensible and straightforward?

MILLIMETRE SPACING

But, alas, we should say nowadays that the pins are spaced, along the line, by 2.54mm., and that the two lines of pins are spaced away from each other by 7.62mm. We should be thinking of Veroboard not in terms of 0.1 and 0.15in. matrix, but as 2.54 and 3.81mm. matrix. We don't do this, of course, and it will probably be a very long time before those 0.1 and 0.15in. Veroboard dimensions finally disappear from the scene.

There are a few other inch dimensions that will remain with us for quite a while yet. Jack plugs afford a good example, coming as they do in 25mm., 35mm. and ¼in. Control spindles still appear at ¼in. too, and the holes we bash out in front panels for most of them remain at ⅜in. Cartridge fuses give quite a motley mixture, the popular sizes being ⅝in., 20mm., 1in., and 1¼in. Loudspeakers cling tenaciously to their inch dimensions, as also do television picture tubes.

This intermixture of millimetres and inches is not, surprisingly, a new thing. From the early days of Mullard valves, a section of the then inch-orientated industry had to deal with millimetres. This is because all Mullard products were dimensioned in metric units to allow interchange of drawings with the Philips plant at Eindhoven. Nowadays it is the millimetres which predominate, whereas in those days it was the inches.

VEROBOARD DESIGN

Talking of Veroboard, this material certainly lends itself both to quick and to more leisured design work. If you want to knock up a circuit in a hurry, a good approach is to use a fairly narrow long piece of Veroboard, with the strips running across the width. This offers a good quantity of individual strips or connection points and you can connect to these as you go along, building up the circuit. The technique involves the use of link wires for carrying earth and supply rails along the length of the board, but this is no great snag.

What I like doing better, however, is to make a more detailed and considered layout, using as little of the Veroboard as is reasonably possible. The design can be worked out on paper first, employing squared paper as is found in children's exercise books. Simply draw lines in ink to represent the copper strips and then work on in pencil, so that errors or layouts to be changed can be easily rubbed out. It is then a matter of ensuring that such things as transistor leads fit neatly into position, with TO5 and TO18 device leads passing into three holes in a triangular layout, the leads of TO92 devices passing into three holes in a row, and so on. Breaks in the strips can be marked on the paper with crosses. When the pencil layout is complete it can be inked in, and the actual work of cutting the copper strips at the right points and of then soldering in the components can start.

It is usual to drill out a couple of the Veroboard holes to take 6BA mounting screws, and it is always advisable to isolate these holes from the rest of the circuit by cutting the strips on either side. It is advisable also to provide isolation for the two neighbouring strips at each hole, these being cut at corresponding points to ensure that there is no risk of short-circuit to a 6BA mounting nut or washer. If you're really pushed for space a useful tip is to simply drill out the mounting holes and then employ 6BA nylon nuts and bolts. These are available nowadays for just a few pence only.

The satisfaction to be obtained from achieving a really neat Veroboard layout is akin to that of correctly solving a difficult crossword puzzle. You have to obtain the desired final answer within the constraints imposed by the Veroboard strips or the lines in the puzzle.

VARICAP TUNING

Varicap tuning of u.h.f. TV tuner units is now becoming the order of the day. Instead of having the usual ganged tuning capacitor inside such units, each section is tuned by a varicap diode. Probably the greatest advantage afforded by varicap tuning is that the tuner unit can be fitted anywhere inside the TV receiver cabinet. With variable capacitor tuning it has to be mounted in a position which allows the capacitor spindle to be mechanically adjusted from the front of the receiver.

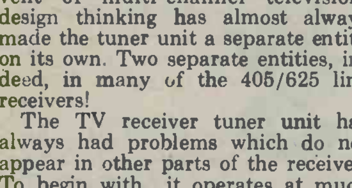
Varicap diodes are of course reverse biased silicon diodes whose capacitance decreases as the reverse voltage across them increases. The tuning control then becomes a potentiometer, or one of a bank of pre-set potentiometres selected by a switch or touch-button system.

There is no reason why the r.f. and oscillator circuits of a TV receiver should not be assembled with the remainder of the circuit on a common chassis, as occurs with the corresponding stages of, say, a short wave communications set. But ever since the advent of multi-channel television, design thinking has almost always made the tuner unit a separate entity on its own. Two separate entities, indeed, in many of the 405/625 line receivers!

The TV receiver tuner unit has always had problems which do not appear in other parts of the receiver. To begin with, it operates at much higher frequencies and one of the greatest difficulties in tuner design is to reduce oscillator frequency drift. This was particularly the case with TV receivers employing valves, which generated much more heat than their semiconductor successors.

Because of factors such as these, tuner unit design became a speciality, and still remains so today. The result is that the tuner unit occupies its own little box, with aerial input, i.f. output and supply connections passing to it conveniently. And also, in its latest form, a reverse tuning voltage for its integral varicap diodes.

WIPER DELAY UNIT



The Variwipe, an automatic windscreen wiper delay unit introduced by Scientronics. Two versions are available, allowing connection into all types of wiper motor switching likely to be encountered.

The above photograph illustrates the "Variwipe", a windscreen wiper delay unit recently introduced by Scientronics. The parts for this unit are assembled on a printed circuit board measuring 50 by 63mm., and there are a maximum of four connections to the car electrics. The unit can be mounted by means of a single hole behind the car's dashboard. Alternatively, it can be fitted inside a black case and mounted at any other convenient position.

Scientronics state that whilst the principle of an electronic unit for windscreen wiper delay is not new, their solution is. The main problem in putting a unit of this nature on the market is the apparent wealth of variations in types of windscreen wiper motors and switches in different cars. There are, however, basically four variations only, and the instructions provided with the Variwipe enable these to be identified and the appropriate connections made.

Two versions of the Variwipe are available. The "ST" version is for the older type of car which uses a single-throw switch with two wires for the motor. The second, "DT", version is for cars with a changeover switch and three wires. The "DT" unit can be employed as a replacement for the "ST" version.

The Variwipe is switched off by turning the potentiometer fully clockwise. To turn it on, the potentiometer is turned sufficiently clockwise to operate its switch. The wipers then give an immediate wipe. At this setting the timing delay is about 50 seconds between wipes. When turned fully clockwise the delay is at its lowest, with only about 2 seconds between wipes.

To operate the Variwipe the control is turned on to give the immediate first wipe. When the desired time interval has elapsed the potentiometer is advanced until another wipe is given. Successive wipes will then occur automatically, with the same time interval as that between the first two wipes.

Further details are available from Scientronics, 40 High Street, Somersham, Huntingdon, Cambridgeshire, PE17 3JA.

