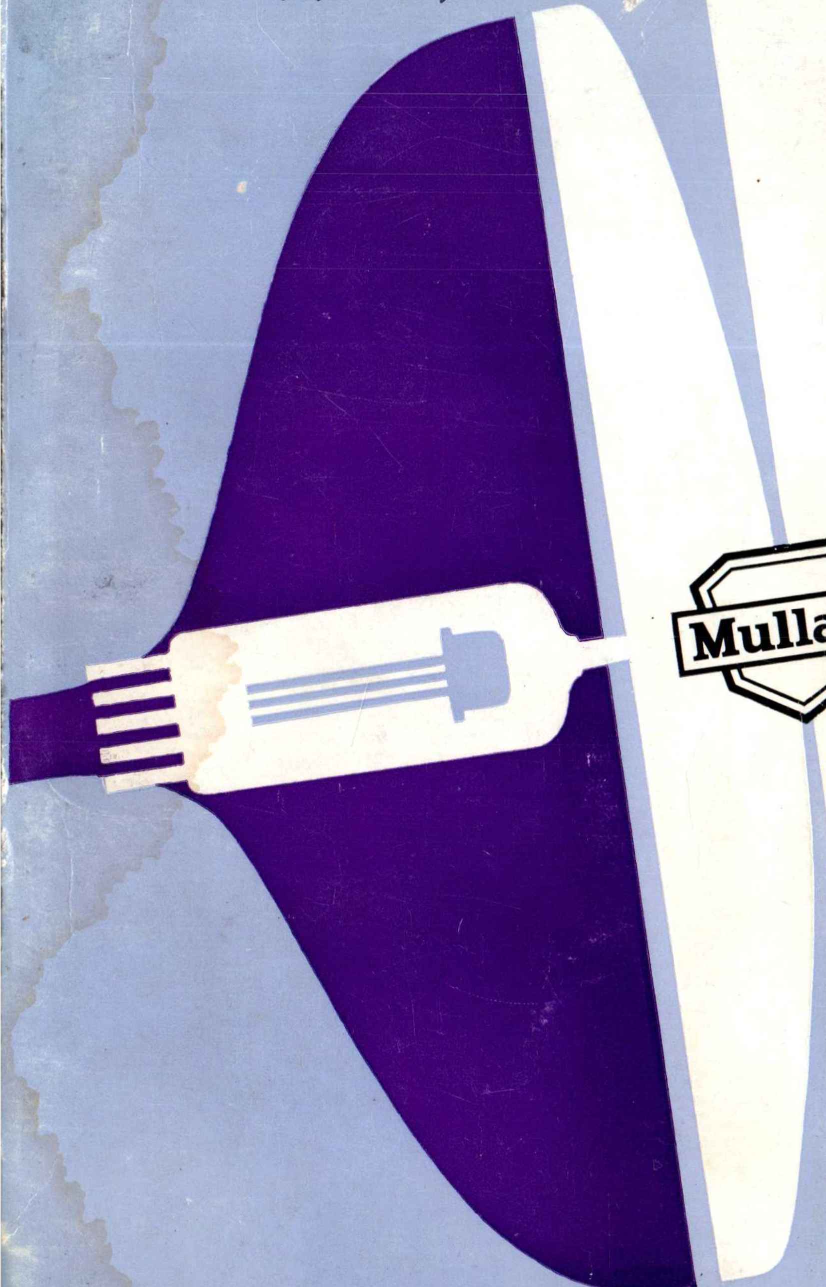
MARK HAYNE



Mullard

Preferred Types

VALVES TUBES & SEMICONDUCTORS

for television, radio and audio equipment

Mullard

VALVE TUBE

AND

SEMICONDUCTOR

GUIDE

ISSUED BY MULLARD-AUSTRALIA PTY. LTD.,
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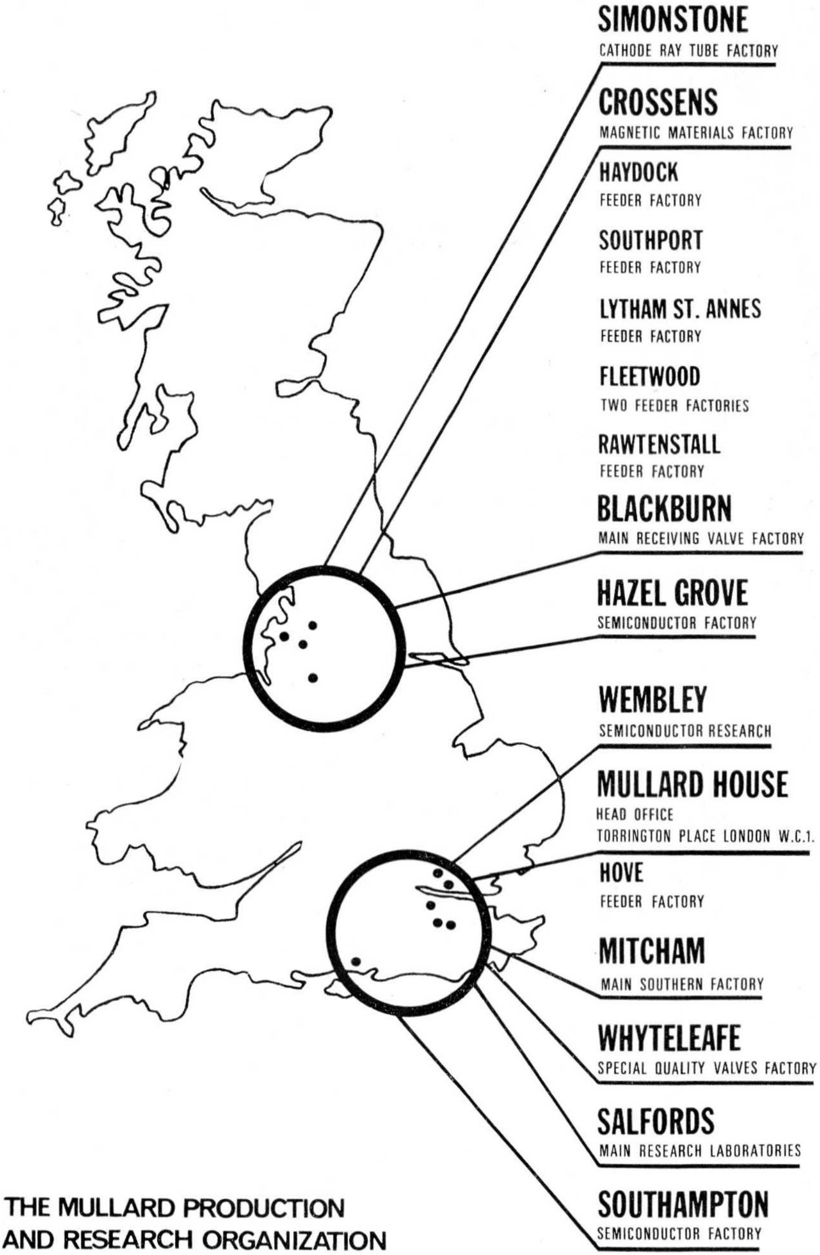
INTRODUCTION

This handbook has been prepared to meet the requirements of a large number of technicians in the countries served by Mullard Overseas Limited. It contains data for some 60 valves, tubes and semiconductors which are used in domestic radio and television receivers, audio amplifiers, tape recorders and record players.

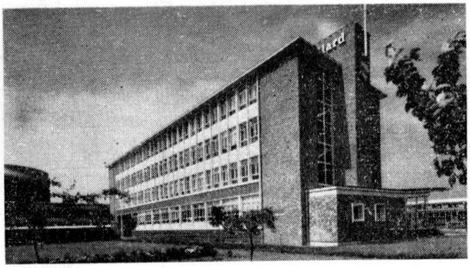
In order to make the best use of the space available, only current types have been included. The data for each type includes characteristics, typical operating conditions and limiting values, as well as mechanical data such as pin connections and dimensions. The data is in fact as comprehensive as possible and is presented in a concise manner. For ease of reference, types are arranged in alphabetical-numerical order.

The book is intended as a selection guide to the Design Engineer when deciding on which types to use in new equipment. It will also be invaluable to the Service Engineer when repairing and maintaining receivers. It has only been possible to include a limited number of curves in this book, and for more detailed information, designers are recommended to use the Mullard Technical Handbook.

