RADIO & ELECTRONICS CONSTRUCTOR

NOVEMBER 1975

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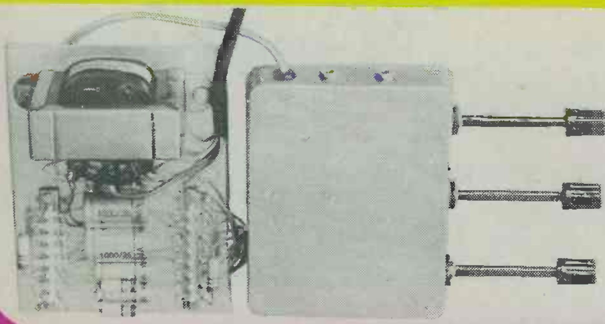

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RADIO & ELECTRONICS CONSTRUCTOR

NOVEMBER, 1975
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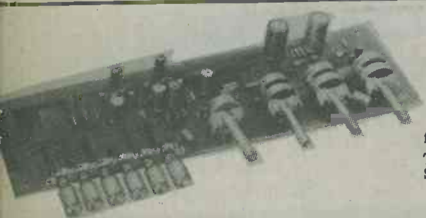

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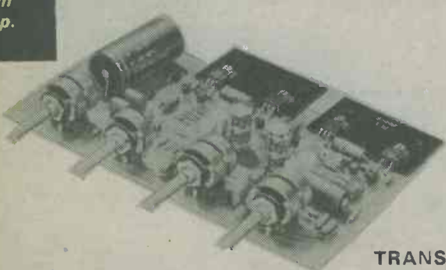

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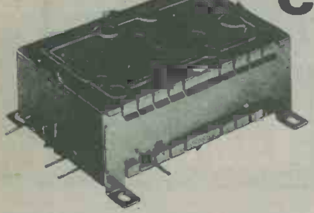

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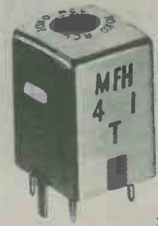

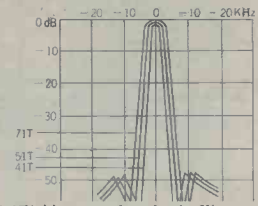

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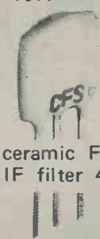

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LIGHT SOLDERING DEVELOPMENTS LTD

97–99, Gloucester Road, Croydon, CRO 2DN. 01–689 0574

LS/M

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 5p) U.K. only.

VALVE BASES

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

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

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

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

1½ METER AUDIO LEAD

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

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

RESETTABLE COUNTER

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

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

RESISTORS

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

POTS

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

THERMISTORS

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

RELAYS

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

Boxed GEC KT88 valve £2

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 4¾″ 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
25+35+97+59+30 ohm — 30p

5¼″ x 2¾″ Speaker, ex-equipment 3 ohm 30p
2 Amp Suppression Choke 5p
PAXOLINE
3 x 2½ x 1/16″ .. 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

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.

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**

SEMICONDUCTORS

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

AC107	12p	BC179B	11p	BF180/1/2/3	20p	BSX20/21	13p
AC128	5p	BC184C	9p	BF184/5	15p	BSY40	28p
AC176	10p	BC186/7	13p	BF194/5/6/7	5p	BU105-01	93p
ACY28	18p	BC213L/214B	9p	BF194A/195C/200	12p	CV7042 (OC41 OC44, ASY63)	7p
AD149	40p	BC261B	10p	BF258/262/263	24p	GET111	40p
AD161/2 matched pr.	69p	BC327	12p	BF336	25p	OC35	32½p
AF116	12p	BC328	10p	BFS28 Dual Mosfet	92p	ON222	30p
AF124/6/7	20p	BC337/8	12p	BFW10/11 F.E.T.	26p	TIP30	52p
AF139/178/180/181	30p	BC547/558A	7p	BFW30	£1.35	TIP3055	50p
AF239	20p	BC548	9p	BFW57/58	20p	TIS88A FET	23p
ASY27/73	25p	BCX32/36	12p	BFX12	20p	ZTX300	8p
BC107A or B	9p	BCY40	60p	BFX29/30/84/88	16p	ZTX341	15p
BC107/8/9	7p	BCY70/1/2	9p	BFX89	30p	2N393/MA393	30p
BC108A/B/109B/C	10p	BD112/3/5/6	40p	BFY50/1/2	12p	2N706	8p
BC147/8/9	6p	BD131/2/3/5	30p	BFY90	50p	2N929	14p
BC147A/B	8p	BD201/2/3/4	£1.00	BR101 } Programmable Unj Junction	30p	2N987	35p
BC148A/B, 9B/C/S	8p	BD232/4/5	46p	BRY39	31p	2N1507/2219	17p
BC157/8/9	6p	BDX77	£1.40	BRY56	34p	2N2401/2412/2483	25p
BC158A/B	11p	BF115	12p	BSV64	40p	2N2904/5/6/7	13p
BC159B/C, 157A	11p	BF167/173	15p	BSV79/80 F.E.T.s	£1	2N2907A	15p
BC178A/B	12p	BF178/9	20p	BSV81 Mosfet	90p	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

IN916	6p
IN4148	2.5p
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

741 8 pin d.i.l. op. Amp	24p
TAD100 AMRF	£1.00
CA3001 R. F. Amp	£1.00
TAA300 1wt Amp	£1.25
NE555v Timer	44p
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	30p	0.6	110	EC433	15p
1.4	42	BY164	28p	5	400	Texas	75p

RECTIFIERS

	Amp	Volt	
IN4004	1	400	4p
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, 4¼" dia. 10p

OPTO ELECTRONICS

BPX40	65p
BPX42	£1.00
BPY10	£1.00

(VOLTIAC)
BPY68, BPY69, BPY77 Diodes £1.00

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
Holdersorpads 50pper100

THYRISTORS

Amp	Volt		
1	240	BTX18-200	50p
1	400	BTX18-300	65p
1	240	BTX30-200	40p
6.5	500	BT102-500R	75p
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

PAPER BLOCK CONDENSER

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

METAL CHASSIS SOCKETS

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

SOLDER

Multicore - 2½p foot

ENAM. COPPER WIRE

SWG.	PER YD.
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

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

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	£3.44
EMI 10 x 6 93870 8 ohm	£2.69
EMI 2½" tweeter 8 ohm	.77
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"	£14.75
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
Fane 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.	£8.50
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
Goodmans 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, 8 or 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
Richard Allan CG8T 8" d/c roll rurr. 8 ohms	£7.50
STC 4001G super tweeter	£6.56
2½" 64 ohm, 70mm 8 ohm, 70mm 80 ohm	.77
2½" 75 ohm	.55
7" x 4" 3, 8 or 15 ohm	£1.63
8" x 5" 3, 8 or 15 ohm	£1.75
10" x 6" 6, 8 or 15 ohm	£2.69

SPEAKER KITS (Carr. 75p each. £1.50 pair)

Baker Major Module 3, 8 or 15 ohm	each	£13.44
Goodmans Mezzo Twinkit	pair	£47.19
Goodsmans DIN 20 4 ohm	each	£14.75
Helme XLK25	pair	£25.44
Helme XLK30	pair	£17.19
Helme XLK50	pair	£46.25
Kefkit 1	pair	£48.44
Kefkit 3	each	£42.50
Peerless 3–15 (3 sp. system	each	£17.19
Peerless 20/2	each	£17.44
Peerless 30/2	each	£24.38
Peerless 20/3	each	£26.56
Peerless 50/4	each	£40.50
Richard Allan Twinkit	each	£10.95
Richard Allan Triple 8	each	£16.50
Richard Allan Triple	each	£23.95
Richard Allan Super Triple	each	£28.75
Wharfedale Linton 2 kit	pair	£23.12
Wharfedale Glendale 3 kit	pair	£40.62
Wharfedale Dovedale 3 kit	pair	£63.12

PA/DISCO AMPLIFIERS (Carr. and ins. £1)

Baker Major 100 watt	£57.25
Linear 30/40	£30.00
Linear 40/60	£35.00
Linear 80/100	£58.95
Linear 100 watt slave	£44.00
Eagle PRO A120, 120 watts RMS	£135.00
Eagle PRO A65, 65 watts RMS	£108.00
Eagle PRO A35, 35 watts RMS	£82.00
Eagles TPA40 mains/12v mobile	£50.00
Eagle HHS 36 watts. mobile 12v.	£37.50
Eagle TPA20 paging amplifier	£45.50
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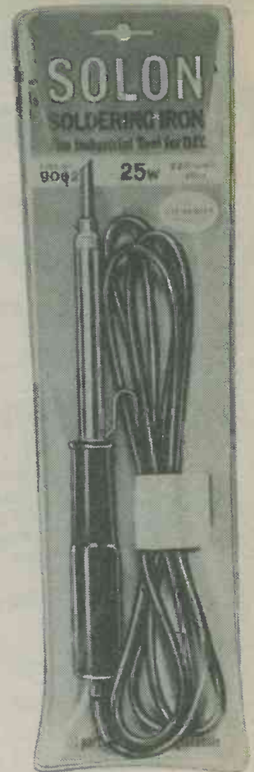

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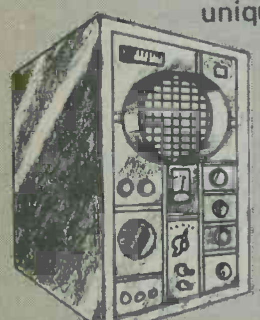

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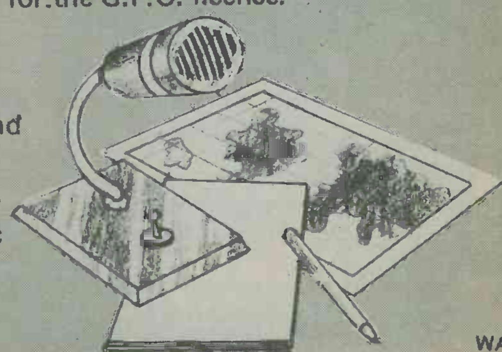

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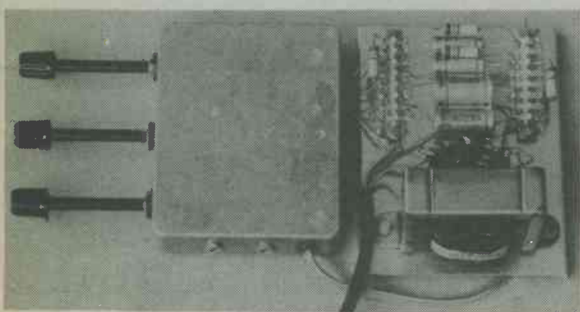
THE 6/12 AMPLIFIER

Part 1

by J. T. Neill

6 watt continuous, 12 watt peak

Incorporating some very neat circuit techniques, this a.f. amplifier also features small size and compact layout. Circuit operation is described this month, and details of construction will appear in next month's concluding article.



The amplifier coupled to the associated power supply unit

Specification

Output power	6/12 watts (see text)
Frequency response	45Hz to 25kHz at –3dB
Input for full output	30mV peak at 2.2MΩ (ceramic p.u.)
	250mV peak at 115kΩ (cassette)
Tone control range	+12dB at 100Hz
	±12dB, –16dB at 10kHz
Signal/noise ratio at full gain	56dB
Power supply (output stage)	±22V at 600mA
Size (excluding power supply)	$4\frac{3}{4}$ x $4\frac{1}{2}$ x $1\frac{1}{8}$in.

The dramatic rise in popularity of audio reproduction has led to the publication of a number of high quality designs. The author has had the opportunity to listen to several of these, and they all represent a high level of fidelity. However, what has been apparent, in the author's view, is that the number of features provided and power levels available have increased the cost of such equipment to the point where a constructor requiring a moderate power output at reasonable quality has no modern design to follow.

Accordingly, the amplifier presented here has been designed to fill that requirement. Only a mono version is described; such a limitation is not considered to be a serious drawback for the programme sources envisaged, namely reproduction of "pop" records from a ceramic pick-up and from the output of a medium quality cassette recorder. A radio tuner is also a very suitable signal source.

The specification appears in the accompanying table and it is from the output quoted there that the amplifier derives its name.

MAXIMUM POWER

The maximum power that can be delivered to a load of 8Ω with the suggested power supply and output transistors is 12 watts; any attempt to drive the amplifier harder results in clipping of the output. However, with the heat sink arrangements provided the output transistors will overheat after about 30 seconds at full output with sine wave drive, and the maximum continuous rating is therefore 6 watts. Sufficiently large heat sinks would enable the continuous rating to be raised to the 12 watt level, but would considerably increase the size of the complete amplifier.

It is appreciated that some readers, and especially those without the appropriate test equipment, would feel uncertain about building an amplifier in which it is possible for the output transistors to overheat under certain signal input conditions. Such readers can ensure that the output transistors will not overheat at any input level by the simple process of connecting the amplifier output to a 15Ω speaker instead of to an 8Ω speaker. The maximum output power with a 15Ω speaker will be restricted to some 4 watts but, bearing in mind the small size of the amplifier, this still represents a very attractive option.

The upper limit to the frequency response is set to allow full benefit to be made of any signal source. The lower limit has been deliberately made slightly higher than is sometimes the case in order to reduce the effects of very low frequency rumble that could otherwise arise from the use of one of the cheaper turntables. The response below 40Hz falls off at about 12dB per octave, as determined by the values of coupling capacitors employed at each stage.

AMPLIFIER CIRCUIT

A block diagram of the "6/12" appears in Fig. 1, while Fig. 2 gives the complete circuit diagram excluding the power supply, of which more later.

A choice of inputs is provided, these being 250mV at 115kΩ input impedence, and 30mV at 2.2MΩ. Switching between them is carried out automatically by the insertion of the appropriate jack plugs.

Amplifier A1 is built around a type 748 integrated circuit, the overall stage gain being about 30 times with the output in phase with the input. Following the volume control is a further 748 i.c. feeding a power

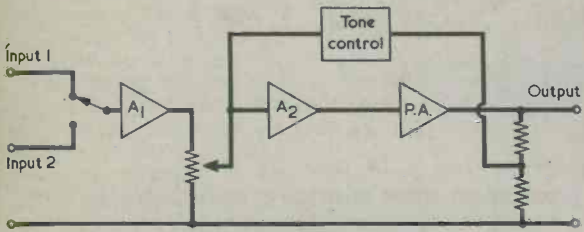
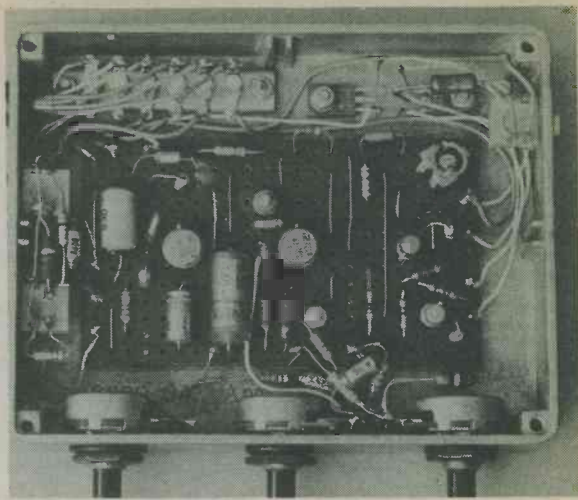


Fig. 1 Block diagram illustrating the amplifier stage line-up



Apart from the power supply, all the amplifier components are enclosed in a neat small die-cast box

COMPONENTS

Resistors
(All fixed values ¼ watt 10% unless otherwise stated)
R1 100kΩ
R2 15kΩ
R3 2.2MΩ
R4 47kΩ
R5 1.5kΩ
R6 47kΩ
R7 1kΩ
R8 3.3kΩ
R9 3.3kΩ
R10 4.7kΩ
R11 22kΩ
R12 22kΩ
R13 180Ω
R14 470Ω
R15 47Ω
R16 180Ω
R17 470Ω
R18 47Ω
R19 1.5kΩ
R20 100Ω
R21 1Ω 3 watt wire-wound
R22 & R23 1.5kΩ ½ watt
R24 & R25 1.5kΩ ½ watt
VR1 10kΩ potentiometer, log
VR2 47kΩ or 50kΩ potentiometer, linear
VR3 47kΩ or 50kΩ potentiometer, linear
VR4 500Ω pre-set potentiometer, miniature skeleton,
horizontal mounting

Capacitors
C1 6,800pF polystyrene
C2 47μF or 50μF electrolytic, 6 V. Wkg.
C3 10pF polystyrene
C4 10pF polystyrene
C5 0.33μF polyester
C6 0.1μF polyester
C7 6,800pF polystyrene
C8 6,800pF polystyrene
C9 10pF polystyrene
C10 22μF or 20μF electrolytic, 16 V. Wkg.
C11 1,000μF electrolytic, 35 V. Wkg.
C12 470μF or 500μF electrolytic, 16 V. Wkg.
C13 1,000μF electrolytic, 35 V. Wkg.
C14 470μF or 500μF electrolytic, 16 V. Wkg.

Transformer
T1 Mains transformer, secondary 20-12-0-12-20V at 0.7A (R.S. Components)

Semiconductors
IC1 748 in TO99 encapsulation
IC2 748 in TO99 encapsulation
TR1 BC108
TR2 BD132 with insulating washer
TR3 BCY71
TR4 BD131 with insulating washer
D1 1N914
D2 OA47
D3-D6 silicon bridge rectifier, 100V 2A

Sockets
J1 3.5mm. jack socket, insulated
J2 3.5mm. jack socket, insulated, with break contact
J3 3.5mm. jack socket, insulated

Miscellaneous
Die-cast box, 4¾ x 3¾ x 1⅛in. (121 x 95 x 29mm.) (S.T.C.)
3 knobs
Veroboard, 0.15in. pitch, 23 holes x 13 strips
Veropins for 0.15in. Veroboard
Aluminium for power supply chassis
1-off 6-way tagstrip
2-off 8-way tagstrips
2-off 6BA nylon nuts.

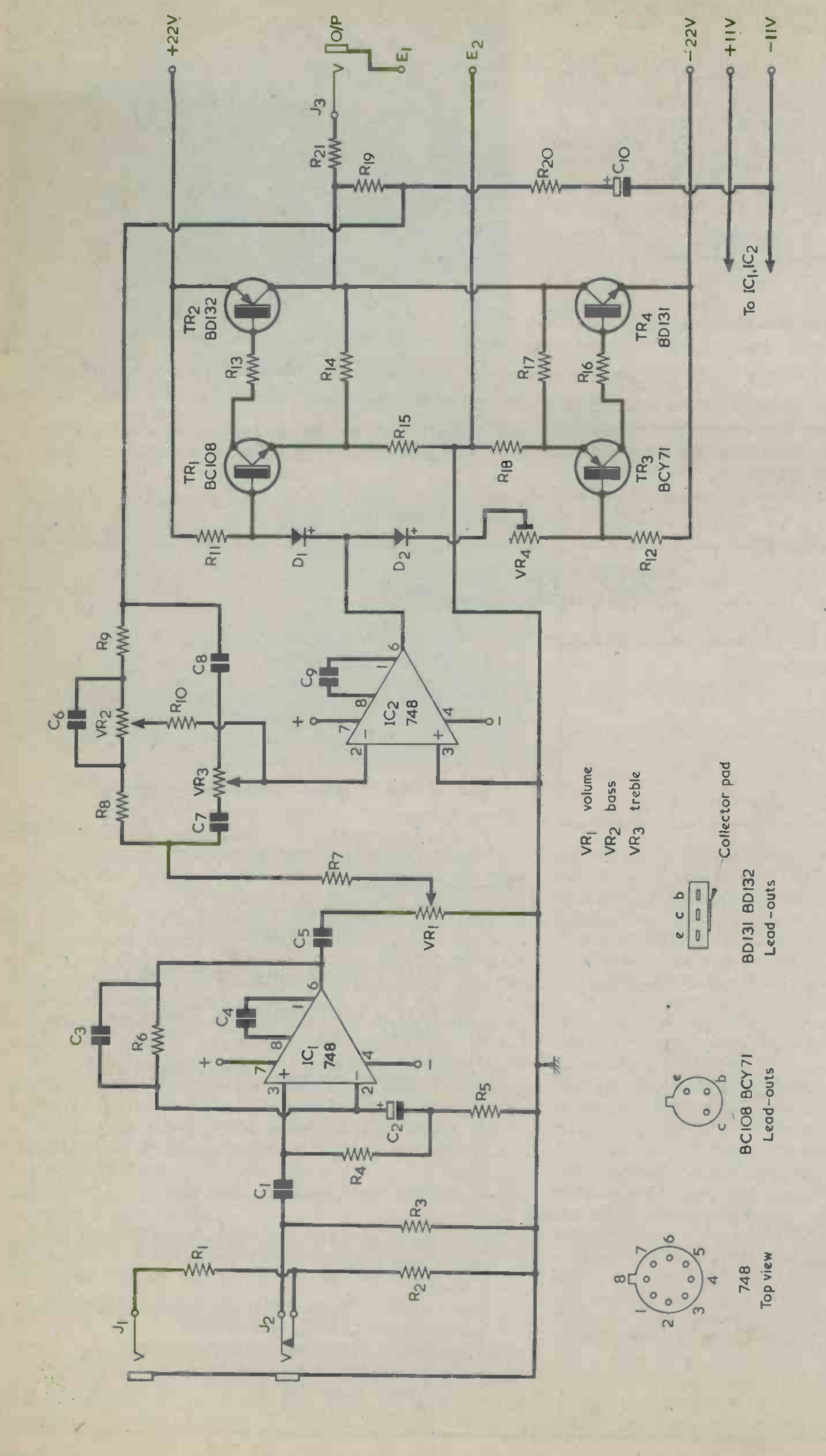


Fig. 2. Complete circuit of the "6/12" amplifier

amplifier using discrete transistors, giving together a voltage gain at 1kHz of 16 times and a phase inversion. Thus the whole amplifier is phase inverting, so reducing the chance of unwanted positive feedback leading to instability, and enabling it to be constructed as a very compact unit as can be seen from the specification and photographs.

Wide range tone controls giving both bass and top boost and cut are, unusually, arranged to function over the entire stage following the volume control. They thereby eliminate the need for a separate tone control stage and further contribute to the compactness of the design.

Signals fed to the high level input J1 in Fig. 2 are reduced in level by the potential divider R1, R2, before being applied to IC1. The insertion of a jack plug into the high impedance input J2 switches out R2, leaving only R3 as load for the signal. IC1 is arranged to have an extremely high value of input impedance, obtained by the bootstrapping of R4. This arises from the action of the large value capacitor C2, which has its upper plate connected to the inverting input of the integrated circuit amplifier; since the negative feedback around that amplifier tends to keep the difference between its inputs very small, almost the same signal appears at both ends of R4. Consequently, there is very little signal current in R4 and it appears to have a very much larger value than its actual physical resistance. With C2 at 50μF, R4 appears to be greater than 2MΩ at all frequencies above 40Hz, and accordingly the input impedance at J2 is substantially set by R3.

The value of R3 is 2.2MΩ, so giving a good low frequency response when a ceramic pick-up is connected to J2. A substantially lower value for R3 would cause unwanted attentuation of bass frequencies, since the signal from a ceramic pick-up is effectively fed in series with a capacitance of about 800pF.

The overall gain of IC1 is determined by the ratio of R6 to R5, so that with maximum permitted signal at either input there is about 900mV at the top of the volume control, VR1. Compensation capacitor C4 sets the open loop gain-frequency characteristic to give the appropriate response.

TONE CONTROL

The second i.c. amplifier and the output stage proper have overall negative feedback applied. A Baxendall type tone control network is included in this feedback loop and gives bass and top boost and cut in the usual way. Fig. 3 shows the frequency responses available. What is not so usual, however, is that the feedback is obtained from a tap in a potential divider across the amplifier output, giving a voltage gain with the tone controls in mid-position of some 16 times between volume control and loudspeaker. This gain is required to rise to 64 times with either tone control at maximum boost, and to assist in ensuring that sufficient gain is available the output stage transistors are given a voltage gain of 11 times. Fig. 4, which is a simplified circuit, makes clear how this is done.