OH DEAR

I am indebted to J. A. Egerton of Crewe for the following.

Q. What sort of telegram would you send to a duck?

A. A coax cable.

U.H.F. CRYSTALS

I note that the Marconi Research Laboratories of GEC-Marconi Electronics have just achieved a major breakthrough in crystal technology. They announce the development of quartz crystal controlled oscillators having fundamental operating frequencies of 1GHz, or 1,000MHz. This has been achieved by using surface acoustic waves (SAW) on quartz crystal substrates rather than the bulk acoustic waves employed in traditional crystal oscillators.

The 1GHz SAW oscillators are capable of being frequency modulated, making them suitable for telemetry. They are also expected to find wide applications in signal processing systems. The high spectral purity achieved by using the high fundamental frequency and the overall ruggedness of the SAW units could permit their use in applications which cannot be undertaken by bulk crystals.

Measurements of short term stability of the SAW oscillators have shown them to be comparable with bulk crystal oscillators. The devices exhibit parabolic frequency — temperature characteristics similar to those of BT-cut bulk crystal oscillators. Also, the zero frequency temperature coefficient point of these characteristics can be varied between –20°C and +70°C by using different cuts of quartz crystal.

SOLDERING

Perhaps the most important ability the home constructor has to acquire is that of good soldering. These days there is hardly any skill to it at all because wires, component lead-outs and tags are, in almost all instances, given a finish which permits instant tinning and soldering. The newcomer to the hobby is strongly advised to obtain a little practice with odd pieces of wire and spare tags before embarking on a constructional project. This advice is not intended to give discouragement, since 15 minutes practice is about all that is required to attain the knack of adequate soldering. When the molten solder *flows* over the surfaces of *both* items being joined, then you know that you are making a good joint. The iron can be removed as soon as this flow is observed. And, of course, it is essential to use a proper rosin-cored solder. Never use paste or liquid flux.

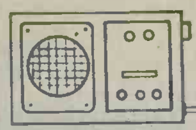
The standard solders employed for electronic work are described as "60/40", which infers that the solder is an alloy of 60 parts by weight of tin to 40 parts by weight of lead. Ersin "Savbit" is very nearly the same as 60/40 solder except that a small proportion of copper is included in the alloy. This helps to prevent migration of copper from the soldering iron bit, and extends its life.

The 60/40 solder alloy does not solidify immediately as it changes, on cooling, from the molten to the solid form. At about 188°C the solder goes into a "pasty" state, and then becomes solid at about 183°C. If you disturb the parts being soldered as the solder is going through the pasty stage you'll get a poor joint.

There is one solder alloy, 63/37, which has no pasty stage at all as it cools. This solder changes directly from the molten to the solid state at 183°C. This is, however, too much of a good thing because a joint made with the solder becomes excessively sensitive to vibration at the instant of setting. The 60/40 alloy, with its small pasty temperature range, offers the best performance in practice.

It's a good plan for the home hobbyist to keep any left-over pieces of solder, even if they're only about an inch long, in an odd box or tin. It is almost inevitable that a day will dawn when you suddenly find you've run out of solder and the shops are shut. You'll be glad that you kept those odd scraps then! ■

In your work-shop



This month we find Dick and Smithy embroiled in the usual rush of Christmas repairs. They are, however, able to service all the faulty equipment in good time, finishing with a television receiver having an SN76013ND audio amplifier section.

It was the very Eve of Christmas, and once again the Workshop was in the throes of the Christmas rush.

As the lay public went happily and uncaringly about their Yuletide activities, Dick and Smithy pressed on manfully to clear the mammoth quantity of radios, television receivers, tape recorders and record players which, unaccountably, always managed to become unserviceable in the week leading up to Christmas Day. This phenomenon had taken place for as long as Dick and Smithy could remember, and they now accepted as natural the annual strain on the symbiotic relationship between service engineer, as supplier of repaired equipment, and set-owner, as supplier of bread.

DECORATIONS

As always, Dick had set the scene for a Christmassy atmosphere by hanging brightly coloured paper-chains between the Workshop corners, and a large paper bell from the bulb at the centre of the ceiling. His work in this respect had been sternly supervised by the Serviceman, due to an unfortunate lapse of the previous year when the enthusiastic Dick had stuck all the decorations in position with Araldite, whereupon they couldn't be got down again afterwards.

The shelf above Dick's bench was gaily covered with Christmas cards from all his aunts. Smithy's display of cards was noticeably more austere, and comprised six cards in all. In five of these a reindeer pulled a sledge over to the right. The sixth card exhibited a disturbing quadrature, and depicted a reindeer pulling a sledge upwards. There was always a depressing sameness about Smithy's Christmas cards.

As the day wore on the stocks of equipment on the 'For Repair' rack gradually lessened, whilst those on the 'Repaired' rack rose encouragingly. Inevitably, the moment approached when only a single item, a modern mains-driven 17 inch monochrome television receiver, stood in isolation on the 'For Repair' rack. Oblivious of each other's presence, Dick and Smithy approached this receiver simultaneously. As they reached out to pick it up, their arms crossed.

"Corblimey," said Dick. "Don't say you're after this one as well."

Smithy dropped his arms, pulled out a handkerchief and mopped his brow. He turned round and looked at the Workshop, untidy now after the day's labours, with tools and test equipment strewn in a disorderly fashion over the benches, and star-splashes of solder on the floor beneath the bench stools. He turned to gaze back to the rack on which the television set stood, and started.

"Ye gods," he gasped, "it's the last one!"

"Stap me," said Dick jubilantly, "so it is. Hey, Smithy, this means that, yet again, we have beaten the Christmas panic.'

"It does indeed," replied Smithy, his voice taking on a noticeably more cheerful tone. "What say we do it together? Me trouble-shooting and you doing the donkey work?"

"Suits me," stated Dick enthusiastically. "We'll take it over to my bench, If there's any soldering to do, I like to do it with my own iron."

Grinning happily, Dick carried the TV set to his bench, plugged it into the mains and connected the u.h.f. aerial. He switched on. Smithy brought his stool over and sat beside him.

"It sounds very quiet," grunted Smithy. "I know this model. It's all-semiconductor and the sound should come on straight away."

After a few further seconds the tube screen began to glow, revealing a picture of good brightness and resolution. Smithy checked on the remaining local channels, to find that these offered equally acceptable pictures. He turned the volume control to full.

"Hush," said Dick, "I think I can hear something."

