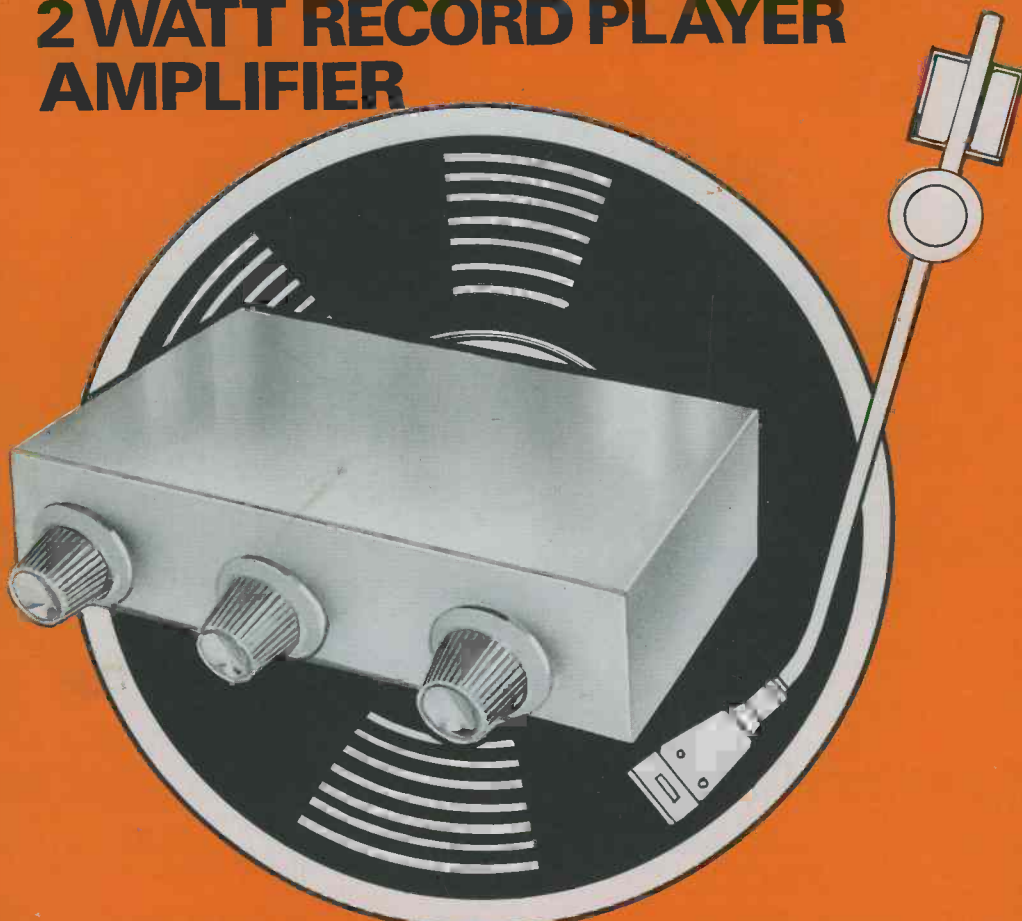


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	22p	22p	20p

Range 2. VCE. Min. 40. HFE Min 40

40 Watt	1-12	13-25	26-50
90 Watt	30p	28p	26p
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Printed circuit B9A - B7G	4p
Chassis B7 - B9G - B7G	4p
Shrouded chassis B7G - B9A	6p
B8A - B9A chassis - B12A tube	6p

TAG STRIP - 6 way 3p	WRIST COMPASS
9 way 5p Single 1p	30p with Needle Lock

1 1/4 glass fuses— 250 m/a or 3 amp (box of 12)	18p
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Brand new Boxed 6K7G	25p
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Bulgin, 5mm Jack plug and switched socket (pair)	30p
12 volt solenoid and plunger	40p
250 RPM 50 c/s locked frequency miniature mains motor	50p
200 OHM coil, 2 1/4" long, hollow centre	10p
Belling Lee white plastic surface coax outlet Box	30p
R.S. 12 way standard plug and shell	30p

SWITCHES

Pole	Way	Type	
4	2	Sub. Min. Slide	18p
6	2	Slide	20p
4	2	Lever Slide	15p
2	2	Slide	10p
1	3	+ off Sub. min. edge	10p
1	3	13 amp small rotary	12p
2	2	Locking with 2 to 3 keys	£1.50
2	1	2 Amp 250V A.C. rotary	16p
1	2	Toggle	10p
Wafer Rotary, all types			30p

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

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Closed 9 1/2", open 38 1/2"
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Up to 10V 25V 50V 75V 100V 250V 350V 500V MFD	
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 — —	
100 5p 6p 10p 12p 19p 20p — —	
250 9p 10p 11p 17p 28p — — —	
500 10p 11p 17p 24p 45p — — —	
1000 13p 17p 40p — — — —	
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 Solid tantalum	15p each
16-32/275, 32-32/275, 100-100/150 100-100/275 50-50/300	20p each
12,000/12, 32-32-50/300, 700/200, 100-100-100-150-150/320	50p each
20-20-20/350	40p each

INDICATORS

Arcoelectric green, takes M.E.S. bulb	20p
Bulgin D676 red, takes M.E.S. bulb	20p
12 volt red, small pushfit	20p
Mains neon, red, pushfit	18p

CAPACITOR GUIDE - maximum 500V

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

TRIMMERS, 20p each

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

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Strong grey plastic box same design as die cast ali 4 3/8" x 2 3/8" x 1 1/2" .. 40p

1" or 1 3/8" or 3/4" CAN CLIPS 2p

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36 ohm 25 watt + 79 ohm 9 watt 20p

TUNING CONDENSERS 50PF, 50p

2 Amp Suppression Choke .. 5p

3 x 2 1/2 x 1 1/4" } PAXOLINE 2p
4 5/8 x 1 1/2 x 1 1/8" } 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

RESISTORS

1/8 1/4 1/2 watt	1p
1 watt	2p
Up to 5 watt wire	10p
10 watt wire	
wound	12p
15 watt ..	14p

GEARED KNOB

Inner to Outer Ratio 8:1 .. 60p

Philips transformer, safety fused. In 200-220-240v. Out 240v 60ma + 6.3v 1a approx 2" x 2 1/2" x 2 1/2" £1.50

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Log or Lin carbon	18p
Switched	28p
Double Pots	45p
Double & switch	60p
Lin wirewound	25p

THERMISTORS

VA1008, VA1034, VA1039, VA1040, VA1055, VA1066, VA1082, VA1100 VA1077, 7p VA1005, VA1026 17p

PARMEKO P480

6000/55, 20 Henry .12A, potted choke 60p

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

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

AC107 .. 14p	BC159C, 157A .. 11p	BF184/5 .. 15p
AC127 .. 11p	BC178A/B .. 14p	BF194/5/6/7 .. 8p
AC128 .. 8p	BC179B .. 15p	BF194A .. 12p
ACY28 .. 18p	BC186/7 .. 20p	BF200 .. 20p
AD149 .. 40p	BC213L .. 11p	BF262/3 .. 23p
AD162 .. 33p	BC337/8 .. 15p	BF336 .. 25p
AF116/7 .. 13p	BC547/558A .. 12p	BFX29/30 .. 25p
AF124/6/7 .. 20p	BCY40 .. 60p	BFX84/88 .. 20p
AF139/178 .. 30p	BCY70/1/2 .. 12p	BFY50/1/2 .. 13p
AF180/1 .. 30p	BD112/3/5/6 .. 50p	BFY90 .. 50p
AF239 .. 20p	BD131 .. 24p	BR101 .. 30p
ASY27/73 .. 25p	BD132 .. 30p	BRY39 } Programmable Unijunction 38p
BC107A or B .. 11p	BD135 .. 28p	BRY56 } 38p
BC107/8/9 .. 9p	BD201/2/3/4 .. £1.00	BSV64 .. 40p
BC108A/B/109B/C .. 11p	BD232/4/5 .. 49p	BSX21 .. 18p
BC147/8/9 .. 7p	BDX77 .. £1.40	BU105/01 .. £1.50
BC147A/B .. 11p	BF115 .. 15p	CA3001 .. £1.00
BC148A/B, 9B/C .. 8p	BF167/173 .. 20p	CV7042 (OC41 OC44, ASY63) .. 10p
BC157/8/9 .. 9p	BF178/9 .. 25p	GET111 .. 40p
BC158A/B .. 11p	BF180/1/2/3 .. 22p	

BRIDGE RECTIFIERS

Amp	Volt RMS		Amp	Volt RMS	
1	1600	BYX10 .. 30p	2	30	LT120 .. 30p
1	140	OSH01-200 .. 30p	0.6	6-110	EC433 .. 30p
1.4	42	BY164 .. 35p	Encapsulated with built-in heat sink .. 15p		

1 AMP RECTIFIERS

IN4003	200 volt	5p
IN4004	400 volt	6p
IN4005	600 volt	6p
IN4006	800 volt	7p
IN4007	1,000 volt	7p

HIGH POWER RECTIFIERS

	Amp	Volt	
SR100	1.5	100	7p
SR400	1.5	400	8p
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	45p
BYX42-600	10	600	65p
BYX42-900	10	900	80p
BYX42-1200	10	1,200	95p
BYX46-300*	15	300	£2.00
BYX46-400*	15	400	£2.50
BYX46-500*	15	500	£2.75
BYX46-600*	15	600	£3.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
BYX52-1200	40	1,200	£2.50

*Avalanche type

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1" Terryclips chrome finish	4p
Cinch 10-way terminal block	15p
Pair of LA2407 Ferroxcor cores with adjuster	25p
Chrome Car Radio fascia	15p
Rubber Car Radio gasket	5p
DLI Pal Delayline	80p
Relay socket	10p
Take miniature 2PCO relay	
B7G or B9A valve can	2p
0-30, or 0-15, black pvc, 360° dial, silver digits, self adhesive, 4 1/4" dia.	10p

Amp	Volt RMS	
1	140	OSH01-200 .. 30p
1.4	42	BY164 .. 35p

OPTO ELECTRONICS

ORP12	44p	Photo transistor	
BPX40	65p	BPX29	£1.00
BPX42	£1.50	OCF71	35p
BPY10	£1.00	BIG L.E.D. 4 1/2 mm 2v 50mA max.	
BPY68	} £1.00	RED	15p
BPY69		ORANGE	} 18p
BPY77		GREEN	
		YELLOW	

F.E.T.'s

BFW10	45p
BSV79	£1.00
BSV80	90p
N. Channel	
BSV81 M.O.S.T.	90p
BFS28 Dual M.O.S.T.	92p
Wire ended glass neons 4p	
650 m/h 2amp. 2ohm chokes 60p	
Plastic, Transistor or Diode Holder 1p	
Transistor or Diode Pad 1p	
Holders or pads 50p per 100	

TO3 HEATSINK

Philips Iron Thermostat	15p
Bulgin 2-pin flat plug and socket	10p
McMurdo PP108 8 way edge plug	15p
Europelec HP1 TO3B individual 'curly' power transistor type. Ready drilled 20p	

Tested unmarked or marked ample lead ex new equipment

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

OC35	25p	2N1091	45p
SN7483	82p	2N1302	15p
TAA570	£1.20	2N2219	18p
TAD100	£1.00	2N2401 (ASY26-27)	20p
2G302	15p	2N2904/5/6/7	13p
2N393/MA393	30p	2N2907A	20p
2N706	8p	2N3053	14p
2N987	35p	2N3055 (992)	33p

Amp	Volt	THYRISTORS	
1	240	BTX18-200	50p
1	400	BTX18-300	65p
1	240	BTX30-200	40p
6.5	500	BT102-500R	80p
10	700	BT106	95p
15	500	BT107	£1.00
6.5	500	BT101-500R	90p
6.5	500	BT109-500R	90p
20	600	BTW92-600RM	£3.00
15	800	BTX95-800R Pulse Modulated	£10.00

OTHER DIODES

IN916	6p	BA182	24p
IN4148	4p	OA5/7/10	10p
BA145	14p	BZY88 Up to 33 volt	7p
Centercel	10p	BZX61 11 volt	17p
BZY61	10p	BR100 Diac.	20p

TRIACS

Amp	Volt	Plastic	
6	400		90p
25	900	BTX94-900	£5.00
25	1200	BTX94-1200	£7.00

CQY11B L.E.D. Infra red transmitter One fifth of trade	£1	WESTINGHOUSE 28TIO 30 AMP 1000VOLT THYRISTER WITHOUT NUT	£4
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PHOTO SILICON CONTROLLED SWITCH BPX66 PNP 10 amp	£1.00
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PAPER BLOCK CONDENSER

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

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

ZN 414 AM RADIO IC £1.00

8 way Cinch standard 0.15 pitch edge socket	20p
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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
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U.E.C.L. 20 way pin socket 2B60800A1R20	20p
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BELLING LEE L1354 TV Aerial diplexer	10p
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Philips electronic engineer kits add on series E1004, E1005 £1.00 each (parts worth more)

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GCS23S Crystal Stereo Cartridge	£1.00
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Rigid light blue nylon 6 1/2" with secret fitting screws	5p
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Rotor with neon indicator, as used in Seafarer, Pacific, Fairway depth finders	20p each
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Miniature Axial Lead Ferrite Choke formers	2p
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DEE PLUG

McMurdo DA15P 15 way chassis plug	15p
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Fairway 18009 Coax. socket	3p
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Nylon self locking 7/8"	2p
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CINCH 150

12 way edge socket	10p
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1lb Mixed nuts, bolts, washers etc.	35p
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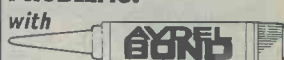
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The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S. The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

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- Distortion better than 0.1% at 1KHz
- Supply voltage 15-50 volts

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- Load — 3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm x 105mm x 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0.25%
LOAD IMPEDANCE	—	8-16 Ω
INPUT IMPEDANCE	f = 1KHz	100 k Ω
FREQUENCY RESPONSE —3dB	Po = 2 WATTS	50 Hz-25KHz
SENSITIVITY for RATED O/P	Ve = 25V. R1 = 8Ω f = 1KHz	75mV. RMS
DIMENSIONS	—	3" x 2 1/2" = 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power out for 2% T.H.D. (RL = 8Ω f = 1KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.

AUDIO AMPLIFIER MODULES

AL 10. 3 watts	£2.19
AL 20. 5 watts	£2.59
AL 30. 10 watts	£3.01

PRE-AMPLIFIERS

PA 12. (Use with AL10, AL20 & AL30)	£4.35
PA 100. (Use with AL60)	£13.15

TRANSFORMERS

T461 (Use with AL10)	£1.60 P. & P. 22p
T538 (Use with AL20, AL30)	£2.80 P. & P. 22p
BMT80 (Use with AL60)	£2.75 P. & P. 37p

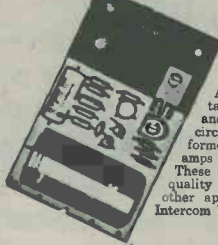
POWER SUPPLIES

PS 12. (Use with AL10, AL20, AL30)	95p
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FRONT PANELS FP 12 with Knobs	£1.00

PA12 PRE-AMPLIFIER SPECIFICATION

The PA12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with "Ceramic cartridges while the auxiliary input will suit most "Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 162mm x 84mm x 35mm.

Frequency response—20Hz-50KHz (-3dB)
Bass control—
Treble control—±12dB at 60Hz
*Input 1. Impedance—1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance—30 K ohms
Sensitivity 4mV



STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

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STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages. Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATIONS

Frequency Response 20Hz—20KHz ± 1dB
Harmonic Distortion better than 0.1%
Inputs: 1. Tape Head 3-25 mV into 50KΩ
2. Radio, Tuner 76 mV into 60KΩ
3. Magnetic P.U. 3 mV into 60KΩ
All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB. from 20Hz to 20KHz.
Base Control ± 15dB at 20Hz
Treble Control ± 15dB at 20KHz
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MK 60 AUDIO KIT

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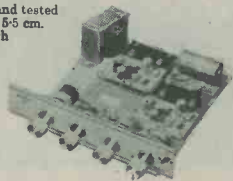
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The STEREO 20

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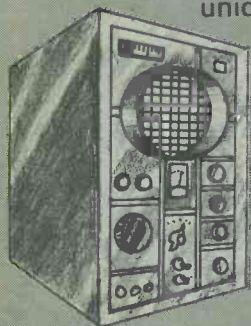
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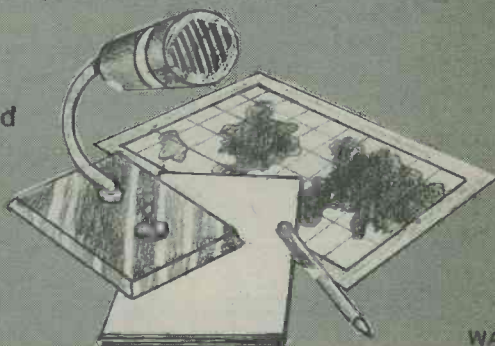
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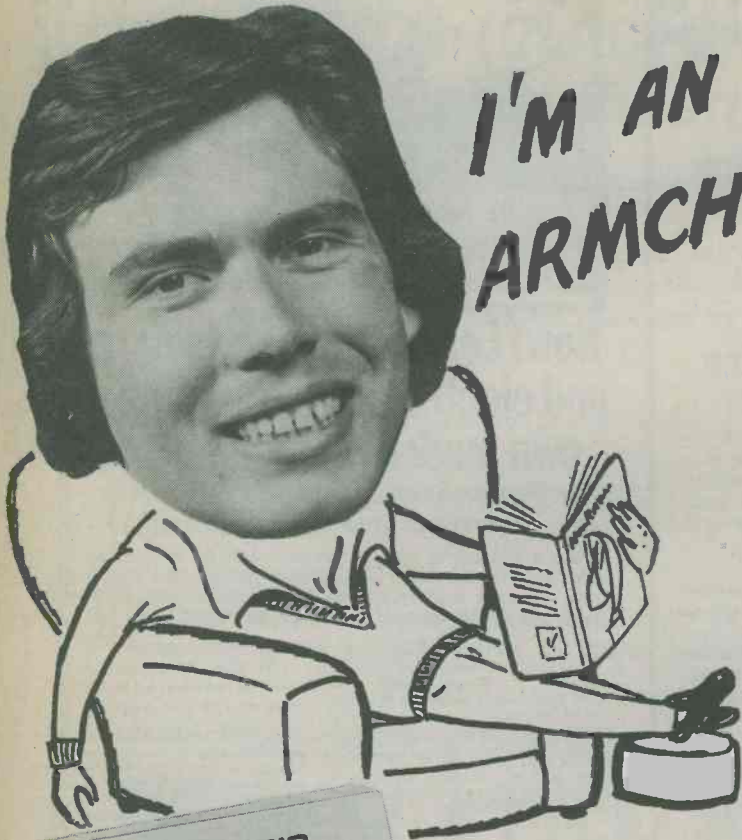
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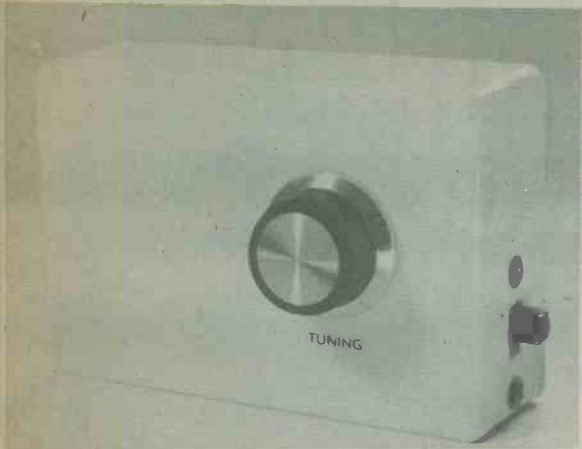
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MARCH ISSUE WILL BE
PUBLISHED ON 3rd MARCH



TWO TRANSISTOR RECEIVER

By A. P. Roberts

This is a simple design which provides earphone reception of the more powerful transmissions in the medium wave band. A simple modification enables the long wave Radio 2 signal to be picked up in areas where this is received at good strength.

THE RECEIVER DESCRIBED IN THIS ARTICLE COVERS THE medium wave band, and is suitable for the reception of local B.B.C. radio stations, as well as Radio Luxembourg and several other Continental stations after dark. The output is for a crystal earphone. Only two transistors are used in the circuit, one of these being a field effect type. Despite its very simple design the set is both sensitive and selective, and the output quality is good with a low noise level. An unusual feature of the circuit, in comparison with most t.r.f. designs, is that no stage of audio amplification is used.

The set is easy to construct, and should present little difficulty to anyone capable of preparing a printed circuit board. A simple modification is described which enables reception of Radio 2 on 1,500 metres long wave, and this modification requires only the addition of two capacitors and a switch.

CIRCUIT OPERATION

The circuit of the receiver is shown in Fig. 1. There are only two stages: an r.f. amplifier incorporating TR1, and a regenerative detector utilising TR2.

TR1 is connected in the grounded source mode, and is provided with a very stable off-set gate biasing system. R1 and R2 form a simple potential divider, and these produce a small positive voltage which is applied to the gate of TR1. The voltage across the source bias resistor, R4, is equal to the voltage at the junction of R1 and R2 plus the f.e.t. gate-source voltage. This gate-source voltage can vary widely between individual specimens of the f.e.t. specified but, by making the gate bias voltage fairly large in comparison, the voltage across the source resistor and thus the current drawn by the f.e.t. can be reliably set.

L1 is the aerial tuned winding, and is wound on a ferrite rod. It is via this winding that the gate bias voltage is fed to TR1. C1 bypasses one side of the aerial winding to the negative supply rail. VC1 is the tuning capacitor and is connected across L1. Since the f.e.t. has an extremely high input impedance there is no need to employ a low impedance coupling winding on the aerial rod, as would be the case if an ordinary bipolar transistor were used. TR1 causes very little loading on the aerial and so a relatively high level of selectivity is obtained, this being especially good when it is considered that only a single tuned circuit is used.

The output of TR1 is developed across the drain load resistor, R3, and is coupled to the base of TR2 via C4. TR2 is wired in the common emitter mode, and has R5 as base bias resistor and R6 as collector load. Due to a certain level of non-linearity in its operation it functions

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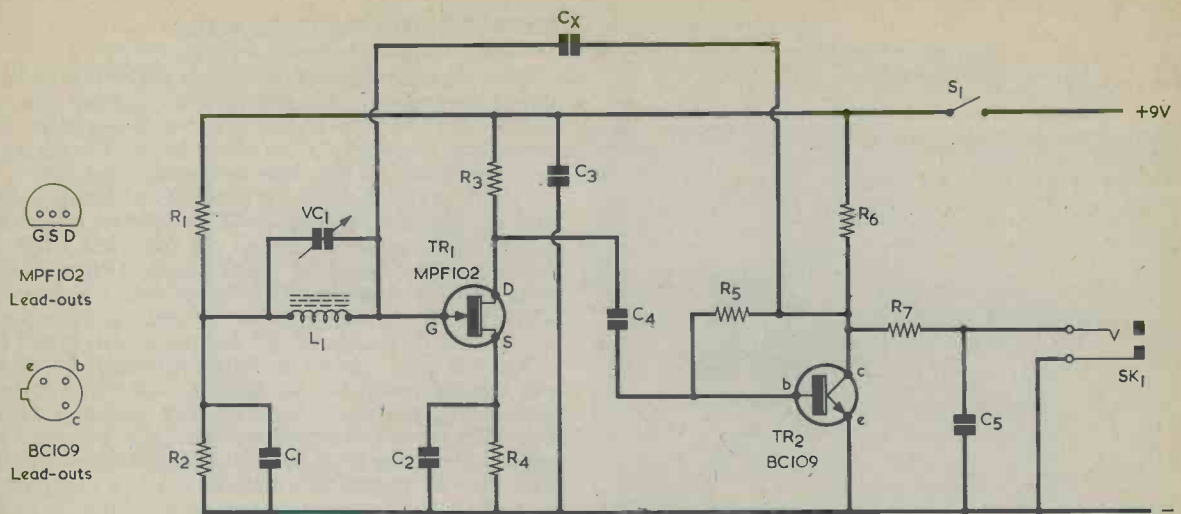


Fig. 1. The circuit of the two transistor receiver. The output is coupled to a crystal earphone

as a detector.

Normally, a capacitor would be connected directly between TR2 collector and the negative supply rail, so as to bypass the r.f. content of the signal at TR2 collector and thereby leave only the required audio signal. In the present circuit, however, R7 is interposed between the collector and the bypass capacitor, which is C5. In consequence no r.f. signal is present at the output jack socket SK1, whilst a small level of r.f. is still present at the collector of TR2. TR1 and TR2 each produce a 180° phase shift, and so the signals at TR1 gate and TR2 collector are in phase. The capacitor shown as CX can, therefore, introduce a pre-set level of

regeneration to the overall circuit. This regeneration will, of course, greatly increase the receiver sensitivity and selectivity.

The receiver audio output is available at SK1, into which a crystal earphone may be plugged. It is important to note that the receiver can only function successfully with a crystal earphone, and that a magnetic earphone must not be used.

C3 is an r.f. bypass capacitor across the supply rails. S1 is the on-off switch, a slide type being used in the prototype set. Power is obtained from a PP3 battery and, since the current consumption of the receiver is a mere 1.5mA or so, battery life is extremely prolonged.