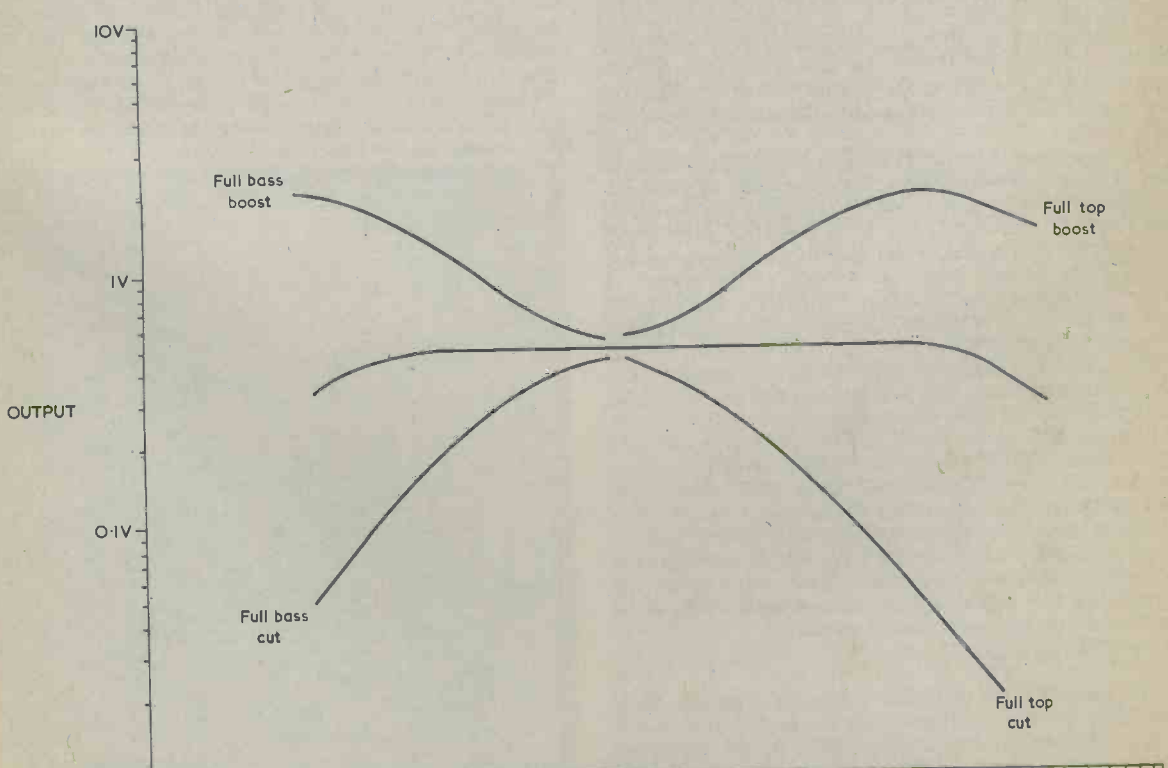
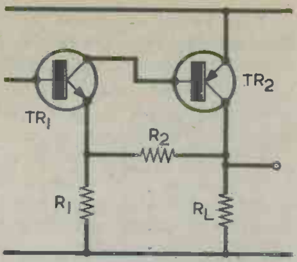


Fig. 3. Frequency response curves for the amplifier

Fig. 4. Simplified diagram illustrating the operation of the output stage



Transistor TR1 in Fig. 4 has a load resistor R1 in its emitter circuit, and under normal emitter follower action the signal voltage present at the emitter is of the same magnitude and phase as that at the base. However, the collector current of TR1 is modulated by the signal and as this current is the base current of TR2, a further amplified version of the input appears at TR2 collector; since the signal has undergone two stages of amplification, each with a phase reversal, it is now in phase again with the input. Its magnitude is determined by the relative values of R1 and R2. If they are equal, then obviously the signal at TR2 collector is twice that at TR1 emitter, that is, twice the input signal. A similar reasoning will show that the corresponding gain of the circuit in Fig. 2 is 11 times.

Thus we have a stage with a voltage gain and, since the transistor used for TR2 is usually a high power type, a high output power is available at a low impedance due to the large amount of negative feedback present within the stage itself.

In the "6/12" amplifier two such stages, each the complement of the other, are used in push-pull, with a voltage gain in each of 11, as determined by the relative values of R14 and R15, and R17 and R18. Resistors R13 and R16 limit the dissipation in the stage (and so therefore, the output power) by limiting the maximum drive to each output transistor base to a safe level.

Voltage gain is incorporated in the output stage, in the manner just described, for a number of reasons.

Besides ensuring that sufficient gain is present at the "boost" settings of the tone controls, the output stage gain also enables the amplifier output voltage swing to be larger than that present at the output of IC2. The supply rail voltages for the i.c. are only 11 volts or so, which restricts the maximum output swing to some 18 volts. This is less than that required for full power output. Voltage gain in the output stage makes up for this situation and permits the full swing of load voltage to be the 28 volts required.

Lastly, the 748 i.c. has a limitation known as "slew rate". Basically, although IC2 has a level frequency response at small signal levels up to well above that required here, the faster rate of change of voltage called for at the higher signal voltages at high frequencies is not within its capabilities. Once again, voltage gain in the output stage compensates for this deficiency, by permitting the signal voltage delivered by IC2 to be less than would otherwise be required.

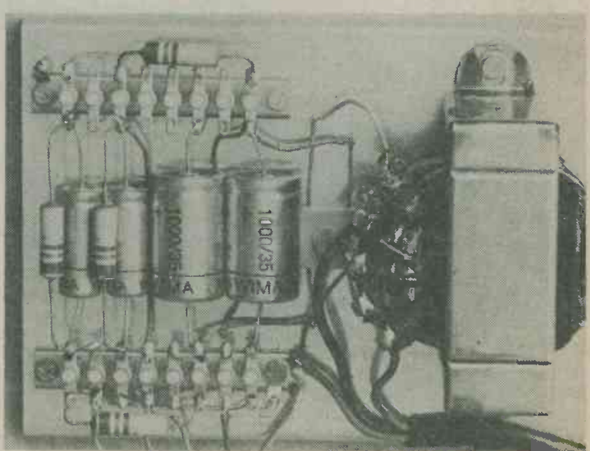
OUTPUT BIAS

The output stage transistors require to be biased so that they draw a small standing current under quiescent conditions, and this is best done by arranging for the bases of TR1 and TR3 to be respectively a small amount positive and negative with respect to earth. Two forward biased diodes, D1 and D2, are used to provide most of this difference voltage, with a small pre-set variable resistor VR4 in series to enable fine adjustments to be made to compensate for component tolerances.

The voltage across D1, D2 and VR4 is substantially constant with variations in power supply voltage due to the almost constant voltage drop across each diode. However, temperature changes are also corrected; for example, a rise which could cause an increase in output stage current reduces the diode voltages and so tends to reduce the standing current. Thus temperature variations resulting from both environmental changes and local heating due to increased dissipation in the output transistors are reduced in effect. Note, however, that the latter compensation can only be present if the diodes are mounted close to the output transistors so that they are affected by any temperature rise in them.

One diode, D1, is a silicon type, the other is germanium. It was found during development of the circuit that the use of two silicon diodes gave too large a standing voltage between TR1 base and TR3 base, while two germanium diodes gave a voltage that was too small. This arises, of course, from the property of a conducting silicon diode to have 0.7 volt or so developed across it, the corresponding figure for a germanium diode being only about 0.4 volt. A compromise seemed in order, even though it is a little unusual. It is worth noting that other amplifier designs frequently call for more complicated arrangements involving an extra transistor used as a voltage multiplier.

The degree of overall negative feedback from output to volume control slider is set, as mentioned earlier, by the ratio of R19 and R20 — at audio frequencies, that is. At very low frequencies the impedance of C10 becomes large compared to R19 so that the degree of negative feedback is thereby increased; for d.c. this increase is such that the overall gain of IC2 and the output stage is unity, so that the d.c. voltage at the junction of TR2 and TR4 collectors is the same as that at the volume control slider, i.e. it is zero with respect to earth. Consequently, the loudspeaker can be connected directly between the output collector junction and the earth line, so eliminating an expensive high value capacitor and contributing to the small size of the unit.



A close-up view of the power supply components

The negative side of electrolytic capacitor C10 is returned to the negative 11 volt supply rail, and not to the earth line. This method of connection ensures that C10 remains properly polarised, with its upper end at earth potential.

A 1Ω resister R21 is used in series with the loudspeaker to reduce a little the large currents that could otherwise flow should a short-circuit appear at the output. The power loss due to R21 is negligible.

OUTPUT POWER

The output transistors used are types BD131 and BD132, a complementary n.p.n.-p.n.p. pair in plastic encapsulation. Although they are each rated at 15 watts maximum (some references state 11 watts) this does not mean that 30 watts can be drawn from the amplifier described here. A primary objection to this is a phenomenon known as secondary breakdown.

A curve showing the current-voltage limits that have to be observed in order to prevent such breakdown is given in Fig. 5 (extracted from Mullard data). It will be seen that at a rail voltage of 22 volts, as provided in the power supply of the "6/12" amplifier, the maximum collector current permitted is 0.6 amp. Resistors R13 and R16 have been chosen so that the greatest mean current through each of the output transistors is 0.6 amp when signal clipping starts. With two transistors in push-pull, 12 watts can be driven into 8Ω and this is the peak rating of the amplifier.

Further limitations arise due to thermal considerations. The heat sinking provided in this design is capable of maintaining a suitable junction temperature only if the average output power over some minutes is limited to 6 watts into 8Ω and this is therefore the maximum mean output of the amplifier. As was stated earlier, the risk of over-heating is obviated if the amplifier feeds into a 15Ω loudspeaker.

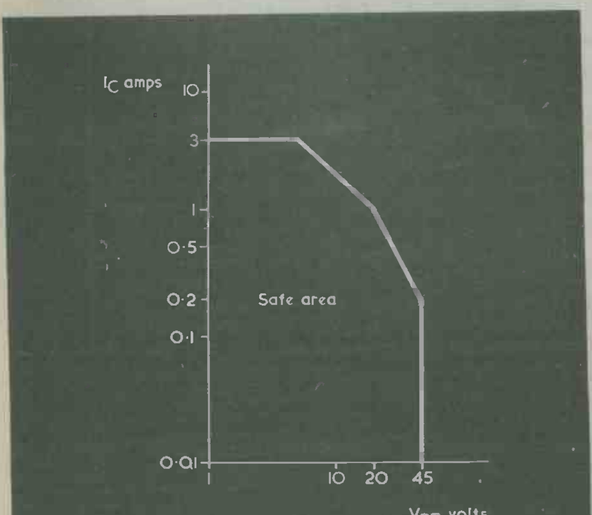


Fig. 5. Secondary breakdown curves for the BD131 and BD132

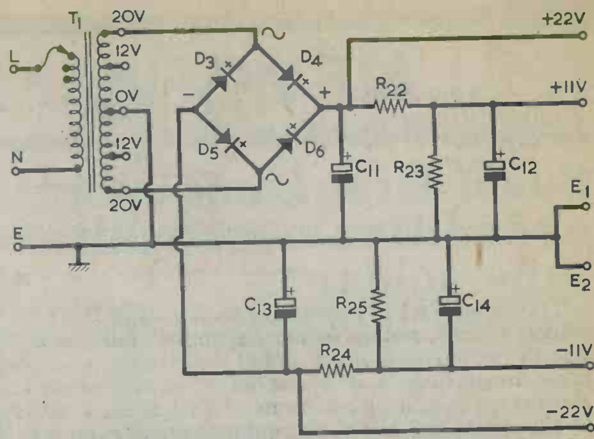


Fig. 6. The power supply. No connections are made to the 12 volt taps in the transformer secondary

POWER SUPPLY

The power supply for the "6/12" is required to offer outputs of 22 volts positive and negative at 600mA and 11 volts positive and negative for the two integrated circuits.

These outputs are easily achieved with the circuit of Fig. 6. The combination of a transformer with a 20-0-20 volt secondary and a bridge rectifier in the configuration shown gives a dual output of about ±30 volts off load, falling to ±22 volts when the amplifier is delivering its full output of 12 watts. The two 748 i.c.'s require lower rail voltages and these are most easily provided by means of two potential dividers. The extra expense of a regulated supply using zener diodes is hard to justify in view of the excellent rejection of supply rail changes by the 748's.

This completes the description of the circuit of the "6/12" amplifier and its power supply, and constructional details will be given in next month's concluding article. The full Components List appears in this issue. The two 748's employed are in the round TO99 (sometimes referred to as TO5) encapsulation and these are available from several retailers. An S.T.C. die-cast box was employed for the prototype amplifier, and this is listed by Home Radio. The three jack sockets have an insulated construction, i.e. both their contacts are insulated from chassis. The two output transistors require an insulating mica washer, which is normally supplied with them. The polystyrene capacitors shown in the Components List are available from Doram Electronics or Electrovalue. The tagstrips employed in the prototype can be seen in the accompanying photographs. The 6-way tagstrip is fitted in the amplifier. It should have all tags insulated from chassis and should not be longer than about 2½in. The two 8-way tagstrips are in the power supply and are not critical with respect to length, although the use of small tagstrips is preferable. The silicon bridge rectifier employed for D3 to D6 may have a voltage or current rating in excess of those stated. Readers having any other queries concerning components should find that these are cleared up in next month's article. ■

(To be concluded)

NEWS . . . . AND .

Successful Himalayan expedition uses multicore tape solder

The photograph shows members of the Polish expedition in the Himalayas, who successfully repaired their electronic equipment with Ersin Multicore Tape Solder.

News recently reached Multicore Solders Limited of Maylands Avenue, Hemel Hempstead, Herts., from their Polish Distributor who reported that during 1974 a Polish mountaineering expedition conquered the highest unclimbed peak in the Himalayas — the Kangbachen Peak (7902 metres). Five Polish mountaineers placed a Polish and Nepalese flag on the peak which had defied all previous expeditions.

The secretary of the expedition, the first one on the peak, was an electrical engineer and physicist, Dr. Eng. Wojciech Branski. Dr. Branski was responsible for servicing and maintaining all the electrical and electronic equipment. He told Muticore's Polish Distributor:

> "Well before the start of the expedition I was concerned about equipment failure as one cannot carry both solder and soldering iron due to weight and space restrictions. The answer to this problem came from Multicore Solders. Specially prepared Tape Solder wound round wire terminals soldered quickly when heated by the flame of a match. Ersin Multicore Flux Cored Tape Solder can be used anywhere and at any height, as I have proved on several occasions in the mountains. Ersin Multicore Tape Solder should be an essential part of any mountaineers equipment."

Dr. Branski also stated that he used Multicore Tape Solder both at home and on his car.

Ersin Multicore match melting Tape Solder has been on the market for many years now and has useful and varied applications, besides the ones described above. For industrial uses it is available in many shapes and forms, according to specific requirements. It is also sold in shops in a convenient pack of pre-cut pieces.

CCTV EQUIPMENT PROBLEM SOLVED WITH SPEEDFRAME

The photographic unit of the GKN Group Technological Centre provides a comprehensive photographic service to meet the requirements of both internal departments and external sectors of the Group.

One of the services run by the unit is a closed circuit television facility which is used for the recording and analysis of industrial processes, work study techniques and training courses.

The CCTV equipment comprises cameras, a video tape recorder, monitors, switching unit and various ancilliary components. All of these parts need to be wired up and positioned correctly for monitoring. This had become a lengthy and inconvenient procedure, since each piece of equipment had to be stored, transported, and set up separately before each video tape session.

Dexion Speedframe proved to be an ideal solution to the problem. A framework of 1" Speedframe measuring 3' x 2' x 2' was constructed to form a purpose built mobile control console for housing all the equipment. The console framework was then fitted with 4" diameter castors and plywood shelves to form a trolley. The top shelf of the trolley is removable so that the unit can be carried easily in an estate car.

Once reassembled and loaded, the trolley becomes a rigid and practical support facility which can transport the equipment quickly and easily from one location to another.

. . . COMMENT

Fire-damaged PCBs cleaned up

Following a serious fire in the computer centre of a Dutch electronics factory over 1000 contaminated PCB assemblies were successfully cleaned to new condition in 'Arklone' solvent at the ICI Technical Service laboratory at Runcorn.

Many of the computer boards still had flux residues adhering to them, dating from their original manufacture, which had to be removed with 'Arklone' K before final cleaning could commence. The remaining fire contamination, consisting mainly of water staining, was removed by 'Arklone' W and rinsing in 'Arklone' P.

Subsequent inspection and testing by the electronics manufacturer has shown that the boards are all usable with the exception of a mere dozen which suffered mechanical damage to cheap and easily replaceable diodes.

The efficiency of 'Arklone' solvents in removing contamination from PCBs and assemblies was clearly demonstrated in this rigorous and unusual exercise.

Further details of the range of 'Arklone' solvents are available from Department P, ICI Mond Division, PO Box 13, The Heath, Runcorn, Cheshire WA7 4QF.

Post Office charges

The recent severe increase in Post Office charges has made life more difficult for most publishers as they are, unavoidably, substantial users of Post Office services.

Solely due to the increase in postal rates, we regret that it has become necessary to increase our annual subscription rate to £4.50 per annum, as from 1st November.

It is perhaps worth mentioning, that our subscription rate is less than the full cover price of the magazine plus postage, by nearly 50p, and of course subscribers are insulated against any further price rises for 12 months.

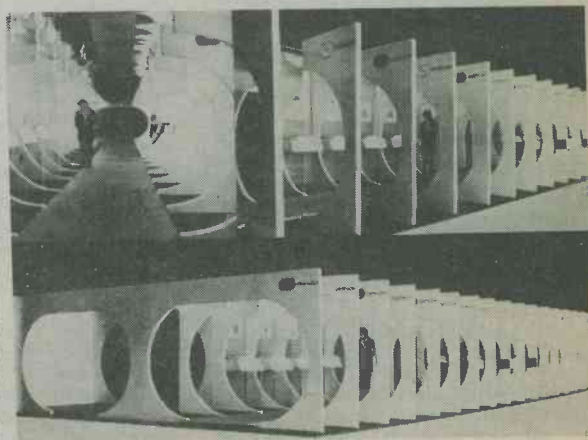
Independent Television in Outer Hebrides

About 17,000 inhabitants of the Isle of Lewis in the Outer Hebrides in Scotland are to be given a choice of television programmes for the first time — and they will be in colour.

To date, the only television service available in the Western Isles has been the black-and-white VHF 405-line service of BBC-1. But the opening of a new high-power UHF 625-line transmitting station by the Independent Broadcasting Authority at Eitshal in early 1976, will bring the programmes of Grampion Television in both monochrome and colour.

The optimum route for the ITV programme signals has been achieved by a co-operative effort between the IBA and the BBC and necessitates the use of an SHF (Super High Frequency) link, over a hundred miles in length.

Unusual stand at Audio Fair



Strathearn Audio's unusual stand in the main hall at this year's Audio Fair. Picture shows the stand which was of unusual and eye-catching design. A special area was set aside for the reception of dealers to provide a forum for discussion. The rest of the stand was devoted to the general public, there were two large areas — one for giving short formal demonstrations of Strathearn products, and another, which ran the entire length of the stand, was a "hands-on-products" area to enable the public to try out of the various turntables for themselves.

"I suppose in your line of business you'd describe that sign you gave me as a double digit display?"

SUGGESTED CIRCUIT 300

MULTI-WAY LATCH CIRCUITS

By G. A. French

In the author's article, "Touch Button Circuits", which appeared in the January 1975 issue of this journal, simple bistable circuits were described which require two transistors and a few other components only. These circuits all took advantage of the fact that the collector of a bottomed silicon transistor has a potential which is approximately 0.2 volt above emitter potential, whilst the base potential under these circumstances is about 0.6 volt above emitter potential.

BASIC CIRCUIT

The basic bistable, with typical resistor values, is illustrated in Fig. 1. In this circuit both transistors are silicon planar types. One transistor is always turned on and one transistor is always turned off.

Let us assume that it is TR1 which is turned on. Its collector is then about 0.2 volt positive of the negative supply rail, whereupon the base of TR2 is held at this potential by way of R2, and TR2 is in consequence cut off. The fact that TR2 is cut off allows base current to flow to TR1 via R4 and R3, maintaining TR1 in the turned on condition. If push-button switch S2 is pressed the circuit remains in this state. This is because TR2 is already cut off, and connecting its emitter to its base merely maintains it in the same condition.

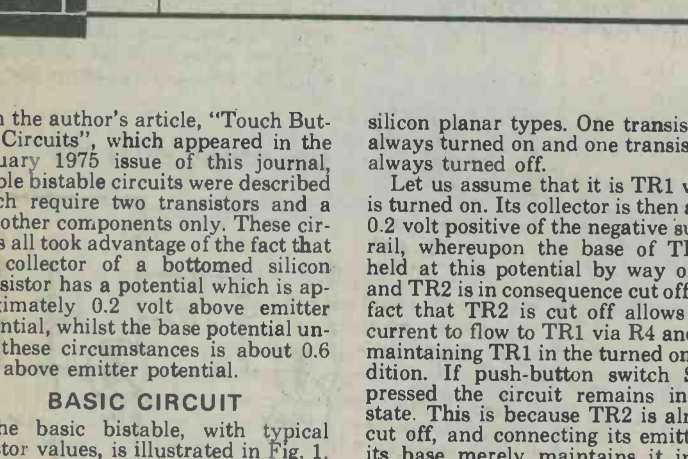


Fig. 1. A latching circuit in which one transistor is always on and one is always off. The circuit changes state when the appropriate push-button switch is pressed

If, on the other hand, S1 is pressed the circuit changes state dramatically. Pressing S1 causes TR1 to turn off, whereupon it draws no collector current via R1. A bias current flows into the base of TR2 via R1 and R2, causing this transistor to turn on and its collector voltage to drop to about 0.2 volt above the negative supply rail. When S1 is released the potential at TR1 base is now equal to that at TR2 collector and TR1 remains cut off.

Thus, pressing S1 has caused TR1 to cut off and TR2 to turn on. If S2 is pressed the circuit reverts to its original state.

The author felt that it would be of interest to see whether this mode of operation could be applied to latching circuits having more than two stable states. If a bias rail is provided which is negative of the lower rail in Fig. 1, it becomes possible to set up a network in which only one of quite a large number of transistors is held on at any time, but this does not take advantage of the simple and inherent latching action provided by the fact that the collector potential of a turned on silicon transistor is lower than its base potential. If it is accepted that a multi-way network allows only one of a number of transistors to be turned *off* at any time, then relatively simple multi-way latching circuits can be assembled which work from the disparity between collector and base voltages, and which require two supply rails only. With reasonably careful control of resistor values it should be possible to incorporate ten or more transistors in a circuit of this nature but the author considered that four transistors represented a reasonable practical maximum. With more than four transistors circuit operation, although still quite simple and reliable, would require rather a large number of intercoupling resistors between the transistors.

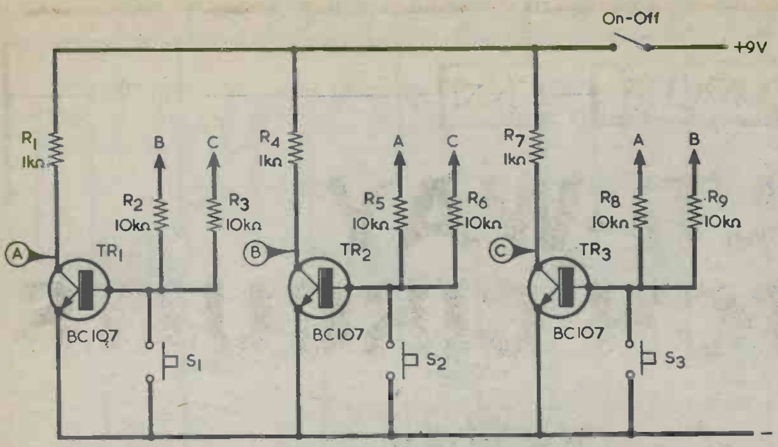


Fig. 2. The circuit can be adapted to take in three transistors. Here, one transistor is always off and two are always on

THREE-TRANSISTOR CIRCUIT

Fig. 2 shows a latching circuit incorporating three transistors and having three stable states. To simplify circuit presentation the three transistor collectors have been designated A, B and C, and the upper ends of the base bias resistors connect to these collectors as indicated. Thus, the upper end of R2 connects to the collector of TR2 and the upper end of R3 connects to the collector of TR3.