They listened intently. The sound accompanying the picture was very faint, and was just audible from the

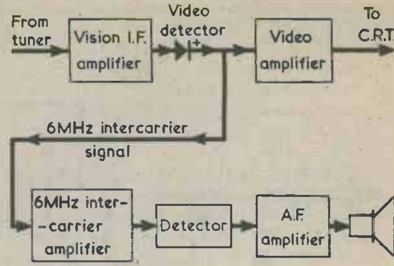


Fig. 1. The signal-handling stages in a 625 line television receiver. The 6MHz intercarrier sound signal is taken off after the video detector

speaker. Smithy returned to the other channels. Each produced the same low level of sound. He switched off the set.

"It doesn't sound tinny or distorted or anything like that," remarked Dick. "It's good quality sound but just very weak. And there's no background hiss at all."

"Well, at any rate," stated Smithy. "We won't have far to look in locating the fault. This is a 625 line set with intercarrier sound. We know that the vision i.f. is getting to the video detector properly because we're getting a good picture which is synching in well on both line and frame. So there must be a snag between the 6MHz intercarrier take-off point after the video detector and the loudspeaker." (Fig. 1.)

"That," commented Dick, "will take in the 6MHz intercarrier amplifier and detector, and the a.f. amplifier up to the speaker."

"True," agreed Smithy. "I'll go and rustle up the service manual for this set. You might as well get the back off and have a look round for obvious faults."

As Smithy walked towards the filing cabinet, Dick removed the back of the receiver. He looked around unsuccessfully for simple visible faults. Next he opened out the printed circuit board on its hinges and examined this closely.

"Any luck?" queried Smithy, returning with a service manual.

"Everything seems to be in apple-pie order," replied Dick. "No wires adrift, no rough-looking joints and no signs of any component cooking."

"Humph," grunted Smithy. "Well, let's take a look at the circuit."

He opened the service manual and smoothed out its circuit diagram.

"Oh dear," said Dick.

"What d'you mean, oh dear?"

"It's the a.f amplifier," stated Dick unhappily. "It uses an integrated circuit. See?"

Dick pointed at the a.f. amplifier section in the service manual. This consisted of an SN76013ND integrated circuit and its associated components. (Fig. 2.)

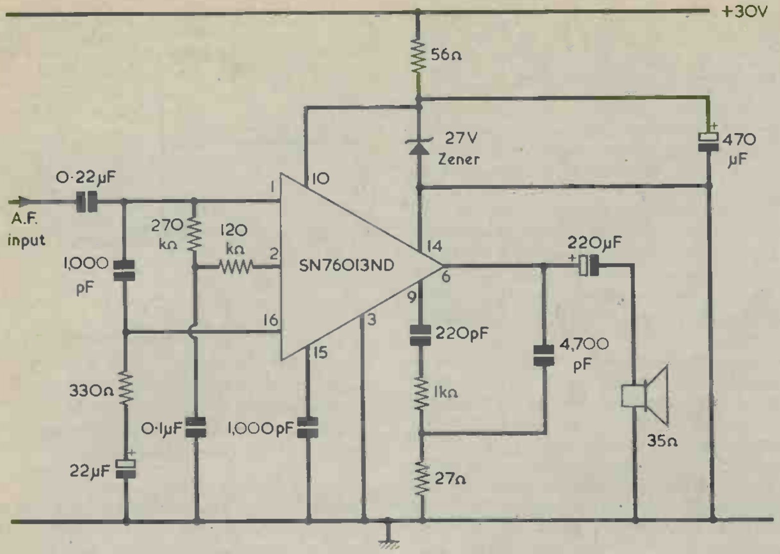


Fig. 2. A television receiver a.f. amplifier stage incorporating an SN76013ND integrated circuit. This circuit is employed in the Thorn 1600 Series of television chassis

I.C. AMPLIFIER

"What's so wrong with an integrated circuit?" returned Smithy. "You've seen plenty of integrated circuits before now."

"I know I have," admitted Dick. "But I never feel quite at home with them when I'm checking the circuits they're in. When you've got circuits made up of discrete components you can always trace a signal path through them. But with integrated circuits all you have are an input and an output together with a lot of capacitors and resistors hanging off the pins in between."

"I must admit," concurred Smithy, "that you have to think along rather different lines when you're servicing sets with i.c.'s in them. The main thing you should bear in mind is that you must resist the temptation to declare that an i.c. is duffy itself before you've checked the components and voltages around it. Now, I've got a feeling in my vitals that the weak sound we're getting here is due to the fact that this a.f. amplifier i.c. isn't doing much amplifying. If the lack of gain had been in the 6MHz intercarrier amplifier we should have at least got a noticeable background hiss when we turned the volume up."

"D'you feel we should start operations around this a.f. amplifier i.c., then?"

"It wouldn't be a bad idea," stated Smithy. "Switch on again, and I'll take a few voltage readings."

Obediently Dick turned on the receiver. Smithy pulled his assistant's testmeter towards him and switched it to a 0-50 volt range. He then studied the printed board closely to familiarize himself with the layout of the components and connections around the a.f. amplifier integrated circuit.

"The obvious thing to do first is to check that there's power getting to the i.c.," he remarked. "So I'll check between pin 3 and pin 10. As you can see from the circuit diagram, there's a 27 volt zener diode across these two points."

Smithy applied the test prods. (Fig. 3(a).)

"The meter," announced Dick, "is reading 27 volts. Or as near 27 volts as dammit."

"Right," commented Smithy. "I'll check next between pin 3 and the ouput at pin 6. This should give us a half supply voltage reading."

Smithy applied the negative test prod to pin 3 and the positive prod to pin 6. (Fig 3(b).) As the prod touched pin 6 the speaker gave a chirpy clicking noise and Smithy frowned.

"The meter," remarked Dick, "is reading just over 14 volts."

"That seems near enough," remarked Smithy. "The d.c. feedback network should be working all right if we're getting a reading of that order." He removed the test prod from pin 6. The clicking noise from the speaker was repeated.

"That output pin seems to be a bit lively," he said thoughtfully. "Normally, the output should be at low impedance and virtually dead so far as external circuits are concerned. Bring over the a.f. signal tracer from my bench, Dick."

"Don't tell me," snorted Dick in disbelief, "that you're going to use *that* grotty old-fashioned thing to check a modern integrated circuit. Why, it's almost sacrilege!"

"Of course I'm going to use it," retorted Smithy, affronted. "And in no way is it old-fashioned. Let me tell you that I made up that signal tracer fifteen years ago and it's given excellent service ever since."

"But it uses *valves*, Smithy. This is the semiconductor age."