COMPONENTS

Resistors

(All $\frac{1}{4}$ watt 10%)

R1	270k Ω
R2	27k Ω
R3	4.7k Ω
R4	4.7k Ω
R5	1.5M Ω
R6	5.6k Ω
R7	47 Ω

Capacitors

C1	0.022 μ F plastic foil, side wires
C2	0.022 μ F plastic foil, side wires
C3	0.033 μ F plastic foil
C4	0.47 μ F plastic foil, side wires
C5	0.022 μ F plastic foil, side wires
VC1	300-350pF variable (see text)

Inductor

L1	Ferrite aerial (see text)
----	---------------------------

Semiconductors

TR1	MPF102
TR2	BC109

Switch

S1	Slide switch (see text)
----	-------------------------

Socket

SK1	3.5mm jack socket
-----	-------------------

Miscellaneous

9 volt battery type PP3 (Ever Ready)
 Battery connector
 Crystal earphone with 3.5mm. jack plug
 Knob
 Ferrite rod, $3\frac{1}{2}$ by $\frac{5}{16}$ in. dia. (see text)
 Case (see text)
 Materials for printed circuit board.



This photograph of the receiver shows the earphone socket mounted on the case side opposite the on-off switch

FERRITE AERIAL

The ferrite rod aerial is home-made, and only requires the one winding. This consists of 70 turns of enamelled or double rayon covered copper wire close-wound on a $3\frac{1}{2}$ in. by $\frac{3}{8}$ in. ferrite rod. The wire gauge can be 30 to 34 s.w.g. The winding starts about one inch from one end of the rod, and then proceeds towards the centre. The winding ends are held in place by two lengths of insulating tape wound around the rod. The coil is made up as neatly as possible with all the turns in a single layer.

It may not be possible to obtain a rod of the specified length, but this can be cut from a longer piece as was the rod for the prototype. The rod is marked with a file at the appropriate point and the excess then carefully snapped off. Alternatively, a rod of a slightly different length can be used, and a suitable 4 in. by $\frac{3}{8}$ in. rod can be obtained from Henry's Radio, Ltd. Henry's Radio also list $\frac{3}{8}$ in. rods in lengths of 5 in., 6 in. and 8 in. if it is desired to obtain the $3\frac{1}{2}$ in. length from one of these.

The fixed capacitors and resistors are all standard types. C1, C2, C4 and C5 are specified as having side wires, and suitable capacitors are available from Home Radio. VC1 requires a value of the order of 300 to 350pF, and the component employed in the prototype receiver was a non-standard type having dimensions similar to those of the Jackson Bros. type 'O' or type '00' capacitors. Any of these capacitors may be used in the present circuit, as can any other variable air-spaced capacitor of the requisite value and having small dimensions. If the capacitor obtained has integral trimmers, these should be set for minimum capacitance.

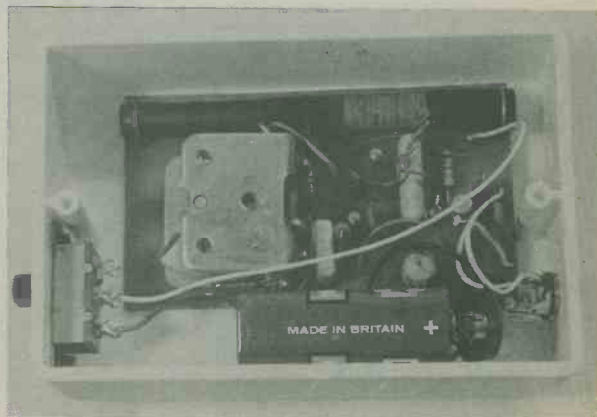
PRINTED CIRCUIT BOARD

With the exceptions of the battery and on-off switch, all the components are mounted on a small printed circuit board. Fig. 2 shows full-size diagrams of the copper and component sides of the board. The diagram showing the copper side may be traced, if desired.

VC1 is mounted on the printed circuit board in the position indicated, and the hole required for its spindle is marked out with the aid of the capacitor itself. It should be just clear of R1 and C1, and its body should be at least $\frac{1}{4}$ in. away from the ferrite rod. If a Jackson Bros. type 'O' or '00' capacitor is used, its front plate may be held direct against the printed board surface by drilling out a $\frac{5}{8}$ in. hole in the latter. Alternatively, a $\frac{1}{4}$ in. hole can be drilled for the spindle, and the capacitor front plate spaced off with spacing washers. These capacitors are secured by three 4BA bolts passing into tapped holes in the front plate, and the positions of these holes may be marked out with the aid of a paper template which has been pressed against the capacitor front plate. The mounting bolts must be short; if their ends pass inside the front plate of the capacitor they can damage the fixed or moving vanes.

The printed board is prepared in the normal way, and when marking out the pattern on the copper side of the board it is advisable to use an etch resist pen, as the pattern is fairly small and detailed and would be more difficult to prepare using any other method. When the board has been etched and drilled, including the drilling of the mounting hole or holes for VC1, the various components can be mounted and soldered into position.

The ferrite rod is held in position by two pieces of stout tinned copper wire at its ends. If the diagram showing the copper pattern is examined, it will be seen that there is a small circle of copper around each of the holes through which the pieces of wire pass. The wires can be soldered to these copper circles. The ends of the pieces of wire must be insulated from each other as, otherwise, short-circuited turns would be effectively applied around the ferrite rod and it would be prevented from functioning correctly. Each of the wires must be



A view inside the case. There is ample space for the small number of parts required

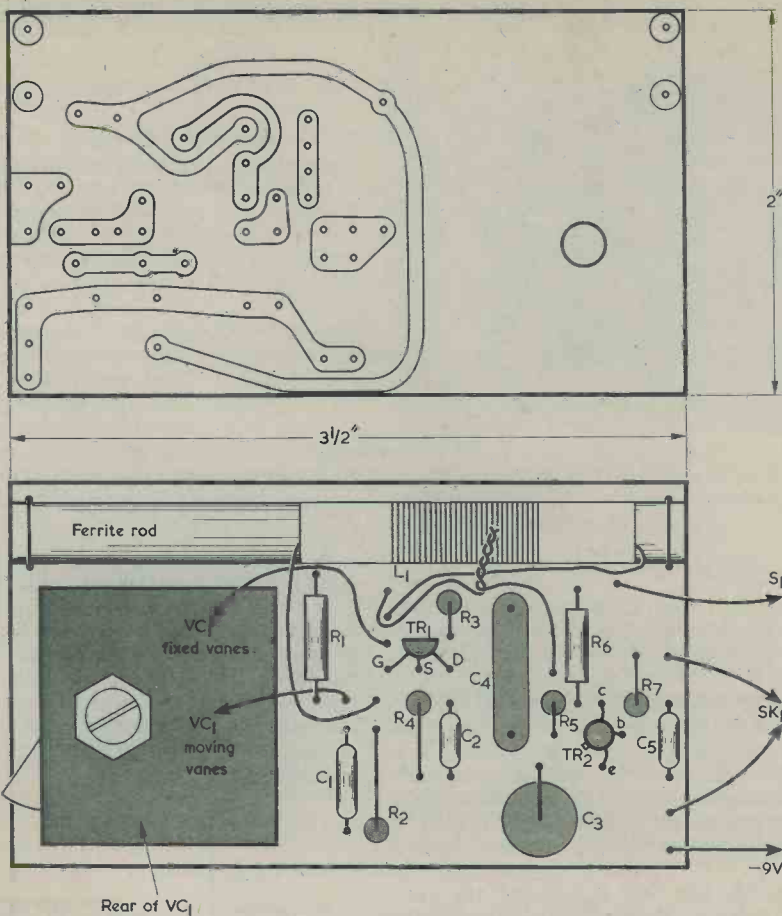


Fig. 2. The copper and component sides of the printed circuit board

pulled tight. The author found that the best method of doing this was to take a short length of the wire and solder one end of this at one of the holes in the board. The other end of the wire, after passing over the ferrite rod, was then passed through the other hole, and firmly pulled tight from the copper side of the board using a pair of pliers. This end was then soldered at its hole and the excess wire cut off with a pair of wire clippers.

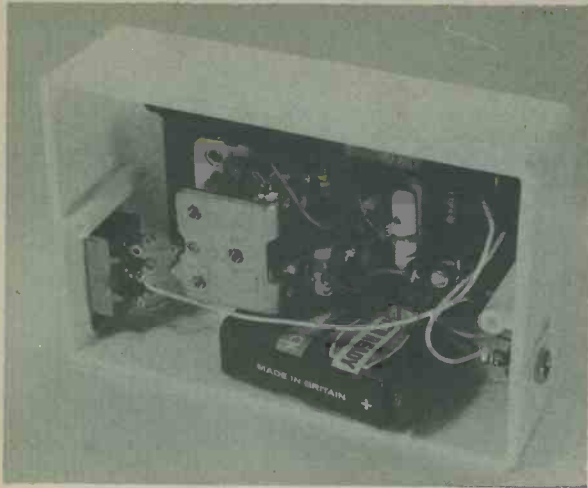
Capacitor CX consists of two lengths of single strand p.v.c. covered wire about 1½ in. long. These are twisted together as shown in the diagram.

To complete the panel the connections to VC1, and the external wiring to SK1, S1 and the battery connector can be carried out. The external leads should be long enough to reach the appropriate components comfortably. The only connection not shown in Fig. 2 is that between the positive battery clip and the tag of S1 which does not connect to the printed circuit board.

THE CASE

The prototype receiver was housed in a ready-made plastic case having internal dimensions of 2½ by 4½ by 1⅞ in. This is described as a 'Norman Rose Type PBI' case and is available from Trampus Electronics Ltd., 58-60 Grove Road, Windsor, Berks. Readers are advised to ensure that the case will accommodate the particular capacitor employed for VC1 before obtaining it. Any alternative non-metallic case of around the same dimensions can, of course, also be used. A suitable case could, again, be assembled with plywood.

The general layout inside the case can be seen from the photographs of the prototype receiver. The exact positioning of the parts is not critical. A standard size slide switch is used as the on-off switch in the prototype, but there is barely enough space for this and it would probably be found more convenient to employ a



Another view of the receiver components

miniature type. Make sure that the printed circuit board is positioned well towards the top of the case so that there is sufficient space beneath it to accommodate the battery.

If the case used by the author is employed there is little danger of cracking the plastic when drilling it, as it is made from a fairly soft and pliable material. It is rather awkward to drill, however, and so great care should be taken during this operation. The rectangular cut-out for the slide switch can be made with the aid of a sharp modelling knife, which easily penetrates the soft plastic.

When all the drilling has been completed, the parts can be mounted in the case. The author held the printed circuit board in position by the simple expedient of fitting a piece of foam plastic to the case lid underside which pressed down on the back of VC1 when the lid was fitted. A second piece of foam plastic can be used to similarly hold the battery in place. Suitable alternative means of securing the printed circuit board may be devised, if necessary.

TESTING

Now that the constructional work has been completed a battery can be connected, but the back of the case should not be fitted yet. The wires forming CX should only be partially and loosely twisted together at this stage. Plug a crystal earphone into the output socket and switch the set on.

It should be found that rotating the control knob of VC1 enables a few stations to be received, although perhaps only fairly weakly. Twisting the two wires which form CX more tightly together should improve performance up to a point. If they are twisted too tightly together the set will oscillate and proper reception will be impossible. Oscillation is heard as a whistle as the set is tuned over a station. For best results the two wires are twisted together as tightly as possible without the set breaking into oscillation at any setting of VC1. When this adjustment has been made the back of the case can be fitted, and the set is ready for use.

LONG WAVE RECEPTION

A simple modification which will allow reception of B.B.C. Radio 2 on the long wave band is shown in Fig. 3. It should be noted that this modification should only be carried out if the receiver is used in areas where there is good reception of the Radio 2 signal. A switch is added which, when closed, connects two capacitors in parallel across the tuned circuit, thus reducing its resonant frequency so that it can be tuned through that of Radio 2, i.e. 200kHz. When the switch is open the circuit operates as before.

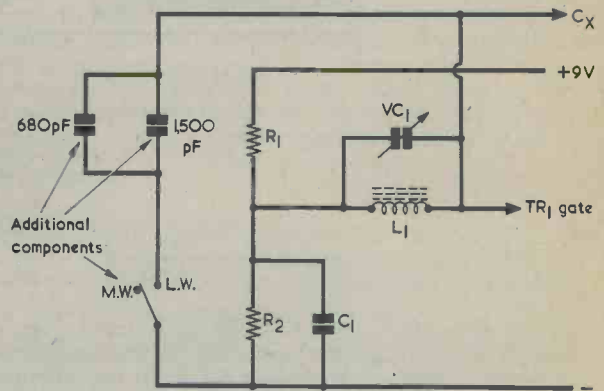


Fig. 3. A simple modification which enables the long wave Radio 2 signal to be received in areas of good signal strength

The values shown for the two capacitors are those which were found to be suitable with the prototype. The 680pF component may need to be replaced by one having a slightly different value with other receivers, due to slight differences between individual ferrite rod aeriels and the tolerances of the capacitors. The added capacitors may be silvered mica or ceramic.

There should be sufficient space in the case above S1 to take the extra switch. The two capacitors are wired between this and the fixed vanes tag of VC1.

RECENT PUBLICATIONS



RADIOISOTOPE EXPERIMENTS IN PHYSICS, CHEMISTRY AND BIOLOGY. By J. B. Dance. 246 pages, 215 x 140 mm. (8½ x 5½ in.) Published by Hutchinson Educational Ltd. Price £1.75.

This title is a considerably expanded and updated version of the author's 'Radioisotope Experiments for Schools and Colleges' which was first published by Pergamon Press in 1967. The main object of the previous and present works is to demonstrate that many safe and instructive experiments can be carried out using compounds of the naturally occurring radioisotopes together with a few sealed sources. Also included in the present book are experiments which show typical applications of unsealed isotopes in chemical and biological work. No sophisticated counting equipment is required and in most cases simple geiger counters or photographic emulsions are employed.

The first section of the book deals with fundamentals, radiation measurement, naturally occurring radioisotopes, health physics and practical considerations. These are then followed by the experiments, of which there are 77. After the experiments, some 21 pages are taken up by sample examination questions, these being followed by appendices, references and the index. Included among the appendices is a summary of the statutory requirements which need to be observed in the handling and transportation of radioisotopes in the U.K.

The volume forms a very helpful textbook for GCE and Advanced level students. The experiments are described in an economic and concise style, and all the essential practical details are dealt with in full. Diagrams are drawn clearly and there are 8 pages of photographs.

RADIO-ELECTRONICS HOBBY PROJECTS. 198 pages, 215 x 130 mm. (8½ x 5¼ in.) Published by Foulsham-Tab Limited. Price £1.45.

This book, which is in the Foulsham-Tab list of American texts with introductory chapters for U.K. readers, is made up of projects which originally appeared in the American journal *Radio-Electronics*. As such, they can be looked upon as having a reliability which has been proven by previous magazine publication. The projects are divided into five broad categories: stereo and hi-fi, electronic musical devices, automobile ancillaries, projects for the home, and test and measuring equipment.

All the active devices used in the 33 projects which appear in the book are solid state, being transistors or integrated circuits. The projects will hold most appeal for the more experienced constructor, who will be more capable of finding equivalents for those components and transistors which are not directly available in this country. The book also provides a useful source of ideas for the experimenter, as well as illustrating constructional thinking on the other side of the Atlantic.

ACOUSTIC TECHNIQUES FOR HOME AND STUDIO. By F. Alton Everest. 230 pages, 215 x 130 mm. (8½ x 5¼ in.) Published by Foulsham-Tab Limited. Price £1.50.

Another title in the Foulsham-Tab series of American texts, 'Acoustic Techniques for Home and Studio' deals with the acoustic treatment of rooms and studios intended both for the reproduction of sound and for the recording, or broadcast, of sound.

The book describes in detail the effects of reverberation and sound reflection, and discusses the various treatments needed to overcome unwanted resonances and similar undesirable characteristics. A wide range of techniques can be employed here, these including contour shaping of walls and ceiling, the use of materials having different absorption characteristics and the fitting of polycylindrical diffusers, or 'polys'. Also dealt with is the exclusion of external noise, and the author discusses, further, economical solutions to acoustic problems which have been employed by small low-budget broadcasting stations.

This is a most interesting book on a subject which receives infrequent attention. It has particular appeal for the reader who is interested in the recording or broadcasting of high fidelity sound as well as for the general hi-fi enthusiast.

LEARN ELECTRONICS BY BUILDING EASY-TO-BUILD PROJECTS. By John Schroeder. 214 pages, 215 x 130 mm. (8½ x 5¼ in.) Published by Foulsham-Tab Limited. Price £1.35.

Written for the beginner, this book is intended to show how experience with elementary electronics may be gained by the assembly of simple working circuits. The book commences with a general review of radio as a hobby then carries on to tools and soldering. Further chapters discuss frequency and wavelength, resistors, capacitors, coils, resonant circuits, transformers, component symbols and circuit diagrams. The subsequent chapters are concerned mainly with the constructional projects, these including a crystal receiver, 2 and 4-transistor amplifiers, a regenerative valve receiver, a regenerative transistor receiver and a pocket transistor receiver.

The book can be readily followed by anyone having a basic knowledge of electricity and the ability to undertake simple constructional work.

CURRENT LIMITING POWER SUPPLY

By G. A. French

Suggested Circuit 291

STABILIZED POWER SUPPLY DESIGNS appear fairly frequently in the pages of the technical press, and range from elementary circuits to quite complicated assemblies offering a wide variety of facilities. The design to be described in this article is reasonably simple and will be found especially suitable for amateur experimental work. The output voltage is continuously variable from zero to about 12.5 volts and the output current can be limited at any level between 20 and 150mA. This last feature offers a particular advantage for experimental work since it ensures that the current flowing in the supplied equipment cannot exceed the limiting value. Thus, components in the supplied circuit are automatically protected from excessive current flow if there is an accident, an error or a fault which would otherwise cause damage. If desired, the limiting current range can be altered to 30 to 200mA by changing the value of one component in the supply. The voltage regulation is reasonably good and should be more than adequate for most amateur experimental work.

CIRCUIT DIAGRAM

The circuit of the supply appears in Fig. 1, and it will be noted that the rectifying and voltage adjustment section follows conventional practice. The 17 volt secondary of transformer T1 couples to the bridge rectifier given by D1 to D4, whereupon a rectified voltage appears across the reservoir capacitor C1. This rectified voltage is applied to R1 and ZD1 in series, causing a stabilized voltage of about 15 volts to appear across the zener diode. The voltage control potentiometer, VR1, is connected across ZD1 and its slider can be adjusted to tap off any potential, with respect to the lower circuit rail, between zero and the full

zener voltage. VR1 slider connects to the input base of the Darlington pair given by TR1 and TR2. These offer a considerable amount of current gain and a positive output with a high current capability is available at the emitter of TR2. The voltage at this positive output point is equal to the voltage tapped off by VR1 slider less about 1.2 volts dropped in the base-emitter junctions of the two transistors. Capacitor C2, between the slider of VR1 and the lower circuit rail, smooths out any ripple that may still be present across the zener diode. It also enables the positive output point to be at a low a.c. impedance with respect to the lower rail.

The section of the circuit so far described follows standard practice for a simple variable voltage power supply. The circuitry around TR3 and TR4 provides the current limiting facility, and this is not so conventional. Essentially, TR3 and TR4 form a constant current generator. A stabilized voltage of about 1.7 volts is formed across the forward biased light-emitting diode, LED1, and this voltage is applied to the base of the germanium transistor TR3. A voltage drop of around 0.1 volt appears in its base-emitter junction, causing a voltage of some 1.6 volts to be applied to the base of TR4. TR4 is a silicon transistor, with a 0.6 volt drop in its base-emitter junction, whereupon about 1 volt appears across the two potentiometers VR2 and VR3.

The collector current of TR4 cannot be greater than its emitter current and, since the emitter voltage is fixed at about 1 volt, the emitter current can be adjusted by varying the values of VR2 and VR3. The collector current of TR4 flows in the supplied equipment and, if this current is lower than the limiting emitter current value in VR2 and VR3, TR4 simply functions as a hard-on transistor with a drop of around 0.2

volt across its emitter and collector. If TR4 collector current, and hence the power supply output current, rises to become nearly equal to the limiting emitter current value the voltage across TR4 increases, thereby causing less output voltage to be available from the power supply. Any attempt to increase the output current merely results in a reduced power supply output voltage. If the output terminals are short-circuited the collector of TR4 takes up the same potential as the emitter of TR2 and the current which flows through the short-circuit is the limiting value set up by VR2 and VR3.

Besides serving as a voltage stabilizing device, LED1 also functions as an indicator that the power supply is switched on. It can be mounted on the front panel of the supply, and it gives a bright red glow when the mains is applied and on-off switch S1 is closed.

Connected across the output terminals is resistor R4. The function of this resistor is simply that of drawing a few milliamps when no current, or a very low current, is otherwise taken from the power supply. This improves regulation at these current levels.

When the unit has been assembled, VR2 is set up such that a limiting output current of 150mA is given when VR3 inserts minimum resistance into circuit. Lower values of limiting current may then be selected by suitable adjustment of VR3, the limiting current value decreasing as this potentiometer inserts more and more resistance into circuit. If TR4 emitter is at the theoretically assumed level of 1 volt, the lowest limiting current of 20mA is given by an emitter resistance of 50Ω. In practice it was found that VR3 had to insert some 60 to 70Ω into circuit to obtain a 20mA limiting current, and for this reason a 100Ω potentiometer is specified for VR3. This enables the 20mA setting to be passed through as the potentiometer spindle is rotated.

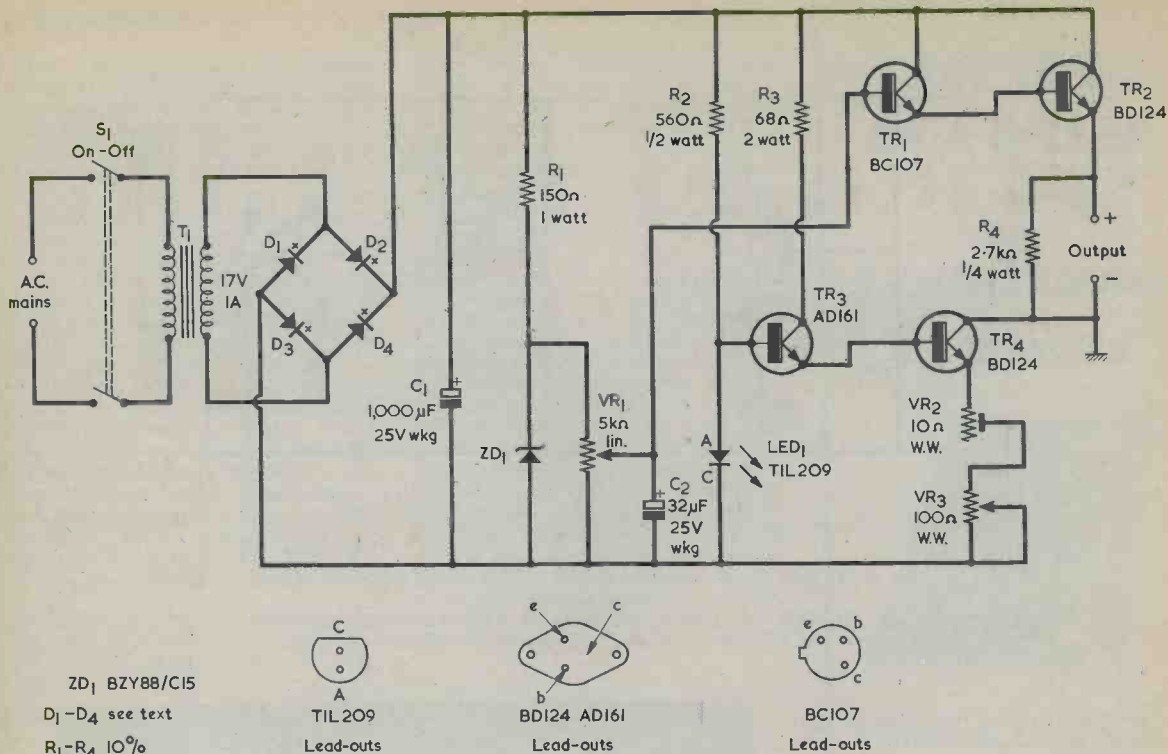


Fig. 1. Complete circuit of the current limiting power supply. Output voltage is controlled by VR1 and limiting current level by VR3

It is possible to calibrate VR3 in terms of limiting current. Also, VR1 may be calibrated in terms of approximate output voltage. In consequence, the power supply can, when assembled, be very quickly set up to produce any desired output voltage and limiting output current within its range, either before or during the time it is connected to the supplied equipment.

If needed, an electrolytic capacitor of any value up to 1,000µF may be connected across the output terminals. A high value capacitor will result in a rather sluggish change in output voltage as VR1 is adjusted, but this effect does not represent a serious disadvantage. With a large value capacitor across the output terminals it is possible for a high surge current to flow from the capacitor should there be a sudden increase in current demand by the supplied equipment. This surge current does not flow from the power supply itself, the output current of which cannot exceed the limiting value.

A chassis connection to the supply is made at the negative output terminal. No other points in the supply are connected to chassis.

FURTHER FACTORS

A number of further factors may now be considered in detail.

As already stated, the positive output point of the supply has a potential equal to that on the slider of VR1 less the voltage drop in the base-emitter junctions of TR1 and TR2. In consequence, it is evident that there will be no positive output voltage until the slider of VR1 taps off at least 1.2 volts from the lower end of its track. Also, the negative output terminal of the supply unit is about 1.2 volts positive of the lower circuit rail due to the circuit around TR4, with the result that VR1 slider has to advance to a setting which taps off about 2.4 volts before an output voltage becomes available at the two output terminals. Because of these two points, some 15% of the total adjustment available in VR1 is 'wasted', since the first 15% of spindle rotation corresponds to zero output voltage. This fact causes no practical difficulties, as the remaining 85% of total slider rotation is still more than adequate to allow precise resolution of the output voltage. Nevertheless, if it is desired to ensure that

nearly all the adjustment in VR1 causes a useful voltage change, a 750Ω 1/4 watt fixed resistor may be inserted between the lower end of VR1 track and the lower circuit rail.