In this circuit one transistor is always off and two transistors are always on. Let us say that it is TR2 and TR3 that are turned on. A potential approximately 0.2 volt positive of the negative rail is then applied to the upper end of R2 and a similar potential to the upper end of R3. These potentials, applied to the base of TR1, maintain TR1 in the off state. A bias current flows via R1 and R5 to the base of TR2, turning this transistor on. R6 couples the base of TR2 to the collector of TR3 but since the voltage across this resistor is only about 0.4 volt (the difference between 0.6 volt at TR2 base and 0.2 volt at TR3 collector) the current which flows through it is much smaller than that in R1 and R5. The latter current predominates, ensuring that TR2 is hard on. A similar situation exists in the base circuit of TR3. A relatively high bias current flows via R1 and R8 to TR3 base and a much smaller current, from TR3 base to TR2 collector, flows via R9. The bias current in R1 and R8 is much the greater of the two and, like TR2, transistor TR3 turns hard on. The circuit is, therefore, stable, with TR1 cut off and TR2 and TR3 on.

If, now, push-button switch S2 is pressed, TR2 turns off. Its collector voltage rises and a base bias current becomes available to TR1 via R4 and R2, and to TR3 via R4 and R9. When S2 is released TR2 remains cut off and the circuit is in the second of its three stable states, with TR2 off and TR1 and TR3 on. Pressing S3 brings the circuit to its third stable state, in which TR3 is off and TR1 and TR2 are on.

To sum up, any of the three transistors can be caused to turn off, and stay off, by pressing the appropriate switch.

When the supply is switched on, any one of the three transistors may assume the turned off condition, although in practice this will most probably be the transistor with the lowest gain. If it is desired that a specific transistor be reliably in the off condition after switch-on, a capacitor may be added between its base and the negative supply rail. Fig. 3 shows the capacitor coupled to TR1 base. It delays the rise in base voltage in this transistor when the supply is applied and so ensures that this transistor is the one which is turned off. The presence of the capacitor does not upset subsequent operation of the circuit. When the supply is switched on sharply by the on-off switch shown in Fig. 2, it is found that a value of 0.01μF is quite adequate for the capacitor. If the rise in supply voltage is more gradual, as occurs when a mains supply unit is switched on at its mains input, a higher value is required in the capacitor, and this has to be found by experiment.

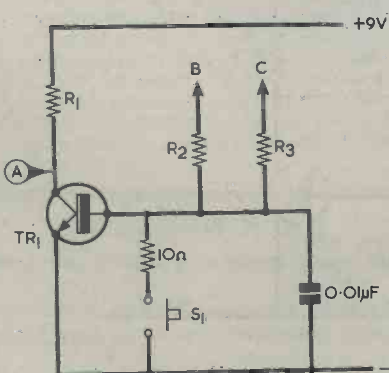


Fig. 3. Adding a capacitor at the base of one transistor ensures that this transistor is off at switch-on

Fig. 3 also shows a 10Ω resistor inserted in series with S1. This resistor is included to limit capacitor discharge current when S1 is pressed. Considering the capacitance and voltages involved the inclusion of the 10Ω resistor is rather a pedantic design point, and it could be omitted if desired. If, however, the use of a mains supply necessitates increasing the capacitor value to 0.1μF or more, it would be preferable to retain the 10Ω resistor.

OBTAINING OUTPUTS

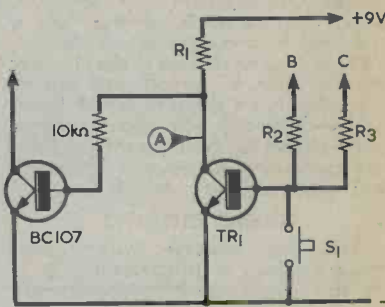


Fig. 4. One method of taking an output from one of the transistors

Should it be desired that two "on" outputs be obtained from the circuit of Fig. 2, the collector circuits of the transistors can be modifed accordingly. An output from the single "off" transistor is a little more difficult to arrange because, even when it is turned off, a current (providing bias for the other two transistors) still flows in its collector circuit.

An "off" output can be changed to an "on" output by the addition of a silicon transistor to one or more of the three transistors in the network. The arrangement is shown in Fig. 4, where the added transistor is coupled to TR1. If TR1 is on, the added transistor is turned off. When TR1 turns off a base current of approximately 0.65mA is available for the added transistor, which can then pass a collector current equal to 0.65mA multiplied by its current gain. The collector load for the added transistor can be returned to the 9 volt positive rail or to any other positive supply point of suitable voltage level.

An "off" output may be obtained by inserting the base-emitter junction of an added silicon transistor between the emitter of one of the network transistors and the negative rail. Fig. 5 shows two silicon transistors added in this way to TR1 and TR2. Each of the added transistors is off when the transistor connecting to it is off, and is hard on when the transistor connecting to it is on. The added transistors cause the emitters of TR1 and TR2 to be effectively 0.6 volt above the negative supply rail. To maintain balance and ensure reliable operation, the emitter of TR3 has also to be 0.6 volt above the negative supply rail, and this is achieved by inserting a forward biased silicon diode between the emitter and the rail. Alternatively, the base-emitter junction of a third added transistor could be inserted in the emitter circuit of TR3. The capacitor circuit of Fig. 3 works equally well with this version of the circuit.

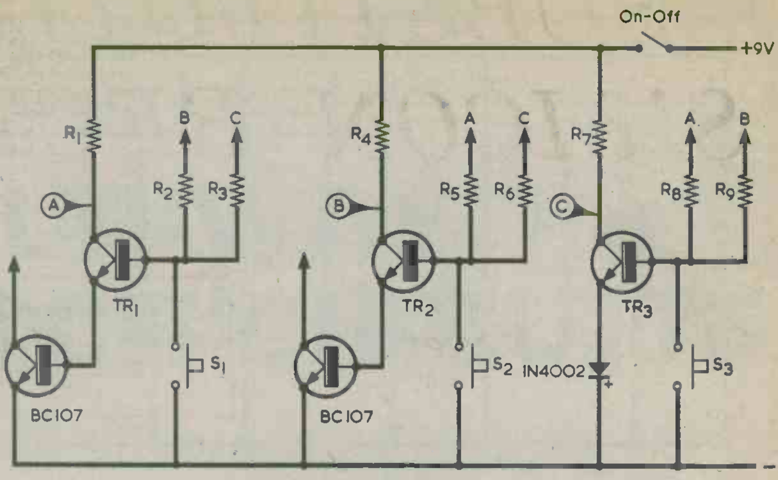


Fig. 5. An alternative output circuit

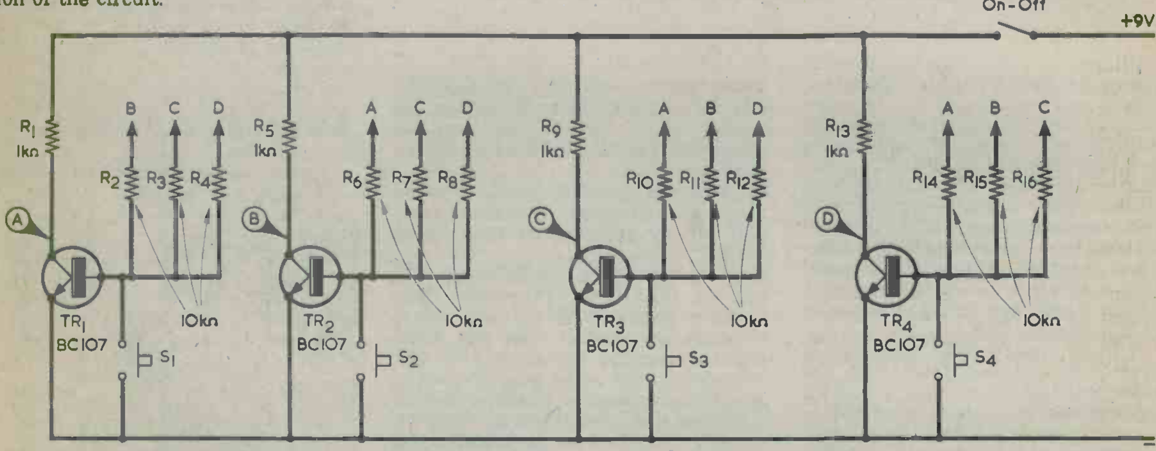


Fig. 6. The basic circuit expanded to incorporate four transistors. This network has four stable states

FOUR STATE VERSION

The latching network can be expanded to include four transistors, and a practical working circuit is given in Fig. 6. In this arrangement one transistor is always off and three transistors are always on. Any transistor can be set to the off state by pressing the switch connected to its base and emitter. The capacitor circuit of Fig. 3 functions satisfactorily with this arrangement, as also do the output circuits illustrated in Figs. 4 and 5.

There is little reason to doubt that more than four transistors could be employed in a multi-way latching circuit employing the basic principles of the three and four transistor networks. However, the circuit complexity increases with each transistor that is added and the four transistor circuit of Fig. 6 is, perhaps, the maximum that is worth assembling with discrete components.

The principles employed in the circuits are of a general nature and the experienced experimenter will be able to incoporate them in any specific applications he has in mind. All the resistors in the circuits can be ¼ watt 5 or 10% types. The author used BC107's throughout, but any similar small silicon planar n.p.n. transistors having a current gain of 100 or more should be equally satisfactory. ■

SUBSTITUTING BY SILICON RECTIFIERS

by F. G. Rayer

Silicon rectifiers offer an economic alternative to valve h.t. rectifiers, and they may be instrumental in prolonging the useful life of earlier equipment.

Silicon rectifiers are compact and inexpensive and they offer an admirable substitute or replacement for most valve rectifiers. They can usually be fitted to replace expensive or difficult to obtain valve rectifiers in transmitting equipment, or in the older audio amplifiers and radio receivers.

Fig. 1 shows a typical half-wave rectifer circuit with a reservoir capacitor and smoothing choke. A resistor is frequently employed instead of the choke. The valve rectifier only conducts on the half-cycles when its anode is positive; electrons then flow from the heated cathode (or the heater itself with directly heated valves) towards the anode. In consequence, a positive rectified voltage is available at the rectifier cathode.

A silicon rectifier carries out the same function as the valve rectifier, but is much smaller and requires no heater. Also, it has a very low resistance when it conducts, which means that the rectified voltage it produces is higher. When replacing a valve by a silicon rectifier it is usually necessary to insert a series resistor so that the rectified voltage does not become too high and to keep charging current surges in the reservoir capacitor to a low level.

A valve rectifier and the plug-in rectifier unit which replaces it

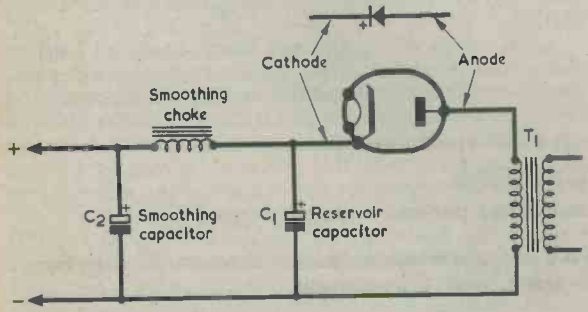


Fig. 1. A typical half-wave valve rectifier circuit supplied by the secondary of mains transformer T1. The symbol for a silicon rectifier appears above the valve rectifier

A silicon rectifier symbol is drawn above the valve rectifier symbol in Fig. 1, and its anode and cathode are identified. These correspond to the anode and cathode of the valve rectifier.

The polarity of a silicon rectifier is most frequently indicated by a coloured band on its body near the cathode end. Sometimes the cathode end is indicated by a tapering of the body. If any doubt exists about the polarity of a silicon rectifier, connect one end to the transformer secondary, leave the other end free and check polarity with a testmeter switched to a

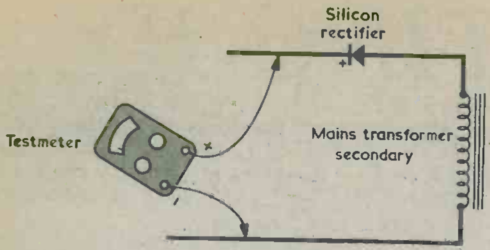


Fig. 2. If any doubt exists, the polarity of a silicon rectifier can be confirmed with a testmeter before connecting the rectifier fully into circuit. The testmeter is set to a suitable volts range

suitable volts range. See Fig. 2. The testmeter needle will give a forward reading if its positive test clip connects to the rectifier cathode. A silicon rectifier connected wrong way round will almost certainly break down reservoir and smoothing capacitors and can cause considerable damage.

RECTIFIER RATINGS

Silicon rectifiers must have ratings adequate for the voltages and currents which appear in the circuits in which they are fitted. Fortunately, silicon rectifiers with adequate ratings for most circuits are readily available.

Peak Inverse Voltage. This is the peak voltage which is applied across the rectifier when it is not conducting. In Fig. 1, suppose that the secondary voltage of the mains transformer, T1, is rated at 300 volts. This is the r.m.s. rating as would be indicated, for instance, by a testmeter switched to an a.c. volts range. The peak voltage is approximately 1.4 times this figure, or 420 volts. If no load current were drawn from reservoir capacitor C1 this could charge up to the peak voltage, with the terminal connected to the rectifier cathode positive. On half-cycles when the upper end of the transformer secondary is negative the total possible peak inverse voltage applied to the rectifier will consist of the 420 volts in the transformer secondary plus the 420 volts in C1, or 840 volts. So the peak inverse voltage rating of a silicon rectifier used in the circuit of Fig. 1 must be greater than 840 volts.

In circuits of the type shown in Fig. 1 the peak inverse voltage rating of the rectifier must, therefore, be greater than 2.8 times the r.m.s. value of the applied alternating voltage. In the full-wave rectifier circuit of Fig. 3 an r.m.s. voltage of 250 volts is applied to each

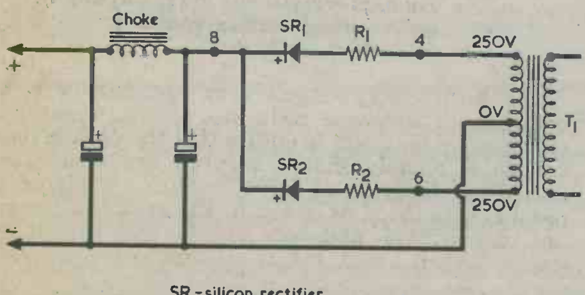


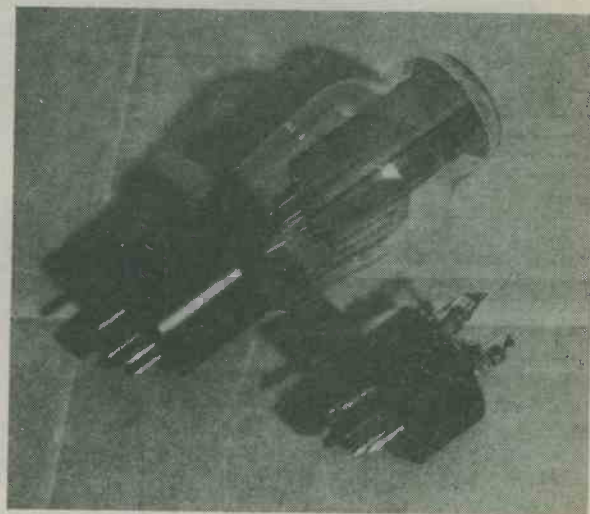
Fig. 3. A silicon rectifier circuit replacing a full-wave valve rectifier

rectifier, so that these must both have a peak inverse voltage rating of greater than 2.8 times 250 volts, or 700 volts.

In circuits such as Fig. 1 and Fig. 3, rectifiers with a peak inverse voltage rating of 800 volts are suitable for applied alternating voltages up to 250 volts r.m.s., and a peak inverse voltage rating of 1,000 volts for applied alternating voltages up to 350 volts r.m.s.

For very high voltages, two or more rectifiers can be connected in series, as is shown later.

Rectified current. Most valve rectifiers have maximum current ratings in the range of 100 to 250mA. Silicon rectifiers rated at 1 amp are readily available, and so it is normally an easy matter to obtain silicon rectifiers of adequate current rating.



Another rectifier and its substitution plug-in unit

HEATER CIRCUIT

Many full-wave valve rectifiers have 5 volt 2 amp or 3 amp heaters, these including the 5R4GY, 5U4G, 5V4G, 5Y3GT and similar types. Others, such as the 6X4 and 6X5GT, have 6.3 volt 0.6 amp heaters. These heaters are normally fed from a 5 volt or 6.3 volt mains transformer secondary. Substitution by silicon rectifiers will merely mean that the load on the transformer is reduced. No compensation for this is needed.

Some items of equipment have the valve heaters connected in series. To take an example, a typical rectifier intended for series heater operation is the 35Z4GT, which has a 35 volt 0.15 amp heater. If such a rectifier is removed, a resistor of suitable value must be connected across the valveholder heater pins to maintain the circuit for the heaters of the other valves in the equipment.

Since the heater of the 35Z4GT drops 35 volts at 0.15 amp, the required resistance is 35 divided by 0.15, or 233Ω. The wattage dissipated by the resistor will be 35 times 0.15, or 5.25 watts, and so the resistor should have a wattage rating of 6 watts or more. It will be difficult to obtain a resistor of 233 Ω, but one at the nearest preferred value of 240 Ω would be adequate. The equipment may have an adjustable dropper resistor in series with the heater chain. In this instance, other more readily obtainable resistors such as 200 Ω or 220 Ω could be used and the dropper readjusted to provide the small extra resistance required. The resistor will run warm and should be clear of other items and have adequate air cooling.

With the 35Z4GT, the heater pins are 2 and 7. It may be convenient to pass the resistor leads through sockets 2 and 7 of the valveholder and solder them to the two valveholder tags. The resistor will then be positioned above the valveholder. Alternatively, it may be possible to include the resistor in a plug-in unit such as that illustrated in Fig. 4.

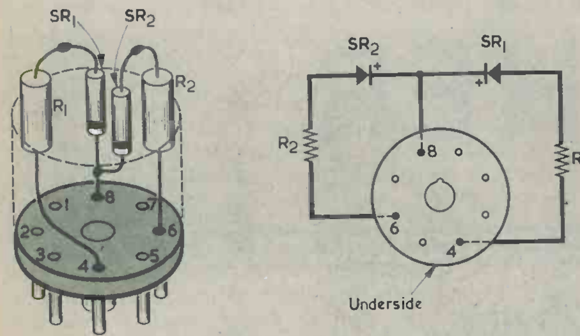


Fig. 4. The silicon rectifiers and series resistors of Fig. 3 can be wired up on an octal valve base to form a plug-in replacement unit

FULL-WAVE CIRCUIT

Full-wave rectification is common in a.c. equipment, and Fig. 3 shows two silicon rectifiers replacing a valve of the 5R4GY, 5U4G and similar types. The points numbered 4 and 6 correspond to the valve anode pins and that marked 8 to the cathode. (The 5R4GY and 5U4G are directly heated rectifiers and point 8 corresponds, in practice, to one end of the heater).

Due to the low forward (i.e. conducting) resistance of the silicon rectifiers, resistors R1 and R2 are added. For most receivers, small amplifiers and similar units, R1 and R2 can be 100 Ω 1 watt. The resistors help to ensure that the rectified voltage provided by the silicon rectifiers is not excessively increased over that provided by the valve rectifier they replace. They also reduce peak currents.

If there is no reservoir capacitor and the rectified voltage is fed to a smoothing choke on its own, R1 and R2 can often be omitted. They may be added if subsequent checks show that the rectified voltage is too high.

PLUG-IN REPLACEMENT

A convenient method of fitting the silicon rectifiers consists of wiring them to a plug which can be fitted to the rectifier valveholder in place of the valve. Octal plugs are available, but a suitable plug can also be obtained from an unwanted octal valve. Other, obsolete, valve bases may be similarly obtained.

First wrap the valve in a good thickness of newspaper or rags and break away the glass. Carefully remove all the glass from the base and clean out the required pins by applying a soldering iron to the tip and pushing a wire through.

The rectifiers and series resistors can then be soldered to the valve base pins, as in Fig. 4. This will make a direct plug-in replacement for the valve rectifier. The resistors can be 100 Ω 1 watt, as already discussed, and the rectifiers may have a peak inverse voltage rating of 800 or 1,000 volts to suit the alternating voltage applied to them.

SAFETY

A plug-in unit like that of Fig. 4 may only be used when equipment is fully enclosed, so that h.t. and other high voltage circuit points cannot be accidentally touched. For the same reason, silicon rectifiers and resistors must not be mounted above the chassis in equipment which is not fully enclosed.

With home-built equipment, or equipment having valves exposed on the top of the chassis, the silicon rectifiers and series resistors must be fitted underneath so as not to leave exposed h.t. or other dangerous circuit points.

HIGHER VOLTAGES

When the applied alternating voltage is above 350 volts r.m.s. it is usually convenient to employ inexpensive wire-ended rectifiers with a peak inverse voltage rating of 1,000 volts in series. A suitable type is the 1N4007. Two such rectifiers in series will be suitable for alternating voltages up to 700 volts r.m.s.

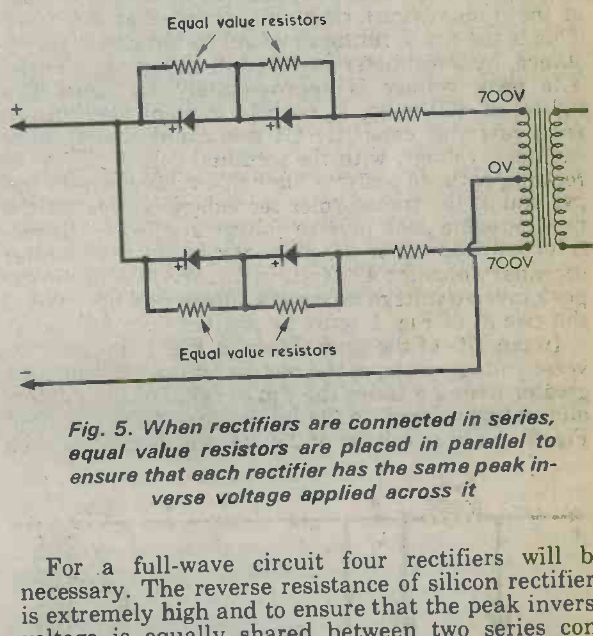


Fig. 5. When rectifiers are connected in series, equal value resistors are placed in parallel to ensure that each rectifier has the same peak inverse voltage applied across it

For a full-wave circuit four rectifiers will be necessary. The reverse resistance of silicon rectifiers is extremely high and to ensure that the peak inverse voltage is equally shared between two series connected rectifiers, equal value resistors are placed in parallel with them, as in Fig. 5. The actual values are not very critical, and each resistor can be, for instance, 220k Ω 1 watt. Where the alternating voltage is close to the limiting level of 700 volts r.m.s. for two series connected rectifiers, the resistors should have a tolerance on value of 5%. Fig. 5 also shows the two series resistors which carry out the same function as R1 and R2 of Fig. 3. ■

SCHMITT RELAY FLASHER

by J. R. Davies

An unusual astable circuit in which a relay carried out an active function.

Despite its usefulness, the Schmitt trigger does not find many applications in home constructor projects. In the design to be described in this short article a Schmitt trigger is employed in company with a relay to form a continually running astable oscillator. The relay energises and releases at a frequency dependent upon the value of a single capacitor, and one of its contact sets may be used to allow a lamp to flash on and off or perform any similar function. The length of the switching cycle may be varied from the fastest frequency at which the relay can operate to periods in excess of 30 seconds. The circuit has the advantage that frequency can be changed by altering the value of one capacitor.

SCHMITT TRIGGER

The circuit of the astable appears in Fig. 1, in which TR1 and TR2 appear in the Schmitt trigger configuration. The relay coil is represented by a rectangle alongside which is the identification letter "A" over the figure "2". This indicates that the coil is part of relay "A", and that it has two contact sets. These are shown elsewhere in the diagram, as A1 and A2, and are illustrated in the de-energised condition. Thus, contact set A1 is normally closed and contact set A2 is normally open.