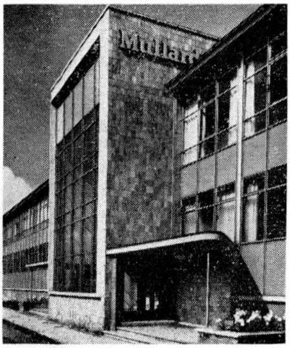
A description of the handbook and the servicing facilities for keeping it up to date are given on p. 219.



THE MULLARD PRODUCTION
AND RESEARCH ORGANIZATION
IN THE U.K.



- Receiving valves (Radio and T.V.)
- Receiving valves (Special quality, submin., etc.)
- High power valves (for transmitting and industrial purposes)
- Gas filled valves (Rectification, control, counting, voltage stabilization and reference)
- Vacuum and gas filled photocells
- Magnetrons
- Klystrons
- Travelling wave tubes
- Backward wave tubes
- Television picture tubes
- Radar cathode ray tubes
- Oscilloscope cathode ray tubes
- Image converters and intensifiers
- Semiconductor diodes
- Semiconductor rectifiers
- Thyristors
- Transistors
- Semiconductor photosensitive devices
- Integrated circuits
- Thin film circuits
- Specialized high vacuum equipment
- Capacitors
- Ferrites

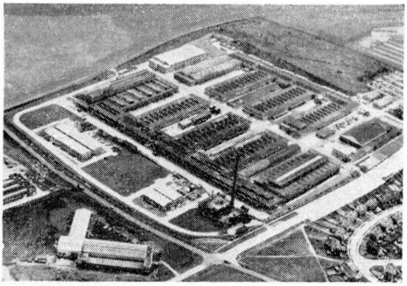


SIMONSTONE. The Mullard Simonstone Factory was designed and built specifically for the production of cathode ray tubes for television.

SOUTHAMPTON. This factory was one of the first in England to be specially built for the mass production of semiconductor devices.

SALFORDS. The Mullard Research Laboratories at Salfords carry out continuous investigations in the fields of electronics, vacuum physics, and solid state physics.