There are also several points outstanding concerning the current limiting section of the supply, and readers who are familiar with constant current circuits may be curious about the inclusion of TR3 between the stabilized voltage point given by LED1 and the base of TR4.

An explanation can be given here with the aid of Figs.2(a) and (b). Fig. 2(a) shows a circuit in which TR4 base is coupled directly to the light-emitting diode, and this represents the usual form taken up by a bipolar transistor when it is employed as a constant current generator. The circuit works quite satisfactorily as a current limiting device, and the constant current from the collector is very nearly equal to the emitter current which is set up by VR2 and VR3.

For the present application, however, the arrangement of Fig. 2(a) suffers from a disadvantage. When the collector current is lower than the con-

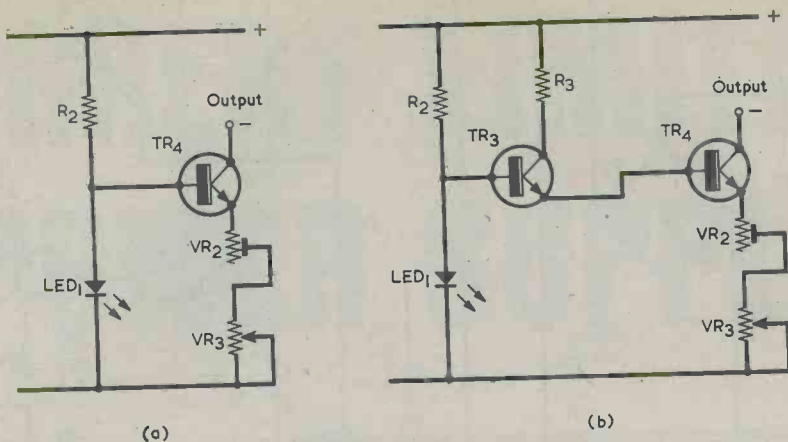


Fig. 2 (a). The current limiting circuit which would be set up if TR3 were omitted
 (b). The inclusion of TR3 ensures that the collector potential of TR4 does not vary with different collector currents

stant current limiting value there is insufficient current available to the transistor to maintain the required voltage across VR2 and VR3. In consequence there is an increase in the current flowing into the base of TR4 via R2. The extreme instance occurs when there is zero collector current, since current from R2 then flows directly into VR2 and VR3 by way of the transistor base-emitter junction, which is now acting as a forward biased diode. As a result there is an increased voltage drop across R2, a reduced voltage at TR4 base and very little current in the light-emitting diode. Further, the voltage at the emitter falls, as also does the voltage at the transistor collector. The overall effect is that the collector goes negative as collector current decreases or, conversely, the collector goes positive as collector current increases. In the present application the collector of TR4 is also the negative output terminal of the power supply, and it needs to be held at a constant potential for all output currents from zero up to nearly the full limiting current. With the circuit of Fig. 2(a) the collector of TR4 goes positive as output current, below the limiting value, increases, and the result is a worsening of the overall voltage regulation performance of the power supply.

The problem is overcome by inserting TR3 between the i.e.d. and TR4, as shown in Fig. 2(b). TR3 is a power transistor and its function is to maintain the required full current in VR2 and VR3 at all times. When TR4 col-

lector current is high, the output current from TR3 emitter into TR4 base is merely that needed to maintain the collector current in TR4. When TR4 collector current is low an increased current flows from TR3 emitter via the base-emitter junction of TR4 into VR2 and VR3, whereupon the voltage across these two components, and in consequence that at the collector of TR4, remains unchanged. At the same time, the maximum current drawn from R2 by TR3 base still cannot exceed the maximum emitter current in TR3 divided by the current gain of this transistor.

Resistor R3 is a current limiting resistor which prevents needless power dissipation in TR3. If VR2 and VR3 are set up for a limiting current of 150mA and zero current flows in TR4 collector, then 150mA flows from TR3 emitter into the base-emitter junction of TR4. R3 has a value of 68Ω and the current of 150mA causes a voltage of 10 volts to be dropped across it. The voltage remaining for TR3 is more than adequate for this transistor to function as an emitter follower. The value specified for R3 is satisfactory also if it is desired to have a maximum limiting current of 200 instead of 150mA, this being the next outstanding point to be discussed. TR3 is germanium instead of silicon, incidentally, because the high reverse base-emitter voltage rating of a germanium transistor prevents possible problems at switch-off when a high value electrolytic capacitor is connected across the supply unit output terminals.

The maximum limiting output current can be increased to 200mA by employing a 68Ω wire-wound potentiometer for VR3 instead of the 100Ω component shown in Fig. 1. Since the maximum limiting current is given when VR3 inserts *minimum* resistance into circuit it would appear that its maximum resistance value cannot affect the matter, but what has to be taken into account here is the current which the potentiometer itself has to pass. Virtually all the wire-wound potentiometers available on the U.K. home constructor market are rated at 3 watts for the entire track, and this limits maximum current over any part of the track to 170mA for a 100Ω component and 210mA for a 68Ω component. Employing a 68Ω potentiometer for VR3 will result in the minimum limiting current which can be conveniently obtained being of the order of 30mA. If, however, a 100Ω wire-wound potentiometer with a rating of 5 watts or more can be obtained this may be employed for VR3, whereupon the maximum limiting current rating can extend to 200mA whilst the minimum current rating remains at 20mA. Suitable 3 watt potentiometers in both 100Ω and 68Ω are available from Home Radio. VR2 is a small pre-set wire-wound potentiometer and can have a rating of 1 watt or more. It should be added that the circuit, in its present simple form, is not suitable for the provision of maximum limiting currents which are much higher than 200mA.

COMPONENTS

The components are all readily obtainable, and the two wire-wound potentiometers have already been dealt with. The voltage control, VR1, can be a standard size carbon track potentiometer. Long-term performance will probably be improved if a 'moulded track' or wire-wound potentiometer is used here.

T1 is a small battery charging transformer having a secondary rated at around 17 volts at 1 amp. Diodes D1 to D4 were 2 amp silicon rectifiers in a metal encapsulation. They may have a p.i.v. rating of 100 volts or more.

Assuming a 200mA maximum output, the maximum possible dissipation in TR2 approaches 4 watts, whilst maximum dissipation in TR3 and TR4 is 1 watt and 2.5 watts respectively. All three transistors need to be mounted on heat sinks. A suitable sink for TR2 would be a flat metal plate about 4 in by 4 in, whilst those for TR4 and TR3 can be proportionately smaller. If a

zero to about 12.5 volts by adjustment of VR1. Finally set VR1 for maximum output voltage and switch off again. Connect a testmeter switched to read 150mA or 200mA, according to the desired output current, across the output terminals and switch on again. A low current of around 10 to 30mA will be indicated. Slowly adjust VR3 until it is at the point where it inserts minimum resistance into circuit. This adjustment should cause the output current to gradually increase, but it will still be below the maximum level. Then carefully adjust VR2 until the desired maximum current figure is obtained. Great care must be taken to ensure that VR2 does not insert too low a resistance into circuit as the output current will then be excessive. As soon as VR2 has been set up it should be left alone and all subsequent current adjustments carried out by VR3 only. This potentiometer may be calibrated in terms of the current indicated by the meter. The current reading meter is then disconnected and a voltmeter connected in its place, allowing VR1 to be calibrated in terms of output voltage.

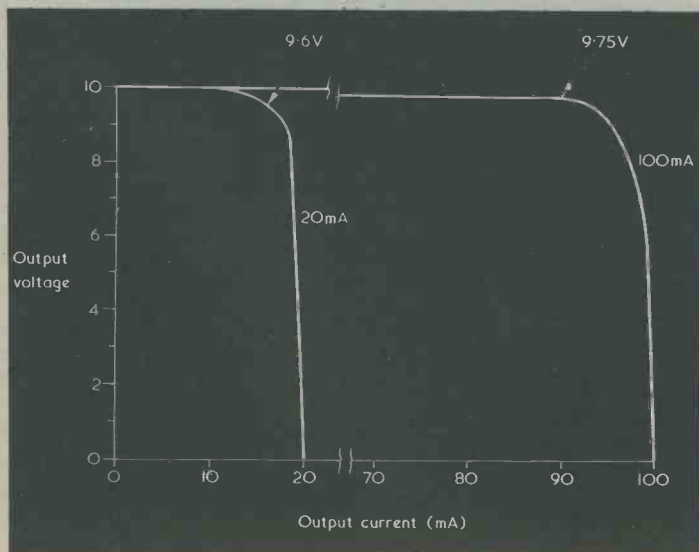


Fig. 3. Curves showing output voltage against output current for limiting current levels of 20mA and 100mA

metal chassis is employed, TR4 can be bolted directly to this, the chassis acting as the heat sink.

When the power supply has been constructed it becomes necessary to set up VR2 and to calibrate VR3 and VR1. Initially adjust VR2 and VR3 to insert maximum resistance into circuit, connect a voltmeter across the output terminals and switch on. It should be possible to obtain output voltages from

FEBRUARY 1975

Fig. 3 shows typical regulation curves for the unit. Both curves in this diagram are for a 10 volt output, one being for a limiting current adjustment of 20mA and the other for a limiting current adjustment of 100 mA. As can be seen, the fall in voltage as the limiting current is approached is quite rapid and in neither instance is the limiting current exceeded.

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Groovac II, the latest version of their unique vacuum record cleaner, is now available from R.I. Audio, of Kernick Road, Penryn, Cornwall. It is more efficient, has even better tracking performance and fits every type of turntable.

Vacuum cleaning is the most effective way of removing the fine dust particles which accumulate at the bottom of record grooves. It is these fine dust particles which cause record and stylus wear, and which generate spurious audible clicks etc. Just as the vacuum cleaner has replaced the broom in the home and elsewhere, so vacuum cleaning is now replacing brush cleaning for records.

The Groovac consists of an arm, similar in appearance and operation to a pick-up arm, together with a suction enclosure. The arm mounts magnetically or by adhesive pad onto the motor board and is connected by light tubing to the suction enclosure. The enclosure can be situated beside the record player or a short distance away. In operation the Groovac arm tracks inwards and removes dust from a band of grooves which includes the track in which the stylus is running.

An anti-skating device has been incorporated into the arm to ensure correct tracking at the very low tracking force of 0.6 gram. This low tracking force permits the use of fine cleaning nozzle hairs which penetrate to the bottom of record grooves, and achieves an almost immeasurable reduction in turntable speed.

Price £11.90 plus VAT (95p): Postage and packing 65p.

HEADPHONES TO PREVENT DEAFNESS

Workpeople sometimes think they're getting used to the noise of surrounding plant or machinery but in fact they are going slowly deaf under the battering of their eardrums. But even when they know the danger they are hard to persuade to wear officially-provided ear-defenders. Now this may change - there is a defender with a built-in persuader, as BBC World Service industrial health correspondent reported. Many workpeople, he said, don't like the feeling of isolation they get when the noise from their surroundings is muffled by ear-defenders.

One way to remove this sense of isolation and at the same time give a person a positive incentive to wear ear-defenders is to turn the defenders into headphones through which music is played.

But a headphone plugged into a wall socket in effect tethers a person to the spot, which can be dangerous as well as a nuisance. The right answer is wire-less transmission of the music to the headphones, and this is the new ear-defender system that has just been launched by the British firm Rediffusion Reditune Ltd.

Anyone who does not want the "piped" music at any time can switch it off with a control knob on one of the earpieces. He can use the same knob to control the volume of the music too.

The defenders have been developed for the company by a former BBC development engineer, Barry Pyatt. He has adapted a commercial type of ear-defender, trademarked Amplivox Sonogard, of the sort used to protect workers' hearing against noise on aerodrome runways.

This may make the defender seem almost too impregnable, but in fact the wearer can hear what is said to him by a person nearby. Tests have shown that the loss of understanding of speech with music in one ear only is much less than with music in both ears.

Radio transmission to the headphones is by means of an induction loop.

TV FAULT FINDING

We have recently published an extensively revised, and enlarged, edition of one of our most popular data books.

TV Fault Finding for 405/625 lines is now in its fifth revised edition, after numerous reprintings. This latest edition has been brought up to date by J. R. Davies, Technical Editor of this magazine.

The book contains more than 100 illustrations, including 60 photographs of a television screen after the appropriate faults have been deliberately introduced. It also contains a valuable comprehensive Fault Finding Guide, cross-referenced to methods of fault rectification described at greater length in the text.

At 132 pages for 90p, it is marvellous value - copies by post £1.00.

COMMENT

AMATEUR RADIO NEWS SERVICE

The Amateur Radio News Service was founded some years ago to fill a void in amateur radio in that there was no worthwhile organisation which sought to create co-operation between the various club paper editors and the public relations people working towards the better understanding of the place of amateur radio in society.

The ARNS has two basic services: Publications and Public Relations. There is a Vice-President for each of these divisions. The ARNS philosophy is that the backbone of amateur radio is the radio club and the most successful clubs are those having a successful club paper.

In the publications field, ARNS exists to aid and assist amateur radio newspaper editors in any manner possible to improve their publication, whether it be from the purely technical viewpoint or the material itself. Newcomers to editing should find the service invaluable in solving problems.

ARNS members derive benefits including a copy of the monthly *Bulletin*, a 20-page offset printed periodical, mailed directly from the printer in Kansas around the 10th of each month.

Details from: N. A. S. Fitch, G3FPK, 40 Eskdale Gardens, Purley, Surrey.

MARCONI WINS CONTRACT FOR SATELLITE EARTH STATIONS

Marconi Communication Systems Limited, a GEC-Marconi Electronics company, has been awarded contracts by the British Post Office and Cable and Wireless Limited worth nearly £1 million which include the provision of equipment to two new satellite earth stations being built in Fiji and Dubai, and to increase the traffic capacity of six other stations already in service.

The contract from the British Post Office is for equipment to increase the traffic capacity of the three satellite earth station terminals at Goonhilly in Cornwall. Marconi is also to increase the capacity of the Cable and Wireless terminals at Hong Kong and Bahrain and, under a contract worth nearly £½ million, will provide microwave receiver chains, modulators and transmitters for the new Cable and Wireless terminals in Fiji and Dubai.

COVER PRICE INCREASE

We regret that, because of continuing substantial increases in costs, the cover price of this magazine will be increased to 30p commencing with next month's issue. The new price will enable us to continue our present standards and maintain our reputation for reliability.

FEBURURY 1975

8 TRACK PLAYER AND CAR RADIO



Radiomobile Limited, of North Circular Road, London, NW2, announce another addition to their range of equipment. The Radiomobile 133SR stereo 8 car tape player and radio.

The new Radiomobile 133SR is most attractively styled and is manufactured to Radiomobile's design specification by the same Company who produce the very popular 102S 8 track player.

There is full manual tuning on both long and medium waves, tone control for both radio and tape, balance control for optimum speaker settings for the stereo tape. Special features include a repeat button for a chosen tape programme and coloured programme indicator panel.

The Radiomobile 133SR with its compact size of 7" x 2" x 6½" is designed for in-dash or under-shelf fitting and like ALL Radiomobile players is supplied complete with its own installation kit and two speakers.

The recommended retail price of the 133SR is £62.50 plus VAT.



"Dad, Mum was ever so surprised I've made her a reading lamp out of the colour TV!"

SN 7400

OSCILLATORS



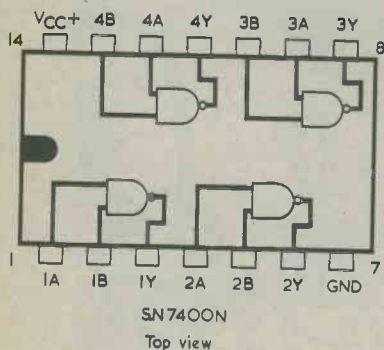
When provided with the requisite input bias, each of the gates in an SN7400 integrated circuit is capable of functioning as an LC controlled oscillator. Circuit configurations are described here for the benefit of the more experienced constructor who is able to obtain or wind suitable coils.

By D. F. W. Featherstone

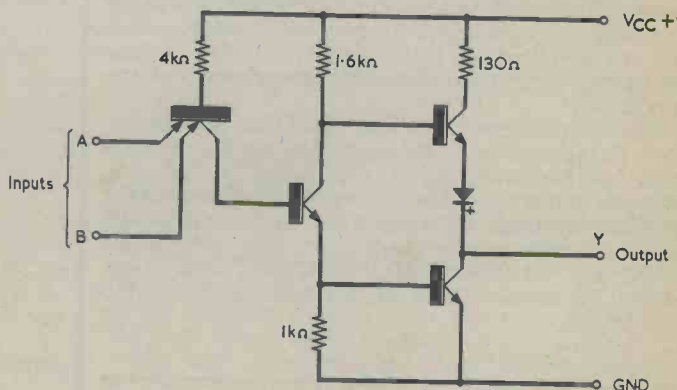
THE SN7400 IS WELL KNOWN AS A VERY USEFUL DIGITAL integrated circuit which is easily obtained at low cost. It is a quad 2-input NAND gate and has been described in earlier issues of this journal. To remind readers, Fig. 1(a) shows the pin layout and the connections to the four gates, whilst Fig. 1(b) gives the internal circuit for one gate.

COMPACT OSCILLATOR

Although the SN7400 has many uses in logic applications, for which of course it was designed, it may not be appreciated that it can also be used as a very compact oscillator requiring very few external components. In this way one SN7400 can provide four separate oscillators.



(a)



(b)

Fig. 1 (a). Pin layout and internal connections of the SN7400 integrated circuit
(b). The circuit of one of the gates

For this application a NAND gate is wired as an inverter, that is with both inputs connected together. The basic circuit is shown in Fig. 2.

It will be seen that as the output and input are in anti-phase a centre-tapped tuned coil is employed in conjunction with a parallel capacitor to determine the frequency of operation, the ends of this tuned circuit being capacitively coupled to the output and input. With no d.c. connection to the input the output remains in the low state, and it is necessary to bias the gate towards the changeover condition to start oscillation. This is achieved by R1. If R1 is initially a pre-set component of $5k\Omega$ it will be found that by reducing the resistance it presents to the circuit a value will be found at which the gate starts to change state and oscillation will begin. If desired, a fixed resistor of suitable value can then be wired in the R1 position.

The output waveform obtained from the basic circuit of Fig. 2 may be almost a square wave, this being particularly the case at low frequencies. The waveshape is due to the low impedance and non-linearity of the NAND gate. An improvement can be given by using coupling capacitors of suitable value for the frequency concerned. The circuit of Fig. 2 is reliable and will operate from the low a.f. to the high r.f. range. Its advantage lies in the simplicity and the low number of external components, which make for a compact layout. The output can be taken from the output pin of the i.c. or from a secondary winding on the inductor.

In Fig. 3 the circuit is modified slightly by the inclusion of tappings in the inductor. These give better matching to the NAND gate and, consequently, much less damping of the tuned circuit. The waveform is therefore considerably improved but it may not always be possible to find centre-tapped inductors with suitably

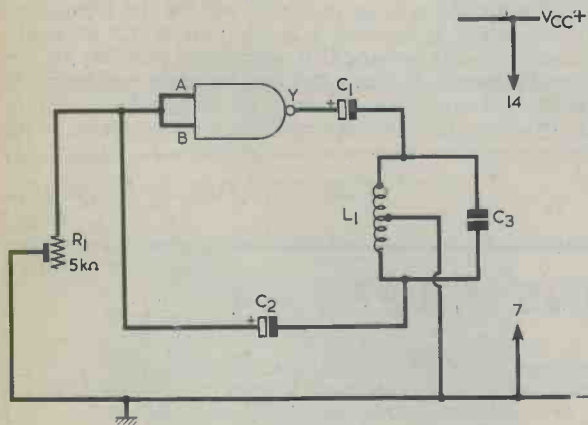


Fig. 2. The basic oscillator, which can incorporate any one of the gates in the integrated circuit. At audio frequencies C1 and C2 need to be electrolytic, at around $5\mu F$, whereupon they have the polarity shown

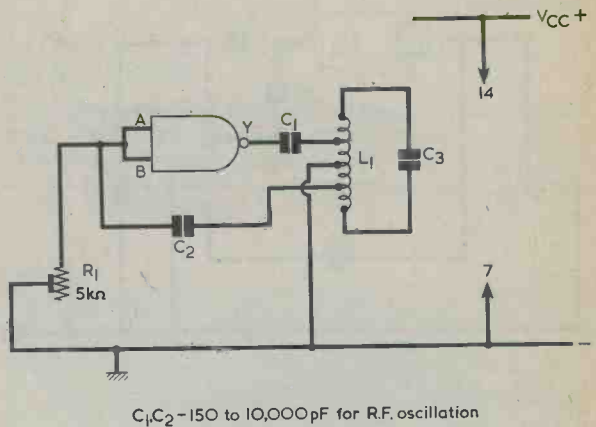


Fig. 3. A circuit which gives improved matching

placed tappings, particularly for audio oscillators. Good results are obtained when the feedback tappings are 25% to 50% out from the centre tap.

CURRENT DRAIN

The rather high current taken by the device makes it unattractive for battery powered circuits, but this is not likely to be a problem in mains powered equipment. The Table shows that at the normal supply voltage of 5

TABLE

Current Consumption (One Gate Oscillating)

Vcc	Current (mA)	Relative Output Amplitude
5	13	1.0
4	9.5	0.7
3	6	0.4
2.5	4	Very low
2	No oscillation	

volts current consumption with one gate functioning as an oscillator is typically 13mA; but this current can be reduced considerably by employing a lower supply voltage. Prolonged operation at 13mA appears to do no harm to the SN7400 and there is no appreciable temperature rise with only one of the four gates in use. This may not apply if two or more gates were operated at 13mA. The third column in the Table indicates relative output amplitude, the amplitude at $V_{CC} = 5$ volts being given the arbitrary value of 1.0.

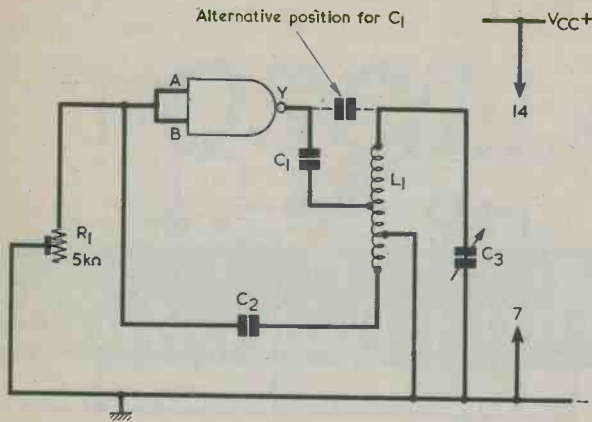
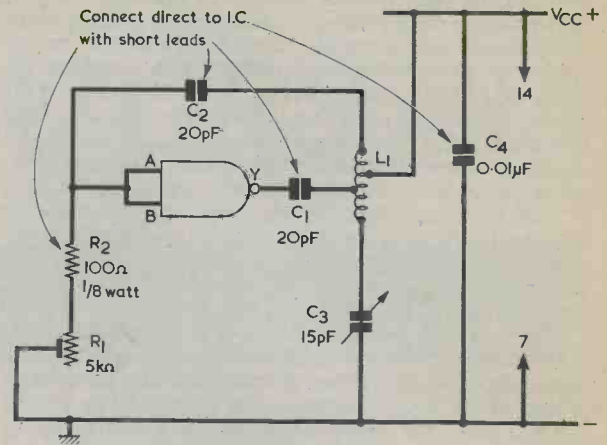


Fig. 4. Oscillator circuit with variable frequency control



L₁ - 6 turns overall of 16 s.w.g. tinned copper, diameter 1/2", length 3/4"
C₁, C₂, C₄ - ceramic

Fig. 5. Experimental v.h.f. oscillator giving possible operation at 90MHz

Fig. 4 shows an arrangement for variable frequency operation. The output capacitor can connect either to the top end of the tuned circuit or to a tapping as shown. A high L/C ratio is preferable in this circuit.

Oscillation appears to be possible up to almost 100MHz but for this sort of frequency the circuit of Fig. 5 is more suitable. It will be noticed that this bears a resemblance to the local oscillator circuit of many v.h.f. receiver front ends, but it is by no means a grounded base configuration.

In the lower frequency ranges a convenient check of oscillation can be made by simply measuring the voltage at the gate output pin with a good quality testmeter set to its 5 or 10 volt d.c. range. Vcc should be 5 volts for this check. If the gate is not oscillating its output

voltage will be high or low, at about 3 volts positive or near chassis potential. If, on the other hand, the gate is oscillating the voltage indicated will be the average of these, which is about 1.5 volts. This is not always a conclusive test because it is sometimes possible for the application of the meter test lead to cause oscillation to cease, but conversely it should not be possible to obtain a 1.5 volt reading without oscillation taking place. ■

CAN ANYONE HELP?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received for to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time.

'Carol' Model TR/7 combined tape recorder and cine synchronising unit made by Confronics Ltd. - A. J. Simmonds, 18 Stuart Evans Close, Welling, Kent - Information on values of volume and tone controls.

Vancouver Radio Laboratories, Model VRL-401 - L. E. Waldron, 60 Catherine Road, Chell Heath, Stoke-on-Trent, Staffs. - Circuit diagram or any information.

G.E.C. Brt. 432 Receiver - P. Horeckyj, 76 Main Street, Broughton Astley, Nr. Leicester, LE9 6RD - Circuit or Service Manual, loan or purchase, or any information.

Trio S.W. Receiver, Jennen 9R-41 - M. Brennan, Green Hill, Kinsale, Eire - Circuit details, purchase or borrow.