"I know it uses valves," replied Smithy. "Or, rather, it uses one valve and that's an ECL82 triode-pentode, with one input at the grid of the triode and another at the grid of the pentode to give two different sensitivities. But valve or not, it has an extremely simple circuit and it's very robust. What's more, it's virtually immune to damage

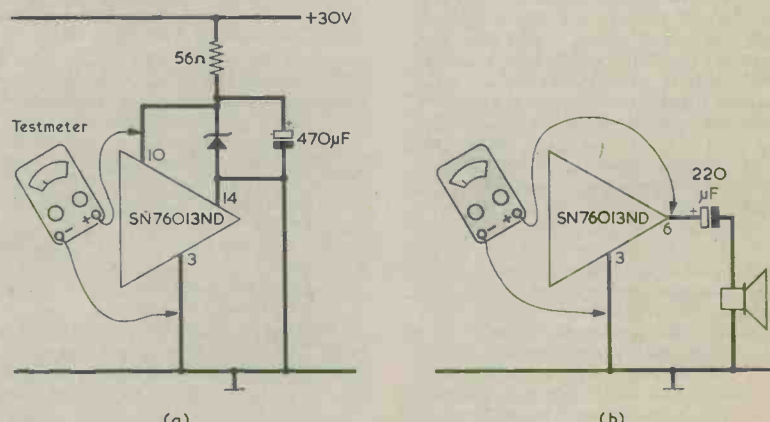


Fig. 3(a). The first and obvious check carried out by Smithy was to measure the supply voltage applied to the integrated circuit (b). The second check was to measure the quiescent voltage at the output pin

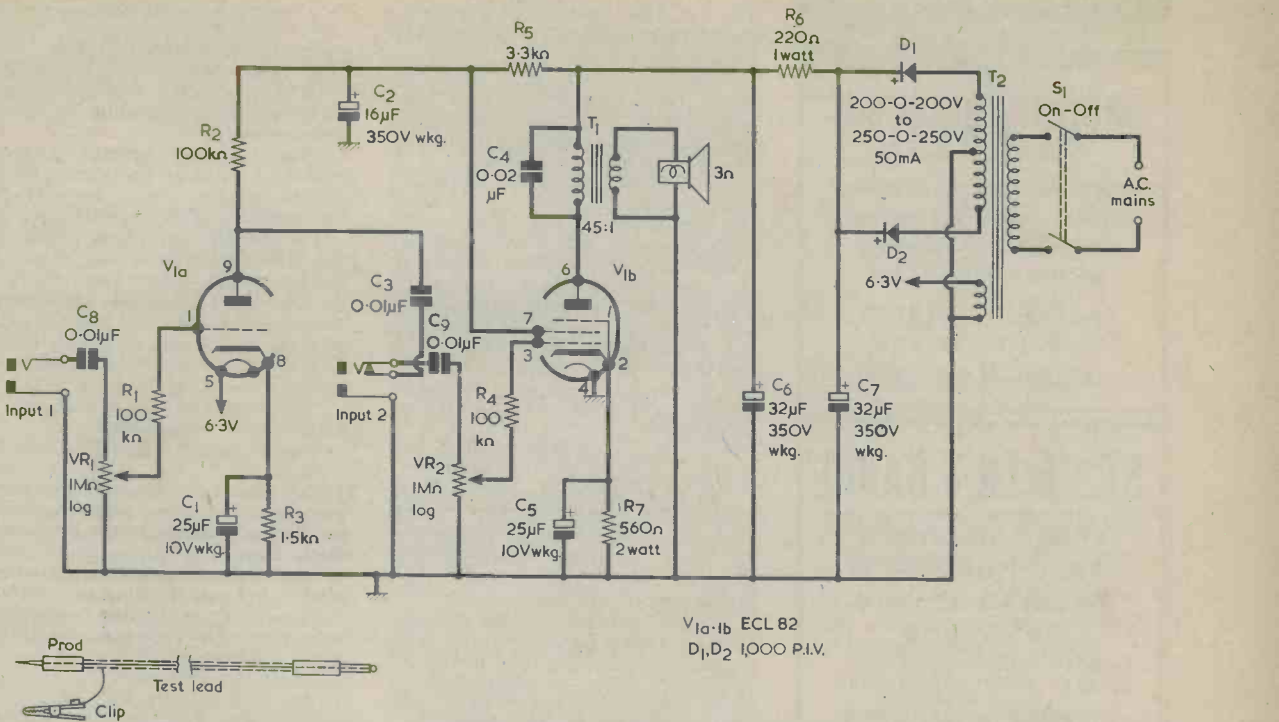


Fig 4. Although derided by Dick as being old-fashioned, this a.f. signal tracer is not unattractive for present-day servicing. Its main advantages are reasonable simplicity, versatility, robustness and the ability to withstand very high input voltages. VR2 is set to its maximum volume position when Input 1 is in use

if you accidentally apply a high input to it. And even if the valve *does* get damaged due to a really high input all you have to do is whip it out and plug in a new one." (Fig. 4.)

Reluctantly, Dick walked over to Smithy's bench and picked up the a.f. tracer. This was housed in a small battered box with an aperture for the speaker on the front panel, together with the on-off switch and the two volume controls and jack sockets. Smithy took the tracer from him, plugged it into the mains and switched it on. He then fitted its screened input test lead to the jack socket connecting to the triode grid, clipped the test lead braiding to the chassis of the television receiver, and applied the test prod to pin 1 of the integrated circuit. (Fig. 5 (a).) The television sound channel became audible from the speaker of the signal tracer. Smithy adjusted the signal tracer volume control for a confortable level of sound in the tracer loudspeaker.

"That," he remarked, "is the audio that's going into the integrated circuit."

"The quality sounds O.K. to me," said Dick, listening critically. "what are you going to do next, Smithy?"

"See what the sound level is like at the i.c. output," responded Smithy. "Here goes!"