On application of the 12 volt supply, capacitor C1 is discharged and the base of TR1 is held at the same potential as the negative rail, whereupon this transistor is cut off. At the same time the supply voltage appears across the series combination of the relay coil, R4 and R5, causing a positive voltage to be applied to the base of TR2. Making the initial assumptions that the relay coil has a negligibly low resistance in comparison with R4 and R5 and that base current in TR2 is very small, the base of TR2 is held positive of the

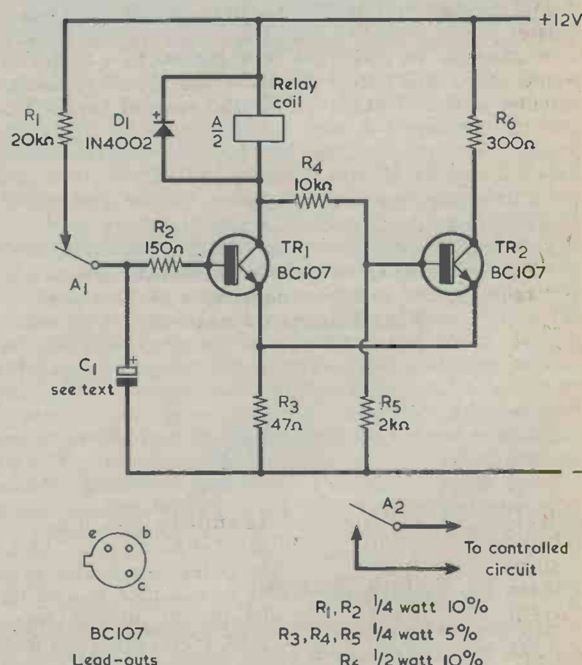


Fig. 1. The circuit of the Schmitt-relay astable. The circuit oscillates at a frequency which is controlled by the value of C1

negative rail by 2 volts. TR2 is in consequence fully conductive and a potential 0.6 volt lower appears at its emitter, giving a voltage of 1.4 volts across R3. This resistor limits TR2 emitter current to 30mA. The current of 30mA flows also through R6, with the result that this resistor drops 9 volts. Thus, the dissipation in TR2 is the remaining 1.6 volts multiplied by 30mA, i.e. 48mw. The only function of R6 is to ensure that dissipation in TR2 is maintained at a low level.

After switch-on, C1 commences to charge via relay contact set A1 and resistor R1. When the voltage across its plates reaches 2 volts, a forward bias of 0.6 volt appears across the base-emitter junction of TR1 and this transistor commences to pass emitter and collector current. As the voltage across C1 continues to increase the emitter of TR1 raises the voltage across R3 above its previous 1.4 volt level. At the same time the increasing collector current passing through the relay coil causes TR1 collector voltage, and hence that at the base of TR2, to fall. TR2 emitter is therefore being taken positive whilst its base is being taken negative. The emitter current TR2 passes through R3 reduces, whereupon the voltage on TR1 emitter goes negative, giving further forward bias for TR1. The effect between the two transistors is cumulative and the overall result is that TR1 is rapidly turned hard on and TR2 is rapidly turned off; the changeover having been triggered when the base of TR1 was taken positive to the level where this transistor commences to turn on. Since TR1 is now conductive the potential at TR2 base is just slightly positive of that on the negative rail.

CAPACITOR DISCHARGE

The changeover causes relay contact set A1 to open, and C1 next commences to discharge via R2, the base-emitter junction of TR1 and R3. As C1 discharges the base current in TR1 reduces whereupon, after a period, this transistor passes a significantly lower collector and emitter current. Because of this, TR1 collector goes positive and TR1 emitter goes negative. When the voltage at TR1 collector is about 6 to 7 volts positive of the negative rail the potentials at the base and emitter of TR2 allow TR2 to commence passing current and the reverse changeover takes place, resulting in TR2 turning fully on and TR1 becoming cut off. The relay de-energises, contact set A1 closes and C1 commences to charge once more. Regular cycles then proceed, with C1 charging until TR1 turns on and energises the relay, followed by periods during which C1 discharges until TR1 is cut off again and the relay releases.

At first sight it might appear that an alternative mechanism is possible when C1 discharges, the effect being that the relay coil current reduces to a level which causes the relay to release, whereupon contact set A1 closes and the capacitor commences to charge once more. However, the circuit will not continue to run under these conditions with many practical relays, because there would be a tendency to reach a condition of equilibrium in which contact set A1 opens and closes over a very small traverse of the relay armature. For positive relay operation it is necessary that the Schmitt trigger changeover occurs both at the end of the discharge period and at the end of the charge period. It will be noted that it is required of the relay that it remain energised at a coil voltage which is significantly lower than that at which it operates. This raises little difficulty because the release voltage of an energised relay, whose armature is held against the relay core, is normally considerably lower than its energising voltage.

Diode D1 is merely the usual protective diode which is connected across any relay coil driven by a transistor, and it prevents the appearance of a high back-e.m.f. across the coil when the relay releases.

The frequency of oscillation is controlled by the value of C1, which can range from less than 100 μF to greater than 2,500μF. At 2,500μF the length of a complete cycle (with R2 at 150Ω) is approximately 30 seconds, and lower values of capacitance give proportionately shorter cycle periods. Thus, with C1 at 250μF the length of a cycle is approximately 3 seconds. The time, during the cycle, when the relay is energised can be altered by varying the value of R2, and this can range from zero (in which case the positive terminal of C1 connects directly to the base of TR1) to some 10k Ω. The relay remains energised for a longer period as the value of R2 is increased. If desired, different frequencies can be selected by switching different capacitors into the C1 position, as indicated in Fig. 2. The electrolytic capacitor or capacitors employed for C1 should have a working voltage of 6 volts or more.

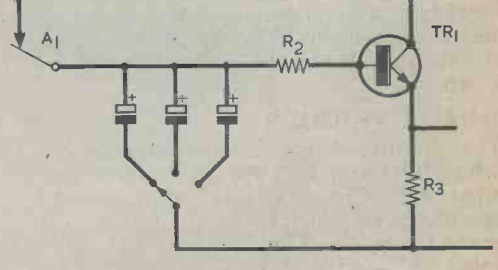


Fig. 2. If desired, alternative frequencies can be selected by switching capacitors of different values into the C1 position

The relay can be any type with the requisite contact sets, a coil resistance between 500Ω and 1k Ω, and an energising voltage of 9 volts or less and a release voltage of 5 volts or less. The author employed a P.O.3000 relay with a 500Ω coil in the prototype circuit. During the explanation of operation given earlier it was assumed that the relay coil resistance was negligibly low in comparison with R4 and R5. In practice, the coil resistance causes the voltage at TR2 base, and the current passed by this transistor, to be a little lower than the figures quoted. ■

ADDED AMBIENCE

By R. N. Soar

A simple means of obtaining "all round" sound with a stereo system.

This is a simple add-on circuit which, when used with a small stereo system and two extra speakers, will give ambience effects from stereo recordings. The stereo amplifier should have a common chassis connection for both its existing speakers, as will normally be the case. The two extra speakers should have the same impedance as the existing speakers.

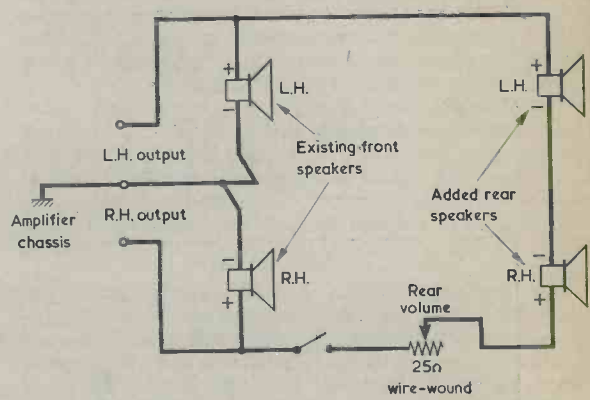
SPEAKER PHASING

As the diagram shows, the circuit depends on correct speaker phasing. Basically the circuit adds the two rear speakers across the non-earthy terminals of the existing speakers. The 25Ω potentiometer enables the rear volume to be controlled. This potentiometer must be wire-wound, and the one used by the author had a rating of 3 watts. The switch is a toggle type which disconnects the rear speakers to give normal stereo reproduction. If a stereo record is played through the system and the switch is closed, the rear speakers produce a surprisingly spacious effect.

It is very important that the speakers be correctly phased. One way of finding the connections for correct phasing is to use a stereo test record which has phasing tests on it. First ensure that the two existing front speakers are in phase and then designate the terminal of each which connects to chassis as "negative" and that which connects to the non-earthy amplifier outputs as "positive".

Disconnect one of the front speakers and replace it with one of the additional speakers and find, with the aid of the test record, which method of connection produces correct phasing. Designate the speaker terminals as "negative" and "positive" accordingly, and then repeat the process with the second additional speaker. Switch the amplifer off whilst changing speaker connections and take great care not to accidentally short-circuit the output as the output circuit could then be damaged. Finally, reconnect the original front speaker.

An alternative method of speaker phasing consists of temporarily connecting a 1.5 volt cell to each speaker and checking whether the cone moves forward or backward. The terminals of all speakers may then be designated with the cell polarity which gives the same direction of cone movement.



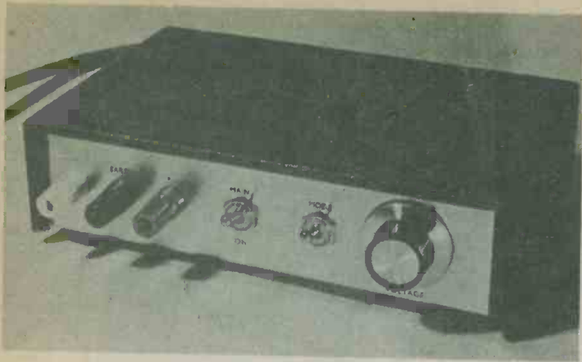
Two rear speakers, connected with the phasing shown here, may be added to a stereo system to produce enhanced ambience

The additional rear speakers are connected up as shown in the diagram. Note that the junction of the two rear speakers is *not* connected to chassis.

It is not necessary that all four speakers should be identical, but the two rear speakers should be a pair. If these are small they could be wall mounted; this improves the effect.

The switch and wire-wound potentiometer can be fitted in a small control box with output jack sockets for the two rear speakers. If the box is made of metal the sockets will need to be insulated types.

In use the circuit gives apparent "four channel" sound, and offers an improvement with most recordings. Sometimes, the effects can be startling. Sounds appear which are not noticed when a record is played in the normal stereo mode and the improvement in reproduction is quite dramatic. ■



POWER S
FOR OP

Using an ingenious voltage splitting tech power unit provides continuously variable p negative voltages for the supply of ill operational amplifier circuits. Further fe voltage stabilization and overload current lin

Integrated circuit operational amplifiers are now being used in an increasing number of applications in the field of amateur electronics, and they are amongst the most versatile active devices available today. The only problem that they are likely to cause is the provision of a suitable power source for testing a prototype design incorporating operational amplifiers, or when experimenting with operational amplifiers.

The problem lies in the fact that, when used as d.c. amplifiers, operational amplifiers require two supply voltages, one positive of earth and the other negative of earth. Most operational amplifiers require equal positive and negative supply voltages but a few types, such as the 710 voltage comparator, require a positive supply having a potential double that of the negative supply.

Few ordinary mains power supply units are equipped to provide these voltages and it is often inconvenient to use batteries, which are in any case expensive in the long term. The mains operated power supply described here has been specifically designed for use with operational amplifier i.c.'s, and it has output voltages which are both positive and negative of earth. In one mode of operation the positive and negative voltages are equal and are continuously variable from some 5 to 16 volts. In an alternative mode of operation the positive voltage is double the negative voltage; in this instance the positive voltage is continuously variable from approximately $6\frac{2}{3}$ to $21\frac{1}{3}$ volts with the negative voltage being continuously variable from about $3\frac{1}{3}$ to $10\frac{2}{3}$ volts.

The maximum output current is 100mA, although this can be increased somewhat if required by altering the value of one resistor. Output current limiting is employed to protect the unit against accidental short-circuits.

VOLTAGE REGULATOR

The circuit diagram of the power supply unit appears in Fig. 1. The alternating voltage from the secondary of T1 is given full-wave rectification by the bridge rectifier formed by D1 to D4, the output of this being applied to reservoir capacitor C1. Regulation and further smoothing of the supply is then provided by IC1, which is a 723C voltage regulator. This has a rather complex internal circuit and the way in which it functions can perhaps be best understood by ex-

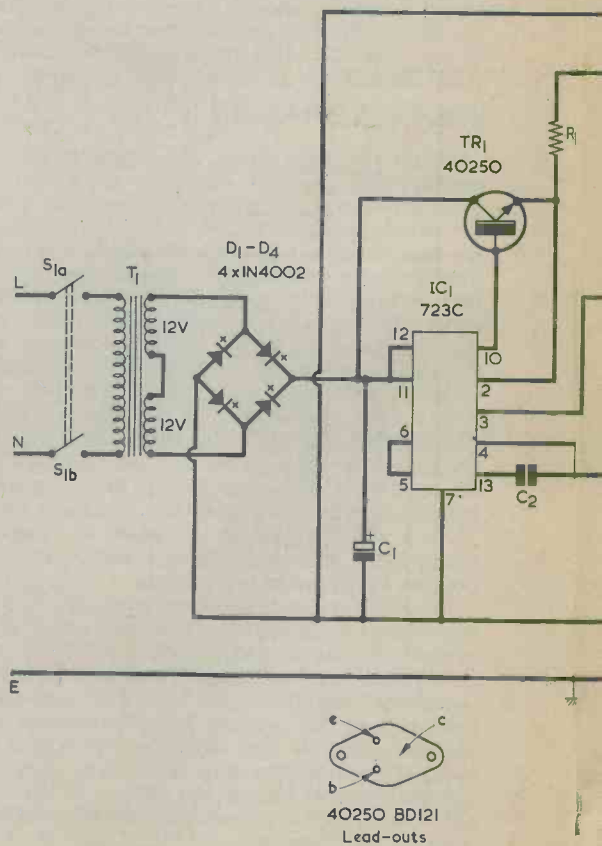


Fig. 1. The circuit of the power supply. This provide c both positive and neg

POWER SUPPLY FOR OP-AMPS

Using an ingenious voltage splitting technique, this power unit provides continuously variable positive and negative voltages for the supply of all standard operational amplifier circuits. Further features are voltage stabilization and overload current limiting.

By A. P. Roberts

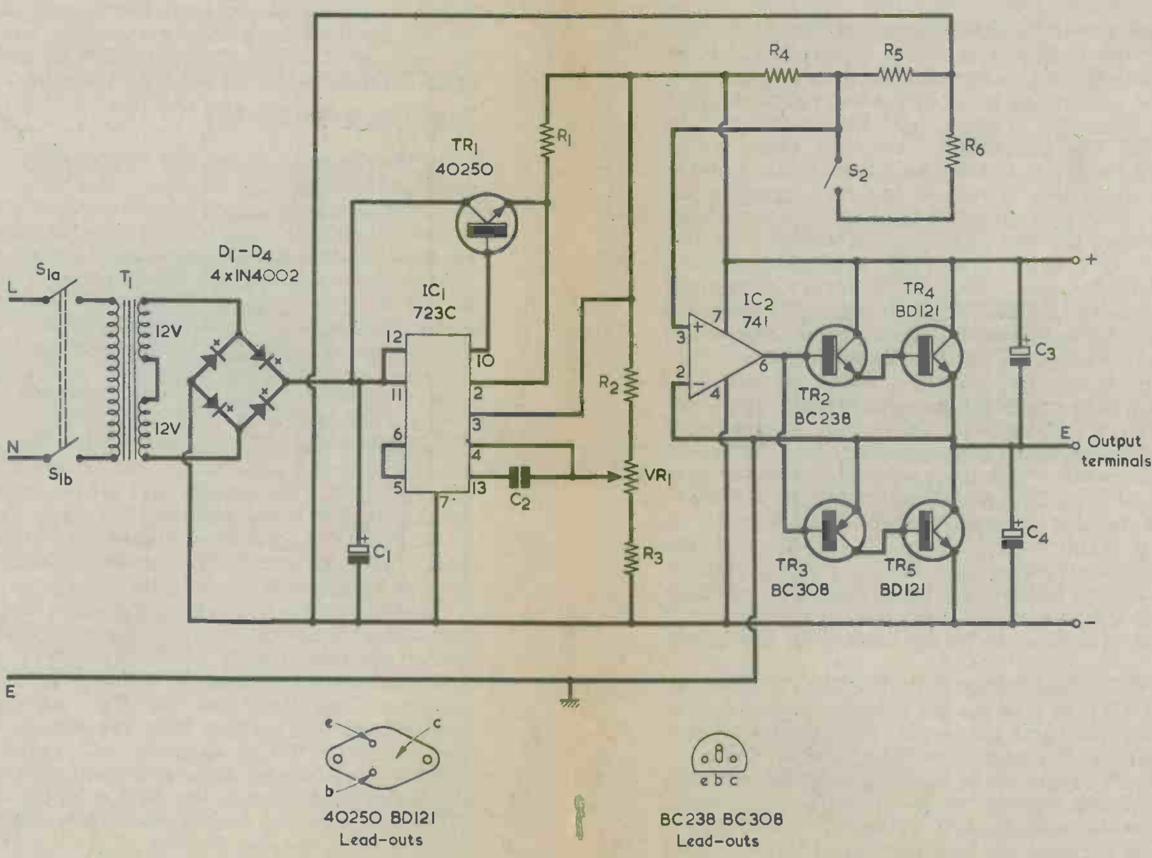


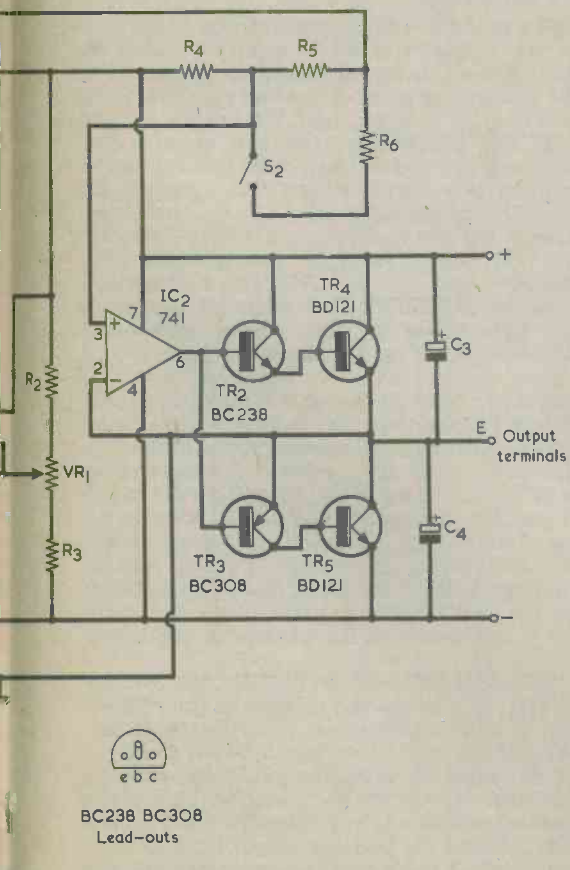
Fig. 1. The circuit of the power supply. This provides continuously variable output voltages which are both positive and negative of earth

SUPPLY

-AMPS

hnique, this positive and ll standard features are limiting.

By A. P. Roberts



s continuously variable output voltages which are negative of earth

COMPONENTS

Resistors
(All fixed values ¼ or ½ watt)
- R1 6.8Ω5% (see text)
- R2 12kΩ2%
- R3 10kΩ2%
- R4 20kΩ1% or 2%
- R5 20kΩ1% or 2%
- R6 20kΩ1% or 2%
- VR1 25kΩ potentiometer, linear

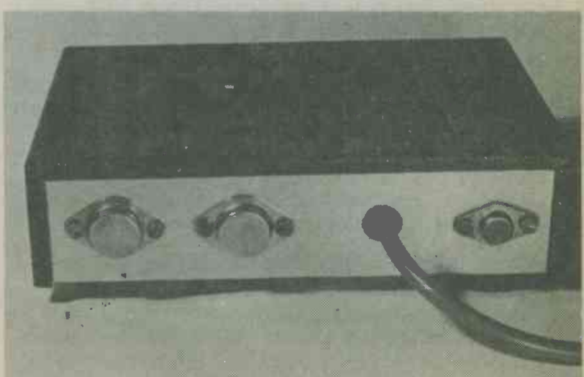
Capacitors
- C1 1,000μF electrolytic, 50 V. Wkg.
- C2 120pF polystyrene or silvered mica
- C3 100μF electrolytic, 25 V. Wkg.
- C4 100μF electrolytic, 25 V. Wkg.

Transformer
- T1 Mains transformer, secondary 24 V at 500mA (see text)

Semiconductors
- IC1 723C (see text)
- IC2 741 (see text)
- TR1 40250
- TR2 BC238
- TR3 BC308
- TR4 BD121
- TR5 BD121
- D1-D4 1N4002

Switches
- S1(a) (b) d.p.s.t. toggle
- S2 s.p.s.t. toggle

Miscellaneous
- Instrument case (see text)
- 3 insulated terminals
- Control knob
- 2 insulating kits (for TR1 and TR4)
- Veroboard, 0.1in. matrix
- Vero pins, as required
- Mains lead
- Grommet
- 4 rubber feet



The three power transistors are fitted to the rear panel of the power supply case

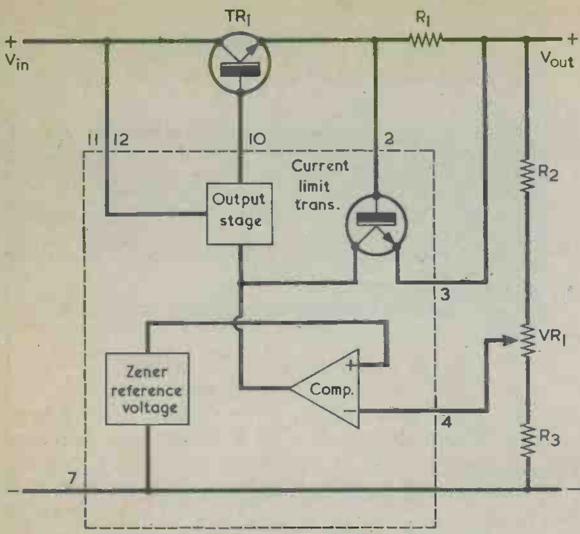


Fig. 2. Simplified diagram illustrating the operation of the 723C voltage regulator

amining the simplified block diagram which is given in Fig. 2.

As will be seen from this, an internal zener reference source couples to the non-inverting input of a comparator. The output of this comparator feeds the output stage, which consists of a Darlington pair emitter follower. The Darlington pair provide a very low output impedance, enabling the i.c. to handle output currents up to 150mA. Although this output current range is sufficient for the present power supply unit design, the i.c. will suffer excessive dissipation at the relatively high output voltages employed. In consequence, the i.c. output is coupled to the external discrete emitter follower, TR1.

If the presence of R1 is temporarily ignored, the inverting input of the comparator connects to the potential divider across the output which is given by R2, VR1 and R3. When the inverting input of the comparator is negative of the non-inverting input its output swings high. If, on the other hand, the inverting input is positive of the non-inverting input the comparator output swings low. The gain of the comparator is extremely high, and only a very small voltage difference is required at its inputs to produce the full, or the minimum, output level.

A negative feedback loop is, as a result, set up via the output of the comparator and the potential divider, and this will stabilize the circuit so as to provide the same voltage at the two comparator inputs. The zener reference source produces approximately 7 volts and so if, for instance, the slider of VR1 taps off exactly half the output voltage with respect to the negative rail then the output will be 14 volts.

Other settings of VRI will provide different output voltages, and with the values specified for the potential divider these range from a little less than 10 to slightly more than 32 volts. Apart from enabling the output voltage to be controlled, the negative feedback loop also provides stabilization despite fluctuations in mains voltage and variations in input voltage due to different loadings on the mains transformer. Such stabilization must obviously exist since the output voltage is dependent upon the zener reference voltage and the resistance values in the potential divider, and not upon the input voltage. The only proviso here, of course, is that the input voltage must be at least a volt or so higher than any required output voltage.

CURRENT LIMITING

R1 and a transistor inside the 723C provide current limiting. This works by virtue of the fact that a silicon transistor starts to become significantly conductive when a voltage of 0.66 volt forward biases its base-emitter junction. Once this voltage has been reached only a small increase is required to take the transistor into saturation.

For the sake of explanation let us assume that R1 has a value of 6.6Ω (actually, it has the nearest preferred value of 6.8Ω). An output current of up to 100mA can flow before the voltage across R1 is sufficiently high to cause the transistor to conduct. If this current is exceeded the transistor conducts heavily and current from the comparator output is conducted to the negative rail via the transistor and the output load. The current drawn from the comparator output reduces the voltage at this point, and the output voltage drops to a level which causes no more than 100mA to flow in R1. If the output is short-circuited the current will still be limited to 100mA and the output voltage will be virtually zero.