Simpson, Model 260 Multimeter (OPV 20,000 DC, 1000 AC) - F. Hill, 19 Leith Road, Sale, Cheshire, M33 2LR - Circuit and/or Service Sheet, to borrow or purchase.

New Products

CALRECK MICROPHONE

Beyer Dynamic, who are the Distributors of Calrec microphones, have introduced the new 656 transistor capacitor microphone. These cardioid microphones offer a choice of bass response for close talking and vocal use or full frequency range for instrumental use. In fact they have been particularly designed for the entertainer, although they will also be used for reporter/interviews.

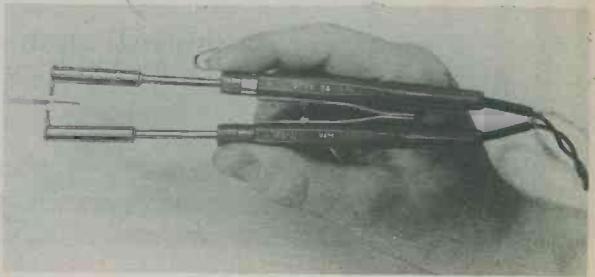
The Calrec 600 series have smooth, extended frequency response. The wide dynamic range eliminates overload and has excellent transient response. The microphones are robust in construction and completely shock resistant. The output is easily adjustable by the user to match any amplifier, mixer or recorder. Finished in a pearlescent satin anti-glare chrome. Two year guarantee.

For further information contact: Eyeline Communications Ltd., 84-86 Chancery Lane, London, WC2A 1DL.



LITESOLD'S THERMAL WIRE STRIPPERS

Litesold's Adamin thermal wire strippers are designed for easy one-handed operation with virtually no risk of damage to the wire conductors. They may be used right or left-handed and will strip coverings up to approximately 4 mm diameter.

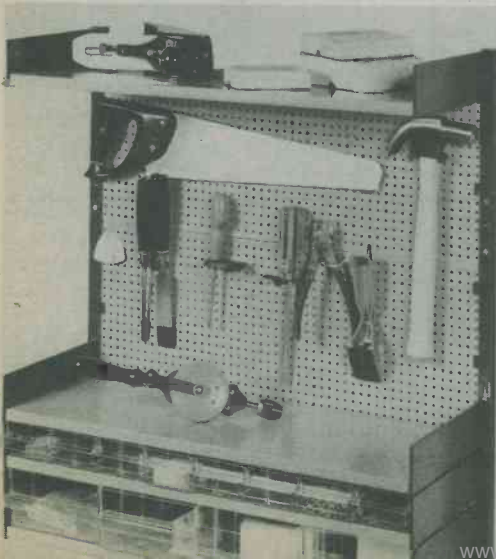


The electrically heated v-shaped jaws are lightly spring loaded in the open position; closing the jaws around the wire melts the insulation which is then simply drawn off the conductor. Thin enamelled copper wires may also be dealt with by using a light scraping action, this will leave the conductor ready for soldering.

Two models of Adamin strippers are available, Model PVC, 14 watts, 12 or 24 volts for PVC, polythene and other low-temperature insulations and Model PTFE, 48 watts, 24 volts only, for P.T.F.E. insulation only.

Full details of both types are in the current Litesold catalogue, available from Light Soldering Developments Limited, 97-99 Gloucester Road, Croydon, Surrey.

RAACO STORAGE CENTRE



A new idea from Denmark is the Raaco Storage Centre.

Designed to screw easily into any garage or workroom wall, the Raaco Storage Centre is a neat and tidy way of storing all tools, tins, paint brushes and small parts.

The bright-orange coloured perforated hardboard backboard accepts a range of brackets for holding different tools such as screwdrivers, hammers and chisels, while the steel shelves take tins of paint and other small items for storage. At the base of the unit are 12 drawers in high-impact clear plastic - 4 large and 8 small to store nails, plugs and small tools.

Easily assembled from instructions supplied with the kit, Raaco Storage Centre is supplied in four different packs, ranging from the Hobby Storage Wall Centre to the Tradesman Storage Centre (illustrated) and the handyman can add to each unit to build a complete range of wall storage units.

Each unit measures 25" across, and depths range from 9½" to 29", depending on model. Price range is from about £2.00 to £16.00.

NOVEL LATCH CIRCUIT

By R. N. Reynolds

An unusual latching circuit which can be controlled by two push-buttons

IN SOME SWITCHING APPLICATIONS IT IS ATTRACTIVE TO have a mechanical or electronic latching arrangement by means of which a load can be turned on by pressing one push-button and turned off by pressing a second push-button. A psychological factor appears to be involved here since the push-buttons are carrying out a function which can be quite satisfactorily met by a simple switch. There is, nevertheless, a certain fascination in the control of circuits by push-buttons, and this is exemplified by the fact that it is more common for commercially made radio receivers to employ push-button wave-change selection than to have rotary wave-change switches.

LATCHING CIRCUIT

The latching circuit to be described here is shown in Fig. 1, and it has been used successfully by the author for switching resistive loads drawing currents of up to 30mA. Its method of operation is rather unusual. There are two push-buttons, these being S1 and S2. The contacts of S1 close when it is pressed whilst those of S2 open when it is pressed.

When the 9 volt supply is applied, TR1 becomes conductive. The base current to TR1 through R1 is sufficient to turn this transistor hard on, whereupon its collector is only a small fraction of a volt positive of the lower negative supply rail. In consequence, no base current is available for TR2, and this transistor is turned off. Also, no current flows through the load. The collector of TR2 is at the same potential as the positive supply rail and diode D1 is reverse biased.

If S1 is pressed, the base of TR1 becomes connected to the negative rail and this transistor cuts off. A base bias current is made available for TR2 via R2 and R3, and TR2 turns hard on, switching on the load. The transistors stay latched into this condition after S1 is released because D1 is then forward biased. The positive potential on TR2 collector with respect to the negative rail is a little in excess of 0.1 volt, and the potential at

the anode of D1 and at the base of TR1 is about 0.25 volt, this being too low to allow the transistor to turn on. It will be seen that two essential features of the circuit are that D1 has to be a germanium diode, with a consequent low forward voltage drop, and that TR1 must be a silicon transistor, which requires a positive voltage approaching 0.6 volt at its base if it is to become conductive.

The load is switched off by pressing S2. This breaks

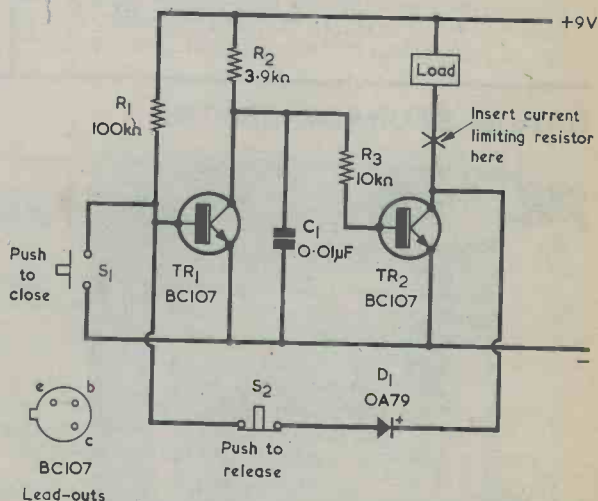


Fig. 1. The basic latch circuit. TR2 turns on and applies power to the load when S1 is pressed. Pressing S2 causes TR2 to turn off again

the circuit from D1 anode to TR1 base, and the latter then receives its bias current via R1. TR1 turns on, thereby turning off TR2, and the circuit returns to its initial state.

If it is desired to switch on the load once more S1 is pressed again, causing TR1 to cut off and TR2 to turn on. And the load can then be switched off after this by once more pressing S2.

Should the load have a high value electrolytic capacitor across its terminals it is necessary to insert a current limiting resistor at the point marked with a cross in Fig. 1. This resistor will ensure that the initial charging current when the load is switched on does not exceed the maximum collector current rating of TR2. The maximum collector current rating for a BC107 is 200mA, whereupon the current limiting resistor should have a value of 45Ω. A current limiting resistor having a lower value could be employed if a power transistor were used in the TR2 position.

If C1 is omitted, the circuit has a tendency to slip into one or other of its two states in random manner when the 9 volt supply is initially applied. Capacitor C1 prevents this random action by slowing the rise in collector potential in TR1, and hence the application of base bias to TR2. The result is that the circuit always starts in the state where TR2 is off when the 9 volt supply is turned on.

The current taken from the supply when TR2 is off is about 2.3mA, this passing mainly through R2. The current drawn from the supply when TR2 is on is that flowing through the load plus about 0.6mA in R2 and R3.

Apart from operation by means of S1 the circuit can also be triggered into the state where TR2 is on by applying a negative-going pulse to the base of TR1.

MULTIVIBRATOR

If the first transistor of Fig. 1 is made part of a one-shot multivibrator, a sensitive latching circuit capable of being triggered by a positive-going pulse results. A practical example is shown in Fig. 2. Here, TR2 and TR3 perform the same functions as, respectively, did TR1 and TR2 of Fig. 1. TR2, in Fig. 2, also enters a one-shot multivibrator in combination with TR1 of this diagram.

Until the circuit is triggered TR2 in the multivibrator is on, with bias current flowing to its base via R3. Since TR2 is on, TR3 is off. TR1 is turned off also, because its base is held just lightly positive of the negative rail by way of R2. The circuit is stable in this state, and capacitor C1 becomes charged to a voltage which is equal to that of the 4.5 volt supply less the voltage drop in the base-emitter junction of TR2.

When a positive-going pulse is applied to the base of TR1, this becomes conductive and its collector goes negative. So also, by way of the charged capacitor C1, does the base of TR2, whereupon TR2 collector goes positive. The positive excursion of TR2 collector is passed to the base of TR1 via R2; there is the usual cumulative amplification given in any multivibrator and the circuit rapidly changes over to the state where TR2 is off and TR1 is on. Since TR2 is off, TR3 comes on also, and switches on the load.

C1 next commences to discharge by way of R3. If D1 were not in circuit C1 would discharge sufficiently for TR2 base to go positive of its emitter, whereupon TR2 would once more become conductive and the multivibrator would revert to its initial condition with TR2

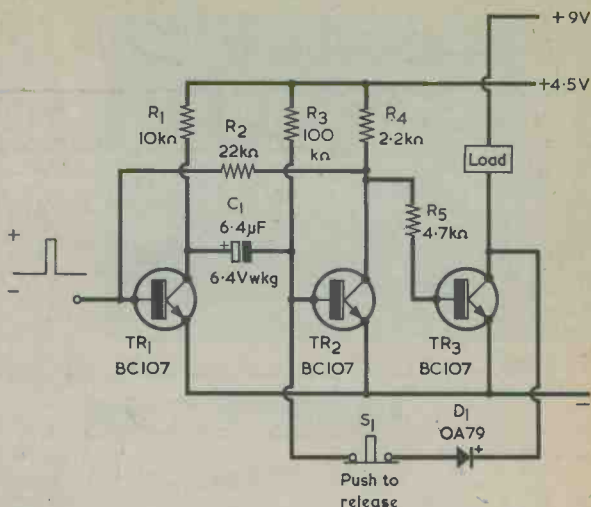


Fig. 2. Combining the circuit of Fig. 1 with a one-shot multivibrator results in a sensitive latch circuit which can be triggered by a positive-going pulse

on and TR1 off. In the present circuit, however, the base of TR2 is clamped below turn-on potential by D1, with the result that, once triggered by the positive-going pulse, the circuit remains in the triggered state. It can only be released by pressing S1. After a very short period, needed for C1 to discharge a little further into R3, TR2 then turns on and the circuit returns to its original state with TR1 off, TR2 on and TR3 off. It is then ready to be triggered by another positive-going pulse.

If D1 were out of circuit, the length of the period in the multivibrator during which TR2 is turned off would be about two-thirds of a second. With D1 in circuit, this provides considerably more than ample time for TR3 collector to assume the low potential needed to clamp TR2 off. A delay in the fall of potential at TR3 collector is feasible if the load has a very high value electrolytic capacitor connected across it. The remarks, when Fig. 1 was discussed, concerning the fitting of a current limiting resistor in series with the load apply equally in Fig. 2. The one-shot multivibrator period can, of course, be reduced if desired by giving C1 a lower capacitance.

The 0.01μF capacitor connected between the collector of TR1 and the negative rail in Fig. 1 is not needed in Fig. 2 as the circuit always takes up the required condition when the supply potential is applied. Until the circuit settles down it may, however, momentarily go through the state in which TR3 is turned on.

TR1 and TR2 are fed from a 4.5 volt supply in Fig. 2 to ensure that the maximum reverse base-emitter voltage rating of TR2 is not exceeded when TR1 turns on and TR2 base is taken negative by the charged C1. The voltage rating for a BC107 is 6 volts, whereupon TR1 and TR2 could alternatively be supplied by a 5 volt line. The latch then becomes compatible with t.t.l. circuits.

2 WATT PLAYER A

By R. A. F.

Intended for an input
or ceramic pick-up,
high impedance source,
is capable of an output
watts. The component
all readily available
incorporates compression
treble boost and

THIS AMPLIFIER HAS BEEN DESIGNED TO ACCEPT THE output from a crystal or ceramic pick-up cartridge, and is principally intended for use as a simple record player amplifier. It is capable of a maximum continuous output power of 2 watts into an 8Ω load, but it will operate well into a 15Ω load with a slightly reduced output power and input sensitivity. An input of approximately 350mV r.m.s. is required to produce the full rated output into an 8Ω load.

BASS AND TREBLE

Separate bass and treble tone controls are provided. The treble control provides about 12dB lift and cut at 10kHz with reference to 1kHz, and the bass control gives about 12dB lift and cut with reference to 1kHz. The output quality is very acceptable with quite low noise and distortion levels.

Construction is very simple and, as can be seen from the accompanying photographs, the whole amplifier is assembled around a single printed circuit board. The completed unit is quite compact, and it measures approximately 6 by 3 by 1½ in., excluding control knobs.

A full circuit diagram of the unit, including the tone control networks, is shown in Fig. 1. Six transistors are used, two in the differential input stage (TR1 and TR2), one in the emitter follower driver stage (TR3), one as an amplified bias stabilizing device (TR4) and two in the complementary output stage (TR5 and TR6).

The heart of the unit is the differential input stage. A differential amplifier has two inputs, one of which is in phase with the output whilst the other is in anti-phase with the output. These are normally termed the non-inverting input (+) and the inverting input (−) respectively. The output of the amplifier is proportional to the difference in the amplitude of the signals at the two inputs. Hence the name 'differential amplifier'.

This explanation of a differential amplifier is somewhat idealised, as in practice the circuit will only operate properly if the two input voltages are kept within well defined limits, and there is of course a limit to the maximum output voltage.

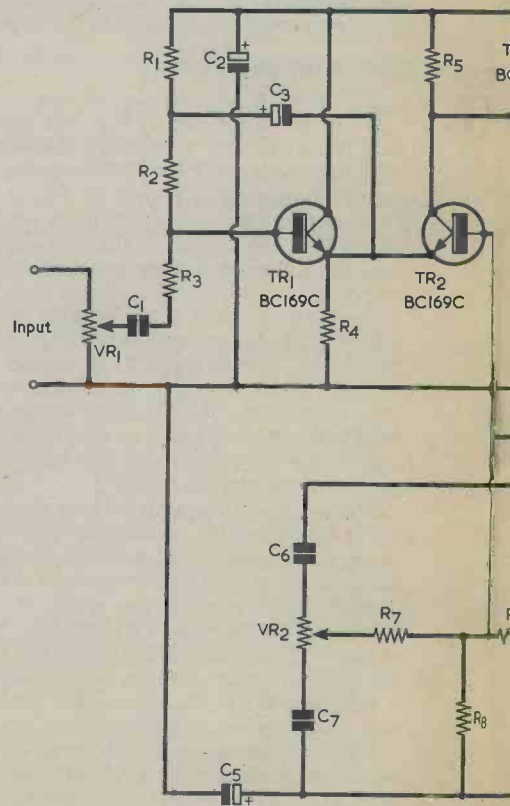


Fig. 1. Complete circuit of

RADIO & ELECTRONICS CONSTRUCTOR

2 WATT RECORD PLAYER AMPLIFIER

By R. A. Penfold

Intended for an input from a crystal or ceramic pick-up, or from a similar high impedance source, this amplifier is capable of an output power of 2 watts. The components required are all readily available, and the circuit incorporates comprehensive bass and treble boost and cut controls.

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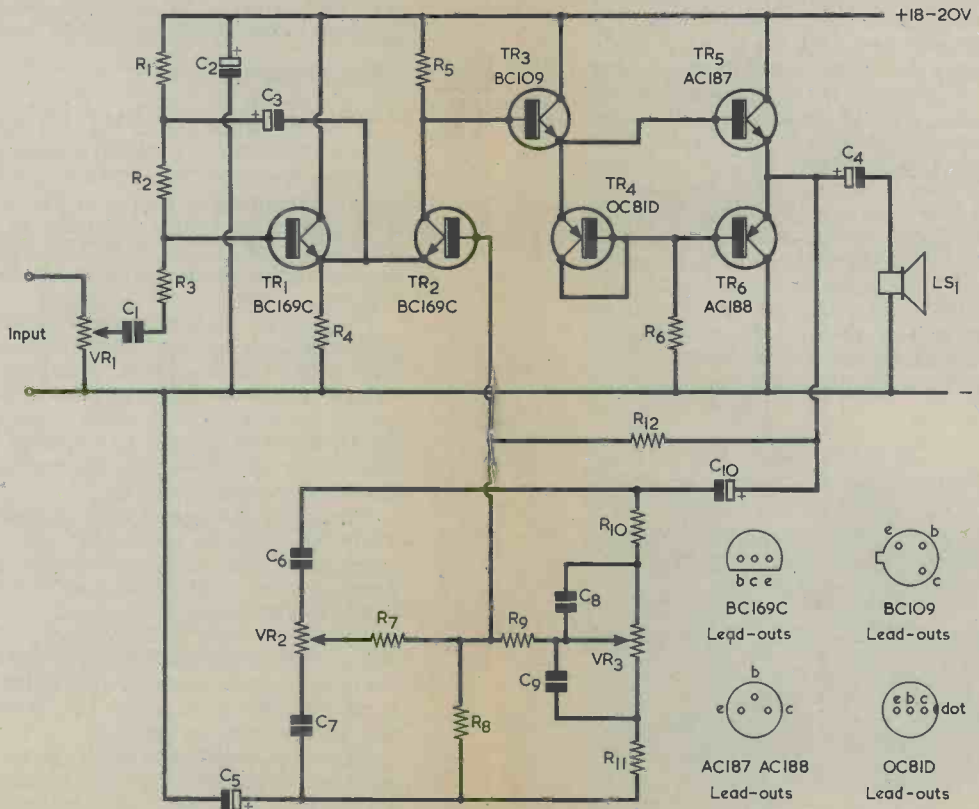
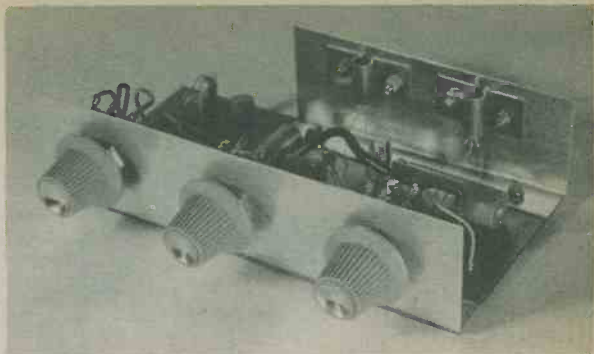


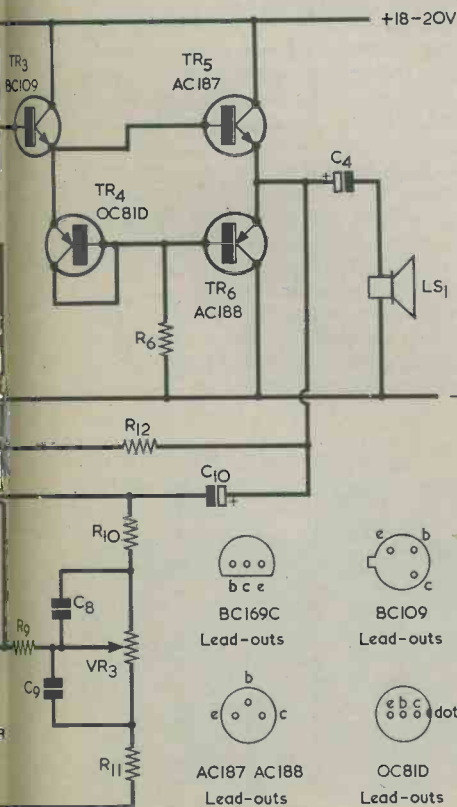
Fig. 1. Complete circuit of the 2 watt amplifier

RECORD AMPLIFIER



Penfold

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or from a similar
source, this amplifier
output power of 2
components required are
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it of the 2 watt amplifier

FEBRUARY 1975

COMPONENTS

Amplifier

Resistors

(All fixed values $\frac{1}{2}$ watt 5%)

R1	220k Ω
R2	470k Ω
R3	15k Ω
R4	680 Ω
R5	10k Ω
R6	1k Ω
R7	4.7k Ω
R8	3.9k Ω
R9	4.7k Ω
R10	15k Ω
R11	1.5k Ω
R12	820k Ω
VR1	2M Ω potentiometer, log track
VR2	50k Ω potentiometer, linear track
VR3	50k Ω potentiometer, linear track

Capacitors

C1	0.22 μ F plastic foil, Type C280 (Mullard)
C2	100 μ F electrolytic, 25 V. Wkg.
C3	4 μ F electrolytic, 16 V. Wkg.
C4	500 μ F electrolytic, 12 V. Wkg.
C5	10 μ F electrolytic, 16 V. Wkg.
C6	0.002 μ F plastic foil
C7	0.022 μ F plastic foil
C8	0.01 μ F plastic foil
C9	0.1 μ F plastic foil, Type C280 (Mullard)
C10	10 μ F electrolytic, 16 V. Wkg.

Transistors

TR1	BC169C
TR2	BC169C
TR3	BC109
TR4	OC81D
TR5	AC187
TR6	AC188

Speaker

LS1	8 Ω speaker
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Miscellaneous

- 3 control knobs
- 22 s.w.g. aluminium sheet for control panel and heat sink
- Printed circuit board, 6 × 3in.
- Screened wire
- Nuts, bolts, etc.

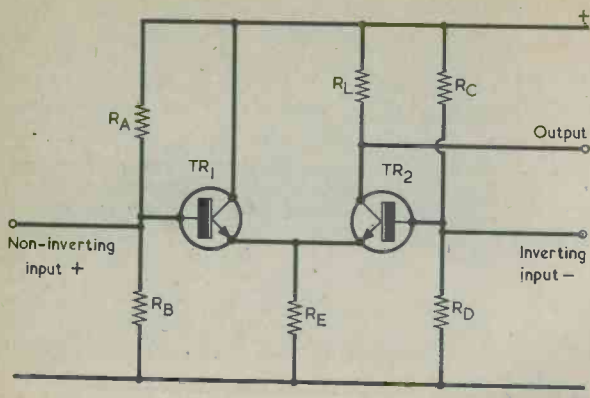


Fig. 2. A basic differential amplifier

BASIC DIFFERENTIAL CIRCUIT

The circuit of a basic differential amplifier is shown in Fig. 2. TR1 is biased by RA and RB, and TR2 is biased by RC and RD. TR1 and TR2 have a common emitter resistor, RE, and the output is developed across RL. In a symmetrical circuit there would also be a resistor in series with the collector of TR1, this resistor having the same value as RL. However, such a resistor is not essential in practice and is not included in the present circuit.

TR1 operates as an emitter follower, and its output, which is in phase with its input, appears across RE. If TR1 base goes positive so also does its emitter and, since the gain of an emitter follower is almost unity, the voltage change at the emitter will be virtually equal to the voltage change at the base. When TR1 emitter goes positive so also does the emitter of TR2. This has the same effect as would be given if the base of TR2 went negative with respect to its emitter: TR2 collector current decreases and the collector potential goes positive. TR2 is, in effect, operating as a grounded base transistor to the signal at its emitter. The overall effect is that when TR1 base goes positive, so also does the collector of TR2. In consequence, the input at TR1 base is in phase with the output and TR1 base can be looked upon as providing a non-inverting input.

If a signal is applied to TR2 base this transistor operates as a common emitter amplifier, and the signal at its collector is out of phase with that at its base. Thus, TR2 base provides an inverting input.

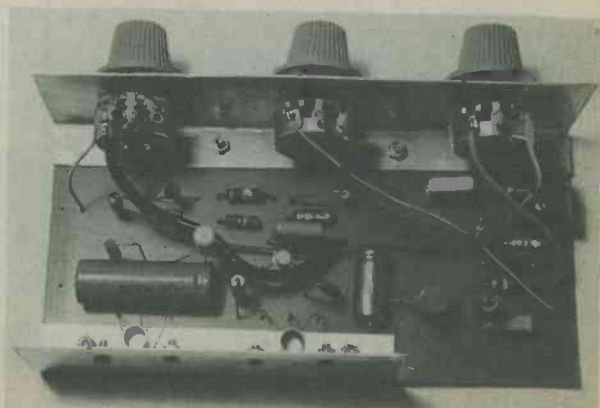
AMPLIFIER CIRCUIT

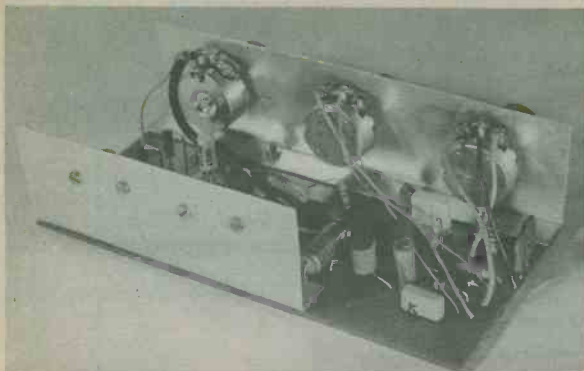
Referring back to the complete amplifier circuit of Fig. 1, a differential amplifier is provided by TR1 and TR2. TR1 is biased by R1 and R2, and TR2 by R12. The input signal is coupled via the volume control VR1, d.c. blocking capacitor C1 and series resistor R3 to the non-inverting input of the circuit. R3 is included to prevent possible amplification at r.f.