He transferred the signal tracer test

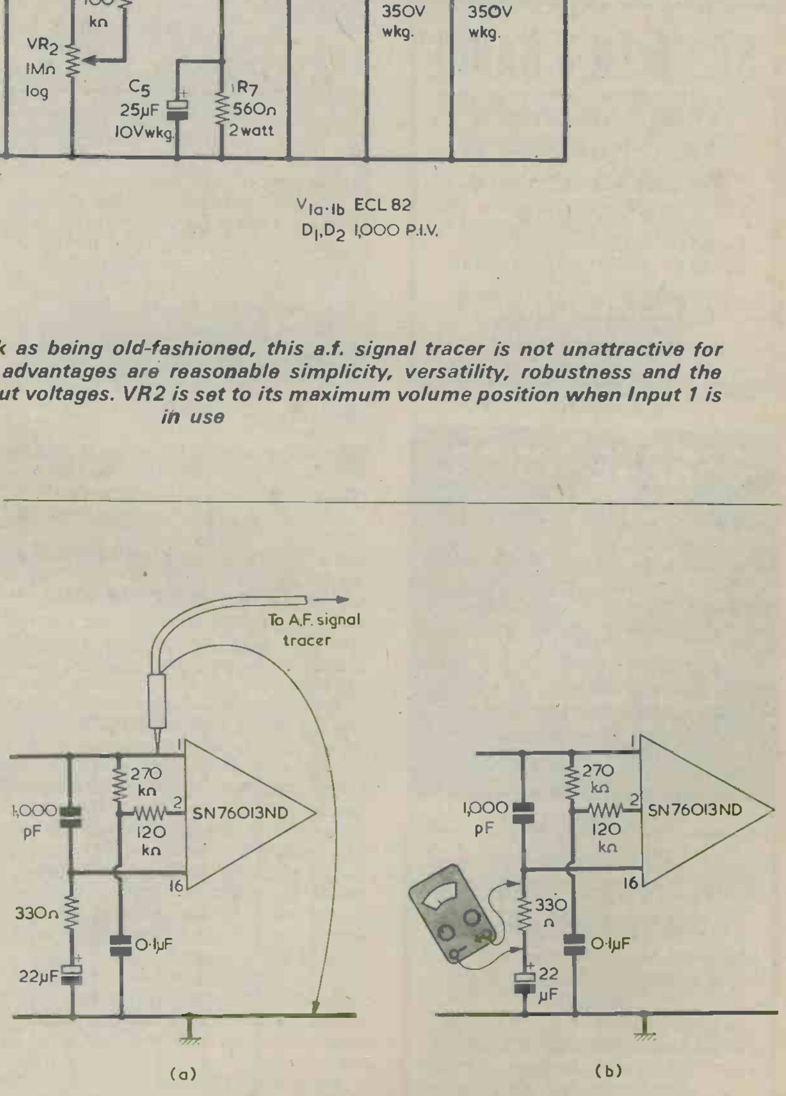


Fig. 5(a). Using the a.f. signal tracer to check the input at pin 1 of the i.c.
(b). Subsequently, Smithy checked the resistance of the 330 Ω resistor in the a.c. feedback circuit

prod to pin 6 of the integrated circuit. The signal was again audible from the signal tracer loudspeaker, but only at a fractionally higher level.

"Well," conceded Dick, "that old signal tracer does seem to have some uses after all. One thing it shows us is that the i.c. isn't doing much amplifying. It must have gone faulty."

"I told you just now," remarked Smithy severely, "that you must avoid the temptation of suspecting an integrated circuit before you check the components and voltages around it. Now, we know that the d.c. feedback is working O.K. because we're getting half the supply voltage at the output pin. What has probably happened is that there's far too much a.c. feedback, and this would explain why the output pin was so lively when I connected the testmeter to it."

"All right," said Dick. "How do you test the a.c. feedback circuit?"

"By checking the external feedback components," replied Smithy. "In this circuit they're the 330Ω resistor and the 22μF capacitor which connect between pin 16 and chassis. Let's check the resistor first."

Smithy switched off the receiver, then set Dick's testmeter to an ohms range. After zeroing the meter, he applied the meter test prods across the 330Ω resistor. (Fig. 5(b).) The testmeter needle barely moved.

"Blood first time," said Smithy exultantly. "I can't quite make out the resistance reading I'm getting here but I'm not much worried because it's obviously a lot higher than 330Ω."

"Blimey," said Dick, impressed. "That was a swift bit of fault-finding, wasn't it? How is it that you were so ready to go for the 330Ω resistor?"

"It was a pretty obvious suspect," responded Smithy. "Also I've been doing a bit of genning-up on these a.f. amplifier i.c.'s recently and I know which pin to look for and the sort of a.c. feedback circuit to expect. Anyway, don't let's waste any more time. Pop a new 330Ω resistor in that set and we'll see if it does the trick."

As Dick busied himself with replacing the faulty resistor, Smithy switched off his a.f. signal tracer, regarded it fondly as one regards a trusted old friend, then unplugged it and carried it back to his bench. After some moments he returned to Dick's bench. He carried a mysterious flat package wrapped in colourful paper bearing a motif of snowmen dressed as Santa Claus with a background of holly leaves, and placed it carefully at the side of Dick's bench.

"Job done," called out Dick cheerfully as he returned his soldering iron to its stand. "I've put the new 330Ω resistor in, so let's see how this TV works nows."

He switched on the set, to be at once rewarded with a very loud sound output from its speaker. Hastily, he reduced the volume to a more acceptable level. The audio quality was obviously as it should be. Dick checked on the alternative channels, to find that the sound signal was reproduced in a similarly satisfactory manner.

CHRISTMAS PRESENTS

"That's it!" said Dick exuberantly. "This completes our final job before Christmas."

"Yes," agreed Smithy, grinning, "we can now relax and start thinking of the holiday. Gosh, we certainly cleared out a pile of work today."

The pair looked happily at the now full "Repaired" rack and the completely empty "For Repair" rack. Smithy settled himself contentedly, then reached down and picked up the package at the side of Dick's bench. Gravely, he handed it over to his assistant.

"Here you are," he announced. "A little present for Christmas."

"Gee thanks, Smithy. This looks interesting."

Quickly, Dick removed the wrapping paper, to reveal a large calendar having a separate page for each month. Each page carried a countryside scene and was headed with the name of the month, followed by the year: 1976.

"This is super, Smithy," said Dick appreciatively. "Very many thanks indeed. It's just what I want for my bedroom at home."

"I'm glad you like it."

"Oh, I do. Now here's a Christmas present for you."

Dick opened a drawer in his bench and produced a package which he passed to the Serviceman. This was wrapped in colourful paper printed with a design consisting of snowmen dressed as Santa Claus and having a background of holly leaves.

Smithy tore off the wrapping paper, to find a large box of chocolates inside. On the Cellophane covering was stuck a gift label bearing the words, "To Smithy from Dick." Smithy pulled at the Cellophane.

"Dear me," he remarked. "This seems to be a bit loose. Ah, here we are."

Smithy opened the box, to reveal a layer of shiny milk chocolates, each lodged it its own dark brown crinkled paper nest.

"Do you like it?" asked Dick anxiously.

"Oh definitely," returned the Serviceman. "I love chocolates. Thank you very much indeed, Dick."

"Don't mention it."

"Now let's see," said Smithy, studying the guide to the chocolates which was printed on the inside of the box lid. "Ah yes, I think I'll start off with a Strawberry Creme."

He glanced over the chocolates, then frowned in bewilderment.