BLACKBURN. Occupying a 45 acre site, the Mullard factory at Blackburn produces the major portion of the company's receiving valves.



MULLARD HOUSE. In this ultra modern building are housed the Mullard head office staff; showroom and demonstrating rooms; and a private cinema and audio theatre.

VALVE TYPE NOMENCLATURE

The type nomenclature for Mullard receiving and amplifying valves and small thyratrons generally consists of two or more letters followed by two or three figures. These symbols provide information concerning the principal uses of the valves, the heater or filament rating and the type of base, according to the following code. In some special valves for 'professional' applications, the figures follow the first letter and precede the second and subsequent letters.

The first letter indicates the filament or heater voltage or current:

A—4.0V filament
C—200mA heater
D—0.5V to 1.5V filament
E—6.3V heater
G—5.0V heater
H—150mA heater
K—2.0V filament
P—300mA heater
U—100mA heater

The second and subsequent letters indicate the general class of valve:

A—Single diode
B—Double diode
C—Triode
D—Output triode
E—Tetrode
F—Voltage amplifying pentode
H—Hexode or heptode
K—Heptode or octode
L—Output pentode
M—Electron beam indicator
N—Thyratron
*P—Secondary emission valve
Q—Nonode
T—Miscellaneous
X—Full-wave gas-filled rectifier
Y—Half-wave rectifier
Z—Full-wave rectifier

*Used as a third letter only.

Note: Two or three of the above letters may be combined, e.g., BC—double diode triode.

The first figure indicates the type of base:

2—B8G (Loctal) base
3—Octal base
4—B8A base
5—Miscellaneous bases
6 & 7—Subminiature bases
8—B9A (Noval) base
9—B7G base

Note: In types with three figures, if the first figure is 1 then the second figure indicates the type of base, e.g., E180F – B9A base.

The second and third figures are serial numbers indicating a particular design or development.

Examples:

ECL86	E 6.3V heater	C triode	L output pentode	8 B9A base	6 serial number	
PABC80	P 300mA heater	A single diode	B double diode	C triode	8 B9A base	0 serial number

TUBE TYPE NOMENCLATURE

The type nomenclature for Mullard cathode ray tubes consists of two or three letters followed by two sets of figures. These symbols provide information concerning the method of focusing and deflecting the electron beam, the type of luminescent screen and the diameter or diagonal of the screen.

The first letter indicates the method of deflection and focusing:

A — Electrostatic focusing, magnetic deflection.
D — Electrostatic focusing and deflection.
M — Magnetic focusing and deflection.

The second letter indicates the properties of the luminescent screen:

B — Short persistence. Bluish fluorescence.
C — Very short persistence. Blue-violet fluorescence.
F — Very long persistence. Orange fluorescence.
G — Medium persistence. Green fluorescence.
H — Medium persistence. Blue-green fluorescence.
L — Long persistence. Orange fluorescence.
M — Double layer screen. Medium persistence. Blue-green fluorescence.
P — Double layer screen. Bluish fluorescence of short persistence followed by greenish-yellow phosphorescence of long persistence.
W — Medium persistence. White fluorescence.

The third letter:

M — Indicates multiple trace.

The first group of figures, immediately following the letters, indicates the diameter or diagonal of the luminescent screen in cm:

7 represents a 7cm (3 in.) screen
13 represents a 13cm (5 in.) screen
43 represents a 43cm (17 in.) screen
53 represents a 53cm (21 in.) screen

The second group of figures is a serial number indicating a particular design or development.

Example:

AW59-91 Cathode ray tube of 59cm screen diagonal having a medium persistence white fluorescence, and employing magnetic deflection and electrostatic focusing.

TYPE NOMENCLATURE

Two type nomenclature systems are currently in existence for Mullard semiconductor devices. All future devices will have type numbers in the 'new system', earlier devices will retain numbers in the 'old system'.

NEW SYSTEM

The type nomenclature consists of two letters followed by a serial number which may consist of three figures or of one letter and two figures depending on the main application of the device.

The first letter indicates the semiconductor material used in the device:

A — Germanium.
B — Silicon.

The second letter indicates the general construction or application of the device:

A — Diode (other than those having a special letter specified elsewhere in this list).
C — Transistor for audio applications (not power types).
D — Power transistor for audio applications.
E — Tunnel diode.
F — Transistor for r.f. applications (not power types).
L — Power transistor for r.f. applications.
P — Photodiode or phototransistor.
R — Controlling and switching device having a specified breakdown characteristic (not power types).
S — Transistor for switching applications (not power types).
T — Controlling and switching power device having a specified breakdown characteristic.
U — Power transistor for switching applications.
Y — Power diode or rectifier.
Z — Reference diode or zener diode.

The remainder of the type number is a serial number indicating a particular design or development and is in one of the following two groups:

(a) Devices intended primarily for use in 'entertainment' applications (radio and television receivers, audio amplifiers, tape recorders, etc.).
The serial number consists of three figures.

(b) Device intended mainly for applications other than in (a), e.g. industrial, professional and transmitting equipments.
The serial number consists of one letter followed by two figures.

Examples:

AF114	Germanium r.f. transistor primarily for entertainment applications.
BCZ11	Silicon audio transistor primarily for industrial applications.