TR3 is an emitter follower and matches the comparatively high output impedance of TR2 to the low input impedance of the output transistors. A small, relatively constant, voltage is dropped across TR4, whereupon R6 functions as the emitter load for TR3. The output stage is quite conventional, employing a complementary Class B emitter follower circuit. TR5 amplifies the positive-going half-cycles and TR6 the negative-going half-cycles. C4 couples the output signal to the speaker and provides d.c. blocking. TR4 is employed as an 'amplified diode', and provides the small standing bias for the output transistors which is needed to eliminate crossover distortion. This transistor also gives a level of thermal stabilization of quiescent output current.

Since TR3, TR5 and TR6 are all emitter followers there is no change of phase between TR2 collector and the junction of the output emitters, and the inverting input is 180° out of phase with the output. The bias resistor, R12, will therefore introduce negative feedback over the amplifier. So also will the tone control circuits, and the overall feedback level is such as to produce the performance figures quoted at the start

Looking down on the board. The screened input lead to VR1 was not fitted when these photographs were taken





A view from the rear. The base is the printed circuit board on which the components other than the controls and output transistors are wired

of this article. With the tone controls at approximately their central settings, all frequencies in the feedback circuit have the same level of bypass to chassis. Where it is desired to boost a range of frequencies the appropriate control provides a higher level of bypass to chassis (and thus less feedback), and where it is desired to cut a range of frequencies these are given a lower level of bypass to chassis.

VR2, C6 and C7 form the treble control network, and VR3, R10, R11, C8 and C9 provide the bass control circuit. R7 and R9 are needed to reduce interaction between the two networks, whilst C5 and C10 give d.c. blocking.

BOOTSTRAPPING

The bias resistance for TR1 is split into two components, R1 and R2, and this enables bootstrapping to be applied to TR1 base circuit by way of C3. Bootstrapping greatly reduces the shunting effect of R2 on the amplifier input impedance and it operates in the following manner. The voltage gain between TR1 base and emitter is almost exactly unity whereupon, due to the presence of C3, any change in signal potential at the base of TR1 produces a similar change in potential at the junction of R1 and R2. This means that the voltage across R2 will remain virtually constant and there will be little flow of signal current in it. Thus, so far as signal voltages are concerned, R2 offers a much higher effective resistance than its actual value, and its shunting effect on the input impedance becomes extremely small.

HEATSINK AND PANEL

The two output transistors are taken up close to their maximum power ratings and they require a small heatsink. This has the dimensions shown in Fig. 3(a) and is made of 22 s.w.g. aluminium. The transistors are secured to the panel by two clips in the positions shown in the photographs. These clips may be Henry's Radio type H13 or home-made from a suitable thin metal. Take care to ensure a good thermal coupling between each transistor and its clip, and between the clips and the heatsink panel. The holes required in the panel for the clips are not shown in Fig. 3(a), as these depend on the actual clips employed. The clips may be secured to the panel with 6BA bolts and nuts.

Fig. 3(b) gives the dimensions of the front panel on which the controls are mounted, and this is also 22 s.w.g. aluminium.

The 90° bends in the heat sink and the front panel

are very easily made if a vice is available. Aluminium is a fairly soft metal and a comparatively thin gauge is used here. It is best to carry out the bending operation after all holes have been drilled or cut out.

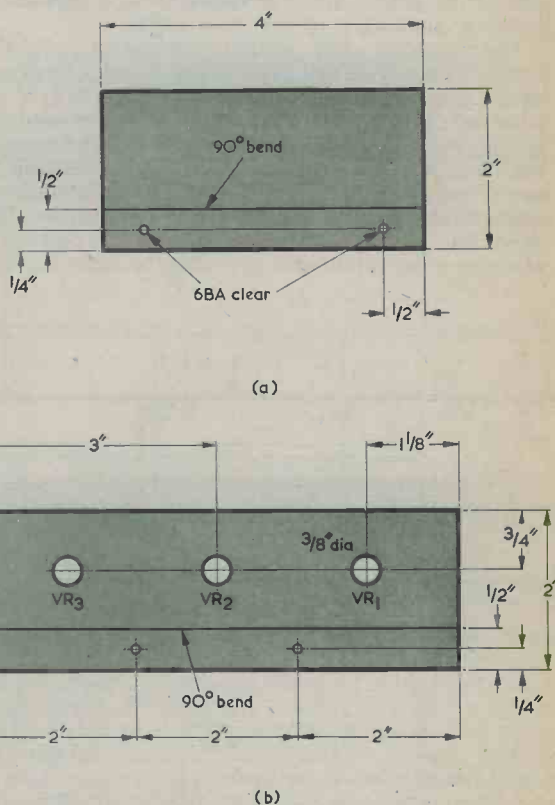


Fig. 3 (a) The dimensions of the heatsink (b). How the front panel is cut out and bent

PRINTED CIRCUIT BOARD

All the components, except for the controls and output transistors, are mounted on a printed circuit board measuring 6 by 3in. Details of the copper pattern and component holes are shown in Fig. 4. This is reproduced full size and may be traced. It is strongly recommended that an etch resist pen be used in the preparation of the board, as it would be difficult to reproduce using any other method. It will probably not be possible to obtain a board of the specified size, and it will have to be cut with a hacksaw from a larger piece.

When the board has been etched and the component mounting holes drilled, it is next necessary to drill out the 6BA clear mounting holes for the panel and heatsink. The positions in which these are mounted can be seen from the photographs of the prototype amplifier, and the holes are marked out using the panel and heatsink as templates. One of the mounting holes for the front panel passes through a copper area which is common with the negative supply rail, whereupon the panel is automatically earthed to this rail. The heatsink is not earthed and the two holes for this should be clear of the copper print. The front panel and heat sink are each mounted with two 6BA bolts and nuts, and their flanges are on the component side of the board. The 6BA bolt heads are on the copper side of the board, and one of the bolts completes the earthing connection to the front panel.

The controls and output transistors are then mounted, as are the rest of the components. Component layout and wiring is illustrated in Fig. 5. A link wire joins two of the copper areas and this must be insulated. So also must the leads which couple from the board to VR3 and VR2. A screened lead couples between the board and VR1. The input lead to the amplifier is similarly screened, as is indicated in the diagram. This input lead can be coupled direct to the pick-up or whatever other equipment provides the input signal.

To avoid the possibility of instability all leads, and particularly those to VR3 and VR2, should be kept as short as is reasonably possible. Be very careful to connect up the output transistors correctly. If necessary, pieces of p.v.c. sleeving of different colours may be placed over their lead-outs to provide reliable identification.

There is one output connection for the speaker. The other speaker connection is to the negative supply rail, and this may be taken up either at the negative output point of the power supply unit, or by making a connection to a solder tag held under one of the 6BA nuts securing the front panel. The speaker impedance must not be lower than 8Ω .

POWER SUPPLY

The amplifier requires a power supply of approximately 18 to 20 volts. The quiescent current drawn is of the order of 18 to 20mA, this rising to several hundred milliamps at full output. It is possible to supply the amplifier by two large capacity 9 volt batteries connected in series, although this would be a rather expensive way of powering the unit in the long term.

A much more economical method is to use a mains power supply unit, and the circuit of a suitable design is given in Fig. 6. This merely consists of a mains transformer with a centre-tapped secondary feeding the full-wave rectifier circuit given by D1 and D2. Capacitor C11 is the reservoir capacitor, and R13 and C12 provide smoothing. The low value in R13 is desirable to ensure that the output voltage does not fall to too low a level when a high current is drawn by the amplifier.

The mains transformer can be any small component offering a secondary voltage of 12-0-12 volt or 13-0-13 volt at 0.5 amp or more. The author employed a 12-0-12 volt transformer with the prototype amplifier and it was found that the supply unit gave an output

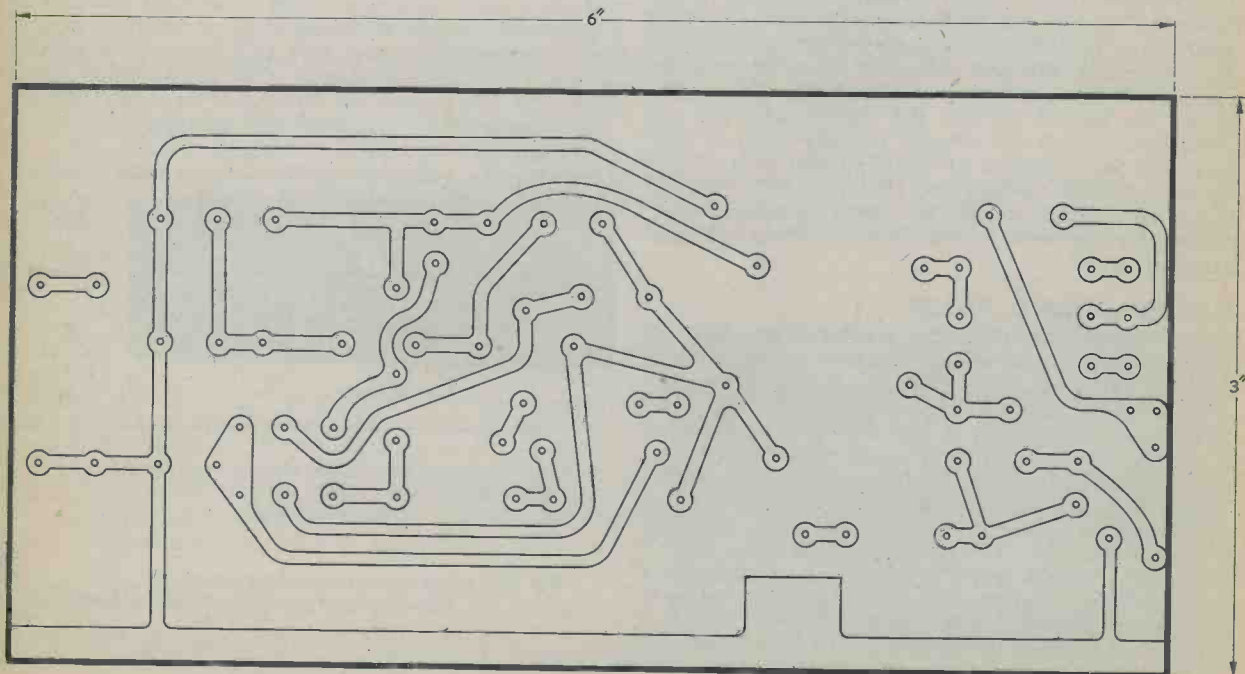


Fig. 4. The copper side of the printed circuit board. This is reproduced full size and may be traced

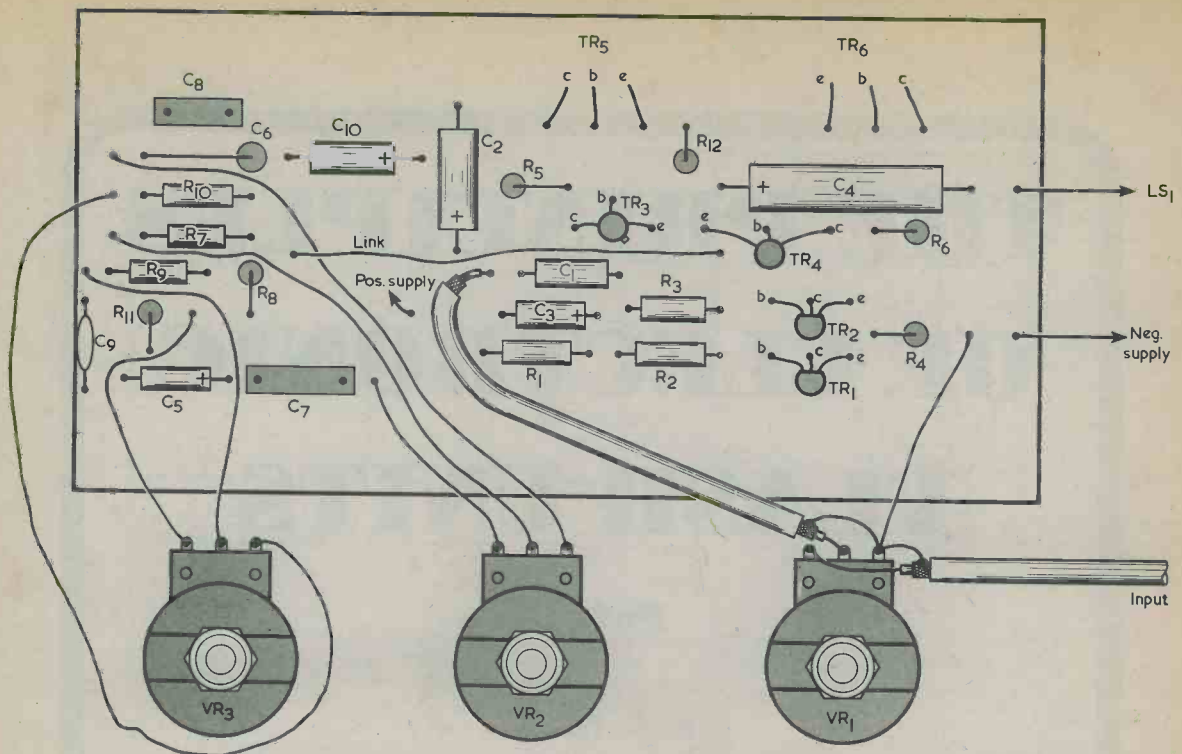


Fig. 5. Components and wiring on the component side of the board. The screened wire between the board and VR1 has its braiding earthed at the end which connects to VR1 only

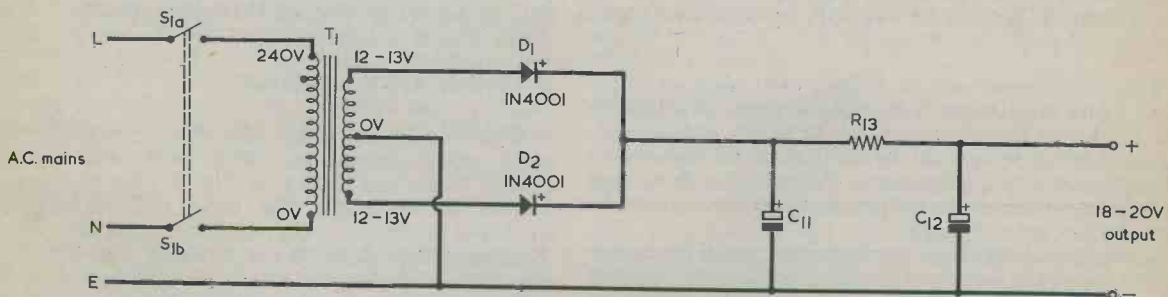


Fig. 6. A simple power supply unit for the amplifier

COMPONENTS

Power Supply Unit

Resistor

R13 1Ω ½ watt 10%

Capacitors

C11 2,000μF electrolytic, 25V. Wkg.

C12 2,000μF electrolytic, 25V. Wkg.

Transformer

T1 Mains transformer, secondary 12-0-12V
13-0-13V at 0.5A or more

Rectifiers

D1 1N4001

D2 1N4001

Switch

S1 d.p.s.t toggle

voltage of 19 volts under quiescent conditions. This is a little higher than would be expected theoretically and is presumably due to the fact that mains transformer secondaries are frequently wound to give a slightly higher voltage than their nominal figure. Due to the internal resistance of the circuit, the voltage from the power supply drops somewhat as the output power of the amplifier is increased. A 13-0-13 volt transformer will give a slightly higher output voltage, with a consequent small increase in output quality at high volume settings.

The construction of the supply unit is not critical and a small tagboard can be employed to mount the rectifiers, capacitors and smoothing resistor. The supply unit should be positioned away from the amplifier to ensure that there is a minimum of hum pick-up in the latter.

THE PRINCIPLES OF ELECTRONIC FLASH UNITS

Part I

By A. Foord

This 2-part series is intended mainly for readers who use, maintain or service photographic flash units, and it gives general details on a subject which is not normally covered in the electronics press

THE ELECTRONIC FLASH OFFERS THE PHOTOGRAPHER many advantages. Large studio units are capable of producing illumination nearly as bright and approximately equal in colour temperature to sunlight, with the result that colour photographs taken by flash need no filters to correct for colour balance. This retains the maximum speed of the film.

The short duration of the flash also makes it possible to obtain sharp images of rapidly moving objects, and if a stroboscopic flash is used velocity and acceleration can be studied. Since the light is cool without the heat produced by conventional illumination, photographs can be taken of subjects which might be destroyed or inconvenienced by excessive heat.

DEFINITIONS

Flash duration is the time interval from the instant the flash reaches one-third of its peak intensity to the instant it decays to the same value.

Recycle time is the time required for the equipment, after producing one flash, to produce a second flash which is 70% as intense as the flash produced when the energy storage capacitor is charged to the full peak voltage. This is equivalent to half a stop less exposure. Since the light output varies approximately with the square of the voltage this recycle time can alternatively be defined as the time required after a flash for the capacitor to reach 84% of the peak voltage.

Peak voltage is the voltage at the energy storage capacitor during a charging cycle when the voltage increase is less than 1% over a 10 second interval.

BASIC BLOCK DIAGRAM

Three basic sections are needed to operate the tube: a d.c. power source, an energy bank, and a trigger circuit. These are shown in Fig. 1, which illustrates (inside the rectangle) the three different methods employed to obtain the high tension d.c. supply.

An electronic flash unit is basically very simple: a capacitor is charged up to a high voltage over a few seconds and this energy is then discharged through the flash tube in a millisecond or so. The tube itself needs a very high voltage pulse to initiate the discharge, and this is produced by a trigger circuit which is operated from the camera shutter or separately, as required. The power supply, capacitor and limiting resistor may be in one case, with the flash tube and trigger circuit in a separate case. Smaller low power units may have all the circuits combined in one case.

POWER SUPPLY

The type of power supply used is determined by the light output, operating costs and portability required. A mains operated unit gives the lowest operating and maintenance cost, and studio units are normally mains operated. For portable units low voltage batteries offer a choice between wet and dry cells. The cost of dry batteries is moderate but they have to be discarded and replaced when exhausted. Lead-acid cells are heavy but have the advantage that they can be recharged. Nickel-cadmium or barium-cadmium batteries are more convenient to use, but cost more than lead-acid

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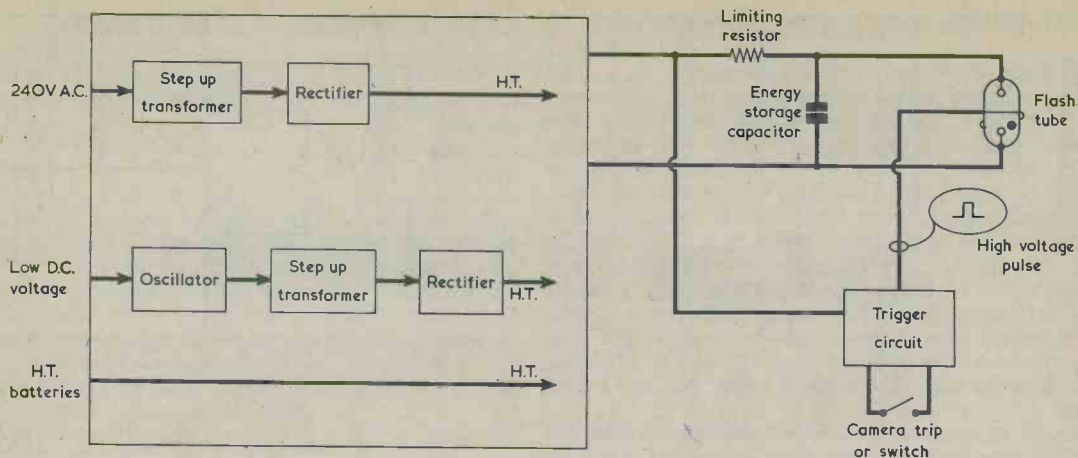


Fig. 1. Basic arrangement for an electronic flash unit. Three different methods of obtaining the high voltage for the energy storage capacitor appear inside the rectangle

batteries.

Most of the recently produced battery operated electronic flash units contain a transistorised monitoring circuit which cuts the oscillator off when the capacitor is fully charged, and thereby reduces the battery drain. The convenience and rapid recycling of a battery h.t. source of 450 volts or so make it perhaps the easiest and most economical to construct. Although such batteries have a high initial cost they last for up to 3,000 flashes and require no maintenance.

CAPACITOR

The capacitor stores the energy from the power supply and releases it to the flash tube; it determines the quantity and duration of the light. Two types of capacitor are currently used: an oil filled type for studio units where very high power is required and where high voltages are used, and an electrolytic capacitor for smaller portable units. These have a lower operating voltage but a correspondingly higher capacitance. An electrolytic capacitor will need minor care and attention to maintain its maximum usefulness. Special low leakage, high capacitance types are manufactured for photo-flash work, but idle periods of four weeks or more may allow the dielectric to deteriorate, causing excessive drain on the battery when it reforms the capacitor. This deterioration can be avoided if the flash is switched on for a few minutes each week. The unit should *not* be flashed before storage, since a residual charge left in the capacitor will help maintain it in good condition. Avoid high temperatures, which increase the deforming rate.

If the state of the capacitor is suspected it may be reformed by using a current limited voltage source, starting at about 50% of the working voltage and gradually increasing this up to the normal working voltage over a period of at least two hours.

If a flash unit has to be dismantled care should be

taken not to touch the high voltage section until the capacitor has been discharged. This may be done with a 2.2kΩ wire-wound resistor of 25 watts rating mounted on an insulated handle. The resistor should be connected across the capacitor terminals several times to remove the residual charge.

LIMITING RESISTOR

The limiting resistor is required to control the maximum charging rate and the recycling time of the capacitor. It also enables the flash tube to de-ionise and not go into a continuous arc after the flash. In some cases where a step-up transformer is employed the high leakage reactance characteristic of this transformer may itself be used.

CAPACITOR ENERGY

The energy stored in the capacitor is given by:

$$J = \frac{1}{2} CV^2,$$

where J is energy in joules, C is capacitance in farads and V is voltage in volts.

The energy stored in the capacitor provides an easy method of comparing the relative powers of different electronic flash units, but it is not necessarily an accurate indication of the actual light output because the tube efficiency increases with higher voltages and because the tube will extinguish before the capacitor is completely discharged.

In a typical circuit the following conditions may be found:

$$V = 400 \text{ volts,} \\ C = 600 \mu\text{F,}$$

whereupon

$$J = \frac{1}{2} CV^2 \\ = \frac{1}{2} 600 \cdot 10^{-6} \cdot 400^2 \\ = 48 \text{ joules.}$$

FLASH TUBE

The form of the flash tube will depend on the mounting and reflector shape while its operating parameters will determine the energy requirements. The tube material is usually hardened glass for low power or quartz for high power, while the arc chamber may be straight or coiled into a helix to concentrate the light. Photographic flash tubes are, in most instances, filled with xenon gas under high pressure and do not fire when connected to charged capacitors but need a high voltage pulse to trigger the discharge. Low pressure tubes flash immediately they are connected to a voltage and these are more often used for stroboscopic flash units where a low power high p.r.f. rate is required. The energy for each flash is much lower, perhaps 1 to 10 joules.

Typical parameters for a medium power tube are 50 joules per flash, an operating voltage of 400 volts and a minimum trigger voltage of 2kV. A typical high power tube can have an energy level per flash of 1,000 joules, an operating voltage of 2kV and a minimum trigger voltage of 15kV.

A professional electronic flash system may have a power unit capable of supplying a total of 1,000 joules to up to four or five flash heads. The flash heads may be 1,000 joules each unit, with interchangeable reflectors to give various types of lighting - soft, key, flood, etc. The power unit will be fitted with switches so that a total power from 100 to 1,000 joules can be shared between one to five flash heads by switching. For example, it would be possible to supply 600 joules on a wide beam to light a background, 300 joules as the main light on the subject, and 100 joules to fill in and soften the shadows on the subject to reduce the contrast ratio.

The flash duration depends on the resistance of the tube during the gas discharge and the value of the storage capacitor. For a 50 joule tube this might be about 300 μ S.

The tube is not normally polarised and the voltage can be connected to it with either polarity.

OSCILLATOR POWER SUPPLY

Various types of single ended or push-pull oscillators can be used for the d.c. to d.c. inverter employed in an oscillator power supply, the choice of oscillator circuit depending on the power requirements and the manufacturer's preferences. For the smaller types of flash unit a blocking oscillator is efficient, while higher powered units may demand a push-pull square wave inverter.

The basic free running blocking oscillator is shown in Fig. 2. The pulse transformer is arranged to give a polarity inversion, and the diode will be fitted if it is desired to limit the cut-off collector voltage of the transistor to Vcc. This is done because the back-e.m.f. developed in the collector winding as the transistor is turned off might cause the transistor collector to go much more positive than Vcc, thus damaging a transistor with a low collector to emitter voltage rating.