SUPPLY SPLITTER

Returning to the circuit diagram of Fig. 1, the output from the regulator is fed to a circuit which, in effect, splits it into two separate supplies connected in series, the connecting point of the two supplies being earthed. When S2 is open, half the output voltage appears at the junction of the two equal value resistors R4 and R5, and this half-voltage is applied to the non-inverting input of the 741 operational amplifier, IC2. The output of this i.c. is coupled to the input bases of the two transistor pairs TR2-TR4 and TR3-TR5. TR2 and TR4 form a Darlington pair emitter follower, and TR3 and TR5 form a compound common emitter amplifier. Both pairs of transistors have unity voltage gain and a low output impedance. The common output of the two transistor pairs is connected back to the inverting input of the 741, whereupon the i.c. and the transistors make up a composite voltage follower with the output voltage being the same as that at the non-inverting input of the 741. Due to forward voltage drop across the emitter-base junctions of TR2, TR3 and TR4, the output of the 741 can shift positive or negative by a small amount on either side of the output voltage, but this has no effect on overall circuit performance due to the high gain inside the voltage follower feedback loop. The common output of the two transistor pairs forms the earth point and is connected to the chassis of the power supply.

When the output voltage from the 723C is varied by means of VR1, so also are the voltages at the positive and negative output terminals, with the earth terminal being at the central voltage between them.

Closing S2 causes R5 to be shunted by R6, with the result that the voltage at the junction of R4 and R5 is one-third of the output voltage. In consequence the voltage between the positive output terminal and earth then becomes twice that between earth and the negative output terminal, as is required by the 710 and similar devices.

Switch S1(a) (b) is the on-off switch for the power supply unit, and C2 is coupled to IC1 to prevent instability. The two electrolytic capacitors, C3 and C4, were added across the output terminals after a little experience had been gained with the supply unit, and they prevent the appearance of a very small ripple voltage which can occasionally appear with some loads. It should be noted that they will allow a momentary discharge current to flow in the load before the current limiting action comes into operation if the output is suddenly short-circuited.

CONSTRUCTION

The power supply unit is assembled in a ready-made instrument case measuring 8 by 5¼ by 2in. One piece of the case consists of an aluminium front, base and rear panel, whilst the other is a black vinyl covered steel top and sides. The drilling for the front panel controls and terminals is shown in Fig. 3. The layout of the mains transformer and component panels on the base can be seen from the photograph of the interior. Layout is not at all critical and there is plenty of space. C3 and C4 are soldered directly to the output terminals.

At the rear panel are required holes for TR1, the mains lead grommet, TR4 and TR5, in that order. The rear panel functions as a heat sink for the transistors and TR1 is to the left, behind the mains transformer. Both TR1 and TR4 need to be insulated from the rear panel, and are fitted with mica washers and insulating bushes. TR5 is bolted direct to the rear panel. The connection to TR5 collector also provides the chassis connection to the power supply circuit. When, later, the mains lead is fitted, its live and neutral leads will connect to S1(a) (b), and its earth lead to the earth output terminal.

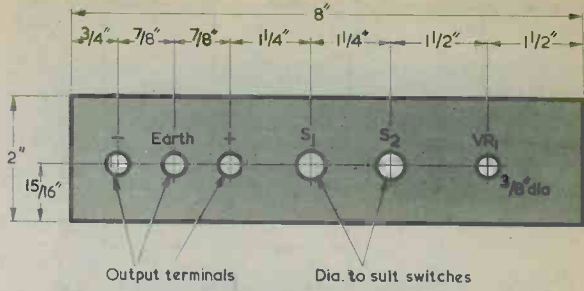


Fig. 3. Drilling details for the front panel

Four rubber feet are fitted at the corners of the base, and suitable holes should be drilled for these.

COMPONENT PANELS

The smaller components are assembled on two pieces of 0.1in. matrix Veroboard, details of which are given in Figs. 4 and 5. It should be possible to cut the two panels from a longer piece 2½in. wide, using a

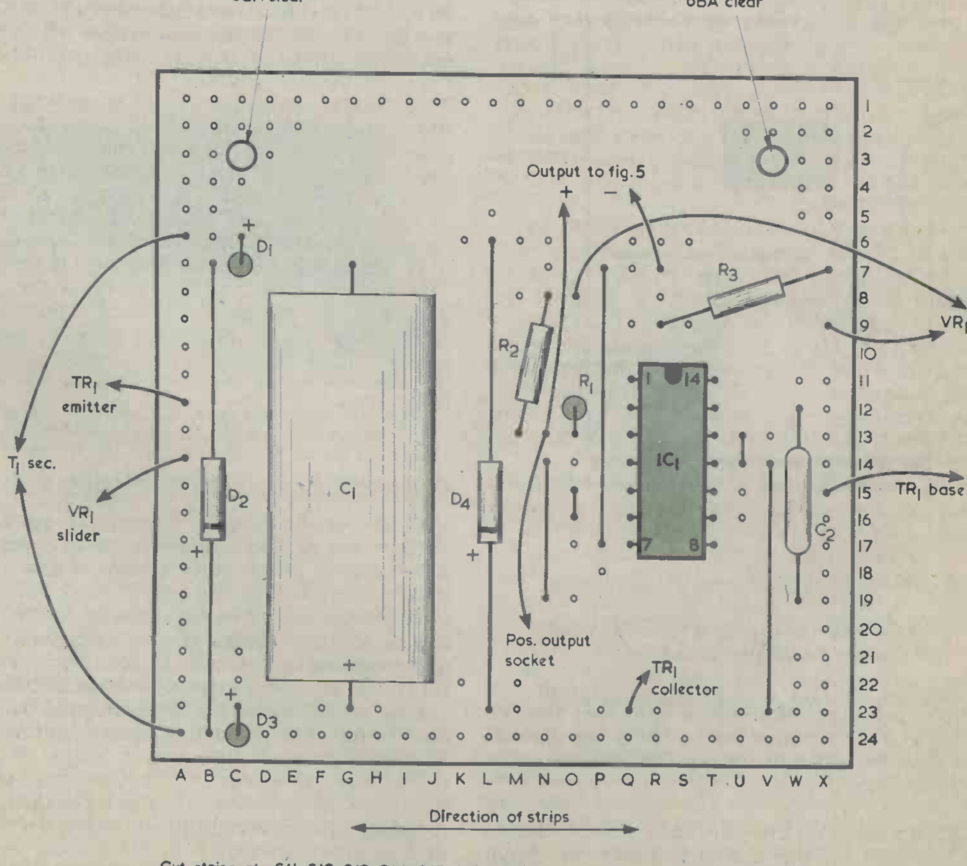
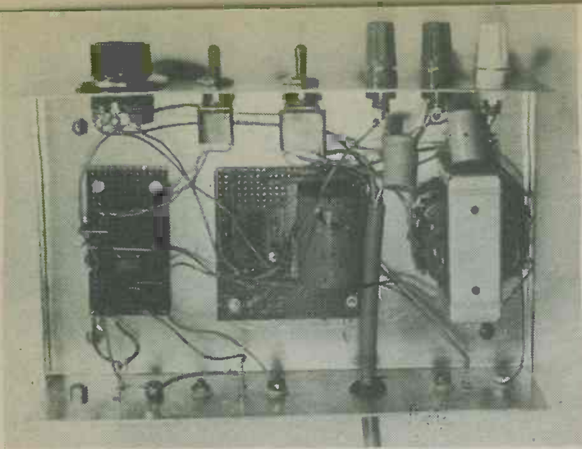
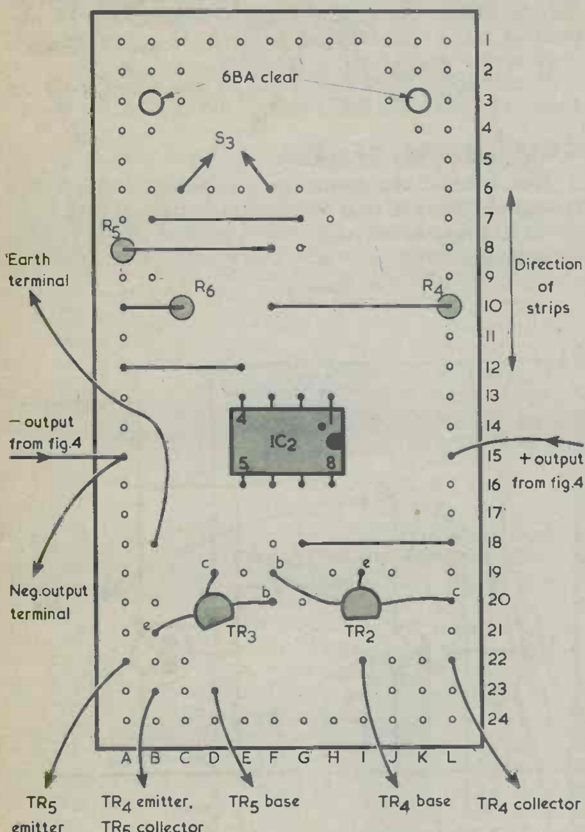


Fig. 4. Wiring and layout of the components on the voltage regulator board



The layout on the chassis is simple and uncluttered. Capacitors C3 and C4 can be seen connected directly to the output terminals



Cut strips at : A5, B5, C5, J5, K5, L5, E14, F14, G14 and H14

Fig. 5. How the components on the supply splitter board are wired up

small hacksaw. The larger panel carries the rectifier, smoothing and regulator circuitry, whilst the smaller has the supply splitter components assembled on it.

Two mounting holes are drilled 6BA clear in each panel with a No. 31 twist drill. The cabinet base may then be marked out and the corresponding 6BA clear holes drilled in it. Next, the copper strips are cut at the points specified in the diagrams.

Link wires, rectifiers, resistors and capacitors are next soldered into position on the panels. A number of connections are made from each panel to external components, such as transistors, etc. Vero terminal pins should be inserted at the appropriate points in the panels and soldered in position. Finally, the two integrated circuits are fitted and their pins soldered.

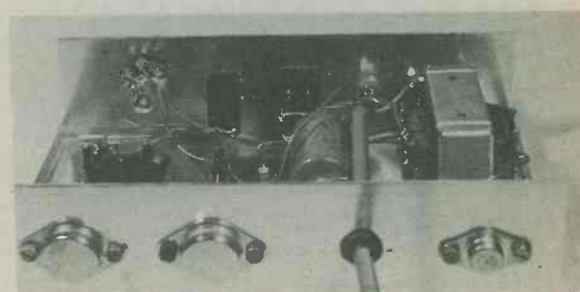
The two panels are then mounted on the cabinet base, each with two 6BA bolts 1in. long. Extra nuts are fitted between the panel undersides and the base, so that they are spaced off adequately. The interconnecting leads between the component panels and external parts may then be fitted. Also, the mains input wiring up to T1 primary can be completed.

If desired, the front panel can have transfers taken from 'Panel Signs' Set No. 4 affixed at the controls and terminals. A dial calibrated in terms of output voltage may be fitted behind the control knob for VR1, although this was not done with the prototype. Instead, a multimeter is connected to its output when required to monitor the output voltage.

COMPONENTS

As already mentioned, the prototype is housed in a cabinet measuring 8 by $5\frac{1}{4}$ by 2in. This is the Instrument Case type BV1, available from Bi-Pak. The integrated circuit type 723C should be obtained in the 14 pin dual-in-line package and the 741 in the 8 pin d.i.l. package.

Mains transformer T1 may be any component offering 24 volts at 500mA or more and which is less than 2in. high. A suitable transformer is the Douglas MT213CT, which is available from Home Radio. This has two 12 volt 500mA secondaries which may be connected in series to give 24 volts at 500mA.



A view from the rear. C3 and C4 were not fitted when this particular photograph was taken

INCREASED OUTPUT CURRENT

If a higher output current is required before limiting takes place, the value of R1 can be reduced accordingly. There is, of course, a restriction to the output current that can be obtained before the mains transformer becomes too heavily loaded to produce the minimum voltage of about 33 volts which is required across C1. If there is insufficient voltage across C1 it will not then be possible to obtain the maximum output voltage from the power supply. In general, the maximum limiting current level is of the order of 150 to 200mA.

The new value required in R1 may be calculated by dividing 0.66 by the limiting current in amps. Thus, if it is decided to have a limiting current level of 120mA, or 0.12 amp, the value of R1 should be reduced to 5.5Ω. The nearest preferred value of 5.6Ω could be used in practice. ■

NEW TRANSISTORISED OSCILLOSCOPE

Part 3 By R. A. Penfold

In this concluding article, the assembly of the flyback blanking amplifier is described. Also dealt with are frequency compensation in both X and Y amplifiers, and the frequency calibration of the oscilloscope timebase.

In last month's issue nearly all the constructional work for the oscilloscope was described, the only component panel not discussed being that for the flyback blanking amplifier. This will be dealt with next.

FLYBACK BLANKING

During the period when the spot is deflected back from right to left across the screen, having completed a sweep, a flyback line can be traced out. At low frequencies this will be very faint, but at higher frequencies the flyback time grows longer in comparison with the sweep time, and a quite bright flyback line can in consequence result. This gives a somewhat confusing trace, and so it is customary to cut off the c.r.t. electron beam during the flyback period, and thus remove the line.

The circuit of the flyback blanking amplifier is shown in Fig. 15. The pulse obtained from the NE555V during flyback is negative-going, and this is applied via C21 to the base of TR15. TR15 functions as a phase inverter, causing a positive-going pulse to be applied to the base of TR16. TR16 again inverts the phase and a high amplitude negative-going pulse is thus applied to the grid of the c.r.t., cutting off the beam during flyback.

The amplitude of the negative-going pulse from the NE555V is greater than the maximum reverse base-emitter voltage rating of the 2N708 employed for TR15. In consequence it is possible for charge and discharge currents to flow in C21. No harm to the NE555V or the 2N708 has been detected in practice with the circuit arrangement used, and dissipation will be very small as the negative-going pulses are extremely brief. The effect of a resistor in series with the base of TR15 has been checked but this slightly reduced the effectiveness of the flyback blanking; since the circuit functions satisfactorily in practice without the resistor it has not been incorporated.

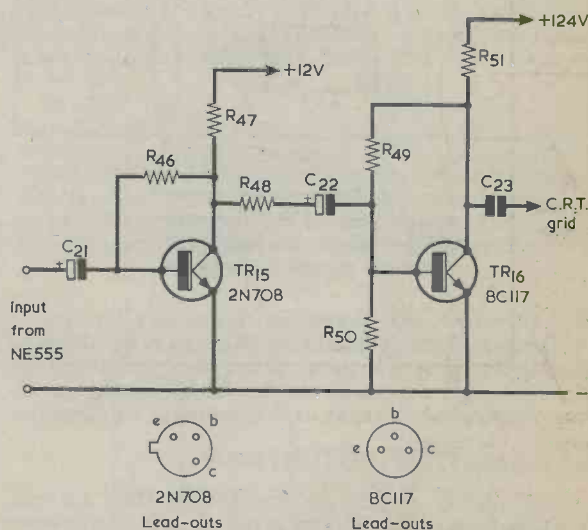


Fig. 15. The flyback blanking amplifier applies a large negative-going pulse to the c.r.t. grid

The flyback blanking circuit is constructed on a printed circuit board which measures 3 by 2in. The etching details of this board are reproduced full size in

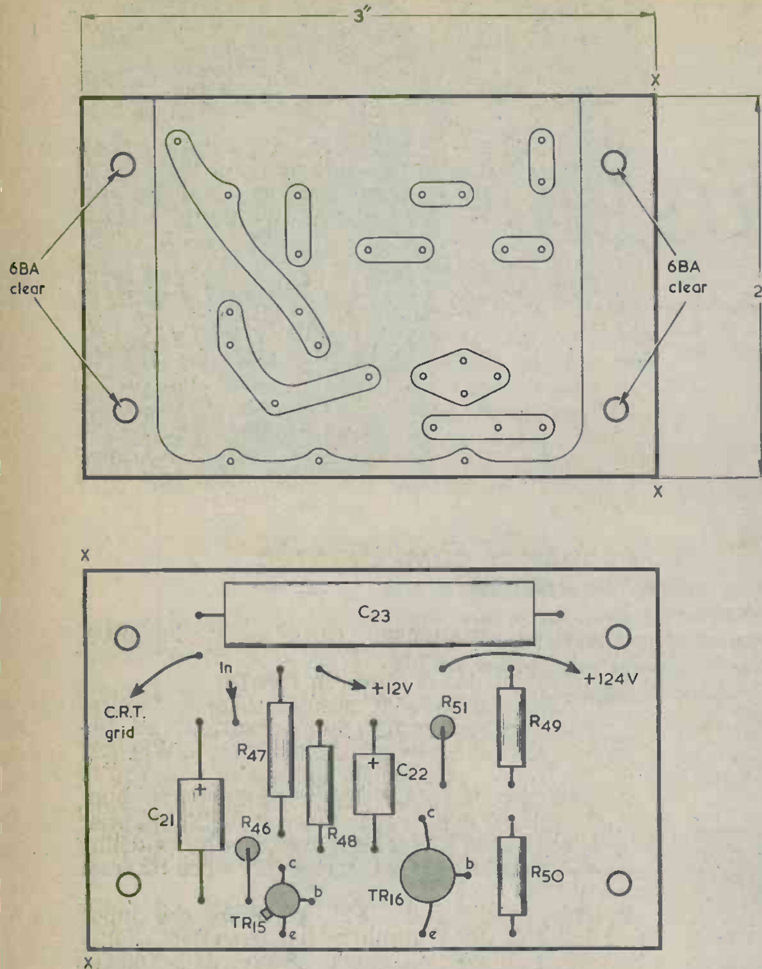
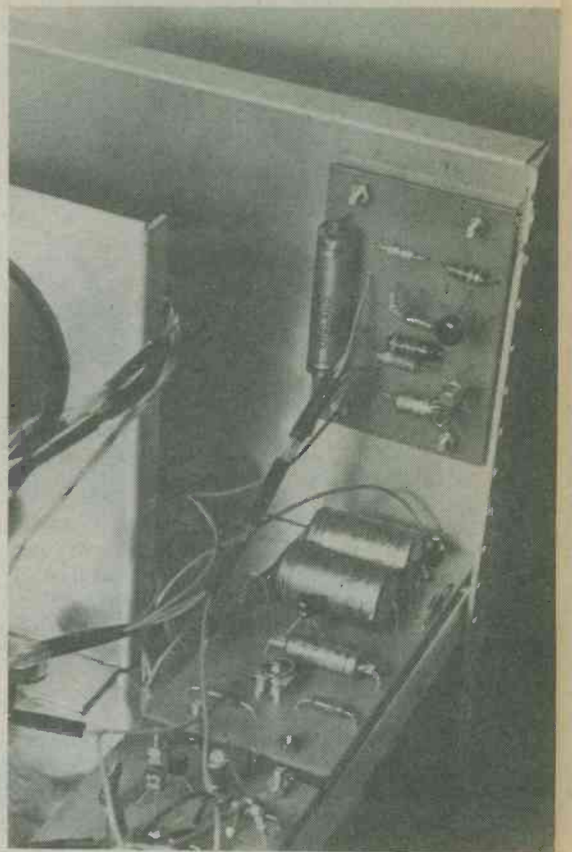


Fig. 16. The printed circuit board assembly for the flyback blanking amplifier is relatively simple to make up



The flyback blanking amplifier board is fitted to the rear panel of the case, above the 12 supply board

Fig. 16, which also shows the component layout.

The completed printed circuit board is mounted on the inside of the rear panel of the case, just above the 12 volt supply board. It can be clearly seen in the accompanying photograph of the prototype oscilloscope.

ASTIGMATISM ADJUSTMENT

The correct setting for the astigmatism control, VR8, is found by trial and error. Couple a sinewave signal to the a.c. Y input, then adjust the timebase controls and the X and Y gain controls to obtain a trace of several cycles which fills the screen.

Next try various settings of the astigmatism control, readjusting the focus control for each new setting. The final setting of the astigmatism control is that which gives the best defined trace at all areas of the screen.

C8 AND C10

The values quoted for the frequency compensating capacitors, C8 in the X amplifier and C10 in the Y amplifier, are those which were found to give optimum results in the prototype oscilloscope. While these values should give adequate results with other units, ideally the values should be selected to suit the individual oscilloscope.

To find the correct value for C8, switch the timebase to about its highest frequency and connect a signal generator to the Y input to obtain a waveform on the screen. If C8 has near enough the correct value there should be no trace of the flyback signal, and the sweep trace should be as bright at the left hand side of the screen as it is at the right hand side. If the flyback signal leaves a trace towards the left hand side of the screen, then C8 must be increased in value. If the trace of the waveform decreases in brightness towards the left hand side of the screen, then the value of C8 is a little too high. The correct value is found by trial and error, and is one which eliminates the flyback trace but does not affect the trace of the waveform.

In order to find the correct value for C10 it is necessary to inject an audio square wave, say at a frequency of about 400 to 1,000Hz, into the Y input with S2 in the "XI,000" position. This should give a

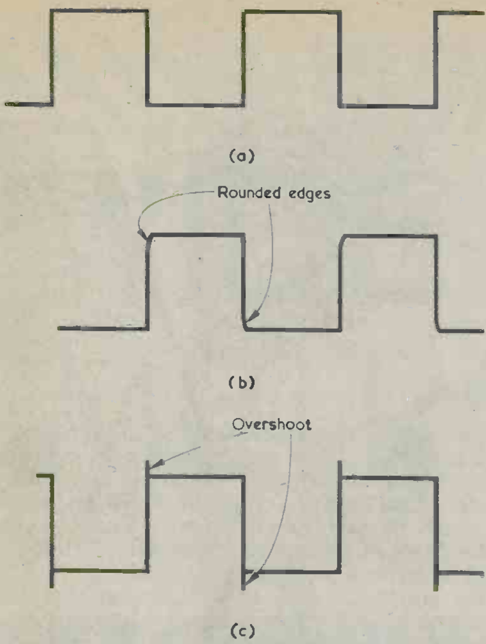


Fig. 17(a). The Y amplifier frequency response may be checked by applying a square wave to the input
(b). Poor high frequency response will result in rounding of the leading edges of the waveform
(c). Excessive high frequency response will produce overshoot

trace which is similar to that shown in Fig. 17(a). However, if C10 has too low a value a trace with rounded leading edges, like that shown in Fig. 17(b), will be obtained. It will then be necessary to try a slightly higher value for C10.

If, on the other hand, C10 is too high in value the trace will look more like Fig. 17(c), with overshoot lines being produced on the leading edges of the waveform. A lower value for C10 must then be tried, the correct value being found empirically.

TIMEBASE CALIBRATION

It is a useful feature to have a scale around the control knob of the timebase fine frequency control which is calibrated in terms of timebase frequency. If a calibrated signal generator is available it can be set to a frequency of 50Hz and connected to the Y input. Set the timebase range switch to position 2 (50 to 700Hz) and adjust VR5 towards the low frequency end of its range.

Switch off the sync at S4 and adjust VR5 to give one complete cycle on the screen. With a single cycle on the screen the timebase and signal generator are running at the same frequency. The scale of VR5 is marked "5" at this point. By using the same process at other signal generator frequencies up to 700Hz (at which point the scale is marked "70") a complete scale can be marked around the knob of VR5.

If an accurately calibrated signal generator is not available the 50Hz mains can be used as a frequency standard. Set the Y attenuator and fine gain controls for maximum sensitivity, and connect a short lead, say about 12 to 18in. long, to one of the Y inputs. With the timebase switch set to position 2, the sync turned off and VR5 adjusted towards the minimum frequency end of the range, it should be possible to obtain a display of a single cycle. The timebase is then running at 50Hz, the Y input consisting of random pick-up from the local mains wiring.

VR5 should now be advanced until a stable trace is obtained consisting of two lines. Each of these is one half cycle and the timebase frequency is then 100Hz (2 x 50Hz). If VR5 is further advanced until a stable trace is again obtained there will be three lines displayed on the screen, each being one third of a cycle long. This indicates a timebase frequency of 150Hz (3 x 50Hz). This procedure can be repeated with four and five lines, and so on, to identify timebase frequencies of 200Hz, 250Hz, and further multiples of 50Hz.