"Shouldn't there be raised patterns on the chocolates to tell you what they are?" he asked. "These chocolates are all smooth on top."

"You can distinguish them by their shape," said Dick quickly. "Here you are, that one is a Strawberry Creme."

Smithy picked up the chocolate indicated by Dick's finger and popped it

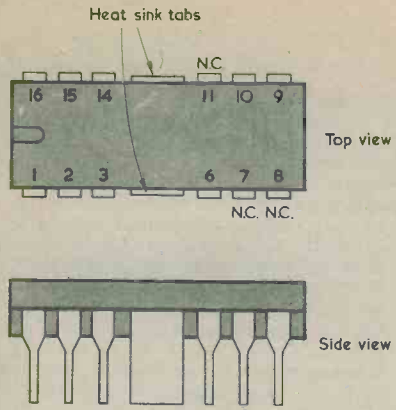


Fig. 6. Four of the SN76013ND pins are replaced by the heat sink tabs

into his mouth. A look of bliss spread over his face.

"Delicious," he remarked. "Quite delicious. Here, you have one."

Smithy offered the box to Dick.

"Er, not for the moment," said Dick hesitantly. "Perhaps I'll have one later."

"Fair enough," commented Smithy, picking out another chocolate. "These certainly are excellent chocolates. They're the best I've had for ages. Thanks again, Dick."

"Think nothing of it," returned Dick. "Now, I know we've finished servicing up till Christmas, but I'm still a bit puzzled about that feedback fault you just cleared. How did you know so promptly where to find those feedback components?"

"As I said," stated Smithy, chewing vigorously. "I've been doing a little genning-up on these a.f. amplifier i.c.'s lately. You know how often integrated circuits from different sources happen to have identical internal circuits. Well, the integrated circuit in this set is a Texas Instruments SN76013ND, and I found out recently that this has the same internal circuitry as the early 'A' versions of the Sinclair Super IC-12."

"But," protested Dick, "all the pictures I've seen of the Super IC-12 show it with a radiating heat sink on it. The i.c. in that set hasn't got a heat sink at all."

"There *is* a heat sink," stated Smithy, "but it's not all that obvious. One version of the SN76013 also has a radiating heat sink, but the 'ND' type which is used here has two heat sink tabs instead. These pass through the printed circuit board and are then soldered to a large area of copper underneath. The copper provides the heat sink. If you look at the i.c. you'll see that it's really a 16 pin dual-in-line job with pins 4, 5, 12 and 13 replaced by the heat sink tabs." (Fig. 6).

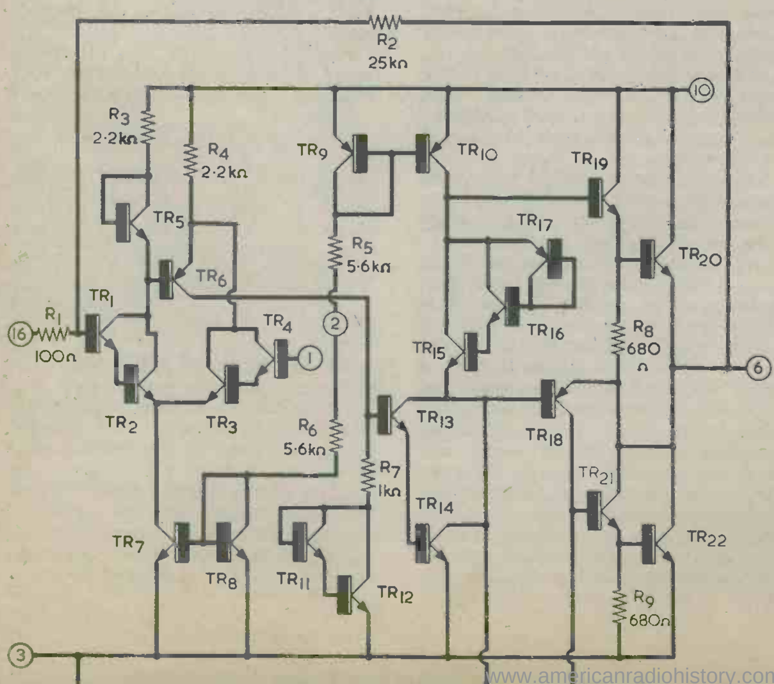
"Yes, I can see that now," said Dick, peering at the integrated circuit. "I wonder what the internal circuit looks like."

"I can show you that now."

Smithy rose, put another chocolate in his mouth then walked over to his bench. He returned with a small booklet and opened it at a page bearing a circuit (Fig. 7.)

"This," he said indistinctly through

Fig. 7. The internal circuitry of the early 'A' version of the now discontinued Sinclair Super IC-12, and also of the SN76013. Later versions of the Super IC-12 (and, incidentally, the SN76023) have R1 and R2 omitted, with the base of TR1 connecting directly to pin 16



the chocolate, "is the internal circuitry of the 'A' type Super IC-12 and also of the SN76013. It's pretty straightforward, and it has two inputs, at pins 1 and 16, going to a differential amplifier consisting of TR1, TR2, TR3 and TR4. This differential amplifier acts just like the differential amplifier following the inputs of an op-amp."

"I wonder," queried Dick musingly, "which is the inverting and which is the non-inverting input."

"We can soon find that out by tracing a signal through. Let's commence by saying that the input at pin 1 goes positive. The two collectors of TR3 and TR4 will then go negative. These connect to the emitter of TR6, and the collector of this transistor will also go negative. It couples to the input base of the Darlington pair given by TR13 and TR14, whereupon the collectors of these two transistors will go positive. If you then trace through the two emitter followers TR19 and TR20 you will see that the output, at pin 6, must also go positive. If, alternatively, you follow the signal path through TR18 collector, TR21 and TR22 you'll also get a positive-going output, although this time there are two phase inversions in the path, these occurring at TR18 and TR22."

INVERTING INPUT

"So," said Dick musingly, "if pin 1 goes positive so also does the output at pin 6."

"That's right," confirmed Smithy. "Whereupon pin 1 becomes the non-inverting input. Following from this, pin 16 must be the inverting input. Or, to be more precise, the base of TR1 is the inverting input. Now, there's a resistor, R2, coupling back from pin 6 to this inverting input, with the result that, assuming there are no d.c. connections to earth at pin 16, the i.c. works as a voltage follower at d.c. with pin 6 taking up the same potential as that at the non-inverting input."

"Oh yes, I can see that," said Dick brightly. "We've been talking about voltage follower op-amps recently and this is the same sort of circuit arrangement."