The transformer turns ratio is such that, when the transistor is operating in its active region, the existing positive feedback is sufficiently large for the circuit to become unstable. The transistor is then rapidly driven into saturation in which condition it will remain for a short time depending on the transformer and transistor characteristics. The base current which flows during the

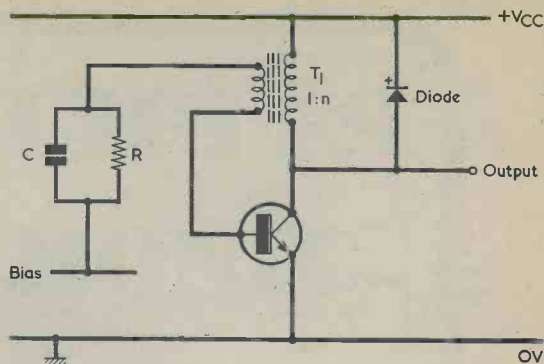


Fig. 2. A basic blocking oscillator circuit

pulse duration charges the timing capacitor C, tending to bring the transistor out of saturation. Due to the positive feedback existing in the system the transistor again moves very rapidly out of saturation and into cut-off. When the transistor is completely cut off the capacitor C starts to discharge through the resistor R until the base voltage is such that the transistor conducts again to repeat the cycle.

The complete theoretical analysis to determine pulse width and p.r.f. is quite complex.

COMPLETE BLOCKING OSCILLATOR

A typical power supply circuit using a blocking oscillator is shown in Fig. 3. When the unit is first switched on the neon lamp is not conducting and produces no base current for TR1, which is held non-conducting by R1. TR2 is also held off and these two

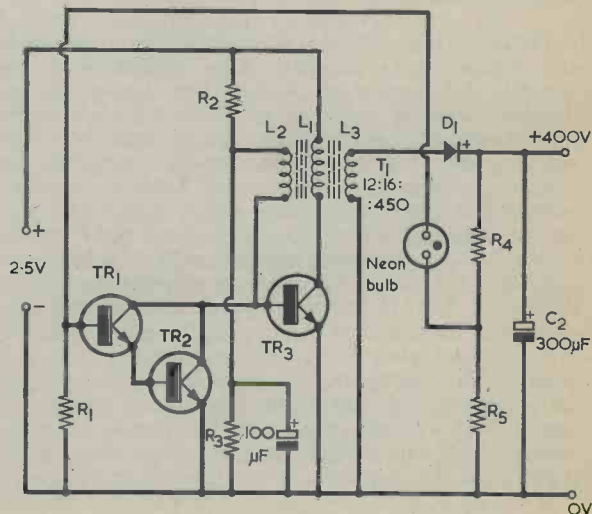


Fig. 3. A blocking oscillator high voltage supply circuit

transistors have no initial effect. At switch on, TR3 acts as a blocking oscillator and produces short pulses at a p.r.f. of about 6kHz. Step-up action in L1 and L3 produces high voltage pulses across L3 which are rectified by D1, charging up C2 to a value of between 300 and 400 volts depending on the values of R4 and R5. When the capacitor is charged to the right value the voltage at the junction of R4 and R5 is sufficient to strike the neon. This then provides TR1 with base current so that both TR1 and TR2 turn on and bottom. TR3 is cut off and the oscillator stops. No more pulses are applied to C2 which discharges (through R4, R5 and the neon circuit) until it falls below the extinguishing voltage for the neon. At this point TR1 and TR2 are cut off again, TR3 is turned on, and oscillations recommence to charge C2. This maintains the charge on C2 at a reasonably constant level and reduces the load on the battery. The neon also indicates that the charge on the capacitor is being maintained.

A typical performance for this type of circuit would be:

Input voltage	2.5 volts +50% -15%
Output voltage	400 volts
Capacitor	300μF
Charging time	10 seconds
Power	$= \frac{1}{2} CV^2$
	$= \frac{1}{2} 300 \cdot 10^{-6} \cdot 400^2$
	$= 24 \text{ joules.}$

The amount of light available will depend on the efficiency of the flash tube and its reflector, but this is a low power unit and might have a guide number of about 40 with 125 A.S.A. film. The nominal 2.5 volt input voltage can be provided by a 2 cell mercury battery. A typical battery of this type provides an open-circuit voltage of 2.8 volts which drops to about 2.5 on load. Alternatively, rechargeable nickel-cadmium cells give about 1.2 volts each on load, and two of these would produce 2.4 volts. Guide numbers will be discussed in Part 2.

ALTERNATIVE CONTROL CIRCUIT

An alternative control circuit can be derived using a p.n.p. transistor for TR1, as shown in Fig. 4. Again initially both TR1 and TR2 are held off, allowing oscillations to commence. In this case C2 and D1 are wired to produce a negative voltage and the phasing of L3 is reversed. When the neon strikes TR1 is turned on, turning on TR2 and cutting off TR3, whereupon the operation is as before. A current limiting resistor (not shown) may be interposed between TR1 collector and TR2 base.

The oscillator high and low voltage sections are essentially separate because of the isolation given by T1, but one side of the h.t. circuit may be common

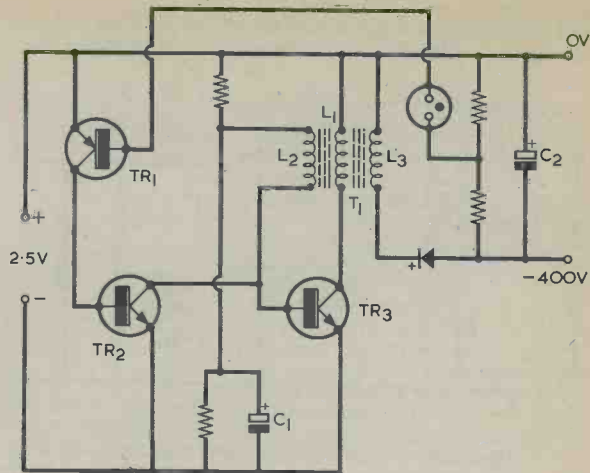


Fig. 4. High voltage oscillator circuit with alternative turn-off control

with one side of the low voltage section. Exactly how this is done will depend on the requirements of the control stages and the flash trigger circuits.

H.T. BATTERY POWER SUPPLY

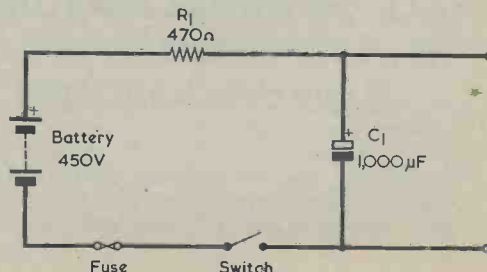
With an h.t. battery power supply, as shown in Fig. 5, all that is required is a limiting resistor to limit the maximum current taken by the capacitor during the charging part of the cycle. The recycling time is determined by the time constant of R1 and C1, while the power available for the tube is determined by C1 and the voltage across it, as previously described.

MAINS POWER SUPPLY

Mains operated power supplies can be half wave, full wave or bridge types. Obviously a half wave supply operating directly off the mains would be the cheapest and most compact arrangement, but special care has to be taken in insulating the complete unit and ensuring that the camera trigger contact is well insulated from the camera body. Circuits of this nature cannot be recommended!

The mains power unit may be built-in or found as a separate item connected to the flash unit by a plug-in

Fig. 5. The simple circuit required with an h.t. battery supply



lead. A typical circuit is shown in Fig 6. Two output voltages are taken from the secondary of the transformer,

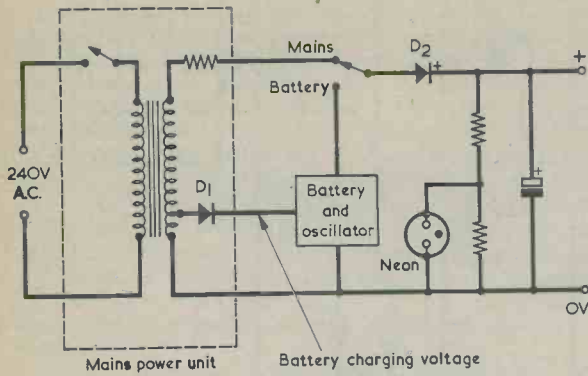


Fig. 6. A mains operated Power Supply

and one of these, after rectification, provides a direct voltage of 300 or more to charge the capacitor. The other voltage, of between 2 to 12 volts, is also rectified and is then used to charge the battery. The diode D2 serves to rectify the high voltage from the mains transformer or the oscillator transformer, as required. On studio type flash guns not using a rechargeable battery the low voltage output and rectifier are omitted. Some units may have switches giving the four possible combinations of:

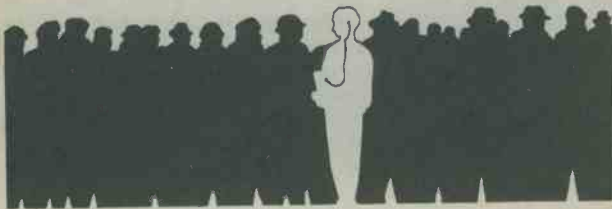
- (a) Mains operate only,
- (b) Mains operate and charge battery,
- (c) Charge battery only,
- (d) Battery operate only.

In this circuit the neon has been shown simply as an indicator across the supply. If it is coupled back to the blocking oscillator as previously described then while the unit is being mains operated it will strike and automatically cut off the blocking oscillator, allowing the battery to charge off load.

(To be concluded)

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Radio Topics

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VALVES HAVE BY NO MEANS FLED the scene yet, and I was interested to see in *Mullard Outlook* for January-February that valve production at the Mullard Blackburn factory has now stabilized at around 27 million a year. These valves consist, mainly, of a basic 40 types which are employed in TV receivers.

It is interesting to examine the history of the replacement of valves by transistors over the last two decades.

SOUND RADIO

Transistors were, of course, a natural choice for sound receivers and it was only to be expected that they would dominate the portable radio sector as soon as it was practicable for them to do so. Transistors took a significantly longer time to break into hi-fi equipment and it is, indeed, only relatively recently that one well-known manufacturer of high fidelity equipment changed over production from valve to transistor amplifiers.

The slowest of all domestic entertainment units to take advantage of semiconductor devices has been the television receiver. Some pioneering firms, such as Perdio, embarked very early on transistor television receivers, but it is only in recent years that the major manufacturers have produced fully solid state designs, and even these were preceded by a series of hybrid sets in which transistors were intermingled with valves. Judging from the American technical press, there has been a similar slowness in changing over to transistor television designs in the States. Nowadays, television receivers are virtually 100% solid state. Apart from the tube, of course!

It is not difficult to understand the relative slowness of transistor incursion into television receiver design. A television receiver is a far more complex device than a sound radio, and designers have to be more cautious in accepting new techniques which may not have the same *known* reliability as are given by existing ones. Somebody had to be the first to embark on large scale manufacture of TV receivers having a line output transistor instead of a line output valve. It has transpired that line output transistors are as reliable, and very probably more

so, than line output valves, but we only know this now because of actual field experience with line output transistors. It could well have been that, say, one in several hundred line output transistors would go pop after six month's use whereupon a TV manufacturer would find himself saddled with a product having an unenviable reputation for unreliability.

TUNER UNITS

And so it was that transistors crept rather than marched outright into television receivers. An obvious point of entry was in u.h.f. tuner units, where they were capable of offering lower noise and a more consistent performance than valves. Then they sneaked into the i.f. strip and, after this, the video amplifier stages. Surprisingly, it was quite some time before they replaced the valve in the a.f. amplifier and audio output stages of television receivers. This was very probably because these last two stages could be so readily provided by triode-pentodes of the PCL82 class, which require only a few resistors and capacitors about them to give a complete two-stage amplifier. Provided that a set had valves elsewhere, whereupon some form of heater supply had to be incorporated, it was easier to use a triode-pentode than the corresponding solid state a.f. amplifier.

But now, at long last, the transistor reigns supreme in current television design, and the transistor is, itself, being ousted by the integrated circuit. The change to solid state has been prolonged but this has probably been a good thing when viewed in the global sense. It has enabled production and service engineers to ease themselves more comfortably into the new thinking which is required with semiconductors, and it has also meant that valve production, which represents a high capital investment, has been able to run down gracefully rather than come to an end with a disastrous thump.

The days when Auntie May used to put her linen on top of a warm TV set for airing have now virtually gone and we have the added advantage, in this energy-conscious period, that power consumption (for a mono-

chrome receiver) has dropped from around 150 watts to less than a third of that figure.

REPEAT SPOT FREQUENCY

I am also indebted to the January-February issued of *Mullard Outlook* for a technical term which I don't recall having encountered before. The term, 'repeat spot', is used in phrases such as 'repeat spot frequency' and 'repeat spot response'. It has to do with interference in superhet receivers and in the *Mullard Outlook* in question is employed in reference to the performance of an f.m. radio front-end.

In general, unwanted signals which can find their way into a superhet and cause interference with the desired signal appear at the intermediate frequency, the image frequency and the repeat spot frequency. If a signal at the intermediate frequency breaks through the r.f. and mixer stages of the receiver it will, of course, be amplified by the i.f. amplifier stages. A signal at image frequency is spaced away from the desired signal frequency by twice the intermediate frequency, and is on the same side of the desired signal frequency as is the receiver oscillator frequency. To take an example, let's say that we have a superhet receiver whose intermediate frequency has the nice round figure of 500kHz. If we want to tune in a signal at 2,000kHz we can set the receiver local oscillator to 2,500kHz. The required 2,000kHz signal will then beat in the mixer with the oscillator signal to produce a 500kHz signal which can be passed on to the 500kHz i.f. amplifier. If an interfering signal at 3,000kHz found its way to the mixer, it could also beat with the 2,500kHz oscillator frequency to produce a 500kHz signal, and this would similarly be amplified by the i.f. amplifier. That 3,000kHz frequency is the image frequency.

The repeat spot frequency is spaced away from the wanted signal frequency by *half* the intermediate frequency, and is on the same side of the wanted signal frequency as is the receiver local oscillator frequency. In other words, it appears midway between the frequencies of the wanted signal and the receiver oscillator. The repeat spot signal can cause interference when its second harmonic beats with the second harmonic of the local oscillator, as the resultant signal is than at intermediate frequency.

Working from our example, in which the wanted signal is at 2,000kHz and the receiver local oscillator is at 2,500kHz, the repeat spot frequency turns up at 2,250kHz. The second harmonic of this frequency is 4,500kHz, and the second harmonic of the oscillator frequency is 5,000kHz. A frequency of 500kHz, which is the same as the intermediate frequency in our example, is given if these two second harmonics are allowed to beat together. ■

EMITTER COUPLED LIMITER

By A. Foord

Some notes on a simple limiter circuit whose function is to produce a square wave output from a sine wave input.

IF A COMMON EMITTER TRANSISTOR STAGE IS USED AS A switch it may not produce a square wave output for a sine wave input. The emitter coupled limiter is much better in this respect.

The circuit of Fig. 1 can be regarded as an emitter follower, common base pair, and it can be used as a double ended clipper to provide a square wave output for a sine wave input, for testing or instrumentation applications.

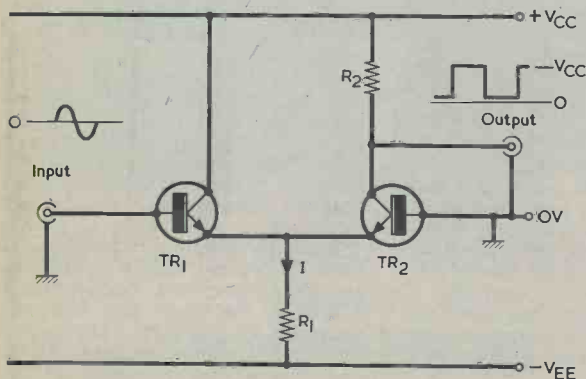


Fig. 1. The emitter coupled limiter in basic form

CIRCUIT OPERATION

The current I , in R_1 , is constant and switches between TR_1 and TR_2 ; when the input voltage is negative with respect to earth TR_1 is cut off and TR_2 conducts. When the input voltage is positive TR_1 conducts and TR_2 is cut off, so that the input signal is amplified but twice limited; once by the cut off of TR_1 and once by the cut off of TR_2 . Since the current I switches from TR_1 to TR_2 , with the total emitter current remaining constant at all times, this circuit is often referred to as a current mode switch. It is not necessary for either transistor to saturate at any time. The circuit can be very rapid in action, and 500MHz input frequency bistables can be constructed using current switching in integrated circuits.

In designing the circuit the junction of the emitters of TR_1 and TR_2 is assumed to be at earth potential and R_1 is chosen in conjunction with V_{EE} to give an appropriate I . The change in output voltage is then $I \cdot R_2$ and R_2 can be chosen so that this change is equal to the supply voltage V_{CC} . This means that the output voltage will swing between V_{CC} and earth, but TR_2 cannot saturate and the inherent switching speed of the circuit is maintained while giving the maximum output.

DESIGN EXAMPLE

To take an example let us say that V_{EE} is -6 volts and V_{CC} is 12 volts, and that we choose a current of about 3mA for I . Then the required value in R_1 is 6 volts divided by 3mA, or $2k\Omega$. We can in practice employ $1.8k\Omega$ for this resistor.

RADIO & ELECTRONICS CONSTRUCTOR

TR1 and TR2 are both germanium transistors having a voltage drop of about 0.15 volt between base and emitter so, allowing for this and having R1 equal to $1.8k\Omega$, the actual current in R1 is now 6 minus 0.15 volts divided by $1.8k\Omega$, or 3.25mA. With V_{CC} at 12 volts we can next find the value needed for R2. This is 12 volts divided by 3.25mA, which is equal to $3.69k\Omega$. A value of $3.9k\Omega$ may be used whereupon we arrive at the practical circuit shown in Fig. 2.

In this circuit the minimum input voltage for good limiting is 1 volt peak-to-peak, whilst the maximum input voltage is 15 volts peak-to-peak. Input impedance is $5.6k\Omega$, and the output voltage is 12 volts peak-to-peak. The output rise and fall times are $3\mu S$ or less, depending on the input level and the frequency.

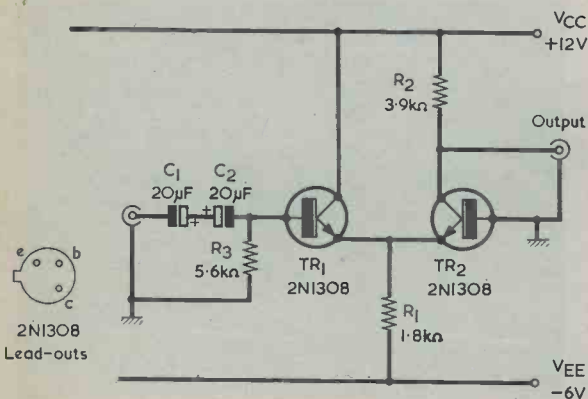


Fig. 2. A practical version of the limiter with component values

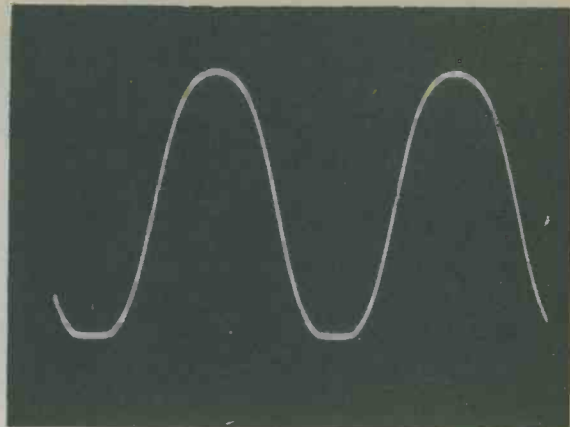


Fig. 3
The output waveform given when the input is 150mV peak-to-peak

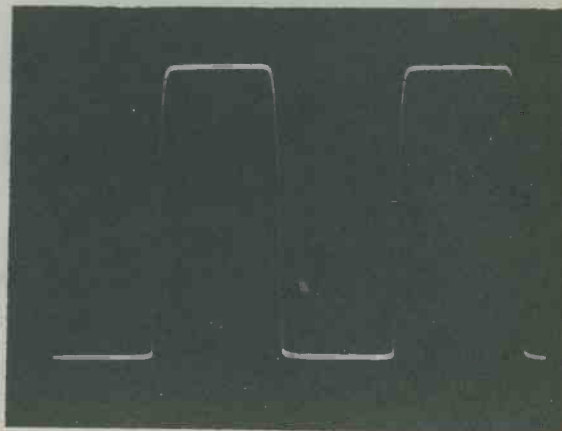


Fig. 4
This output waveform is given by an input of 1 volt peak-to-peak

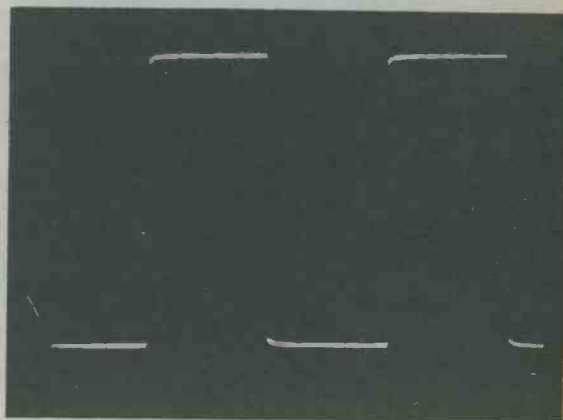


Fig. 5
Here the input is 10 volts peak-to-peak. In this photograph, and in those above, frequency is 1kHz

SWITCHING ACTION

An exact analysis of the switching action is complex because the collector currents vary exponentially with the base-emitter voltages, but it can be shown that the total input voltage needed to carry the output through its entire swing is proportional to a parameter which takes into account the recombination of carriers in the junction transition region. Such recombination is negligible in germanium but not in silicon. This factor, combined with the high reverse base-emitter voltage rating for germanium transistors, is the reason for using germanium devices in the circuit of Fig. 2.

The input capacitor in Fig. 2 consists of two electrolytic capacitors connected back to back in series. A single capacitor could be employed if the d.c. level from the circuit preceding the limiter allows this. R3 is given a relatively low value because leakage current in the germanium transistors could otherwise slightly alter the symmetrical limiting. Preferably, R3 should not be greater than $10k\Omega$.

Fig. 6

The frequency here is 10kHz with an input waveform of 10 volts peak-to-peak

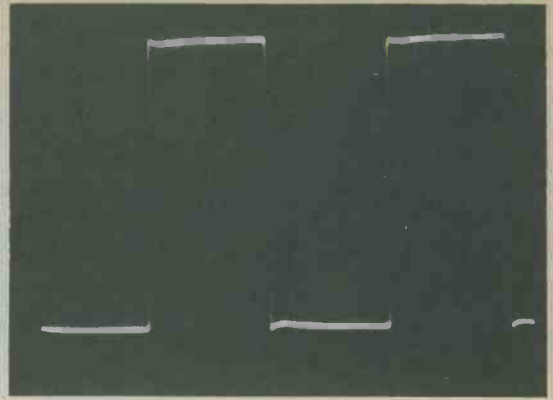
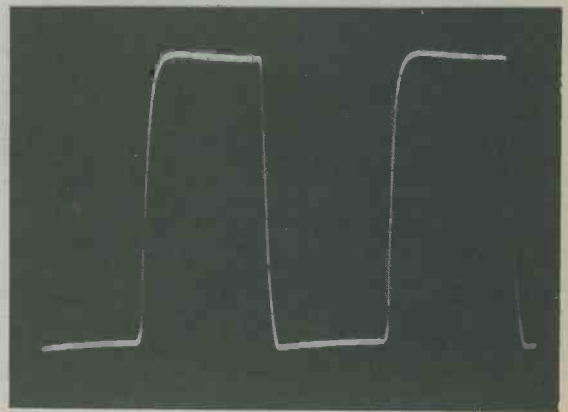


Fig. 7

An input of 10 volts peak-to-peak at a frequency of 100kHz gives this output waveform



The circuit works best when overdriven, since there is no feedback to sharpen up the edges of the output waveform. The Schmitt trigger is better in this respect but does not normally give a 1:1 mark-space ratio for a sine wave input. If really good edges are needed the emitter coupled limiter should be driven by a 10 volt peak-to-peak sine wave and followed by a Schmitt trigger.

WAVEFORMS

The waveforms shown in the photographs are actual oscillograms obtained with the circuit of Fig. 2.

Fig. 3 illustrates the output given when the input is

150mV peak-to-peak. The output is 11 volts peak-to-peak. The onset of limiting is slightly non-symmetrical due to variations in the base-emitter voltages of the two transistors. The frequency is 1kHz.

The frequency is also 1kHz in Figs. 4 and 5. In Fig. 4 the input voltage is 1 volt peak-to-peak and in Fig. 5 it is 10 volts peak-to-peak. In both cases the output is 12 volts peak-to-peak.

Fig. 6 shows the output for a 10kHz sine wave input having an amplitude of 10 volts peak-to-peak. The output is 12 volts peak-to-peak. The same output is given in Fig. 7, which illustrates operation at 100kHz with a 10 volt peak-to-peak sine wave input. The rise and fall times in this last waveform are about 1 μ S. ■

CATALOGUE

Currently available is Edition 1 of the Doram home-constructor mail-order catalogue. This lists over 4,000 different items, each having an order number to eliminate errors and to facilitate delivery. Products available cover almost the whole gamut of amateur interests, and also include hardware in the form of nuts, screws, boxes, cases and similar items. Photographs illustrate

the components listed, and dimensions are included where applicable. The section devoted to transistors also gives details of characteristics and lead layout.

The Doram catalogue can be obtained for 25p from Doram Electronics Ltd., P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds, LS12 2UF.

SHORT WAVE NEWS

FOR DX LISTENERS

By Frank A. Baldwin



Times = GMT

Frequencies = kHz

In the last issue, mention was made of some of the Dx stations that may be heard on the HF bands, conditions permitting. For the interest of those readers who would like to further extend their activities, more of these Dx stations are listed here.