It is possible to use the oscilloscope for approximate frequency measurement by employing this procedure in reverse. If, for instance, the timebase frequency is 600Hz and there are five complete cycles displayed on the screen, then the input frequency is 600 times 5, or 3,000Hz.

FREQUENCY COMPENSATED ATTENUATOR

If required, the attenuator can be modified to incorporate frequency compensation. The circuit of the modified attenuator is shown in Fig. 18.

With S2 in the "X1,000" position there is of course no need for frequency compensation, as the attenuator is in effect switched out of circuit. When S2 is in the "X100" position the attenuator will tend to reduce the upper frequency response due to the shunting effect of the input capacitance of the Y amplifier on resistors R21 to R24. This is overcome by switching a low value capacitor, C24, across R20 when S2 is set to "X100."

In the "X10" and "X1" positions the input capacitance of the Y amplifier has less effect as it is shunting a lower resistance. Stray capacitances around R20 and R21 then have the most pronounced effect, causing an increase in the frequency response at high frequencies. TC1 is used to shunt R22, R23 and R24, and so counteract these stray capacitances.

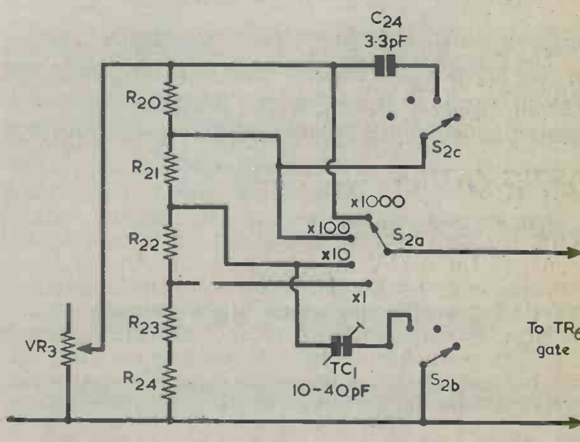


Fig. 18. Modifying the Y input attenuator to give frequency compensation

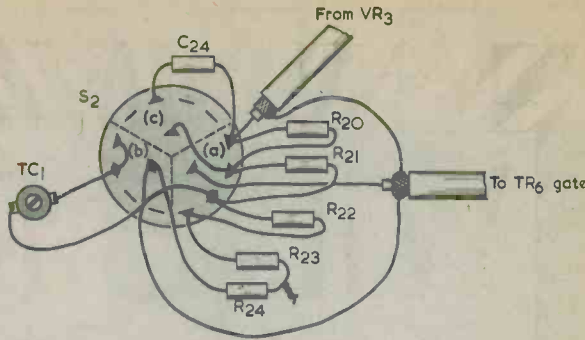


Fig. 19. The modified wiring at the attenuator switch

The additional two components are mounted on S2, and the wiring of the modified attenuator assembly is shown in Fig. 19. For ease of presentation the components and wiring in Fig. 19 are shown spread out, but in practice all wiring here must be kept short.

Note that the value of C24 might need to be altered to suit individual oscilloscopes. If necessary, the correct value can be found by trial and error using the same procedure as was employed to find the value of C10 in the Y amplifier. The correct capacitance for TC1 is found in the same way.

The two additional capacitors are not included in the Components List which accompanied Part 1 of this series.

SENSITIVITY

It is of course necessary to know the sensitivity of the Y amplifier if the oscilloscope is to be used to measure signal amplitudes. A suitable a.c. calibrator is not described here as a number of designs have been published in the recent past. These include "Oscilloscope Calibration Generator" by P. R. Arthur, which was published in the March 1975 issue of this journal, and "Oscilloscope Amplitude Calibrator" by A. Foord which appeared in the December 1974 issue.

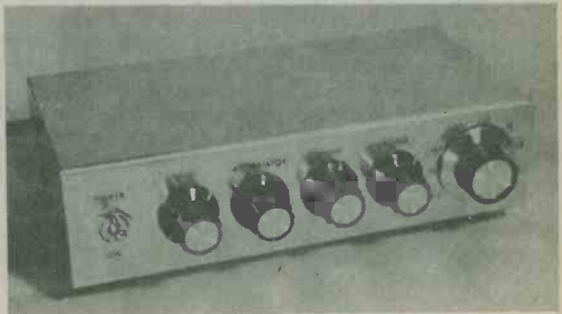
Since the oscilloscope is d.c. coupled it is not even essential to use an a.c. calibrator, as a d.c. voltage of known value can be employed instead.

(Concluded)

IN NEXT MONTH'S ISSUE

WEIN BRIDGE AUDIO SIGNAL GENERATOR

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.



PLUS MANY OTHER ARTICLES

RADIO & ELECTRONICS CONSTRUCTOR

PRICE 30p

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WIDE RANGE METRONOME

By M. G. Robertson

This simple design, which incorporates a 555 timer i.c., produces audible tone bursts of controllable length over a wide range of frequencies.

Electronic metronomes have been described in the past in the home constructor electronic press, but these have almost invariably produced audible outputs in the form of regularly spaced "clicks". A typical instance is given when the "clicks" are discharge pulses from a unijunction transistor oscillator. The audible energy in such pulses is low, even when some form of amplification is provided to increase their current amplitude.

The present design employs an alternative approach, and it produces short bursts of an audio tone instead of single d.c. pulses. These bursts have a much higher energy level and can be more readily heard against ambient noise levels. At its lowest frequency the prototype circuit produced 1 burst every 8 seconds, whilst its highest frequency was well in excess of 3 bursts per second. The length of each burst is controllable.

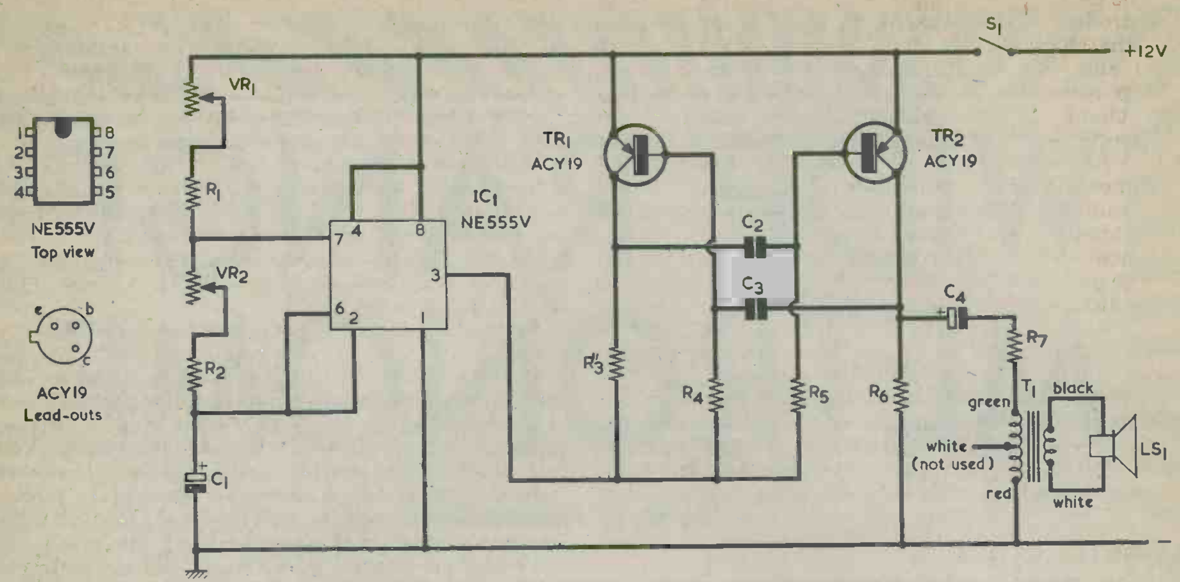
555 TIMER

The circuit of the metronome can be seen in the accompanying diagram. This employs an NE555V timer i.c., or equivalent, in conjunction with a simple multivibrator incorporating TR1 and TR2. The multivibrator is turned on periodically by the NE555V, and it then oscillates at approximately 400Hz.

The NE555V operates in a standard astable circuit, with its pin 2 (trigger) and pin 6 (threshold) connected together. Under these conditions, capacitor C1 charges via VR1, R1, VR2 and R2 until the voltage across it reaches two-thirds of the supply potential. The internal circuitry of the i.c. then changes state, and pin 7 falls to very nearly the same potential as the negative rail. C1 next discharges via VR2 and R2 until the voltage across it is one-third of the supply potential. At this voltage, the internal circuitry of the i.c. reverts to its previous state, and the capacitor commences to charge once more. Since the capacitor discharge path is by way of VR2 and R2 only, whereas the charge path is by way of VR1 and R1 as well as VR2 and R2 the discharge period is shorter than the charge period. In the present design the multivibrator is turned on during the discharge period.

The output of the NE555V at pin 3 goes low (i.e. negative) during the discharge period and is high during the charge period. Thus, during the charge period the lower ends of R3, R4 and R5 in the multivibrator are at a potential which is very close to the positive rail and the multivibrator cannot operate. During the discharge period the lower ends of these resistors are taken nearly to the negative rail, whereupon the multivibrator is able to oscillate in normal fashion.

The collector of TR2 is coupled via C4 and R7 to the primary of output transofmer T1, the secondary of



The circuit of the wide range metronome. The multivibrator is turned on and off successively by the NE555V timer

which connects to the loudspeaker. In consequence, the loudspeaker reproduces the multivibrator tone during the discharge period for C1, and the bursts of tone from the loudspeaker constitute the metronome output. Capacitor C4 in the primary circuit of T1 is a d.c. blocking component. R7 is included to prevent the inductance in T1 primary from upsetting multivibrator operation. Without R7 the multivibrator frequency tends to vary and is not fully controlled by the multivibrator timing components.

TR1 and TR2 are germanium rather than silicon transistors. This is because silicon transistors have low reverse base-emitter voltage ratings which would be exceeded during multivibrator operation. The transistors specified for TR1 and TR2 have a maximum reverse base-emitter voltage rating of 12 volts, which just satisfies present circuit requirements.

TIMING PERIODS

The length of the timing periods can be calculated with the aid of several simple equations. It is helpful first to find the discharge period, this being approximately equal, in seconds, to 0.7 times the product of the capacitance (C1) and the resistance in the discharge path (VR2 and R2). When VR2 is set to insert minimum resistance the discharge path is given by R2 on its own, at 2.2k Ω. The corresponding time is about 15.5 milliseconds. With VR2 set to insert maximum resistance the discharge resistance is 12.2kΩ and the discharge time then calculates as 85 milliseconds. In consequence, the tone burst produced during the discharge of C1 can be varied, by means of VR2, from 14.5 to 85 milliseconds.

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)
R1 10k Ω
R2 2.2k Ω
R3 2.7k Ω
R4 22k Ω
R5 22k Ω
R6 2.7k Ω
R7 470 Ω
VR1 1M Ω potentiometer, log
VR2 10k Ω potentiometer, linear

Capacitors
C1 10μF electrolytic, 12 V. Wkg.
C2 0.1μF plastic foil
C3 0.1μF plastic foil
C4 4μF electrolytic, 12 V. Wkg.

Transformer
T1 Output transformer type LT700 (Eagle)

Semiconductors
IC1 NE555V, or equivalent
TR1 ACY19
TR2 ACY19

Speaker
LS1 3Ω moving coil

Switch
S1 s.p.s.t. toggle

The charge time is approximately equal to 0.7 times the product of the capacitance and the resistance in the charge path (VR1, R1, VR2 and R2). With both VR1 and VR2 set to minimum resistance the total charge resistance is given by R1 and R2 in series, and the charge period calculates, once more, at 85 milliseconds. If VR2 is set to maximum resistance and VR1 to minimum resistance, the charge period becomes 155 milliseconds. When VR1 and VR2 insert maximum resistance into circuit the charge period is a little higher than 7 seconds.

Since none of the resistors in the discharge and charge paths is a close tolerance component, and since in particular C1 will have a wide tolerance on value, practical versions of the circuit can be expected to offer discharge and charge periods which vary quite considerably from the calculated values. As already mentioned, the lowest frequency obtained with the prototype was 1 tone burst every 8 seconds, whilst the highest frequency was well in excess of 3 bursts per second. Results with the prototype agreed, in consequence, quite well with the calculated figures.

CONSTRUCTION

There are few constructional problems as the circuit is very simple and layout is not at all critical. VR1, VR2 and the on-off switch are mounted on the front panel of the unit, as also may be the loudspeaker. VR1 is specified as a log component, since a log track enables adjustment at the higher frequency end to be "opened out" as the potentiometer spindle is rotated. The potentiometer is wired up such that the resistance it inserts into circuit increases as its spindle is turned clockwise. This causes frequency to decrease with clockwise rotation. VR2 is wired up in a similar manner, to ensure that both controls operate in the same sense.

With regard to the other components, C1 should be a good quality modern electrolytic capacitor. No connection is made to pin 5 of the NE555V. The batteries can be any combination which makes up the 12 volts required. Current consumption is reasonably low, being 5.5 to 6mA between bursts, rising to about 10mA when a burst is produced.

After the unit has been completed, a little experience will soon provide familiarity with the controls. VR2 varies the length of each burst while VR1 controls the time between bursts. At frequencies close to the high end of the range the controls become interdependent, and it will be found that adjusting VR2 for a shorter pulse will also reduce the period between pulses. This is not a disadvantage and it merely necessitates first setting up VR2 for the desired burst length and then adjusting VR1 for frequency. If, however, it is desired to calibrate VR1 accurately in terms of frequency it would be better to make VR2 a pre-set potentiometer which is mounted inside the unit. It may be set up for any burst length favoured by the constructor and then left alone. After this, VR1 can be calibrated by checking burst frequency against a watch fitted with a second sweep hand. ■

ELECTRONIC ODDITIES

An off-beat glance at the electronic scene. **by R. River**

When capacitors have a holiday do they go to the C-side Faraday?

In 1875 Alexander Graham Bell invented the telephone; this was a failure until 1876 when he invented the other telephone.

Barkhausen is German for dog-kennel.

Guide to metrication:
10 hertz = 5 bicycles per second
10 millipedes = 1 centipede
10 decimals = 1 mal
10^{12} pins = 1 terrapin
Millicent = Hector
Centigram = unit for weighing rose petals.

Transistors? They're as easy as EBC.

Dud f.e.t.'s — money down the drain.

What sort of mathematics do trees do?
Logs and twig.

A meter takes a sample
And shows if the current is ample.
It also shows up faults
By measuring the volts.

Why does an American tube have a plate?
For the 'eather!

Use of stone — Stone Age.
Use of iron — Iron Age.
Use of electricity — Volt Age.

Soot all over the bench! It came out of the sweep generator.

Cat's whiskers — are they made of mumetal?

Guide to technical terms:
Portable — it has a handle on it
Hi-Fi/Stereo — it has 2 loudspeakers.

I don't like your explanation about how transistors work. It's full of holes.

Cheap alternative to the videocassette recorder — wait 3 months then turn the set on again.

SHORT WAVE NEWS
FOR DX LISTENERS

Times = GMT

Frequencies = kHz

By Frank A. Baldwin

It is at this time of the year that many Dxers set their receiver dials on the appropriate frequencies, at the times most likely to produce results, in the quest for Dx from the East and Far East. The reception and identification of some of these signals probably represents the greatest challenge of all to the short wave Dxer. As an aid to the comparative newcomer, some of these transmission times and frequencies are mentioned here.

As an introduction to Far East listening, Radio Singapore will probably prove to be the easiest to receive. Listen on **5010** or **5052** around 1530 or from 2230. Then there is Kuching, Sarawak on **4950 with** schedule is from 2230 to 1630.

Malaysia would be next and a watch should be kept on **4985** at 1530 for the time-check and newscast in English from Penang. The afternoon transmission closes at 1630 and the late night session commences at 2230. Then there is Kuching, Sarawak on **4950** which programmes in both English and Chinese and is scheduled on the air from 2200 to 0100 and from 0800 to 1600; listen therefore from around 1530 and from 2200 onwards.

Signals from Kathmandu, Nepal, will certainly interest the Dxer. Although located nearer to the UK than the above mentioned transmitters, reception of signals from Nepal will provide a sense of satisfaction to the newcomer. Listen from around 1530 and from 0020 for programmes in the Home Service scheduled from 0020 to 0350 and from 1150 to 1720, also in parallel on **3425**.

Next month, more transmissions from the East and Far East will be brought to the attention of readers interested in broadcast band Dx.

CURRENT SCHEDULES

● LEBANON

"The Overseas Service of Radio Lebanon", Beirut, broadcasts to Europe and Africa in English from 1830 to 1900 on **11795.** The English transmission directed to North and Central America is from 0230 to 0300 on **9675.**

● VATICAN CITY

"Vatican Radio" presents a service in English to the U.K. from 1450 to 1505 on **7160, 9625** and on **11825**; from 2030 to 2045 on **6190, 7250** and on **9645.**

● SAUDI ARABIA

The "Broadcasting Service of the Kingdom of Saudi Arabia", Riyad, operates a Home Service entirely in Arabic from 0300 to 2300 as follows — from 0300 to 2300 on **6000, 7220, 9720** and on **11950**; from 1600 to 2300 on **6130**; 1545 to 2300 on **7110**; from 0500 to 0830 on **7285**; from 0830 to 1600 on **9605**; from 1900 to 2300 on **9730**; from 0500 to 0800 on **9770**; from 1530 to 1900 on **11780**; from 0500 to 1545 on **11890**; from 0800 to 1530 on **15205** and from 0500 to 1530 on **15275.**

● SUDAN

"Radio Omdurman" has a Home Service in Arabic from 0400 to 2200 on **7200, 9508** and on **11835,** this programme also being on **4994** and **6150** except for the period 1300 to 1500 when these two channels carry the Southern Provinces programme in Arabic, English and vernaculars.

● FRANCE

"Radio France", Paris, radiates a "France Inter" service, in French, from 1800 to 2100 on **3965** and from 0700 to 2100 on **6175.**

● ISRAEL

The evening programme in English directed to Western Europe is on the air from 2000 to 2055 on **7395, 9815** and **11642.** Lower powered transmitters will be on **9495** and **12025,** the programme also being beamed to Africa on **9009.**

Other programmes in English are from 0500 to 0515 to Western Europe on **5900, 7395** and **9009**; from 1200 to 1230 to Western Europe on **12025** and **15100.** Additional frequencies (low powered) for the 0500 transmission will be **11642, 12025** and **15405,** those for the 1200 transmission being **15405, 17685** and **17815.**

● YEMEN ARAB REPUBLIC

"Radio San'a" may be heard by listening to the Domestic Service, in Arabic, from 0300 to 0700, from 1100 to 2015 on **5805** and **7300**; from 2015 to 2200 on **7300** only.

● NORTH KOREA

"Radio Pyongyang" directs an External Service transmission to Europe in English from 2000 to 2200 on **3890, 6565** and **9420.** The Domestic Service in Korean is on **2850** from 2000 to 1800; **3015** from

1500 to 1800; **4270** from 1100 to 1800; **6290** from 2000 to 0830; **6600** from 2000 to 0830 and from 1500 to 1800 and on **11350** from 2000 to 1050.

● SOUTH KOREA
"Radio Korea", Seoul, has an English and General Service directed to Europe from 0630 to 0700 and from 1900 to 1930 on **9640** and **15335**.

● PHILIPPINES
From Manila, broadcasts in English directed to Asia are made from 1000 to 1200 and from 2200 to 2400 on **6170**.

● INDIA
AIR Delhi on **3905** at 1929, closing announcements by YL in Arabic, off at 1930 without National Anthem. This is the Foreign Service which operates from 1445 to 1545 in Pushtu, from 1615 to 1715 in Farsi (Persian), from 1730 to 1930 in Arabic and from 2245 to 0115 in English. The Home Service on this channel operates from 0130 to 0335 and from 1130 to 1445.

● MALTA
Radio Mediteranee on **9755** at 2053 with identification "Malta Calling", followed by pop records, local news, tourist and export news items.

● AUSTRALIA
ABC Brisbane on **4920** at 1910, programme of pop records with announcements in English. Schedule of this one is from 1900 (Sundays 1930) to 1402 and the power is 10kW.

● INDONESIA
Jakarta on a measured **4804.5** at 2200, OM with newscast in Malindo. RRI (Radio Republik Indonesia) Jakarta, listed on **4805**, radiates the "Programme Nasional" from 2200 to 0100 and from 1000 to 1600, power is 20kW.

● MALAYSIA
Kuala Lumpur on **4845** at 2205, Indian-type music, YL and OM in duet. This is the Radio Malaysia Tamil Service which operates Monday to Friday from 2130 to 0130 and from 0545 to 1530; Saturdays from 2130 to 0330 and from 0545 to 1530 and on Sundays from 2130 to 1530, power is 50kW.

● CHINA
Radio Peking on **3450** at 2119, military music, announcements by OM in Standard Chinese. This is the Home Service 1 having a schedule from 2000 to 2200, also in parallel on **4905**.
Radio Peking on **4250** at 2125, Chinese music, YL with song in Standard Chinese in the Home Service 2 programme. Schedule is from 2100 to 2240 and from 1330 to 1600.
Radio Peking on **6225** at 2035, local music, songs by YL chorus. This is the Home Service 1 having a schedule from 2000 to 0100 and from 1100 to 1735. These transmissions are also carried in parallel on **4800, 5860, 5880, 6750** and on **7095**.
PLA (People's Liberation Army) Fukien on **3400** at 2126, YL with talk, military music. This transmitter operates a service to the offshore islands, the schedule being from 2005 to 0155 and from 1000 to 2000.

● HONDURAS
Voz Evangelica, Tegucigalpa, on **4820** at 0339, light music and songs, OM with announcements in English. Schedule of Voz Evangelica is from 1000 to 0430 the English programmes being from 1500 to 1600 and from 0300 to 0430.

● DOMINICAN REPUBLIC
Radio Norte, Santiago, on a measured **4807.5**, Latin American music, OM with local pops. This transmitter commenced operations last year and is listed as having a 24 hour schedule on a nominal **4805** but is sometimes reported closing at 0400!

● ECUADOR
Sistema de Em. Atalaya, Guayaquil, on **4790** at 0349, OM with sports commentary then into a discussion with a YL, several mentions of Guayaquil. Schedule is from 1100 to 1330 and from 0100 to 0500 and the power is 10kW but beware, this one (like that above) exhibits those charming traits often displayed by Latin American stations, wandering (from **4790** to **4795**) and closing anytime (between 0405 and 0615).
Radio Nacional Espejo, Quito, on a measured **4670** at 0404, Latin American music, songs in Spanish, OM announcer. With a 24 hour schedule, this one can wander and is often reported operating on **4678** or **4679**.
Emisora Gran Colombia, Quito, on **4910** at 0410, light music programme, songs in Spanish. Schedule is from 1100 to 1500 and from 2200 to 0500 and the power is 5kW but — here we go again — the frequency is known to vary from that quoted to **4912** and has been reported operating as late as 0540.

● COLOMBIA
Radio Surcolombiana, Neiva, on **5010** at 0423, OM with sports commentary in Spanish. This one has a 24 hour schedule and the power is 2.5kW.

● PERU
Radio Andina, Huancayo, on **4996** at 0420, guitar music, OM with frequent local announcements. This one is easy to identify, the announcements are obviously made in an empty room, the echo-effect is not electronic! The nominal frequency of this one is **4995** and the schedule is from 1100 to 0600 but it has been reported when closing at 0545 and as late as 0900.

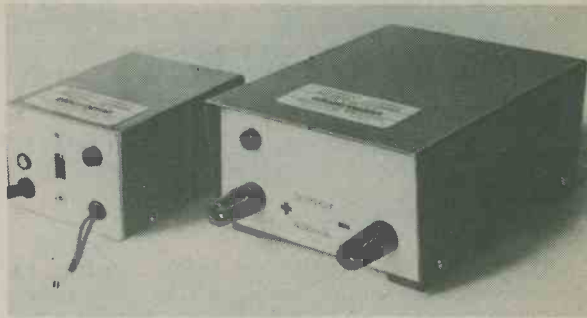
● BRAZIL
Radio Brasil Central, Goiania, on **4985** at 0415, OM with announcements, local music, several mentions of Brazil. Schedule is from 0800 to 0500 and the power is 5kW. Formerly on **4995**, this transmitter, like most Brazilians on the Tropical Bands changed channel on May 1st in a major revision of frequency allocations.

● ZAIRE
Kinshasha on **4880** at 1848, OM in vernacular, local orchestra with local pops. Kinshasha has a 24-hour schedule and the power is 10kW.