OLD SYSTEM

The type nomenclature consists of two or three letters followed by a group of one, two or three figures.

The first letter is always 'O', indicating a semiconductor device.

The second (**and third**) **letter**(**s**) indicate the general class of device:

A — Diode or rectifier.
AP — Photodiode.
AZ — Zener diode.
C — Transistor.
CP — Phototransistor.
RP — Photoconductive cell.

The group of figures is a serial number indicating a particular design or development.

Examples:

OA90	Semiconductor diode.
OAZ200	Zener diode.
OC81	Transistor.

SELECTION CHART OF MULLARD PREFERRED TYPES OF VALVES, TUBES AND SEMICONDUCTOR DEVICES

AUDIO EQUIPMENT

	A.F. Amplifiers	Output Stages	Rectifiers
A.C. operated	ECC83 ECL86 EF86	ECL86 EL34 EL84	EZ81 GZ34
Semiconductor	AC125 AC126 AC127 BC107 OC71 AC176	AC127 AC146 AC128 AD149 AC128	—
	LFH3		
	OC81D	2-OC81	
	LFK3		
	OC81D	AC127 OC81	
	LFK4		
	AC127 OC81D	AC127 OC81	

RADIO RECEIVERS

	Frequency changers	R.F. or i.f. amplifiers	Diodes	A.F. amplifiers	Output stages	Rectifiers
A.C. operated	—	—	—	ECC83 ECL86 EF86	ECL86 EL84	EZ81 GZ34
Semi-conductor	AF102 AF115 AF116 AF117 AF125 AF126 AF127	AF102 AF114 AF115 AF116 AF117 AF124 AF125 AF126 AF127 AF186 BF115	AA129 OA90	LCR4		
				2-OC82DM	2-AD140	
				LFH3		
				OC81D	2-OC81	
				LFK3		
				OC81D	AC127 OC81	
				LFK4		
				AC127 OC81D	AC127 OC81	

SELECTION CHART OF MULLARD PREFERRED TYPES OF VALVES, TUBES AND SEMICONDUCTOR DEVICES

TELEVISION RECEIVERS

	Tuners		I.F. Amplifiers	Diodes	Video Output	Timebase	Line Output	Rectifiers			Sound Section
	R.F.	Mixer						Mains	Booster	E.H.T.	
D.C./A.C. operated	PC900 PCC89 PCC189	PCF86 PCF801	EF80 EF183 EF184 PCF801	—	EF80 PCL84 PFL200	ECC82 ECH84 PCL84 PCL85 PCF802 PCH200	PL500	—	PY88	DY87	EH90 PCL86
Semi-conductor	AF180 AF186	AF178 AF186	AF115 AF179 AF181	AA119 OA90	BF109	AD149	—	BY100 BY114	—	—	AA119 AD148 OA90

CATHODE RAY TUBES

11 inch 19 inch	A28-13W A47-11W AW47-91	23 inch	A59-11W AW59-91

SYMBOLS AND ABBREVIATIONS

These symbols are based on British Standard Specification No. 1409 : 1950,
'Letter Symbols for Electronic Valves', and No. 3363 : 1961,
'Letter Symbols for Light-Current Semiconductor Devices'.

1. SYMBOLS FOR ELECTRODES

Anode	a	Beam plates	bp
Base	B	Fluorescent screen or target	t
Cathode	k	External metallisation	M
Collector	C	Internal metallisation	m
Emitter	E	Deflector electrodes	x or y
Grid	g	Internal shield	s
Heater	h	Resonator	Res
Filament	f		

NOTE 1. In valves having more than one grid, the grids are distinguished by numbers—g_1, g_2, etc., g_1 being the grid nearest the cathode.

NOTE 2. In multiple valves, electrodes of the different sections may be distinguished by adding one of the following letters:

Diode	d	Hexode	h
Triode	t	Heptode	
Tetrode	q	Octode	
Pentode	p	Rectifier	r

Thus, the grid of the triode section of a triode-hexode is denoted by g_t.

NOTE 3. Two or more similar electrodes which cannot be distinguished by any of the above means may be denoted by adding one or more primes to indicate of which electrode system the electrode forms a part.
Thus, the anode of the first diode in a double diode valve is denoted a′.

2. SYMBOLS FOR ELECTRIC MAGNITUDES

Voltages		Current	
Direct voltage	V	Direct Current	I
Alternating voltage (r.m.s.)	$V_{r.m.s.}$	Alternating current (r.m.s.)	$I_{r.m.s.}$
Alternating voltage (mean)	V_{av}	Alternating current (mean)	I_{av}
Alternating voltage (peak)	v_{pk}	Alternating current (peak)	i_{pk}
Peak inverse voltage	P.I.V.	No signal current	I_o
		Collector leakage current (Common base)	I_{CBO}
		Emitter leakage current (Common base)	I_{EBO}

Miscellaneous

Frequency	f	Anode efficiency	η
Frequency at which $\|h_{fe}\| = 1$	f_1	Sensitivity	S
Amplification factor	μ	Brightness	B
Current gain (common emitter)	h_{fe}	Temperature	T
Current gain (large signal)	h_{FEL}	Thermal resistance	θ_{j-amb} θ_{j-case}
Mutual conductance	g_m	Time	t
Conversion conductance	g_c		
Distortion	D		