● INDONESIA

RRI (Radio Republik Indonesia) Pekanbaru on 5855 around 1545. FK. RRI Manado on 5987 from 1455 with Indonesian musical programme. CL. RRI Jajapura on 7190 from 1445 till 1456 when the signal is blocked by VOA. CL.

● THAILAND

Thai TV Co., on 6010 at 2300 with anthem and identification "Thini Thor Thor Thor". BK.

● CHINA

Sinkiang on 6280 at 2330, talk in Chinese dialect, local music. CL.

● CLANDESTINE

Radio National Lao on 6130 at 2310, Lao songs, identification at 2330 then newscast in Lao. CL.

The above stations have recently been reported in the journal of the Danish Shortwave Clubs International "Shortwave News" and the credits are - FK = Finn Krone; CL = Christian Leuner and BK = Bernd Kreh.

Or you could try 9660 from 0700 for Brisbane as a starter to your day!

CURRENT SCHEDULES

● ITALY

RAI Rome has a National Programme in the Home Services which can be heard on short waves, all programmes being in Italian. National Programme, Caltanissetta on 6060 and 9515 from 0500 to 2230 except from 1430 to 1500; the Second Programme on 7175 from 0500 to 1110, 1130 to 1330 and 1400 to 2230; the Third Programme from Rome on 3995 from 1600 to 2200.

● AUSTRIA

From Vienna there is an External Service in English to Europe from 0830 to 0900 on 6155, 15410, 17850 and on 21675; from 1230 to 1300 on 6155, 9770, 11965 and on 17775; from 1830 to 1900 on 6155, 15200, 15335, 17770.

● GHANA

Ghana Broadcasting Corporation, Accra, operates an

FEBRUARY 1975

External Service in English to West Africa from 0600 to 0800 on 6130; to East Africa from 1400 to 1430 on 21720; to Central, South and East Africa and Australasia from 1445 to 1530 on 15285, 21545 and on 21720; to West Africa from 1600 to 1700 on 6130; to East Africa from 1645 to 1730 on 15285; to North America and the Caribbean from 2000 to 2100 on 11850; to West Africa from 2000 to 2300 on 6130 and to Europe from 2045 to 2215 on 9545 and on 15285.

● CHINA— 1

Radio Peking broadcasts in English to Europe from 2030 to 2130 on 5220, 6270, 6410, 6860 and on 7590; from 2130 to 2230 on 6270, 6860 and on 9030.

Other broadcasts in English from Peking are - to N. America (E. Coast) from 0001 to 0100 on 6810, 8300, 9940, 11945 and on 15060; from 0100 to 0200 on 7060, 8240, 9940, 10865, 11375, 11455, 11945, 15060 and on 15165; also on Tirana relay on 7120 and 9780; to N. America (E. Coast) from 0200 to 0300 on 7060, 8240, 9940, 10865, 11455, 12055 and on 15060; to N. America (W. Coast) from 0300 to 0400 on 8240, 9460, 10865, 11375, 11650, 12055, 15060 and on 15165, also on Tirana relay on 7120 and 9780; from 0400 to 0500 on 8240, 9460, 10865, 11650, 12055, 15060 and on 17530.

To Australia and N. Zealand from 0830 to 0930 on 9460, 11600, 11720, 12450, 15060 and on 15435; from 0930 to 1030 on 9460, 11600, 11720, 12450, 15060 and on 15435. To S.E. Asia from 1200 to 1300 on 6290, 6590, 7660, 9480, 11600 and on 11650; to N. America (E. Coast) from 1200 to 1300 on 4130, 5250, 8260 and on 11685; to S.E. Asia from 1300 to 1400 on 6290, 6590, 7660, 9480, 11600 and on 11650; to South Asia from 1400 to 1500 on 3985, 5030, 7315, 7470 and on 9860; from 1500 to 1600 on 4020, 5030, 7315, 7470 and on 9860.

To East and S.E. Africa from 1600 to 1700 on 4020, 5030, 7590, 8345 and on 9860; from 1700 to 1800 on 4020, 5030, 5545, 7590 and on 9860. To S. Asia from 1800 to 1900 on 6590; to North and West Africa from 1930 to 2030 on 5545, 6400, 7620 and on 9470 and from 2030 to 2130 on 5545, 6400, 7620 and on 9470.

● KUWAIT

The English transmission from Radio Kuwait is now from 1700 to 2000 on 9715 and on 15415.

● PAKISTAN

The evening World Service transmission directed to the U.K. has been extended and is now from 1915 to 2145 on 6235 and on 7085. The timing of the three language sections are as follows - from 1915 to 2000 in

Urdu, from 2000 to 2015 in Sylheti, from 2015 to 2100 in Urdu and from 2100 to 2145 in English.

● CZECHOSLOVAKIA

Radio Prague broadcasts to the U.K. in English from 1630 to 1700 on 5930 and on 7345; from 1900 to 1930 on 5930, 7245 and on 7345; from 2000 to 2030 on 5930 and on 7345 and from 2130 to 2200 on 6055.

● GERMANY (WEST)

"Deutsche Welle - The Voice of Germany", Cologne, presents a daily service in English to Asia from 0120 to 0220 on 6065, 7210, 7285 and on 9670; to N. America (East Coast) from 0100 to 0205 on 6010, 6040, 9565, 9690, from Malta relay on 6100, 9745 and on 11865; to N. America from 0300 to 0350 on 6040, 6075, 6185 and on 9545; to Central and E. Africa from 0430 to 0515 on 5990, 9615, from Kigali, Rwanda relay on 7225 and on 9565; to N. America (W. Coast) from 0445 to 0550 on 6075, 6185 and on 9545; to W. Africa from 0600 to 0630 on 9700, 9765, 11765 and on 11775; to Asia, Australia and N. Zealand from 0930 to 1030 on 9650, 11850, 11925, 15275, 17800, 17825, from Kigali relay on 17780 and on 21540; to Central and E. Africa from 1045 to 1115 on 17875, 21500, 21600, from Kigali relay on 11785 and on 15410; to W. Africa on 17875, 21600, from Kigali relay on 15410 and on 17765; to Central and E. Africa from 1715 to 1745 on 11810, 11850, from Kigali relay on 7285 and on 9735; to Asia from 1720 to 1750 on 7160, 11785, from Malta relay on 11705 and on 15320; to W. Africa on 9765, 11795 and on 11905; to Asia, Australia and N. Zealand from 2100 to 2200 on 6185, 7130 and on 9765.

● ISRAEL

The Israel Broadcasting Authority operates an External Service in English as follows - from 0500 to 0515 to Europe and N. America on 6000, 7395, 9009, 9495, 12025 and on 17690; from 1130 to 1200 to Europe, N. America, S.E. Asia and the Pacific on 9009, 12025, 15100, 15130 and on 17690; from 2000 to 2055 to Europe, N. America and Africa on 7395, 9009, 9495, 9630, 9815, 11645, 12025, 15100 and on 17690.

A relay of the Home Service Second Programme, in Hebrew for overseas listeners, is radiated as follows - from 2000 to 2305 on 7125; from 1700 to 1955 and from 2100 to 2305 on 9495; from 0400 to 0700 and from 1100 to 1200 on 11645; from 0400 to 1655 on 12045 and from 0700 to 1100 on 15130.

● AUSTRALIA

Radio Australia, Melbourne, has the following English transmissions in the Overseas Services, from 0100 to 0300 to N. America on 11970, 15320 and on 17795; from 0330 to 0500 to Africa on 15290 and on 17820; from 0700 to 0845 (in Simple English) to Papua, New Guinea on 7220, 9760 and on 11885; from 0815 to 0915 to the U.K., Europe and Pacific on 9570 and on 11765 and from 1115 to 1245 to N. America on 9580.

● CHINA—2

For Dxers, the Mongolian Service of Radio Peking; from 1400 to 1500, is being relayed by the regional transmitters at Huhehot on 4068 and on 4895 and from Hailar on 3900.

The Hindi Service of Radio Peking is being relayed from Lhasa from 1600 to 1700 and from 1700 to 1800 (rebroadcast of former transmission) on 4035, 5935 and on 9490.

AROUND THE DIAL

● CLANDESTINE

Radio Mother of Vietnam, S. Vietnam, at 1340 on 9810, OM & YL in Vietnamese with local music as interludes, lost in the QRM by 1400.

Voice of Iraqi Kurdistan at 1458 on 10050, Arabic music, identification in Kurdish, OM with announcements, Moslem chants till 1507 then more music, also in parallel on 5868.

Radio Pathet Lao on 1350 on 6211, song by YL in Lao, YL announcer at 1351 then OM with song, parallel on 6199 but signal much weaker.

● CHINA—2

Foochow on 4975 at 1540, YL with song in Chinese dialect, talk by YL.

Radio Peking on 4800 at 1550, YL with song, local music; on 3830 at 2005. YL in Standard Chinese to Taiwan.

PLA Fukien Front on 3535 (amid the amateur CW signals) at 1940, YL with song, local music in the Amoy Service to Offshore Islands and Taiwan; on 4380 at 2013 with YL in Standard Chinese, local music.

PBS Sinkiang on 6280 at 2318, Chinese music, OM announcer, YL with song.

Urumchi on 4110 at 2310, YL with song, local music (not parallel with 4500). On latter channel, same time, OM in Chinese dialect.

Wuhan on 3940 at 2308, YL with song, local music.

● MONGOLIA

Ulan Bator on 5053 at 2204, news (?) in Mongolian read by YL till 2205 then OM announcer, severe utility QRM on channel.

● SRI LANKA

Colombo on 3385 at 1603, YL with song in Sinhala with programme of local music, OM announcer.

● MALAYSIA

Penang on 4985 at 1536, Moslem chants after announcements by OM; R. Sabah on 4970 at 1542, YL with song, local music, OM announcer in vernacular; Kuching on 4835 at 2225, OM announcer, local music; Kuching on 5005 at 2240, YL announcer in programme of local pops.

● ZAIRE

Lumbumbashi on 4750 at 2115, OM in French with announcements then into a discussion on local affairs.

● BURUNDI

Bjumbura on 3300 at 1625, YL's in chorus, local mx, then into religious service in vernacular, complete with hymns.

● ECUADOR

Radio Nacional Espejo on 4679 at 0445, OM with identification, Latin American style music.

● PERU

Radio Samaren (formerly Radio Amazonas) on 4815 at 0435, LA music, OM with songs in Spanish.

● CLANDESTINE

We end this section as we began, try for the Voice of the Malayan Revolution on 11830 and 15790 from 1500 to 1530 when they are in English (believed located in Hunan province of China).

In your workshop



This month Dick and Smithy decide to examine some of the basic factors of capacitive reactance. In the process, Smithy is able to demonstrate the simple properties of low and high pass RC filters, and to show how these can be expressed in terms of time constant.

A DEAD EASY FAULT," BOASTED Dick. "It was a little sound radio which gave no output and I found the snag without even having to get my testmeter into action."

Smithy took a gargantuan bite from his sandwich.

"Go on," he said indistinctly. "What was the trouble?"

"It was the electrolytic coupling the output stage to the speaker," replied Dick. "I happened to touch it when I was poking around inside the case and the sound came on, just like that."

"Cold joint?"

"No," stated Dick. "The joints which held the electrolytic in place were as solid as the Rock of Gibraltar. There was an intermittent connection inside the electrolytic itself. You could get the sound from the speaker to come on and off simply by waggling the capacitor about on the board. I just fitted a new capacitor and that was that. Job done." (Fig. 1.)

CAPACITANCE VALUE

"Humph," grunted Smithy. "What value did the capacitor have?"

"Oh," said Dick carelessly, "the faulty one was 500 μ F. We don't have any electrolytics of that value in stock at the moment, and so I put a 400 μ F one in its place."

"That should be near enough for an application like that," commented Smithy. "Most low voltage electrolytics have a tolerance on value of the order of minus 25% to plus 100%, and so it wouldn't matter all that much if you used a slightly different value for a speaker coupling capacitor in a small sound radio. Even so, it's always

best to replace with the same nominal value if you possibly can do, as the chap who designed the set will have taken the tolerances into account when he specified the original one."

After which comment, Smithy picked up his battered tin mug and drank deeply. It had been a pleasant morning, with work proceeding briskly and evenly. Now, he and Dick were enjoying a leisurely lunchbreak. Dick, inevitably, had steered the conversation towards matters electronic.

"Does the capacitance matter all that much?" queried Dick. "After all, an electrolytic is just a high value brute-force sort of component, isn't it?"

"Of course the capacitance matters," said Smithy sharply. "In that speaker coupling circuit of yours, for instance, the value of the series coupling capacitance determines the bass response from the speaker."

"Well," retorted Dick, "what about the case where you've got, say, a faulty 100 μ F decoupling capacitor? Would it hurt if you replaced it with a 200 μ F capacitor? Or even a 1,000 μ F capacitor?"

"Provided," said Smithy carefully, "that the capacitor was intended purely for decoupling purposes, it probably wouldn't matter in most instances if it was replaced with a larger value. But if there are any surge currents lurking around, as you'd get in a power supply circuit, a larger replacement value could conceivably lead to trouble."

He popped the last of his lunch-time sandwich into his mouth and chewed meditatively.

"Now, let's see," he remarked thoughtfully. "The original electrolytic in that set of yours had a value of 500 μ F. That would mean that it had a reactance of about 3 Ω at 100Hz."

"Hey, hang on a minute," said Dick uneasily. "What's all this ohms business? We've been talking about microfarads up to now."

Smithy turned towards his assistant and raised his eyebrows.

"Dear me," he remarked in a tone of surprise, "your basic electronics isn't even rusty, it seems to be completely non-existent. Now, I hardly have to tell you that the most common function of a capacitor is to allow the passage of alternating current through it. The capacitor offers some opposi-

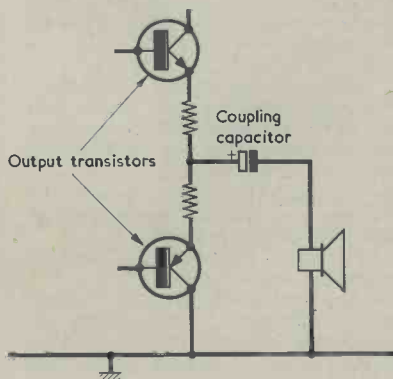


Fig. 1. A complementary output stage with an electrolytic capacitor coupling the output emitters to the speaker.

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tion to the flow of alternating current, and we call this its reactance. And the reactance is measured in ohms."

"Oh, that," scoffed Dick. "Why, that's just text-book stuff. I forgot all about reactance as soon as I started practical servicing."

"Well, you shouldn't forget about it," retorted Smithy. "You can understand the operation of a circuit much more readily if you have an idea of the reactance that the capacitors in it present. And it's well-nigh essential to know about capacitor reactance if you're going to do any serious design work."

Smithy drained his mug and held it out to his assistant, whereupon Dick rose and replenished it for him from the battered kitchen effects which stood alongside the Workshop sink. He returned and placed the mug on Smithy's bench, after which Smithy picked it up and took a copious draught. Over the years, the Workshop Tea Ritual had become so formalised as to rival its Japanese counterpart.

"All right then," said Dick. "Let's get back to this reactance business. When I start to think about it, I suppose I'll be right if I say that reactance goes down as capacitance goes up. This must be the case, because a high capacitance will let a larger alternating current through than will a small capacitance."

"That's true," confirmed Smithy. "Reactance goes down, also, as the frequency of the alternating current increases. This is again pretty obvious because we know that radio frequencies require lower value coupling capacitors than audio frequencies do."

REACTANCE TABLE

"All right then," said Dick. "Let's have a look at some actual reactance values. If I remember correctly, you said just now that a 500 μ F capacitor has a reactance of 3 Ω at 100Hz. How can you quote a reactance value off the cuff just like that?"

Smithy grinned smugly.

"When you're dealing with things like reactances," he pronounced, "it's worth-while remembering one particular reactance so that you can work out other reactances from it. The particular reactance I keep in my mind is that for 100 μ F at 100Hz. The reactance of 100 μ F at 100Hz is 16 Ω ."

"But how," pressed Dick, "can you remember those numbers?"

"Ah," said Smithy proudly, "I made up a mnemonic which gives an association between them."

"Did you?" replied Dick, impressed. "But what sort of mnemonic will couple together two 100's and a 16?"

"A dead easy one," pronounced Smithy triumphantly. "100 times 100 is 10,000, and 10,000 in binary is 16 in decimal! Got it?"

"Ye gods," snorted Dick in disgust.

"You call that a mnemonic? Blow me, it needs someone with a brain as devious as yours to even think of something like that. Well, okay then, let's start off with 100 μ F and 100Hz giving a reactance of 16 Ω . You said that a 500 μ F capacitor gave a reactance of 3 Ω at 100Hz. How do you arrive at that?"

"I said about 3 Ω ," Smithy corrected him. "Well now, 500 μ F is 5 times 100 μ F, and so its reactance is one-fifth of that given by 100 μ F. The frequency remains the same, at 100Hz, and so the reactance of the 500 μ F capacitor is one-fifth of 16 Ω , or about 3 Ω ."

"This sounds easier than I thought it would," remarked Dick, his interest patently aroused. "Let's work out some other reactance values."

"I've got a better idea than that," said Smithy, reaching for his note-pad. "Let's make up a table of reactances for the whole range of audio frequencies, and for the whole range of capacitances you're likely to encounter at these frequencies. All we need is a starting off point. Now, the reactance of a capacitor is equal to 1 over $2\pi fC$, where reactance is in ohms, f is in Hz and C is in farads."

Smithy wrote down the equation.

"Now," he went on. "I'll work out the reactance of 100 μ F and 100Hz to three significant figures from this formula, just to show you that my brilliant mnemonic - and I just can't understand why you're so scornful about it - is accurate enough for normal work."

The Serviceman busied himself with his figures. (Fig. 2).

$$\begin{aligned} \text{REACTANCE} &= \frac{1}{2\pi fC} \\ &= \frac{1}{2\pi \times 100 \times 100 \times 10^{-6}} \\ &= \frac{10^2}{2\pi} \\ &= \underline{\underline{15.9\Omega}} \end{aligned}$$

Fig. 2. Calculating the reactance of a 100 μ F capacitor at a frequency of 100Hz.

"Here we are," he pronounced after some moments. "The reactance calculates out as 15.9 Ω . Corrected to two significant figures, this becomes 16 Ω , and we'll use that figure to start off our table."

RADIO & ELECTRONICS CONSTRUCTOR

Smithy tore the top page from his pad and drew a series of vertical and horizontal columns on the fresh sheet underneath. He next commenced writing frequency and capacitance values along the top and left hand sides, and then entered '16Ω' at the appropriate space for 100μF and 100Hz. (Fig. 3.) Intrigued, Dick took his stool over and perched himself alongside the Serviceman.

"Stap me," he remarked, "you're going all the way down to 10pF. Don't tell me that 10pF has any significant effect at audio frequencies."

"It can have a small effect at the higher frequencies," replied Smithy. "We'll say at the outset that we shan't bother to enter any reactances that are higher than 10MΩ, and so there won't actually be many entries along the 10pF line. Also, we shan't enter any calculated values lower than 1Ω. I'll explain about that in a moment or two."

"Have we got to work out that 1 over 2πfC equation for all these entries?"

"No", stated Smithy. "We just proceed from the single reactance value of 16Ω. We can start off with the 100Hz column. The formula tells us that reactance varies inversely with capacitance, which means that if the capacitance is multiplied by 10 the reactance is divided by 10. So we can enter the reactance for 1,000μF straightaway. This is one-tenth of 16Ω, or 1.6Ω."

Smithy entered the figure.

"Blimey," said Dick, "this is easy. What about 10μF? Will this be ten times 16Ω?"

"It will be," confirmed Smithy, "and the numbers above will be multiplied by 10 again each time until we get to 1.6MΩ at 1,000pF. We won't put in any figures higher than this because we said we'd have a limit of 10MΩ." (Fig. 4(a).)

"Gosh," said Dick. "This really is a piece of cake. Shall we do the 50Hz column next?"

"If you like," replied Smithy. "This time, since the frequency is halved the reactance at 100μF is doubled. If we work from the three significant figures number of 15.9, the reactance of 100μF at 50Hz is twice 15.9, or 31.8Ω. But we are presenting our results to two significant figures, and so we can put 32Ω in the table against 100μF. Then, all we do is divide by 10 for the 1,000μF entry, and keep on multiplying by 10 for all the entries above."

Smithy entered the figures in the 50Hz column. (Fig. 4(b).)

"This is a steal," said Dick excitedly.

"The numbers work out so easily it just isn't true. What about the frequency columns above 100Hz?"

"Things are just as simple there," said Smithy. "At 500Hz the reactance of any capacitor is one-tenth of its reactance at 50Hz. So all the lower entries in the 500Hz column are simply those in the 50Hz column

	50Hz	100Hz	500Hz	1kHz	5kHz	10kHz
10pF						
100pF						
1,000pF						
0.01μF						
0.1μF						
1μF						
10μF						
100μF		16n				
1,000μF						

Fig. 3. The table made up by Smithy in its initial state. The reactance of 100μF at 100Hz provides a suitable starting point for completion of the table.

divided by 10. And we divide by 10 again for the 5kHz column."

"You'll do the same sort of thing," cut in Dick eagerly, "for the 1kHz and 10kHz columns. These will have the figures in the 100Hz column divided by 10, and then by 10 again."

"Exactly," confirmed Smithy. "In fact, the best thing I can now do is to leave you to complete the table

yourself."

Smithy pushed his note-pad towards his assistant. Dick started to enter the remaining figures in the table.

"What do I do," he asked, "when the calculated figure is below 1Ω?"

"Just," replied Smithy, "enter 'less than 1Ω'."

	50Hz	100Hz
10pF		—
100pF		—
1,000pF		1.6Mn
0.01μF		160kn
0.1μF		16kn
1μF		1.6kn
10μF		160n
100μF		16n
1,000μF		1.6n

(a)

	50Hz	100Hz
10pF	—	—
100pF	—	—
1,000pF	3.2Mn	1.6Mn
0.01μF	320kn	160kn
0.1μF	32kn	16kn
1μF	3.2kn	1.6kn
10μF	320n	160n
100μF	32n	16n
1,000μF	3.2n	1.6n

(b)

Fig. 4(a). Entering the reactance in the 100Hz column involves multiplying or dividing by 10, as applicable.
(b). Entries in the 50Hz column consist of the 100Hz figures multiplied by 2.

	50Hz	100Hz	500Hz	1kHz	5kHz	10kHz
10pF	—	—	—	—	3.2M Ω	1.6M Ω
100pF	—	—	3.2M Ω	1.6M Ω	320k Ω	160k Ω
1,000pF	3.2M Ω	1.6M Ω	320k Ω	160k Ω	32k Ω	16k Ω
0.01 μ F	320k Ω	160k Ω	32k Ω	16k Ω	3.2k Ω	1.6k Ω
0.1 μ F	32k Ω	16k Ω	3.2k Ω	1.6k Ω	320 Ω	160 Ω
1 μ F	3.2k Ω	1.6k Ω	320 Ω	160 Ω	32 Ω	16 Ω
10 μ F	320 Ω	160 Ω	32 Ω	16 Ω	3.2 Ω	1.6 Ω
100 μ F	32 Ω	16 Ω	3.2 Ω	1.6 Ω	<1 Ω	<1 Ω
1,000 μ F	3.2 Ω	1.6 Ω	<1 Ω	<1 Ω	<1 Ω	<1 Ω

Fig. 5. The completed reactance table.

OVERALL PICTURE

Dick soon had the table completed. (Fig. 5.)

"There you are," he announced excitedly. "One capacitive reactance table, all complete."

"Good, good," said Smithy. "If you take an overall look at it you'll find quite a lot of interesting points. For instance, in the old valve days we used to look upon 0.01 μ F as virtually the standard value for an a.f. coupling capacitor to a valve control grid. But, as you can see from the table, this wasn't quite as good a coupling capacitor as we fondly imagined. At 500Hz, a 0.01 μ F capacitor has a reactance of 32k Ω , and at 100Hz the reactance is as high as 160k Ω ."

"With transistors," said Dick, "it's more common to use something like 1 μ F or 10 μ F for a.f. coupling to a transistor base. At 100Hz, 1 μ F has a reactance of 1.6k Ω and 10 μ F has a reactance of 160 Ω . Blow me, Smithy, making out a table like this certainly opens your eyes to things as they really are."

"Very true," replied Smithy. "Before proceeding further, I'll next tell you why we aren't entering calculated values for reactances below 1 Ω . The reason for this is that capacitors which produce these low reactances are bound to be electrolytic types, and these can be assumed in practice to have internal impedances, quite apart from their capacitive reactances, which are of the order of an ohm or so. Indeed, if the capacitors are miniature electrolytics they can have internal impedances which are somewhat higher, even."

"You could use this table," said Dick reflectively, "to work out a tone control circuit. How would you set about finding the values for a top cut circuit for an audio amplifier?"

"Ah," said Smithy. "Well, there's a fairly elementary approach we can use here. In its simplest form, a top cut circuit can consist of a series resistor followed by a parallel capacitor. This is known as a low pass filter because it allows low frequencies through without attenuation but it attenuates high frequencies. The frequencies which are attenuated then depend upon the values of the resistor and capacitor."

Smithy removed the sheet with the reactance table from his pad, then drew the circuit of the low pass filter. (Fig. 6.) Catching sight of the tin mug on his bench, he picked it up and drank avidly from it. As he watched the Serviceman, Dick's thoughts momentarily wandered from the subject of reactance.

"With the amount of tea you drink," he commented accusingly, "your insides must be all stained brown by now."

"I drink tea," explained Smithy with dignity, "as a means of keeping my system in a state of equilibrium. A generous intake of fluids keeps my internal parts nicely lubricated and functioning smoothly."