● MALAWI
Blantyre on **3380** at 2035, Euro-style pop music records, announcements in English. The evening schedule is from 1700 to 2210 and the power is 100kW.

New Products

NiCd CHARGER RANGE



A new, bigger range of Nickel Cadmium modular chargers is available ex-stock from Electroplan, the Royston based distributor of electronic instruments and accessories.

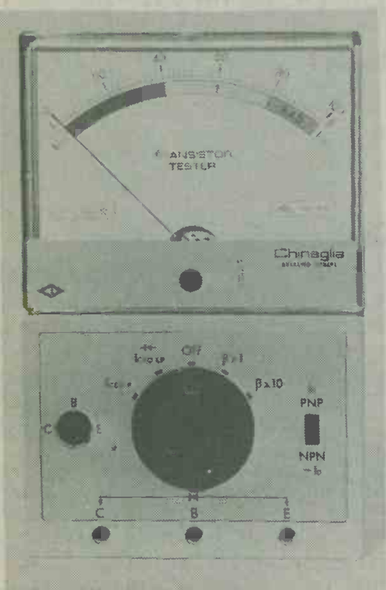
Manufactured by Crowborough Electronics, the new charger units provide true constant current operation and are intended for recharging NiCd cells. Output currents range from 10mA to 400mA and up to 10 cells may be charged simultaneously in series. Each charger incorporates a neon "power-on" indicator and the higher current modules are fused.

Two case sizes are available depending on power output, each with a dual tap mains transformer enabling 240V or 110V operation. Mounting is by two 4BA tapped holes.

Prices range from £9.00 +VAT for a 10mA 1-10 cell charger up to £12.25 + VAT for the 400mA 7-10 cell charger.

Further details from:— Electroplan Limited, P.O. Box 19, Orchard Road, Royston, Herts. SG8 5HH.

TRANSISTOR TESTER



This simple-to-use special purpose instrument has been added to the Chinaglia range of professional equipment specifically to meet the need for fast device testing, both in and out of circuit.

Not only will the new instrument cope with the normal n.p.n./p.n.p. germanium/silicon variations, but it can deal with both low signal and power devices in addition to carrying-out in-circuit tests at reduced accuracy.

Constructed to the usual high Chinaglia standard, the transistor tester has a tough ABS plastic case and an easy-to-read scaling which both indicates device state in a "Good" — ? — "Bad" colour indication and shows leakage and B to ample accuracy. The basic movement is a class 1.5, 1mA, 50Ω unit with core magnet and sprung bearing jewels.

Range switching is simple, with a slide switch for p.n.p./n.p.n. selection and a rotary switch for other functions. A small signal device socket is mounted on the instrument face in conjunction with sockets for test leads supplied for connection to external circuits and devices.

Power is supplied by internal batteries.

Price, **complete of carrying case and leads,** *£25.70 VAT incl.*

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

CATALOGUE

Doram Electronics Limited have now issued Edition 2 of their component catalogue. Priced at 60p (including postage), this supersedes the first Doram catalogue. It has 100 pages and includes a new 16-page data section giving design information on components, both active and passive, as well as describing a 10 watt stereo tuner-amplifier incorporating the Mullard LP1186, LP1185, LP1400, LP1184/2 and LP1173 modules. Also included for the purchase price of the catalogue is a free up-date product and price information service.

Of particular interest to radio and hi-fi enthusiasts will be the inclusion of a new turntable kit and record deck, a full range of quality blank cassettes, magnetic cartridges, speakers and speaker cabinets, microphones, earphones, quartz crystals, variable capacitors, radio and audio modules, and a full range of pick-up styli.

The new Doram catalogue is available by return of post from Doram Electronics Ltd., P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF. ■

THE SN76023N POWER AMPLIFIER

By P. R. Arthur

The Texas Instruments SN76023N is an integrated circuit a.f. power amplifier which is particularly useful for home constructor applications. This article describes a basic amplifier incorporating the i.c. and shows how it may be employed as a replacement for the Sinclair Super IC-12 in earlier designs.

Despite the availability of specialist integrated circuits for virtually every purpose these days, it is still probably true to say that audio i.c.'s hold the greatest interest for the amateur electronics enthusiast. One of the most versatile of the audio i.c.'s currently available is the Texas Instruments SN76023N. This is typically capable of an output power of 5 watts r.m.s. into an 8 Ω load when using a 24 volt supply. It will work satisfactorily with supply voltages as low as 8 volts, although with reduced maximum output power and performance. Higher impedance loads can also be used if less power is required, but loads lower than 8 Ω must not be employed. The maximum permissable supply voltage is 28 volts.

The SN76023N contains an integral pre-amplifier which enables a high input impedance and sensitivity to be obtained if required. Noise and distortion are both low, with distortion being typically less than 1% provided the output power does not exceed a certain level for a given load impedance and supply voltage. For an 8 Ω load this is 3.3 watts at 20 volts rising to more than 6 watts at 28 volts. The noise level is approximately –70dB.

The device is contained in a standard 16 pin d.i.l. package, except that the two centre pins of each row are missing and are replaced by heat tabs. The SN76023N has these coupled to an extruded aluminium heat sink. There is another version, the SN76023ND, which has the heat tabs only. These tabs are intended to be soldered to an area of the copper on the printed circuit board, which then acts as a heat sink. The minimum load impedance for the SN76023ND is 15 Ω, and minimum output power into this impedance at 24 volts supply is 3 watts.

SIMPLE AMPLIFIER

Fig. 1 shows the circuit diagram of a simple a.f. amplifier incorporating the SN76023N. This was primarily designed as a replacement amplifier for the Sinclair Super IC-12 units employed in the "Four Channel Synthesiser" and "Mains Table Radio" articles which appeared respectively in the April and May 1975 issues of this journal. The IC-12 has now been discontinued.

The SN76023N is very nearly a direct equivalent to the IC-12, but it does not have quite such a stringent specification, and it is not supplied with a matching printed circuit board. It is similar to operational amplifiers in many ways and has both an inverting input (pin 16) and a non-inverting input (pin 1). It is intended for single supply operation, however, and has a Class AB power output stage.

Feedback from the output to the inverting input is provided via R5. At d.c. R5 provides virtually 100% negative feedback over the amplifier, and this helps to give a stable biasing system. In order to provide a useful voltage gain at a.f. some of the feedback must be decoupled; this is carried out by C4, with R4 limiting its effect so that quite a large level of feedback remains. This, of course, has the benefits of reducing noise and distortion.

The values given to R4 and R5 determine the closed loop voltage gain of the amplifier, and the voltage gain is approximately equal to (R4 + R5) divided by R4. The gain of the circuit can thus be altered by altering the values of these resistors. With R4 maintained at 100 Ω, it is probably best, in the interests of good stability, to keep R5 within the range of 10k Ω to

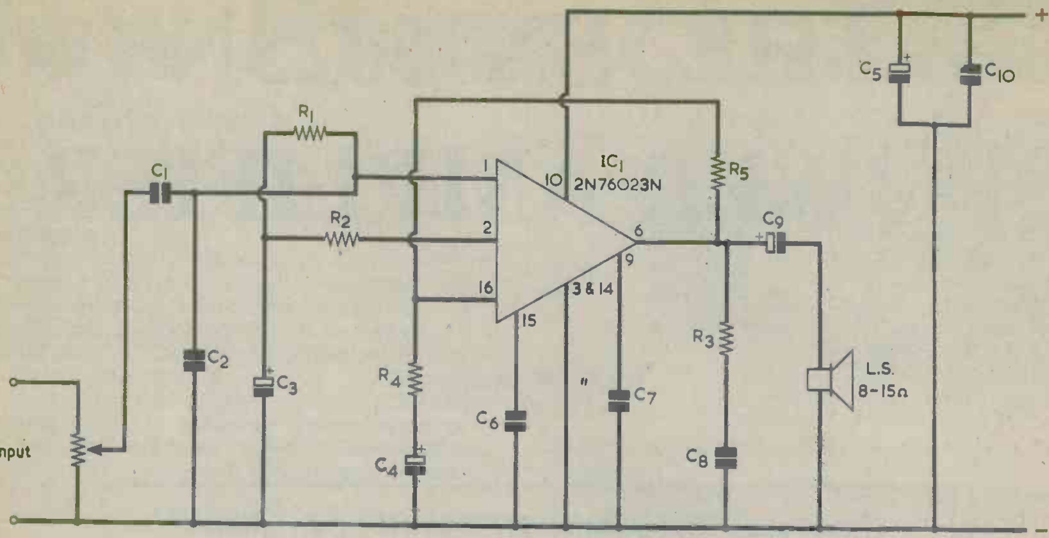


Fig. 1. The circuit of a simple amplifier incorporating the SN76023N

100kΩ, which gives a range of approximate voltage gains of 100 to 1,000 times (40 to 60dB).

Biasing for the non-inverting input of the i.c. is provided by R1 and R2 from an internal potential divider circuit in the device. C3 removes any mains hum or other noise which may be present on the supply lines, and ensures that this does not find its way to the non-inverting input where it would be amplified and fed to the speaker. R1 determines the input impedance of the circuit, and the input impedance can be regarded as being approximately equal to the value of this resistor. R1 can have any value up to 1MΩ. The input signal is coupled to pin 1 via C1, which provides d.c. blocking.

C6 and C7 are required to prevent instability. R3 and C8 compensate for the fact that the speaker impedance rises with frequency. C2 reduces the input impedance at high frequencies and so also helps to give good stability. With low values of R1, say up to 10kΩ, this capacitor will probably be unnecessary. C9 couples the signal from the output of the i.c. to the speaker, and provides d.c. blocking. C5 and C10 are

COMPONENTS

Resistors
(All ¼ watt 10%)
- R1 100kΩ (see text)
- R2 100kΩ
- R3 18Ω
- R4 100Ω
- R5 22kΩ (see text)

Capacitors
- C1 0.1μF, type C280 (Mullard — see text)
- C2 270pF ceramic plate
- C3 4μF electrolytic, 16 V. Wkg.
- C4 100μF electrolytic, 16 V. Wkg.
- C5 100μF electrolytic, 30 V. Wkg.
- C6 1,500pF disc ceramic, or paper or plastic foil
- C7 1,000pF disc ceramic
- C8 0.01μF disc ceramic, or type C280 (Mullard)
- C9 500-1,000μF electrolytic, 16 V. Wkg.
- C10 0.068μF, type C280 (Mullard)

Integrated Circuit
- IC1 SN76023N (or SN76023ND)

Miscellaneous
- 8-15Ω speaker (see text)
- 0.1in. Veroboard

An amplifier assembled to the layout of Fig. 2 bypass capacitors, and it is important that C10 be connected physically close to the i.c. Otherwise, high frequency instability may result, particularly if long supply leads are employed.

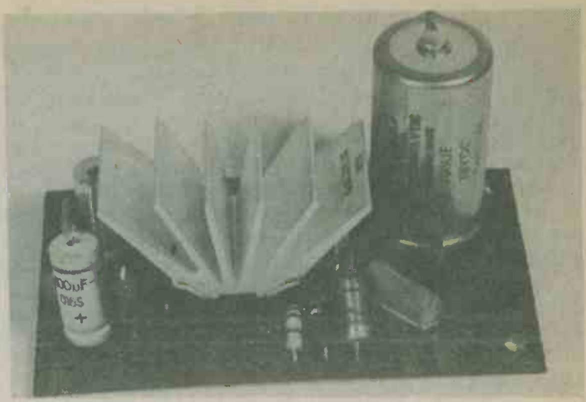
The component values given in the Components List are suitable if the amplifier is used in the Synthesiser circuit. If the amplifier is employed in the Mains Table Radio circuit, R1 should be 27k Ω and R5 47k Ω. C1 is 0.22 μF in the Mains Table Radio version. In the Mains Table Radio circuit the amplifier follows a ZN414, whereupon the r.m.s. input signal voltage is of the order of 30mV.

The amplifier of Fig. 1 can, of course, be used for applications other than in these two circuits, bearing in mind the notes just given concerning the values of R5 and R1. No value is given for the input volume control shown in Fig. 1. The value is not critical and, in general, it should be lower than R1.

The output capacitor, C9, is specified in the Components List as 500-1,000μf. Any value in this range will be satisfactory, although a slightly improved bass response will be given by a capacitor at or near 1,000μF. The speaker employed should be capable of handling the output power given by the i.c.

CONSTRUCTION

A suitable layout for the amplifier on Veroboard of 0.1in. matrix is shown in Fig. 2. The Veroboard should be cut out to the correct size and the copper strips cut at the points indicated. Two 6BA clear holes for mounting purposes are also drilled out.



The amplifier board seen from the other side

If the version of the i.c. having the integral heat sink is employed, then it is probably best to mount the i.c. first and then fit the other components around it. Mount those closer to the i.c. before fitting those that are situated further away.

When using the version of the i.c. that so does not have the heat sink, it is best to leave the mounting of

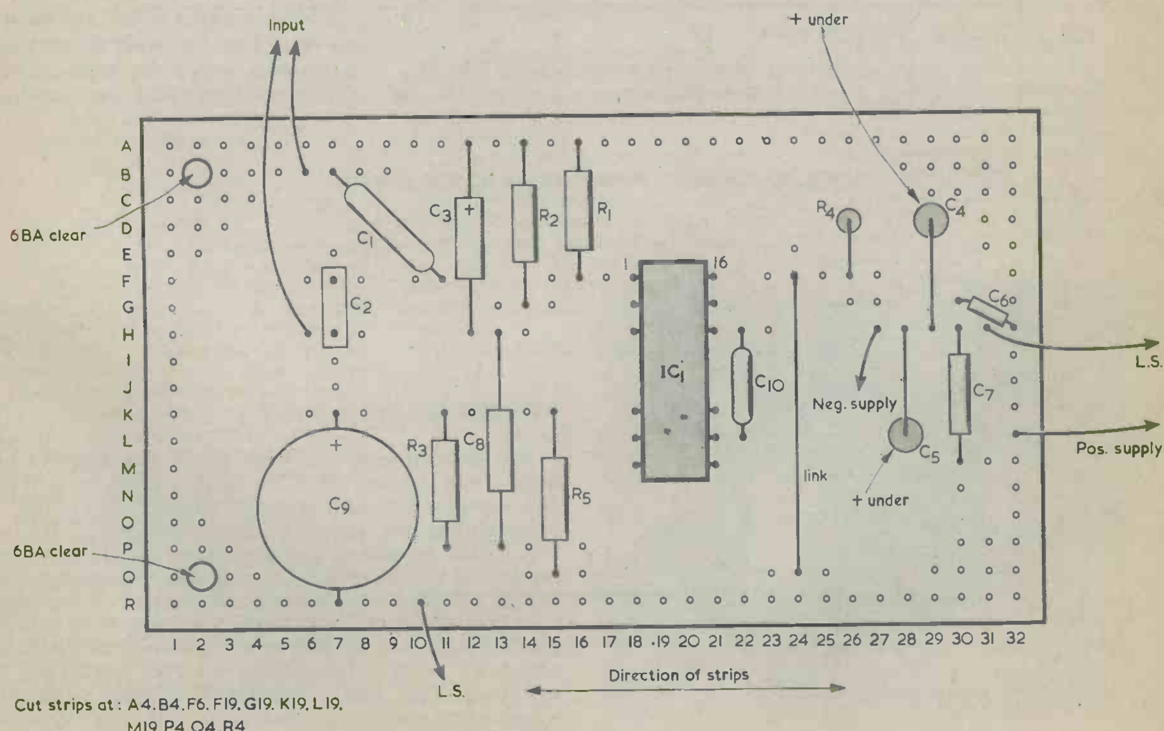
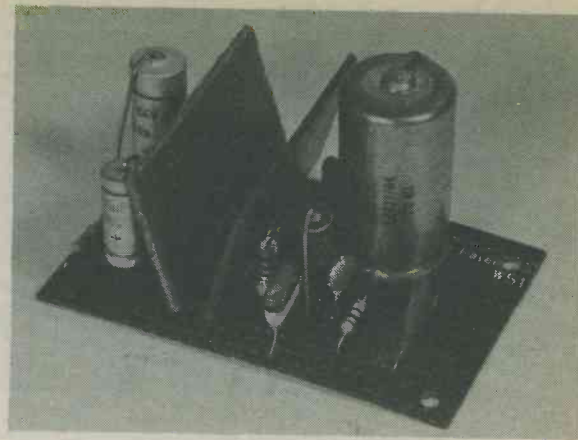


Fig. 2. Amplifier layout on a Veroboard panel with components uppermost

the i.c. until last. The tabs of the device are carefully bent up through about 150°. Two rectangles of copper laminate board are soldered to the tabs in order to provide the necessary heat radiation. These heat fins should have an area of about 3.5cm. by 4.5cm., or more if sufficient space is available. Remember that this version of the i.c. should not have a speaker load impedance of less than 15Ω.

An amplifier using this type of heat sink is shown in the accompanying photographs. It is assembled on a Veroboard layout slightly different from that of Fig. 2.

The pins of the i.c. without the integral heat sink can be identified with the aid of the usual cut-out in the top of the case between pins 1 and 16. With the other version of the i.c., pin 1 is the pin near the Texas Instruments trade mark afte the SN76023N type number. If in any doubt about the identification of the pins, pins 3 and 14 of the device connect to the heat sink and can be located with the aid of an ohmmeter.



A similar amplifier incorporating the SN76023ND

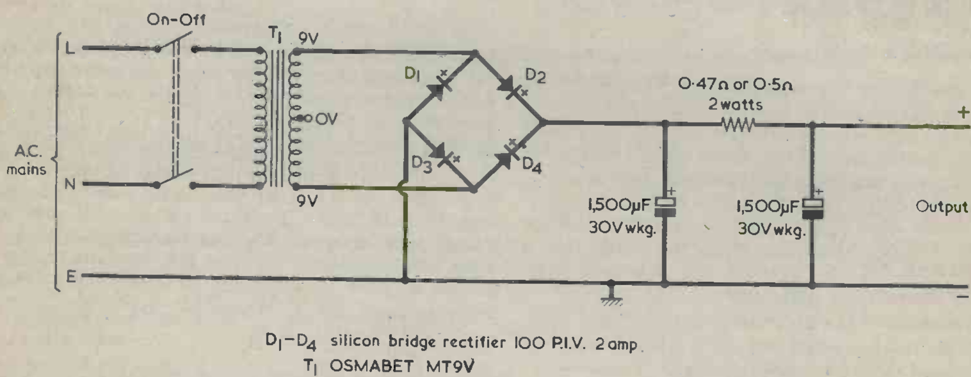
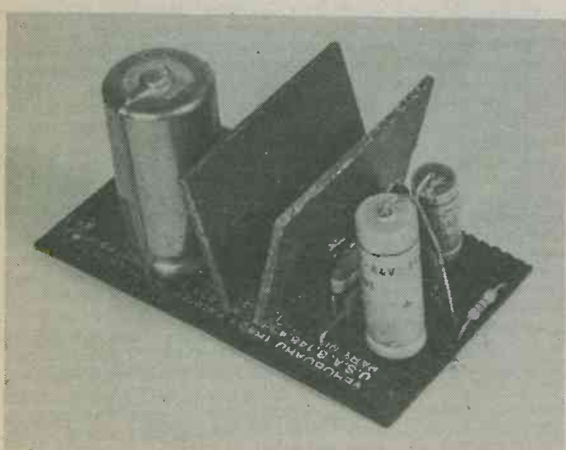


Fig. 3. A suitable power supply for the amplifier



Another view of the SN76023ND amplifier. The radiating fins are rectangles of copper laminate

POWER SUPPLY UNIT

For constructors who wish to use the amplifier of Figs. 1 and 2 as an amplifier in its own right, and not as a replacement for the earlier articles, the circuit of a suitable power supply is illustrated in Fig. 3.

A highly smoothed and stabilized supply is not essential for the SN76023N, and the simple unregulated supply circuit shown is quite satisfactory. It is important that the maximum supply voltage does not exceed 28 volts, and for this reason a transformer offering about 18 volts r.m.s. under no-load conditions is specified. This has a 9-0-9 volt 1 amp secondary whose outer ends are connected to a silicon bridge rectifier. No connection is made to the secondary centre-tap. The smoothing circuit consists of the two electrolytic capacitors and the smoothing resistor shown. ■

In your workshop

This month we find Smithy's assistant, Dick, wrestling with the complexities of TV line and vertical blanking circuits. However, he is given a little aid by the Serviceman and is eventually able to trace and clear quite an unusual television snag.

"Ah, that should fix it!"

With a grunt of satisfaction Dick replaced his soldering iron on its rest and carefully examined the connections to the 1kΩ resistor he had just soldered to the printed circuit board of the 12 inch monochrome TV on his bench. The two solder joints at the resistor lead-outs were, as was always the case with Dick, immaculately finished. As Dick himself admitted, he might not be too clued up on technical details but when it came to soldering he was a real past master.

Dick switched on the receiver and waited expectantly. It had been quite an interesting piece of trouble-shooting: the collector feed resistor for the first i.f. transistor had gone high in value, a fact that had been readily revealed by voltage checks around the transistor and its immediate components. Dick had now replaced that resistor.

LINE BLANKING

After a short while the picture tube came to life and Dick was delighted to see that this depicted a bright, well focused scene of good resolution. As he watched cheerfully, he saw three masked Mexicans traverse the little screen on horseback as they converged on the friendly neighbourhood bank. He advanced the volume control. The sound quality was good, too, with the clatter of horses' hooves being backed by a 50-piece orchestra softly playing music to raid banks by.

The scene changed to the interior of the bank, and the screen went darker. Dick leaned forward to look more closely and then suddenly gave a frown. Approximately a third of the way from the left of the picture was a vertical line, about a quarter of an inch wide, which was noticeably brighter than the rest of the scene. The line jiggled slightly to left and right in an irritating fashion. The picture changed to the brighter scene outside the bank and the vertical line disappeared. Then the picture returned to the bank interior and the line came back again. As he watched, Dick noticed also a series of vertical striations to the left of the line.

Visited by a subconscious inspiration, Dick reached for the brightness control and turned it to a higher level. The jittering vertical line now became visible both on the indoor and the outdoor scenes. Dick returned the brightness control to its proper setting and scowled at the receiver. The Mexicans had now entered the bank and the resultant unbroken dark scene continually revealed the vertical line with all its annoying tremor.

"Hey, Smithy."

The Serviceman, completely absorbed in the chassis of another television set on his own bench, gave no indication that he had been called.

"Hey, Smithy!"

There was still no response.

"Hey," roared Dick, *"Smithy!"*

Smithy looked up absently, as though in response to some mild stimulus, then returned to his television set. But his concentration had patently been broken because, after a moment, he turned round to face his assistant.

"Is," he asked vaguely, "something wrong over there?"

"Blow me," snorted Dick. "I've been calling you for ages."

"Have you?" replied Smithy in the satisfied tone of one for whom a minor problem has been solved. "Then that explains the noises I thought I heard."

"Well, before you go back into your coma," said Dick quickly, "can you have a quick look at this TV set I've got here?"

Sighing, Smithy rose from his stool and walked over to examine the picture displayed by the television receiver. The masked Mexicans were now emptying the bank strong-room, in the murky shadows of which clearly trembled the vertical line.

"What's probably happened here," remarked Smithy, "is that the line blanking circuit has gone duffy. Is this vertical line the fault that the set came in with?"

"No," replied Dick, "the main fault was very weak signal I've cleared that, and now I find I've got this darned waggling line. It only shows up on dark scenes."

"I should guess that that line was there for quite some time before the major fault occurred," surmised Smithy. "The set-owner probably put up with it or didn't even think it was a fault. Anyway, now you've repaired the major snag you might as well clear up this minor one. If you get the service manual out I'll show you where the line blanking circuit is."

"I've got the manual out already," responded Dick. "Here it is, and here's the circuit of the set."

"Dear me," said Smithy, impressed. "It must have been a tricky snag for *you* to consult the manual. Well, let's have a look at it. Ah yes, here's the bit which gives you line blanking."

Smithy pointed to a section of the receiver circuit. (Fig. 1.)

"Is that it?" said Dick uncertainly, as he gazed at the circuit area indicated by Smithy. "What exactly is it supposed to do?"

"It's supposed to cut off the picture tube during line flyback. Which reminds me that it may also be called a line flyback suppression circuit."