	Inside valve	Outside valve
Resistance	r	R
Reactance	x	X
Impedance	z	Z
Admittance	y	Y
Mutual inductance	m	M
Capacitance	c	C
Power	p	P

3. AUXILIARY SYMBOLS

Battery or other source of supply	b
No signal	o
Input	in
Output	out
Total	tot
Average	(AV)
Centre tap	ct
Junction	j
Ambient	amb

4. COMPLEX SYMBOLS

Symbols in Sections 1 and 3 above may be used as subscripts to symbols in Section 2, to denote such magnitudes as anode current, grid volts, etc., e.g.:

Anode voltage	V_a	Anode current (r.m.s.)	$I_{a(r.m.s.)}$
Collector emitter voltage	V_{CE}	No signal anode current	$I_{a(o)}$
Control-grid voltage	V_{g1}	Control-grid current	I_{g1}
Anode supply voltage	$V_{a(b)}$	Total distortion	D_{tot}
Filament voltage	V_f	3rd Harmonic distortion	D_3
Heater voltage	V_h	Equivalent noise resistance	R_{eq}
Anode dissipation	p_a	Limiting resistor	R_{lim}
Output power	P_{out}	Cathode bias resistor	R_k
Total dissipation	P_{tot}	Peak value of the total emitter current	I_{EM}
Drive power	P_{drive}		
Anode current (d.c.)	I_a		

	Internal	External
Anode resistance	r_a	R_a
Insulation resistance (heater to cathode)	r_{h-k}	
Resistance between control-grid and cathode	r_{g1-k}	R_{g1-k}
Capacitance (cold):		
Anode to all other electrodes	c_{a-all}	
Anode to control-grid	c_{a-g1}	
Control-grid to cathode at working temperature	$c_{g1-k(w)}$	
Control-grid to all other electrodes except anode (input capacitance)	c_{in}	
Anode to all other electrodes except control-grid (output capacitance)	c_{out}	
Inner amplification factor	μ_{g1-g2}	

5. Y PARAMETERS

		Common base	Common emitter
Output short-circuited	Input admittance	y_{ib} (y_{11})	y_{ie} (y'_{11})
	Input conductance	g_{ib} (g_{11})	g_{ie} (g'_{11})
	Input capacitance	c_{ib} (c_{11})	c_{ie} (c'_{11})
	Phase angle of input admittance	ϕ_{ib}	ϕ_{ie}
Input short-circuited	Output admittance	y_{ob} (y_{22})	y_{oe} (y'_{22})
	Output conductance	g_{ob} (g_{22})	g_{oe} (g'_{22})
	Output capacitance	c_{obs} (c_{22})	c_{oes} (c'_{22})
	Phase angle of output admittance	ϕ_{ob}	ϕ_{oe}
Output short-circuit	Transfer admittance	$\|y_{fb}\|$ ($\|y_{21}\|$)	$\|y_{fe}\|$ ($\|y'_{21}\|$)
	Transfer conductance	g_{fb}	g_{fe}
	Transfer capacitance	c_{fb}	c_{fe}
	Phase angle of transfer admittance	ϕ_{fb} (ϕ_{21})	ϕ_{fe} (ϕ'_{21})
Input short-circuited	Feedback admittance	$\|y_{rb}\|$ (y_{12})	$\|y_{re}$ (y'_{12})
	Feedback conductance	g_{rb}	g_{re}
	Feedback capacitance	c_{rb}	c_{re}
	Phase angle of feedback admittance	ϕ_{rb} (ϕ_{12})	ϕ_{re} (ϕ'_{12})