"I'm glad you've remembered," said Smithy approvingly. "The next thing to note is that there is a reference point at half-supply voltage which is provided inside the i.c. itself. This is given at pin 2, which connects to the junction of the equal-value resistors R5 and R6. If you go back to the television receiver circuit, you'll see that pin 2 couples back to pin 1 via a 120kΩ resistor, a 0.1μF bypass capacitor to chassis and a 270kΩ resistor. The 270kΩ resistor is the input resistor for the incoming a.f. signal and the 120kΩ resistor and the 0.1μF capacitor decouple its lower end from any signal voltages appearing on the supply lines for the integrated circuit. And the two resistors give a d.c. coupling to pin 1 which ensures that, under quiescent conditions, the output at pin 6 is held at half-supply voltage." (Fig. 8(a).)

"Gosh," said Dick excitedly, "this is all crystal-clear now. I can also see the a.c. negative feedback set-up, too. The output couples back to the inverting input at the base of TR1 via R2 inside the i.c., after which you have R1 and the external 330Ω resistor which goes down to chassis via the 22μF electrolytic. The electrolytic acts as an open-circuit at d.c. and doesn't upset the d.c. feedback arrangements. But at a.f. it's almost a dead short, whereupon the a.c. feedback is governed by the values of the three resistors." (Fig. 8(b).)

"That's right," confirmed Smithy. "The overall voltage gain then becomes equal to the sum of the three resistors divided by the sum of the internal 100Ω resistor and the external 330Ω resistor. If we call that last resistor RX, to cover the cases where it has other values, we can then write out a general formula for voltage gain."

He took out a pen and scribbled an equation in the margin of the service manual. (Fig. 8(c).)

"That explains," said Dick, "why the voltage gain of the amplifier dropped so much when the 330Ω resistor went high in value."

"True," agreed Smithy, popping yet another chocolate in his mouth. "So there's no more mystery there."

Idly, he picked up the Cellophane which had been wrapped around the box of chocolates. As he glanced through the transparent material at the underside of the gift label, he noticed what appeared to be the back of another label. Intrigued, he picked at a corner of the top label and was soon able to peel it off. Underneath was a second label: "To Auntie Eff with love from Dick."

"That's funny," remarked Smithy. "How comes it that there's a label meant for your Auntie Eff underneath the one meant for me?"

"I originally bought the chocolates for Auntie Eff," explained Dick hastily. "Then I thought you'd like them better."

"Oh, I see."

Smithy pondered on this fact, and also on the apparent looseness of the Cellophane when he had originally unwrapped it and, further, on the unusually smooth finish of the chocolates. An unwelcome thought rose, unbidden, in his mind. He dismissed it but, inexorably, it returned.

"Doesn't," he asked gently, "your Auntie Eff keep rather a large number of cats?"

"Er yes, well I suppose she does, rather."

"There's more to these chocolates," he went on accusingly, "than just one label stuck on top of another, isn't there?"

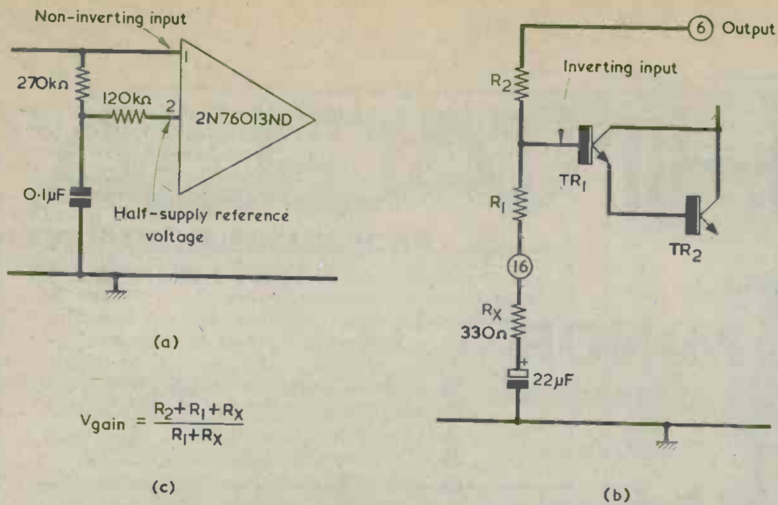
Dick maintained an unhappy silence.

"Isn't there?"

There was still no reply.

"*Isn't there?*" roared Smithy.

Dick looked up fearfully at the



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

(c)

Fig. 8(a). Illustrating the manner in which the half-supply reference voltage is applied to the non-inverting input
(b). The a.c. feedback network. R1, R2, TR1 and TR2 are inside the integrated circuit
(c). The voltage gain of the i.c. amplifier is governed by the values of R1, R2 and RX

furious Serviceman, who now hovered over him menacingly.

"Now, Smithy, take it easy, please."

"What happened to them?"

"Well," said Dick hesitantly, "I took the chocolates to my Auntie Eff last night and we opened them and put them to one side. But when we went to get them later we found that one of her cats had licked all the patterns off them."

"After that," went on Dick quickly, anxious to complete his story, "neither my Auntie Eff or me fancied the chocolates any more. So I thought I'd give them to you as a Christmas present."

"Ye gods," grated Smithy in a tone of utter disillusion. "Talk about the Season of Goodwill! I'll probably get distemper or hard-pad after eating all those darned cat-licked chocolates. And to think of all the trouble I went to in getting *you* a nice Christmas present."

"Yes, it *is* a nice present," agreed Dick, eager to propitiate the Serviceman.

He picked up the calendar.

"It's got a *smashing* picture for January," he continued, turning over the first sheet, 'and an even better one for February. Hey, just a minute."

"What's wrong?"

"there's something odd here," remarked Dick slowly. "Isn't 1976 a Leap Year?"

"Blimey," said Smithy uncomfortably, "is it?"

"Yes, of course it is," returned Dick. "But the February page in this calendar you gave me only goes up to the 28th."

He turned a puzzled glance on the calendar and examined it more closely. Suddenly, he started turning the pages over rapidly one after the other.

"Why, you tight-fisted mean old buzzard," he snorted. "This is a 1970 calendar. You've been through all the pages changing the 1970's to 1976's!"

"Well, so what?" retorted Smithy defensively. "I don't believe in throwing away old calendars because if you wait long enough you're bound to find a year when the dates fit again. Both 1970 and 1976 start on a Thursday."

"Ah yes," returned Dick viciously with a demoniacal delight at having, at long last, scored off the Serviceman. "But you slipped up this time, didn't you? You forgot that 1976 is a Leap Year and 1970 wasn't."

SPIRIT OF CHRISTMAS

For once, Smithy had no reply to make. The pair sat, glowering at each other.