"Huh," snorted Dick scornfully. "I should imagine that what internal

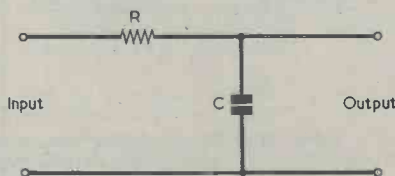


Fig. 6. A simple RC low pass filter

parts haven't been washed away by now have gone all soft and soggy. When they cut you open they'll find you're like one gigantic sopping wet crumpled-up chammy leather inside."

"Let's," said Smithy hastily, "get back to this low pass filter."

"I wouldn't be at all surprised," went on Dick, warming to his theme, "if a few odd tea leaves haven't got through down there and taken root. I'd guess you've got a tea-tree growing inside you, and you have to keep drinking more and more tea all the time to keep it nurtured."

"For goodness' sake," snarled Smithy irately, "change the conversation. And you don't have tea-trees, you have tea-bushes."

"And I bet," continued Dick inexorably, "that you've got a prime sample of one sprouting up inside that great guts of yours."

"Will you please belt up?" shouted Smithy furiously. "I don't want to hear any more about tea. I want to talk about filters."

"Like parallel-T ones?"

"So help me," roared Smithy furiously, "one of these days I'll swing for you. Now, for Pete's sake give it a rest."

"All right," said Dick obligingly. "From now on I'll talk only about electronics."

"Thank goodness for that," grunted Smithy. "You've got me so flustered now that I've clean forgotten what I was talking about."

"You'd just drawn that circuit for a low pass filter," said Dick, pointing to Smithy's note-pad.

"Oh, so I did," responded Smithy, collecting his scattered thoughts. "Well now, let's see what comes next. Ah yes, the filter characteristic. If you draw a curve showing filter output voltage against frequency, you'll find that at frequencies where the reactance of the capacitor is much higher, in ohms, than the value of the resistor, there is virtually no attenuation of the input voltage. As the frequency rises the reactance falls, and at a frequency where the reactance comes close to the resistance, the filter begins to give attenuation. At the frequency where the reactance is equal to the resistance the attenuation is such that the output voltage is 0.707 of the input voltage. This frequency is known as the 'cut-off frequency' of the filter. As frequency increases further so does the rate of attenuation, until the attenuation settles down to a steady 6dB per octave."

ATTENUATION RATE

"Whoa up!" interrupted Dick. "I was with you all the way up to the last sentence. What's this 6dB per octave bit?"

"It's simply another way of saying that the output goes down by a half when the frequency is doubled. This can be shown most clearly if you draw

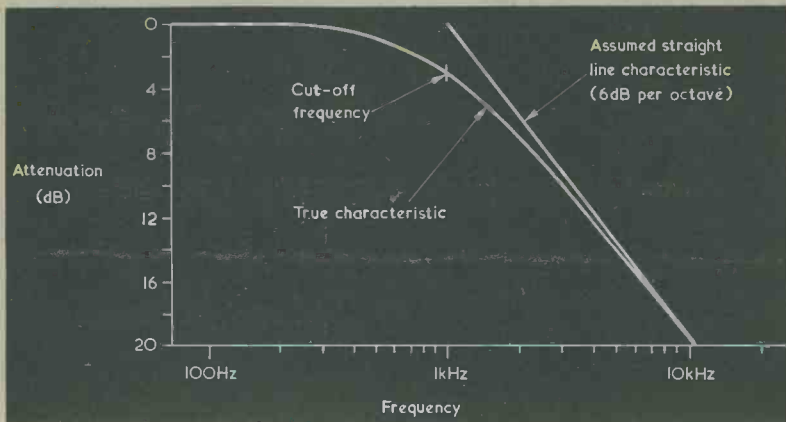


Fig. 7. The characteristic of the low pass filter, drawn for a cut-off frequency of 1kHz

a curve with the vertical axis graduated in dB's of attenuation. Something like this."

Smithy sketched out a curve on his note-pad. (Fig. 7.)

"As you can see," he went on, "there is a fairly gradual increase in attenuation around the cut-off frequency until the downward-going part of the curve starts to straighten out. If we add a straight line to the curve, touching it at the straightest bit, we can say with only a small amount of error that this straight line constitutes the attenuation characteristic."

Smithy added the straight line.

"If," he continued, "we work to the straight line we can then say, with a slight error only, that the output falls off at 6dB per octave above the cut-off frequency itself. If the cut-off frequency is 1kHz, then the output is one-half at 2kHz, one-quarter at 4kHz, one-eighth at 8kHz and so on. This may also be described as a high frequency roll-off starting at 1kHz."

"I've got the idea," said Dick, pulling the reactance table they had prepared towards him. "Well, this table tells us that the reactance of a 1,000pF capacitor at 1kHz is 160kΩ. Will the filter have a cut-off frequency of 1kHz if it has a 1,000pF capacitor and a 160kΩ resistor?"

"It will," confirmed Smithy. "The cut-off frequency will also be 1kHz with values of 0.01μF and 16kΩ, 0.1μF and 1.6kΩ or 1μF and 160Ω. We haven't included a 2,000pF capacitor in our table, but since its capacitance is twice that of a 1,000pF capacitor its reactance will be half of 160kΩ, or 80kΩ. So you'll also get a cut-off frequency of 1kHz with 2,000pF and 80kΩ, 0.02μF and 8kΩ, 0.2μF and 800Ω and so on."

"These figures are rather fascinating," said Dick. "As the capacitance value goes up the resistance value goes down."

"That's very true," agreed Smithy. "In fact, if you multiply the capacitance, in microfarads, and the resistance, in ohms, in each of the capacitor and resistor pairs I've just mentioned, you'll find that all the answers come out the same, at 160. Now, we refer to the product of capacitance and resistance as a 'time constant', and this allows any simple RC low pass filter to be defined in terms of that time constant. Microfarads multiplied by ohms come to microseconds, and so we can state that a low pass filter with a cut-off frequency of 1kHz has a time constant of 160 microseconds. It's merely a convenient way of defining the capacitance and resistance which makes up the filter."

"This time constant business seems to ring a bell," commented Dick. "Isn't there something about a 50 microsecond time constant in f.m. receivers?"

"There is," replied Smithy. "The transmitted signal has a pre-emphasis at the higher audio frequencies, and this is cancelled out by a de-emphasis circuit at the receiver. The de-emphasis circuit can be a low pass filter of the type we've been discussing, and for British f.m. signals it should have a time constant of 50 microseconds. You'll get this with a 0.05μF capacitor and a 1kΩ resistor, a 0.005μF capacitor and a 10kΩ resistor, and so on. Any resistor and capacitor which give a time constant of 50 microseconds can be used to provide the de-emphasis. They could, for instance, also be 0.1μF and 500Ω, whereupon you can see

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from our reactance table that the cut-off frequency of the filter will be close to 5kHz on the 1kHz side."

Dick looked thoughtfully at the circuit of the low pass filter.

"I must say that all this seems very easy to follow," he remarked musingly. "I can see now how you get a low pass filter when you have a parallel capacitor following a series resistor. Also, I can visualise how you can select the cut-off frequency you want by choosing appropriate values of resistance and capacitance. So that's a low pass filter. What happens if you have a parallel resistor following a series capacitor?"

"You get a high pass filter!"

"Just like that?"

"Just like that," confirmed Smthy.

The Serviceman sketched out the high pass filter circuit. (Fig. 8.)

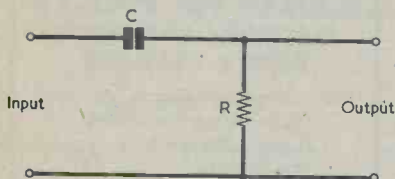


Fig. 8. A high pass filter

"This type of filter," he pronounced, "passes the higher frequencies and attenuates the lower frequencies. What is more, it acts just like a mirror image to the low pass filter. Here, I'll show you the characteristic."

Smthy sketched out a further graph. (Fig. 9.)

"Why," exclaimed Dick, "that's the same as the low pass filter curve but the other way round."

"Exactly," agreed Smthy. "As before, you have a cut-off frequency which is given at the frequency where the reactance and resistance are equal. Frequencies well above the cut-off frequency are not attenuated, and attenuation commences when the frequency falls close to the cut-off frequency. At the cut-off frequency itself the output voltage is 0.707 of the input voltage, and as frequency drops

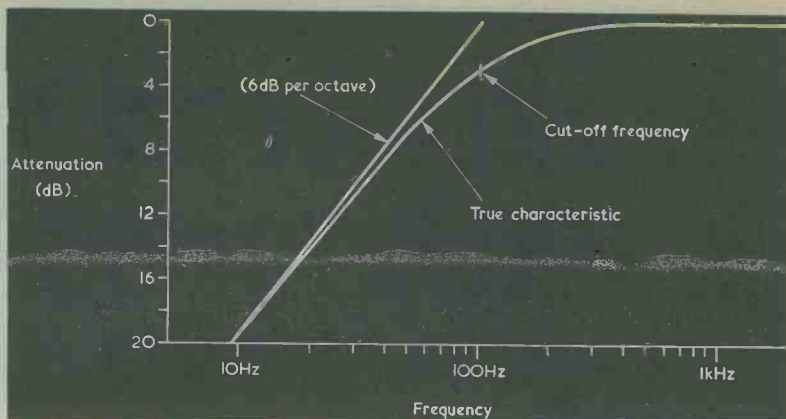


Fig. 9. The high pass filter characteristic, shown for a cut-off frequency at 100Hz

further, the attenuation curve takes up the approximate 6dB per octave slope we had with the low pass filter. Only this time the attenuation increases as frequency falls, rather than increasing as frequency rises."

"This could help you in the selection of a.f. coupling capacitors," remarked Dick. "If you know the resistance value which follows an a.f. coupling capacitor, you can choose the latter to give the required cut-off figure."

FULL CIRCLE

He broke off as a thought suddenly occurred to him.

"Why, blow me," he remarked.

"This is where we came in!"

"How d'you mean?"

"Well, we started off this discussion by talking about the electrolytic capacitor which coupled the output stage of that radio I fixed to its speaker. With this high pass filter business you can find just the value of coupling capacitor you need here."

"You can," responded Smthy guardedly, "but only in a very approximate manner. Still, I'll stay with you on this. Let's say you've got a 16Ω speaker and then let's make the very wide assumption that this is a 16Ω resistive impedance. From the table, we see that a 10μF capacitor has a reactance of 16Ω at 1kHz, so if you used 10μF as the coupling capacitance,

the bass cut-off frequency given by the capacitor and the speaker becomes 1kHz. With 100μF, the bass cut-off frequency is 100Hz, and with 1,000μF it's 10Hz. But I must repeat that these are very broad approximations, because speaker impedance is a mixture of resistance and inductance, and because this impedance itself varies with frequency. Again, the electrolytic capacitors you'll be using have the wide tolerance I referred to earlier. Still, this approach does give you a guideline to work to when choosing a series output coupling capacitor for a speaker."

"I must say," said Dick, pleased, "that this business of speaker capacitance value rounds things off very nicely."

He ruminated contentedly over the facts about capacitive reactance he had acquired.

Smthy rose from his stool.

"Hello," said Dick, "where are you off to?"

"I've been considering," replied Smthy, as he walked towards the door, "those very rude remarks you made some moments ago concerning the insides of my body. In consequence, I've decided to make a small adjustment to it."

"A small adjustment?"

"I intend," said Smthy gravely, as he stood framed in the doorway, "to re-position its centre of gravity." ■

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BASIC POWER AMPLIFIER

By I. D. Campbell

Employing basic circuit techniques, this a.f. amplifier offers a high level of fidelity and uses easily obtainable components.

THIS AMPLIFIER WAS DEVELOPED TO FULFIL THE BASIC requirements of low cost together with reasonable output power and quality. As regards cost, the two output transistors are the popular 2N3055 type and these are offered by some manufacturers at very low prices. The driver and voltage amplifier transistors are small-signal devices and retail for less than 20 pence each. Three amplifiers employing the same circuit have been built by the author and friends and have been found to give very low noise levels and good output power. Theoretical r.m.s. output power, with a stable 40 volt supply, is about 21 watts into an 8 Ω load.

OUTPUT STAGE

The amplifier circuit appears in Fig. 1. The output transistors are TR6 and TR7, and these run with a quiescent current of 20mA. R11 and R12 increase thermal stability. TR4 and TR5 are the current drivers for the output transistors, and the presence of R9 causes them to offer roughly similar impedances at their bases. Fuse F1 is rated at 1.5 amps and should provide a reasonable level of protection, but it may not protect the output transistors against such eventualities as an output short-circuit when the amplifier is handling a high level signal. In general it is recommended that the output load be 8 Ω or more. If a low gain specimen is

employed for TR6 or TR7 there will be a fairly high dissipation in TR4 or TR5, as applicable. However, no problems have arisen with these transistors in practice.

The input stage incorporates TR1, and this is directly coupled to TR2. C3, in the collector circuit of TR1, prevents spurious oscillations. TR2 is a voltage amplifier, and the upper end of its collector load resistor, R6, is bootstrapped to the output via C7 to maintain an effective constant current. C4, between collector and base of TR2, also assists in keeping the circuit stable. VR2 and TR3 provide the bias conditions required for correct quiescent current in the output stage. The output point at the junction of C7 and C5 is set to half the supply voltage by means of VR1. Both VR1 and VR2 must be good quality components having reliable contact between the slider and the track.

The input signal is taken in via C1. The circuitry around TR1 and the base of TR2 is at low impedance, with the result that C3 can have a relatively high value without unduly affecting frequency response. With a neat and well built layout it should be possible to reduce the value of C3 and, likewise, C4, but these capacitors should, at least initially, have the values specified. It should be noted that, if oscillation results following a reduction in value in either or both of these capacitors, the amplifier may draw a high overall current.

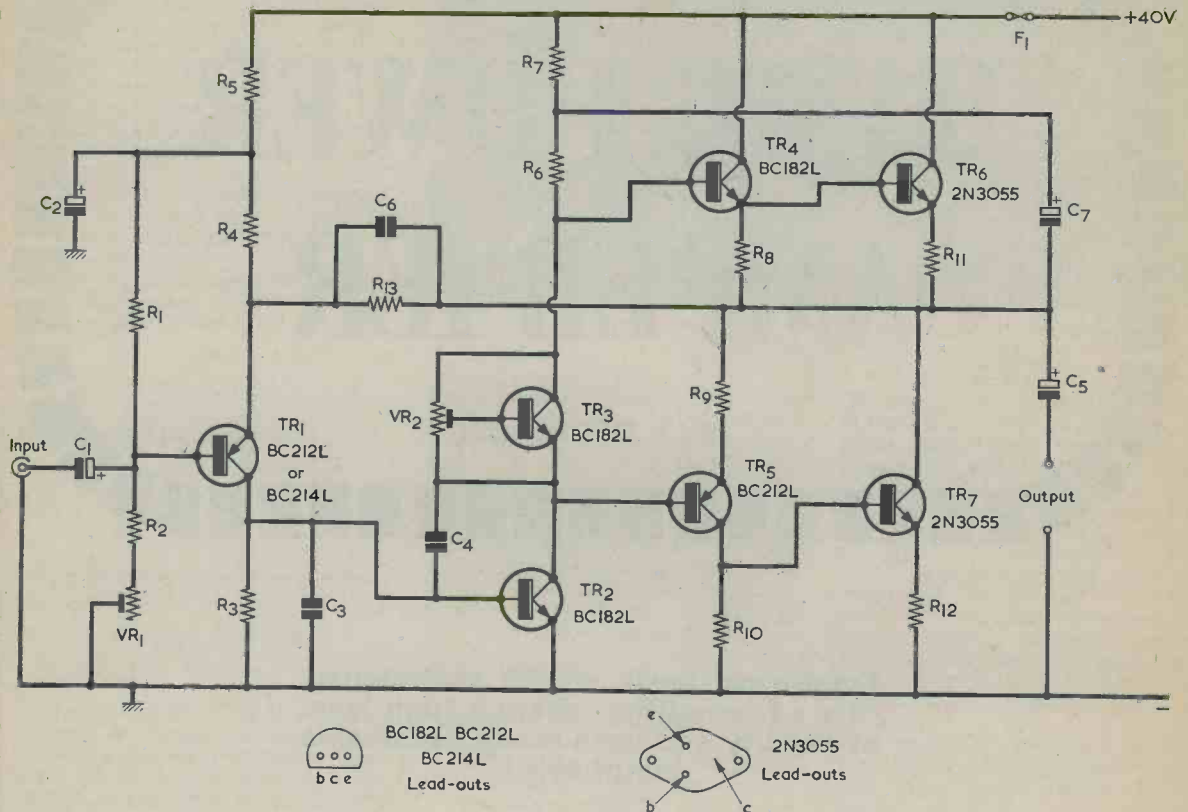


Fig. 1. The circuit of the a.f. amplifier

COMPONENTS

Resistors

(All fixed values $\frac{1}{4}$ watt 5% unless otherwise stated)

R1	33k Ω
R2	150k Ω
R3	470 Ω
R4	560 Ω
R5	22k Ω
R6	4.7k Ω
R7	1k Ω
R8	1k Ω
R9	82 Ω
R10	1k Ω
R11	0.22 Ω 1 watt, wire-wound
R12	0.22 Ω 1 watt, wire-wound
R13	82k Ω
VR1	100k Ω pre-set potentiometer, miniature
VR2	2.2k Ω or 2.5k Ω pre-set potentiometer, miniature

Capacitors

C1	4 μ F electrolytic, 40 V. Wkg.
C2	200 μ F electrolytic, 40 V. Wkg.
C3	0.005 μ F
C4	100pF
C5	1,000 μ F electrolytic, 50 V. Wkg.
C6	100pF
C7	25 μ F electrolytic, 50 V. Wkg.

Transistors

TR1	BC212L or BC214L (see text)
TR2	BC182L
TR3	BC182L
TR4	BC182L
TR5	BC212L
TR6	2N3055
TR7	2N3055

Fuse

F1	1.5 amp cartridge fuse
----	------------------------

Miscellaneous

2 heat sinks (see text)	Input socket
Fuseholder	Output sockets.

FEEDBACK

The emitter of TR1 is held at half the supply voltage under quiescent conditions. It is coupled to the output via R13 and C6, the latter being included to increase stability. Since, at a.c., C2 decouples the upper end of R4 to chassis, a.c. feedback is provided by way of the potential divider given by R13 and R4. The resulting amount of feedback means that about 80 millivolts of input signal is theoretically required for full output. In practice a slightly higher input signal was required. Experimenters may be interested in reducing the value of R13. A lower value here will reduce the overall voltage gain of the amplifier but will increase the level of feedback. The input impedance at TR1 base is of the order of 20k Ω .

There was found to be an almost complete absence of hum in the amplifier. This is mainly due to the fact that the base and emitter of TR1 are virtually completely isolated from supply ripple due to the presence of C2. Any hum introduced in the TR2 stage is largely cancelled out by the negative feedback.

Noise level apart from hum is due to general 'component noise', and this can be kept down by using good quality parts. In the TR1 position, a BC214L may produce slightly less noise than a BC212L.

As has been mentioned, the components required are readily available. It is, of course, quite in order to use electrolytic capacitors having working voltages somewhat higher than those quoted in the Components List. If difficulty is experienced in obtaining the 0.22 Ω 1 watt resistors required for R11 and R12 these may be obtained in a 2 $\frac{1}{2}$ watt rating from Home Radio.

The amplifier requires a nominal 40 volts at 1.5 amps, and a suitable power supply circuit is shown in Fig. 2. The mains transformer requires a secondary voltage of 30 volts at 2 amps or more, a suitable component here being the Douglas MT3 or MT3AT available from several suppliers. This will produce a voltage across the reservoir capacitor which is slightly in excess of 40 volts under low load conditions. The voltage will fall a little when the amplifier draws a high current over sustained periods. The reservoir capacitor should have a value as large as is reasonably possible and certainly not less than 1,000 μ F. It may have a working voltage of 50 volts. The four diodes are silicon rectifiers with a forward current rating of at least 2 amps and a p.i.v. of 100 volts. If there is any doubt about rectifier polarity (as can occur when surplus diodes are employed) complete the power supply circuit with the

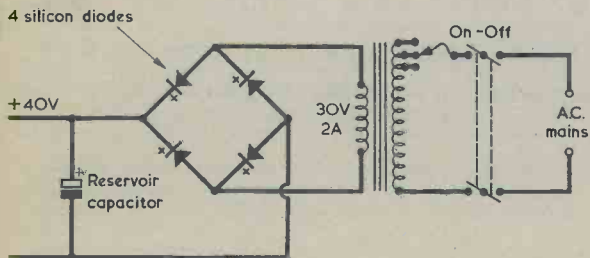


Fig. 2. A suitable power supply for the amplifier

reservoir capacitor omitted. Then apply the mains supply and check the voltage at the points to which the reservoir capacitor will connect with a testmeter. If the polarity of this voltage is correct the reservoir capacitor can then be wired in circuit.

CONSTRUCTION

Construction does not raise any critical points provided standard procedures and practices are followed. The amplifier should be built neatly, and if the parts are well spaced out it will be easier to spot any mistakes that might be made during construction. Input leads and wiring should be kept well away from output leads and components. Also, the power supply should be spaced well away from the input.

The output transistors, TR6 and TR7, need to be mounted on heat sinks. In the author's amplifier, each output transistor was bolted direct to a separate U-shaped heat sink measuring 4 by 2 by 2 in., as illustrated in Fig. 3. The material was thick 10 s.w.g. aluminium,

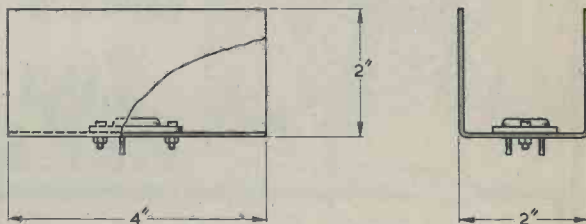


Fig. 3. One of the two heat sinks used in the prototype. In the side view part of the metal is shown cut away to indicate the position of the transistor

but a thinner gauge of aluminium sheet, say 14 s.w.g., should also be satisfactory. The two heat sinks were insulated from the amplifier chassis, and were mounted such that the 4 in. length was vertical.

When the amplifier has been completed it has to be checked and set up. The slider of VR1 should be put to mid-travel, whilst that of VR2 should be set at the track end which connects to the collector of TR3. A testmeter switched to read current is inserted in series with the positive supply line. Initially, the meter should be set to a high current range in case a fault in the amplifier causes an excessive current to flow.

The a.c. mains is then switched on. If the preliminary meter indication shows that it is safe to do so, the mains is switched off, the meter set to read 50 or 100mA f.s.d. and the mains switched on again. A reading of the order of 10mA should be given. The slider of VR2 is next slowly adjusted until the current increases by some 20mA. The mains is switched off and the testmeter removed.

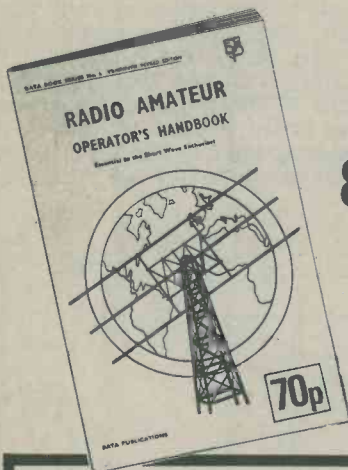
The testmeter is next set to a voltage range capable of giving a clear indication of 20 volts and is connected between chassis and the junction of C5 and C7. The mains is switched on once more and VR1 adjusted for a reading of 20 volts in the meter. The amplifier is then operational.

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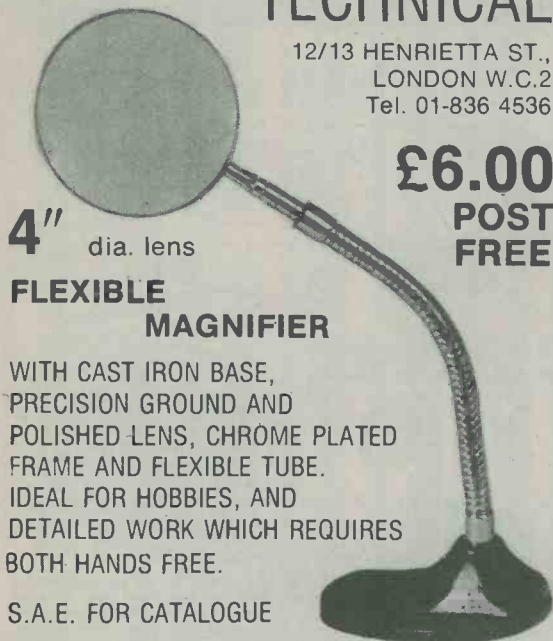
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(Continued on page 445)

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(Continued from page 444)

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(Continued on page 447)

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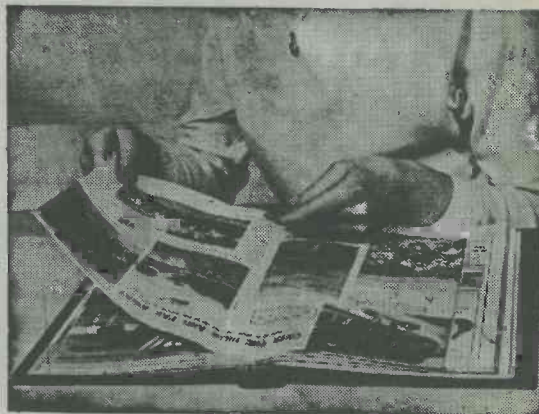
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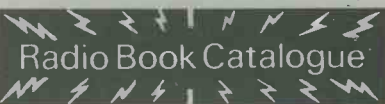
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