VALVE, TUBE AND SEMICONDUCTOR DEVICE EQUIVALENTS

Type number	Mullard equivalent	American equivalent	Type number	Mullard equivalent	American equivalent
A28-13W	—	—	DF97	DF97	1AN5
A47-18W	A47-18W	—	DH77	EBC90	6AT6
A59-11W	A59-11W	—	DH109	UABC80	—
AA119	AA119	—	DH719	EABC80	6AK8
AA129	AA129	—	DK92	DK92	1AC6
AC125	AC125	—	DK96	DK96	1AB6
AC126	AC126	—	DL94	DL94	3V4
AC127	AC127	—	DL96	DL96	3C4
AC128	AC128	—	DM70	DM70	1M3
AC176	AC176	—	DP61	EF95	6AK5
AD149	AD149	—	DY86	DY86	1S2
AF102	AF102	—	DY87	DY87	1S2A
AF114	AF114	—	EABC80	EABC80	6AK8
AF115	AF115	—	EB91	EB91	6AL5
AF116	AF116	—	EBC81	EBC81	6BD7A
AF117	AF117	—	EBC90	EBC90	6AT6
AF124	AF124	—	EBC91	EBC91	6AV6
AF125	AF125	—	EBF83	EBF83	6DR8
AF126	AF126	—	EBF89	EBF89	6DC8
AF127	AF127	—	EC95	EC95	6ER5
AF178	AF178	—	EC97	EC97	6FY5
AF179	AF179	—	ECC81	ECC81	12AT7
AF180	AF180	—	ECC82	ECC82	12AU7
AF181	AF181	—	ECC83	ECC83	12AX7
AF186	AF186	—	ECC84	ECC84	6CW7
AW43-80	AW43-80	17BTP4	ECC85	ECC85	6AQ8
AW43-88	AW43-88	—	ECC88	ECC88	6DJ8
AW47-90	AW47-90	—	ECC89	ECC89	6FC7
AW47-91	AW47-91	—	ECC189	ECC189	6ES8
AW53-80	AW53-80	21CLP4	ECF80	ECF80	6BL8
AW53-88	AW53-88	—	ECF82	ECF82	6U8
AW59-90	AW59-90	—	ECF86	ECF86	6HG8
AW59-91	AW59-91	—	ECH81	ECH81	6AJ8
B109	UCC85	—	ECH83	ECH83	6DS8
B152	ECC81	12AT7	ECH84	ECH84	6JX8
B309	ECC81	12AT7	ECL82	ECL82	6BM8
B319	PCC84	7AN7	ECL84	ECL84	6DX8
B329	ECC82	12AU7	ECL85	ECL85	6GV8
B339	ECC83	12AX7	ECL86	ECL86	6GW8
B719	ECC85	6AQ8	EF80	EF80	6BX6
BC107	BF107	—	EF85	EF85	6BX7
BF109	BF109	—	EF86	EF86	6267
BF115	BF115	—	EF89	EF89	6DA6
BY100	BY100	—	EF93	EF93	6BA6
BY114	BY114	—	EF94	EF94	6AU6
C17AA	AW43-88	—	EF95	EF95	6AK5
C21AA	AW53-88	—	EF97	EF97	6ES6
D77	EB91	6AL5	EF98	EF98	6ET6
D152	EB91	6AL5	EF183	EF183	6EH7
DAF91	DAF91	1S5	EF184	EF184	6EJ7
DAF96	DAF96	1AH5	EH90	EH90	6CS6
DF91	DF91	1T4	EK90	EK90	6BE6
DF92	DF92	1L4	EL34	EL34	6CA7
DF96	DF96	1AJ4	EL36	EL36	6CM5

VALVE, TUBE AND SEMICONDUCTOR DEVICE EQUIVALENTS

Type number	Mullard equivalent	American equivalent
EL81	EL81	6CJ6
EL84	EL84	6BQ5
EL86	EL86	6CW5
EL90	EL90	6AQ5
EL95	EL95	6DL5
EM81	EM81	6DA5
EM84	EM84	6FG6
EY81	EY81	6R3
EY82	EY82	6N3
EY86	EY86	6S2
EY87	EY87	6S2A
EY88	EY88	6AL3
EZ81	EZ81	6CA4
EZ90	EZ90	6X4
GZ32	GZ32	5AQ4
GZ34	GZ34	5AR4
HBC90	HBC90	12AT6
HBC91	HBC91	12AV6
HF93	HF93	12BA6
HK90	HK90	12BE6
HL92	HL92	50C5
HY90	HY90	35W4
LCR3	LCR3	—
LCR4	LCR4	—
LFG3	LFG3	—
LFH3	LFH3	—
LFK3	LFK3	—
LFK4	LFK4	—
LZ319	PCF80	9A8
LZ329	PCF80	9A8
N19	DL94	3V4
N25	DL96	3C4
N119	UL84	45B5
N152	PL81	21A6
N379	PL84	15CW5
N709	EL84	6BQ5
N727	EL90	6AQ5
OA70	OA70	1N87
OA79	OA79	1N541
OA81	OA81	—
OA90	OA90	—
OA95	OA95	1N618
OA210	OA210	—
OC22	OC22	—
OC26	OC26	2N1315
OC44	OC44	—
OC45	OC45	—
OC70	OC70	2N279
OC71	OC71	2N280
OC72	OC72	2N281
OC75	OC75	—
OC81	OC81	—
OC81D	OC81D	—
OC82DM	OC82DM	—
OC169	OC169	—
OC170	OC170	—
OC171	OC171	—
PABC80	PABC80	9AK8
PC97	PC97	—
PC900	PC900	—
PCC84	PCC84	7AN7
PCC85	PCC85	9AQ8
PCC88	PCC88	7DJ8
PCC89	PCC89	7FC7
PCC189	PCC189	—
PCF80	PCF80	9A8
PCF86	PCF86	7HG8
PCF801	PCF801	—
PCF802	PCF802	9JW8
PCH200	PCH200	—
PCL82	PCL82	16A8
PCL84	PCL84	15DQ8
PCL85	PCL85	18GV8
PCL86	PCL86	14GW8
PFL200	PFL200	—
PL36	PL36	25E5
PL81	PL81	21A6
PL84	PL84	15CW5
PL500	PL500	27GB5
PY32	PY32	—
PY33	PY33	—
PY81	PY81	17Z3
PY82	PY82	19Y3
PY88	PY88	30AE3
RFG3	RFG3	—
U153	PY81	17Z3
U154	PY82	19Y3
U192	PY82	19Y3
U291	PY32	—
U319	PY82	19Y3
U381	UY85	38A3
U709	EZ81	6CA4
UABC80	UABC80	—
UBC81	UBC81	—
UBF80	UBF80	17C8
UBF89	UBF89	19FL8
UCC85	UCC85	—
UCF80	UCF80	—
UCH81	UCH81	19D8
UCL82	UCL82	50BM8
UCL86	UCL86	—
UF80	UF80	—
UF85	UF85	—
UF86	UF86	—
UF89	UF89	—
UL84	UL84	45B5
UM81	UM81	—
UU12	EZ81	6CA4