Dick quickly put the printed circuit board of the television receiver to its normal position and replaced the back of the set. He reconnected the aerial and switched the set on for its final check. At once, the Workshop was filled with the sound of Bing Crosby singing "I'm Dreaming of a White Christmas."

Gravely they shook hands. The magic of Christmas had yet again woven its spell.

"Merry Christmas, Smithy."

"A Merry Christmas to you too, my lad," returned Smithy warmly.

He rose and walked towards the spares cupboard, then returned accompanied by the pleasant clink of glass against bottle. He charged the two glasses and handed one to Dick, after which they both stood, holding their glasses high.

"Let us now," stated Smithy, "wish a very Merry Christmas, and a truly Happy New Year, to all the readers who've put up with our antics over the last twelve months."

They drank deeply.

"And," concluded Dick, "let us once more finish, as on so many previous Christmasses, by saying, 'God bless us, every one!' " ■

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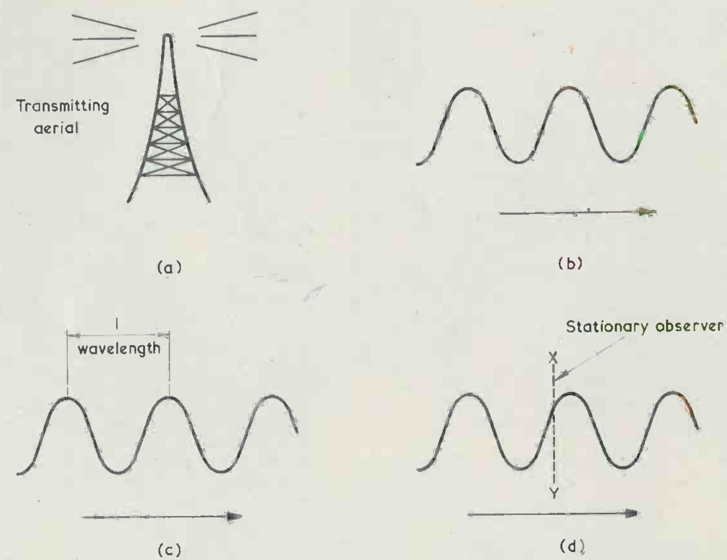
A stationary observer at line XY is introduced in (d) with the task of counting the number of wave crests which pass him in 1 second. This number will represent the frequency of the signal in cycles per second.

If the wavelength of the signal were 1 metre then, since the signal velocity is 300,000,000 metres per second, the number of wave crests, or cycles, passing the observer in 1 second would be 300,000,000. Had the wavelength been 1,000 metres the number of cycles in 1 second would be 300,000. In these, and all other instances, the wavelength in metres multiplied by frequency in cycles per second is equal to 300,000,000. Because of this relationship, frequency decreases as wavelength increases, and vice versa.

Modern usage employs the Hertz (Hz) as the unit of frequency, with 1 Hertz being equal to 1 cycle per second. The two examples just quoted are then expressed as: 1 metre corresponds to 300,000,000Hz, or 300MHz; and 1,000 metres corresponds to 300,000Hz, or 300kHz.



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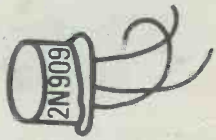

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Look at the entry for 2N909

TRANSISTOR NUMBER	PM DA LT	PACK-AGE	LEAD INFO	VCB MAX	VCE MAX	VEB MAX	I C MAX	T J MAX	P TOT	F T MIN	C OB MAX	H FE	H FE BIAS	USE	MFR	EURO EQVT.	USA EQVT.	ISS
2N909	NS	TO18	LO1	60V	30V	5V	200MA	175C	500MWF	50M	25P	110MN	50MA	AMG	SGI	BSX 33	2N731	0

This is what you will learn from it

TYPE NO	POL & MAT	CASE OUTLINE	LEAD IDENTIFN	V_{CBO} MAX	V_{CEO} MAX	V_{EBO} MAX	I_C MAX	T_J MAX	P_{TOT} MAX	f_T MIN	C_{OB} MAX	h_{FE}	I_C (h_{FE} BIAS)	USE	SUPPLIER	UK SUB	USA SUB	ISS
(EXAMPLE) 2N909	NS	TO18	LO1	60V	30V	5V	200 MA	175C	500 MWF	50M	25P	110 MN	50 MA	AMG	SG1	BSX 33	2N 731	0

- TYPE NO: NUMERO-ALPHABETIC LISTING
- POL & MAT: N = NPN, P = PNP, G = GERMANIUM, S = SILICON
- CASE OUTLINE: REFER TO CASE-OUTLINES APPENDIX C
- LEAD IDENTIFN: REFER TO LEAD DETAILS – APPENDIX B
- V_{CBO}: MAXIMUM PERMISSIBLE COLLECTOR–BASE VOLTAGE WITH EMITTER OPEN-CIRCUIT
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- T_J: MAXIMUM PERMISSIBLE JUNCTION TEMPERATURE
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- f_T: MINIMUM FREQUENCY CUT OFF, F_T, INDICATED IN K = KILOHERTZ M = MEGAHERTZ G = GIGAHERTZ. F_T = FREQUENCY AT WHICH COMMON-EMITTER CURRENT GAIN DROPS TO UNITY. TYPICAL F_T CAN BE TAKEN AS ROUGHLY TWICE $F_{T\,min}$
- C_{OB}: MAXIMUM COLLECTOR CAPACITANCE (TYPICAL USUALLY ½ TO ⅔ MAX) – NORMALLY EMITTER OPEN-CIRCUIT AND INDICATED BY "P" = PICOFARAD OR "N" = NANOFARAD – FOR HF DEVICES C_{RE} IS GIVEN AND PICOFARADS THEN INDICATED BY "R" INSTEAD OF "P"
- h_{FE}: CURRENT GAIN, NORMALLY D.C. (BUT SOMETIMES RELATED A.C. GAIN) AT I_C BIAS SPECIFIED – WHERE MIN ("MN") ONLY IS SPECIFIED TYPICAL ("TP") CAN BE TAKEN AS TWICE MIN AND VICEVERSA
- I_C (h_{FE} BIAS): BIAS CURRENT AT WHICH CURRENT GAIN H_{FE} IS CHARACTERISED
- USE: CODE INDICATION OF APPLICATION USAGE – SEE APPENDIX A
- SUPPLIER: CODE INDICATION POSSIBLE SUPPLIER OF DEVICE – SEE "SUPPLIER" APPENDIX F
- UK SUB: SUGGESTED PROELECTRON STANDARD POSSIBLE SUBSTITUTE
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