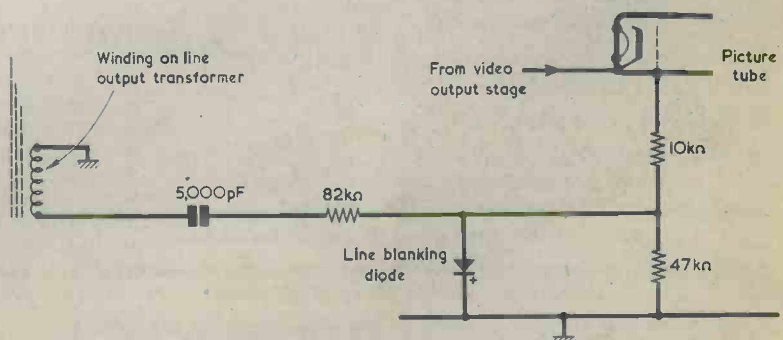


Fig. 1. A typical line blanking circuit, as encountered in monochrome television receivers. Component values are representative of current design practice

SYNC PULSE OVERSHOOT

"I don't quite understand this," said Dick. "Why, for a start, do you *have* to cut off the tube during line flyback? The signal is at black level or lower than black level during the flyback period in any case."

"The *signal* may be," retorted Smithy, "but not so far as the picture tube is concerned. Now let me ask you a question for a change. What happens to the signal when you come to the end of a line of picture information?"

"Well," said Dick, "the signal amplitude goes down to black level for a short period and then goes down further to sync level to give the start of the line sync pulse. After that it returns to black level and, a little later, the next line of picture information starts." (Fig. 2(a).)

"Fair enough for now," commended Smithy. "The bit before the sync pulse is known as the front porch and the bit after the sync pulse is called the back porch. Also, in the 625 line system, the black and the blanking levels are both the same. Now, in a perfectly ordered world, the picture tube would be set up such that black level would always coincide with the tube being just cut off." (Fig. 2(b).)

"I suppose," put in Dick, "that you would obtain this condition by adjusting the brightness control correctly."

"You could do," replied Smithy, "but the brightness control would need to be set up more carefully than most viewers would do, and you'd also have to have full d.c. coupling of the signal all the way from the video detector to the picture tube. But these monochrome 625 line sets don't have d.c. coupling. They have an a.c. coupling to the tube, which means that the average voltage at the tube modulating electrode, which is normally the cathode, varies according to the overall brightness of the scene being transmitted. If, with bright pictures, the average voltage is such that black level corresponds to the tube being just cut off, dark pictures will cause the black level to come well within the range of signal voltages that give visible effects on the screen." (Fig. 2(c).)

"That's exactly what happened with this set," said Dick excitedly. "The vertical line wasn't visible with a bright scene, but it showed up quite clearly on the dark scenes. Now, let's think a minute."

His brow furrowed in concentration.

"At the end of the line," he went on slowly, "we get the front porch and then the start of the line sync pulse. Now, if there was direct line sync in the set the start of the sync pulse would actually initiate the flyback, and so the pulse start couldn't have any visible effect during flyback. Present day sets have flywheel sync but, even so, the start of the line sync pulse will still occur approximately at the same time as the start of line flyback."

"So?"

"So," continued Dick, "the thing which causes this waggly line to appear must be the *end* of the sync pulse, when it goes up from sync level to black level."

"You're very nearly there," commented Smithy. "If the sync pulses were perfectly shaped the end of each pulse would still, however, have little visible effect on the tube screen, even when the tube screen isn't cut off at black level. This is because the spot on the screen is travelling extremely quickly to the left during flyback and the end of the pulse would have a gradual effect. If, on the other hand, something in the system between the transmitter camera and the receiver picture tube caused a sharp *overshoot* to appear at the end of the line sync pulse, then the result on the screen would be quite noticeable. What's causing that line on the screen of your set is a sharp overshoot pulse at the end of the line sync pulse. This overshoot pulse is very short in duration, much shorter in fact than the flyback period, and so it causes the screen to go a little brighter each time it appears. Since the overshoot pulse appears during every line flyback period, and at about the same time in the period, it builds up a vertical line on the screen." (Fig. 2(d).)

"Well," remarked Dick, "that explains the presence of the line. Why does it waggle to left and right?"

"Partly because of slight discrepancies between the width of successive sync pulses," replied Smithy, "and partly because of slight differences in flyback initiation in the receiver line timebase. These wouldn't have any effect if the spot was travelling across the tube screen at the relatively slow scan speed, but they become noticeable at the very much higher flyback speed. Another thing we haven't even mentioned yet is the fact that present-day transmissions carry colour burst signals on the back porch. These will follow your overshoot pulse and will be causing those vertical striations you can see. So, apart from guarding against the overshoot effect, line blanking is necessary to remove any visible effects due to colour bursts."

"I can see the situation now," replied Dick. "How about looking at the line blanking circuit in this particular set?"

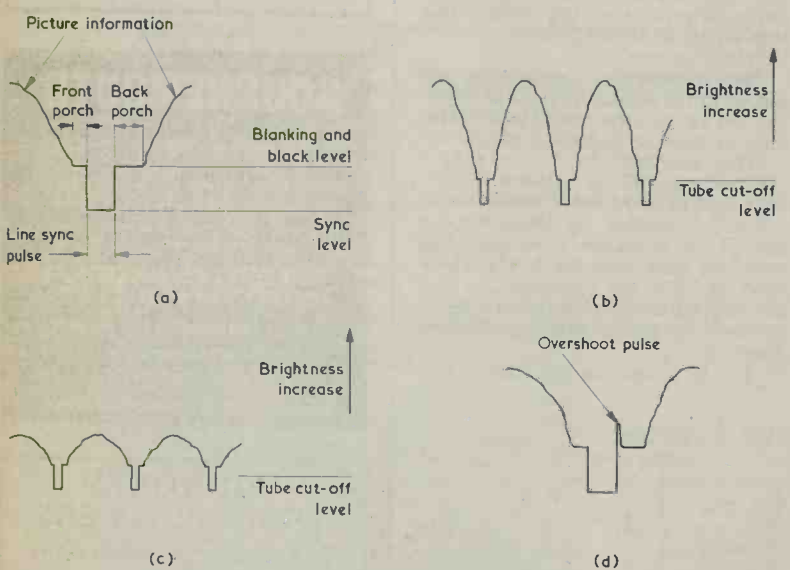


Fig. 2(a). The line sync pulse in the 625 line system. The colour burst on the back porch is not included here

(b). Ideally, the signal presented to the picture tube should have its black level just at tube cut-off level

(c). When there is a.c. coupling of the video signal to the tube, a reduction in the overall picture brightness causes the blanking level to rise above tube cut-off level

(d). The line sync pulse can produce a visible effect on the screen if there is overshoot after its trailing edge

SHUNT DIODE

"We'll do that right now," stated Smithy. "If you look at that circuit I indicated, you'll see that a winding on the line output transformer couples to a 5,000pF capacitor and an 82kΩ resistor. The winding is connected so that there is a line output waveform with negative-going flyback pulses at its non-earthy end. This waveform is

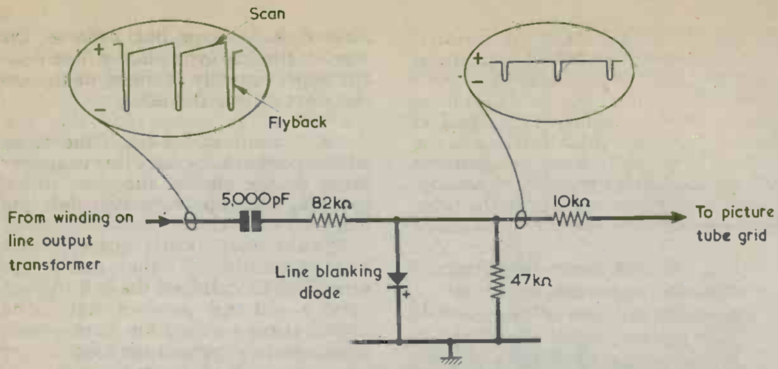


Fig. 3. The waveform from the line output transformer winding in Fig. 1 is changed to a series of negative-going pulses for application to the picture tube grid. These pulses have a lower amplitude than those at the transformer winding because of potential dividing action in the 82kΩ and 47kΩ resistors

applied to the 5,000pF capacitor and 82kΩ resistor, after which it arrives at the line blanking diode. The 5,000pF capacitor offers a much higher impedance to the slow scan sections of the waveform than it does to the considerably quicker flyback pulses, with the result that the waveform appearing at the diode consists of negative-going flyback pulses with flat parts in between." (Fig. 3).

"I suppose," remarked Dick, "that these flat parts will be around chassis potential."

"They will be," agreed Smithy. "The diode prevents the waveform going positive of chassis by more than its forward voltage, with the result that the 5,000pF capacitor takes up a charge which keeps the flat parts of the waveform at this voltage level. So we've now got some nice regular negative-going pulses appearing during line flyback, and these are applied to the grid of the tube via the 10kΩ series resistor. As a result the tube is neatly cut off during the line flyback."

"What's the 10kΩ resistor for?"

"It's to limit current in the event of an internal flash-over to the grid," explained Smithy. "It has nothing to do with the line blanking operation."

"Fair enough," remarked Dick. "This line blanking business doesn't seem to be so complicated after all."

"It's dead easy," replied Smithy. "In fact, the provision of line flyback blanking is often carried out by circuits that are even simpler than the one we've just considered. Hang on a jiff and I'll show you."

Smithy walked over to the filing cabinet and selected two service manuals.

"Here we are," he said, returning to Dick's bench. "I'll show you another line blanking circuit. Take a look at this."

Smithy opened one of the manuals and pointed at its circuit. (Fig. 4).

"Blimey," remarked Dick. "This one's a piece of cake. All you've got here is a winding on the line output transformer coupling to the grid of the tube by way of a 200kΩ resistor and a 5,000pF capacitor. Hullo, there's a 47kΩ resistor and a 0.05μF capacitor coupling from the vertical output stage, too."

"That's to give vertical blanking, or vertical flyback suppression," explained Smithy.

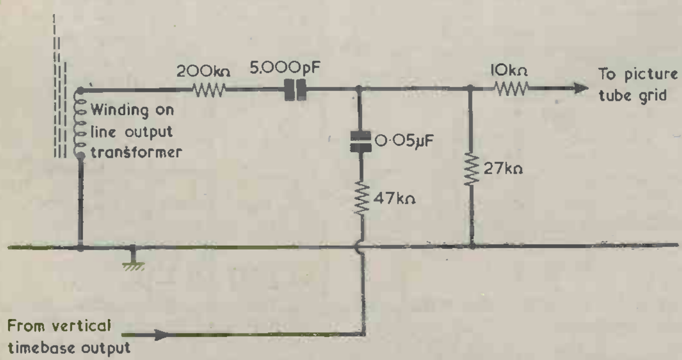


Fig. 4. A simple circuit which gives both line and vertical flyback suppression. The waveforms from the line output transformer winding and the vertical timebase output stage have negative-going flyback pulses. Component values are representative

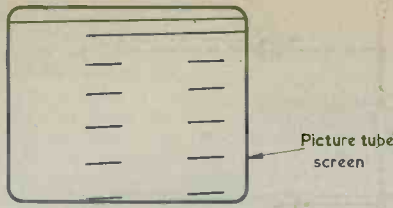


Fig. 5. Without vertical flyback suppression it is possible for part of the vertical synchronising signal to produce sloping lines on the picture tube screen similar to those shown here

"Gosh," exclaimed Dick, "do you have to cut off the tube during vertical flyback as well?"

"Oh, definitely," said Smithy. "It's just as important to have vertical flyback blanking as it is to have line blanking. The vertical flyback is relatively quite slow, and if the tube happens to give a response at blanking level, the frame sync pulse waveform produces a number of sloping lines as the spot moves upwards." (Fig. 5).

"I hadn't realised that," stated Dick. "Let's have a look at another blanking circuit."

"Right you are," said Smithy cheerfully. "Here's an unusual one which employs a separate transistor as a blanking amplifier."

Smithy put another circuit in front of his assistant. (Fig. 6).

"It looks," remarked Dick, "as though this provides both line *and* frame blanking."

"It does," confirmed Smithy. "The collector of the line output transistor couples to the base of the blanking amplifier by way of the 1.5MΩ resistor. The line output transistor collector goes positive during line flyback and so it turns on the blanking amplifier and produces a negative pulse at the blanking amplifier collector. The multivibrator in the vertical timebase couples to the blanking amplifier base via the 47kΩ resistor, and this also turns on the blanking amplifier during vertical flyback. So there are negative-going pulses at the collector of the blanking amplifier during both the line and the vertical flyback periods. These are applied via a 10μF capacitor to a shunt rectifier which acts in the same way as the shunt diode in the set you've got on your bench. The negative-going pulses are then passed to the grid of the picture tube."

VIDEO AMPLIFIER

"These blanking circuits seem pretty obvious, once you've sorted them out," remarked Dick.

"Most of them are simple enough," responded Smithy. "Sometimes, you find that the blanking is achieved by way of the video amplifier. A typical example consists of injecting positive-going frame flyback pulses to the emitter of the video output transistor These cause the collector to go positive, too, whereupon the cathode, and not the grid, of the picture tube is driven positive during the flyback period. Driving the tube cathode positive is, of course, the same as driving the tube grid negative." (Fig. 7).

"Blimey, Smithy," said Dick appreciatively, "you've certainly given me some real gen on this blanking business."

"Think nothing of it," remarked Smithy carelessly. "Anyway, I want to get back to my own TV now."

Left to himself, Dick turned on the television receiver once more. The vertical line was still present. Also, the three Mexicans had progressed quite some way through their story, and were now quarrelling savagely over the loot. Dick switched the set off and pulled his testmeter towards him.

He pondered for a moment. Since the picture tube was working satisfac-

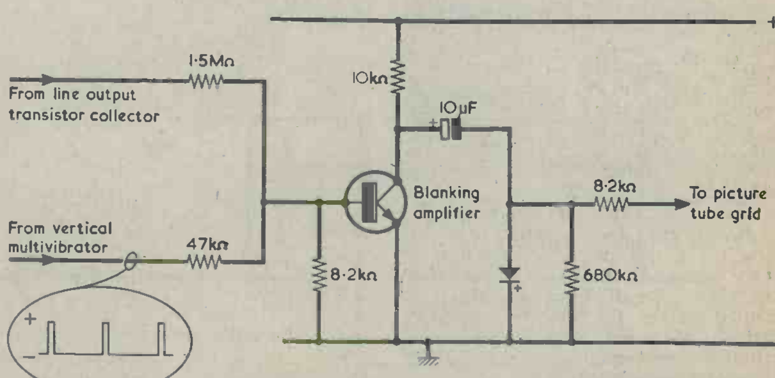


Fig. 6. Here, a blanking amplifier transistor has positive-going flyback pulses from both the line and vertical timebases. These are inverted and applied to the picture tube grid. (This circuit is incorporated in the I.T.T. Television Chassis type VC300).

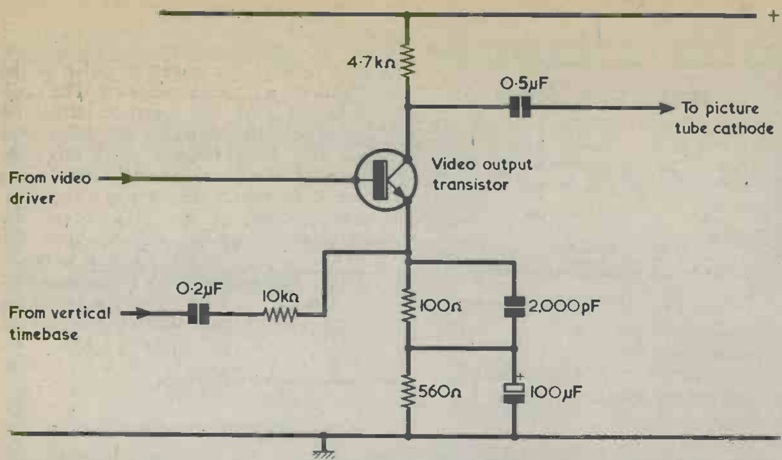


Fig. 7. Simplified circuit, again with representative component values, illustrating how vertical blanking can be obtained by applying positive flyback pulses to the emitter of the video output transistor

torily apart from the vertical line and its attendant striations, it was fairly certain that its grid was coupling to chassis via the 10kΩ resistor and the 47kΩ resistor across the blanking diode. So these components should not be faulty. The blanking diode could have become short-circuit, but this seemed less likely than a fault in a resistor or capacitor. It occurred to him that the line output transformer winding might have become open-circuit.

Dick quickly put this frightening thought to the back of his mind and considered more cheerful probabilities. There were two components left: the 5,000pF capacitor and the 82kΩ resistor. One of these could be open-circuit.

He pulled his testmeter towards him, selected an ohms range and zeroed the meter. Consulting the service manual, he located the 82kΩ resistor on the board and connected the testmeter prods across it. The testmeter read approximately 82kΩ (Fig. 8(a).)

No luck so far.

Dick next selected a 5,000pF capacitor from a box of spares on his bench and temporarily soldered it across the capacitor in the receiver. (Fig. 8(b).) He switched it on and waited impatiently for the picture tube to warm up. The screen flickered into life, to reveal one of the Mexicans bashing the living daylights out of the other two.

The vertical line had disappeared.

Jubilantly, Dick turned up the brightness, and the picture was now as it should be. All that could be seen was the successive piling of two Mexican bodies on the floor as the argunentative one successfully pursued the ritualistic movements of karate, kung fu and plain skullduggery.

Dick happily switched off the receiver, removed the existing 5,000pF capacitor, fitted a new one and then switched the set on again. He looked anxiously to see if the vertical line reappeared, but it continued to be absent.

"Hey, Smithy."

No reply.

"Hey, Smithy!"

Still no reply.

"Hey, *Smithy*!",

At last, the Serviceman turned round.

"You were calling?"

"Ye gods," said Dick irritatedly, "I could have been lying here on the floor electrocuted and screaming my head off for all the attention you'd pay."

"Well, what's your problem now?"

"I've got no problem," replied Dick, allowing his annoyance to die down. "It's just that you were right about that line blanking circuit being faulty. The 5,000pF coupling capacitor to the line blanking diode had gone open."

"Good, good," responded Smithy. "It's nice to have snags like that which are easy to diagnose. These single-standard 625 line black and white TV's are probably the simplest jobs we handle nowadays, because they offer fault symptoms which are almost straight out of the text-book."

ANOTHER LINE

With which words, Smithy returned to his bench and his own television receiver. Dick quickly put the printed circuit board of his receiver back in position, screwed on the cabinet back, gave the set a final check on all the local channels, then carried it triumphantly to the "Repaired" rack. He turned to the "For Repair" rack and examined its contents. There seemed to be nothing else but TV sets today. Dubiously, he selected a rather battered dual-standard monochrome model, then returned with it to his bench and connected it to the mains and to the u.h.f. and v.h.f. aerials.

He switched it on, selected 625 lines, and waited for it to warm up. The set was dead. Experimentally, he turned over to 405 lines, to be immediately rewarded with both a picture and sound. And, although he now had fewer lines to occupy, there was the single victorious Mexican riding off

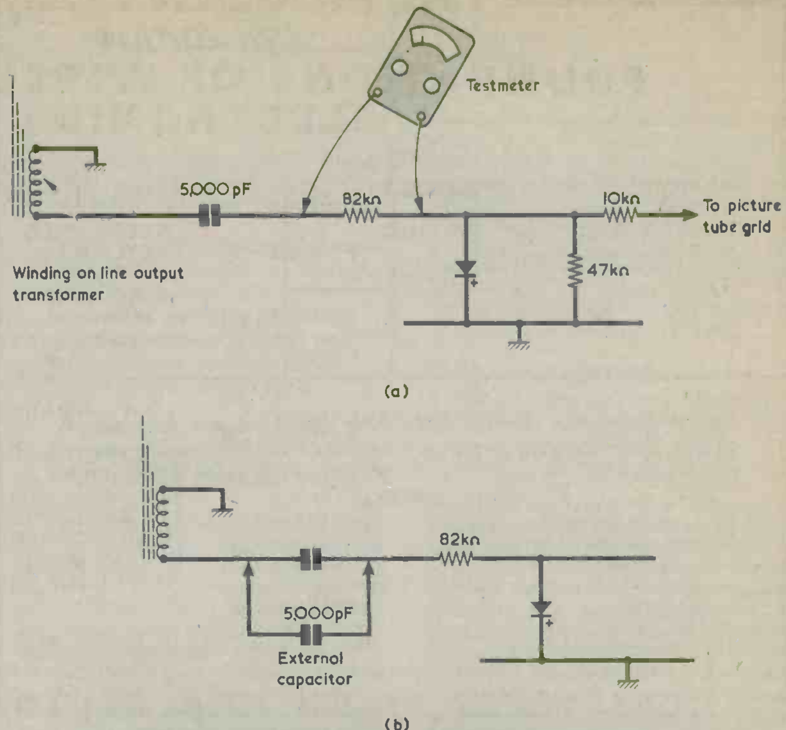


Fig. 8(a). Dick initially checked the resistance of the 82kΩ resistor in the line blanking circuit of his receiver

(b). He next bridged the capacitor in the circuit with an external 5,000pF capacitor

with the swag that he had wrested from his two partners in crime.

Just as the television scene flashed to the ambush awaiting the Mexican, a vertical line of bright individual circles appeared on the screen, about a third of the way from the left.

As Dick watched incredulously, the line jiggled uncertainly from side to side and then moved slowly to the right. It disappeared, and then reappeared at the left. Dick decided to waste no time on intermediate approaches.

"Hey, *Smithy*!"

"Dear, oh dear," came Smithy's voice from the other side of the workshop. "What on earth are you yelling about now?"

"I've got *another* vertical line," wailed Dick. "Only this time it's made up of flashes and it's moving all over the picture."

Smithy walked over, glanced quickly at Dick's receiver then returned to his own bench. There was the click of a switch and the vertical line on Dick's receiver disappeared.

"Blimey," said Dick, startled, "what did you do then?"

"I turned off the TV on my bench," replied Smithy. "It's another dual-standard job, and I also had it running on 405 lines, but tuned to a different channel."

"Then what caused the vertical line?"

"There must be a spot of e.h.t. corona in the line output stage of my set which appears during line flyback. Your set was picking it up, and since the corona appeared after each transmitted line it showed up as a vertical line of flashes."

"But why did the line keep moving sideways?"

"Because, my lad, the line frequencies in the two sets weren't exactly identical, and the position of the line on your screen varied according to the phase difference between them."

"Well, blow me, that's *something* to be thankful for. Still, it's the first time you've cleared a picture snag on my bench by turning off a set on yours!"

"Servicing," said Smithy philosophically, "is full of these little surprises. That's what keeps us on our toes."

With which little homily Smithy returned to his work, leaving Dick to determine why the set he'd selected didn't work on 625 lines. But, before switching back to the defunct u.h.f. channel, Dick allowed the Mexican on the screen to play out his last part. Riddled with bullets, the bank raider writhed into his final death-throes, surrounded by the sheriff, his deputies, the bank manager, the bank teller, the two other Mexicans and the bank manager's daughter (we missed the earlier bits where she appeared).

Which drives home yet a further homily. Crime, conducted carelessly, does not pay. ■

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7B6	.88	DK96	.70	EF91	.50	PCF801	.65	UF80	.41	OC82D	.14
7Y4	.80	DL92	.47	EF92	.60	PCF802	.50	UF85	.52	OC83	.26
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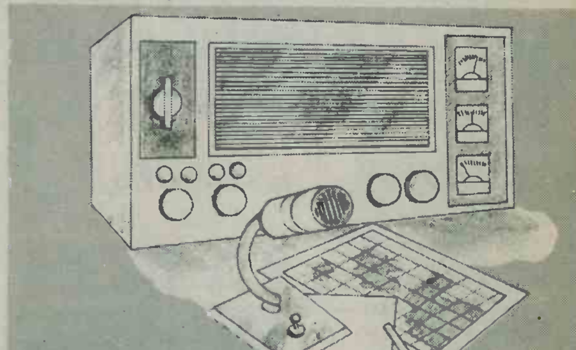

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(Continued from page 251)

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WANTED: *"Everyday Electronics"*, January 1975. Whole issue or copy of articles. Price ? John Hunt, 251 West Bruceton, Pittsburgh, PA 15236, U.S.A.

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(Continued on page 254)

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(Continued from page 253)

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(Continued on page 255)

SMALL ADVERTISEMENTS

(Continued from page 254)

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