Mullard

VALVE, TUBE AND SEMICONDUCTOR DEVICE EQUIVALENTS

Type number	Mullard equivalent	American equivalent	Type number	Mullard equivalent	American equivalent
UY85	UY85	38A3	6AJ8	ECH81	6AJ8
UY89	UY89	—	6AK5	EF95	6AK5
W17	DF91	1T4	6AK8	EABC80	6AK8
W25	DF96	1AJ4	6AL3	EY88	6AL3
W719	EF85	6BY7	6AL5	EB91	6AL5
W727	EF93	6BA6	6AQ5	EL90	6AQ5
X18	DK92	1AC6	6AQ8	ECC85	6AQ8
X20	DK92	1AC6	6AT6	EBC90	6AT6
X25	DK96	1AB6	6AU6	EF94	6AU6
X77	EK90	6BE6	6AV6	EBC91	6AV6
X719	ECH81	6AJ8	6BA6	EF93	6BA6
X727	EK90	6BE6	6BD7A	EBC81	6BD7A
Y25	DM70	1M3	6BE6	EK90	6BE6
Z152	EF80	6BX6	6BL8	ECF80	6BL8
Z719	EF80	6BX6	6BM8	ECL82	6BM8
Z729	EF86	6267	6BQ5	EL84	6BQ5
ZD17	DAF91	1S5	6BX6	EF80	6BX6
ZD25	DAF96	1AH5	6BY7	EF85	6BY7
1AB6	DK96	1AB6	6C12	ECH81	6AJ8
1AC6	DK92	1AC6	6C16	ECF80	6BL8
1AH5	DAF96	1AH5	6CA4	EZ81	6CA4
1AJ4	DF96	1AJ4	6CA7	EL34	6CA7
1AN5	DP97	1AN5	6CJ6	EL81	6CJ6
1C2	DK92	1AC6	6CM5	EL36	6CM5
1C3	DK96	1AB6	6CS6	EH90	6CS6
1F1	DF96	1AJ4	6CW5	EL86	6CW5
1F2	DF92	1L4	6CW7	ECC84	6CW7
1F3	DF91	1T4	6D2	EB91	6AL5
1FD1	DAF96	1AH5	6DA5	EM81	6DA5
1FD9	DAF91	1S5	6DA6	EF89	6DA6
1L4	DF92	1L4	6DC8	EBF89	6DC8
1M1	DM70	1M3	6DJ8	ECC88	6DJ8
1M3	DM70	1M3	6DL5	EL95	6DL5
1N87	OA70	1N87	6DR8	EBF83	6DR8
1N541	OA79	1N541	6DS8	ECH83	6DS8
1N542	2-OA79	1N542	6DX8	ECL84	6DX8
1N618	OA95	1N618	6EH7	EF183	6EH7
1P1	DL96	3C4	6EJ7	EF184	6EJ7
1P11	DL94	3V4	6ER5	EC95	6ER5
1S2	DY86	1S2	6ES6	EF97	6ES6
1S2A	DY87	1S2A	6ES8	ECC189	6ES8
1S5	DAF91	1S5	6ET6	EF98	6ET6
1T4	DF91	1T4	6F19	EF85	6BY7
2N279	OC70	2N279	6F22	EF86	6267
2N280	OC71	2N280	6FC7	ECC89	6FC7
2N281	OC72	2N281	6FD12	EBF89	6DC8
2N282	2-OC72	2N282	6FG6	EM84	6FG6
2N1315	OC26	2N1315	6FY5	EC97	6FY5
2-OA79	2-OA79	1N542	6GV8	ECL85	6GV8
2-OC72	2-OC72	2N282	6GW8	ECL86	6GW8
3C4	DL96	3C4	6HG8	ECF86	6HG8
3V4	DL94	3V4	6JX8	ECH84	6JX8
5AQ4	GZ32	5AQ4	6L12	ECC85	6AQ8
5AR4	GZ34	5AR4	6L13	ECC83	12AX7

VALVE, TUBE AND SEMICONDUCTOR DEVICE EQUIVALENTS

Type number	Mullard equivalent	American equivalent
6L16	ECC84	6CW7
6LD12	EABC80	6AK8
6N3	EY82	6N3
6P15	EL84	6BQ5
6R3	EY81	6R3
6S2	EY86	6S2
6S2A	EY87	6S2A
6T8	EABC80	6AK8
6U8	ECF82	6U8
6X4	EZ90	6X4
7AN7	PCC84	7AN7
7DJ8	PCC88	7DJ8
7FC7	PCC89	7FC7
7HG8	PCF86	7HG8
8A8	PCF80	9A8
8D8	EF86	6267
9A8	PCF80	9A8
9AK8	PABC80	9AK8
9AQ8	PCC85	9AQ8
9JW8	PCF802	9JW8
10C14	UCH81	19D8
10FD12	UBF89	19FL8
10LD12	UABC80	—
10L14	UCC85	—
10P18	UL84	45B5
10PL12	UCL82	50BM8
12AT6	HBC90	12AT6
12AT7	ECC81	12AT7
12AU7	ECC82	12AU7
12AV6	HBC91	12AV6
12AX7	ECC83	12AX7
12BA6	HF93	12BA6

Type number	Mullard equivalent	American equivalent
12BE6	HK90	12BE6
14GW8	PCL86	14GW8
15CW5	PL84	15CW5
15DQ8	PCL84	15DQ8
16A8	PCL82	16A8
17BTP4	AW43-80	17BTP4
17C8	UBF80	17C8
17Z3	PY81	17Z3
18GV8	PCL85	18GV8
19D8	UCH81	19D8
19FL8	UBF89	19FL8
19SU	PY82	19Y3
19Y3	PY82	19Y3
21A6	PL81	21A6
21CLP4	AW53-80	21CLP4
25E5	PL36	25E5
27GB5	PL500	27GB5
30AE3	PY88	30AG3
30C1	PCF80	9A8
30L1	PCC84	7AN7
30P18	PL84	15CW5
35W4	HY90	35W4
38A3	UY85	38A3
45B5	UL84	45B5
50BM8	UCL82	50BM8
50C5	HL92	50C5
54KU	GZ32	5AQ4
64SPT	EF80	6BX6
171DDP	UBF80	17C8
6267	EF86	6267

TELEVISION TUBE A28-13W

28cm (11in.) rectangular direct viewing television tube with metal backed screen and reinforced envelope. A separate safety screen is not required. Especially for use in portable receivers.

HEATER

V_h	11	V
I_h	68	mA

The heater supply circuit should provide a nominal voltage of 11 Volts either d.c. or a.c.

In case of a.c. mains, V_h should not exceed 11 Volts ±17%; this takes into account 10% mains fluctuations and 7% components variations.

In case the heater is fed from any stabilised supply (or from the line output transformer) V_h should not exceed 11 Volts ±10%.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be earthed, and the capacitance of this to the final anode is used to provide smoothing for the e.h.t. supply.

CAPACITANCES

c_{g-all}	6.0	pF
c_{k-all}	3.0	pF
$c_{a2+a4-M}$	550 to 850	pF
$c_{a2+a4-B}$	125	pF

SCREEN

Metal backed

Fluorescent colour	white	
Light transmission (approx.)	59	%

FOCUSING

Electrostatic

The range of focus voltages shown in "OPERATING CONDITIONS" results in optimum overall focus at a beam current of 100μA.

DEFLECTION

Double magnetic

The deflection coils should be designed so that their internal contour is in accordance with the reference line gauge shown on page D6.

RASTER CENTRING

Centring magnet field intensity	0 to 6.28	Gs
Maximum distance of centre of centring field from reference line	5.5	cm

Adjustment of the centring magnet should not be such that a general reduction in brightness of the raster occurs.

MOUNTING POSITION .. .. Any

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

This tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the base pins whilst handling the tube.

It is advisable to keep this pin protector on the base until it can be replaced by the socket after installation of the tube in any equipment.

Note—The metal band (B) must be connected to the chassis via a 2MΩ resistor.

TYPICAL OPERATING CONDITIONS

V_{a2+a4}	11	11	kV
V_{a3} (focus electrode control range)	0 to 350	0 to 350	V
V_{a1}	250	200 to 350	V
V_g for visual extinction of focused raster	−35 to −69	−35 to −69	V
V_k for visual extinction of focused raster	32 to 58	approx 45	V

DESIGN CENTRE RATINGS (unless otherwise stated)

*V_{a2+a4} max. (at zero beam current)	12	kV
V_{a2+a4} min. (when measured at 200μA beam current)	7.5	kV
$+V_{a3}$ max.	500	V
$-V_{a3}$ max.	50	V
V_{a1} max. ($V_{g1-k} = 0$)	350	V
V_{a1} min.	200	V
†$-V_{g(pk)}$ max.	350	V
‡$-V_g$ max.	100	V
$\pm I_{a3}$ max.	25	μA
$\pm I_{a1}$ max.	5.0	μA
**V_{h-k} (design maximum values)		
d.c. max.	80	V
pk max.	130	V
R_{h-k} max.	1.0	MΩ
Z_{k-e} max. (f = 50c/s)	100	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50c/s)	500	kΩ

*Adequate precautions should be taken to ensure that the receiver is protected from damage which may be caused by a possible high voltage flashover within the cathode ray tube.

†Maximum pulse duration 22% of a cycle with a maximum of 1.5ms.

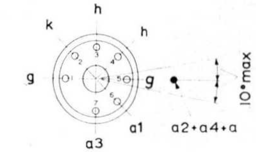
‡The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +1V.

It is advisable to limit the positive excursion of the video signal to +5V (pk) max. This may be achieved automatically by the series connection of a 10kΩ resistor.

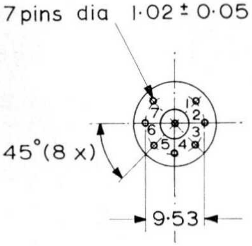
**In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible ($<$ 20V r.m.s.).

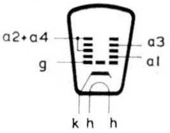
WEIGHT

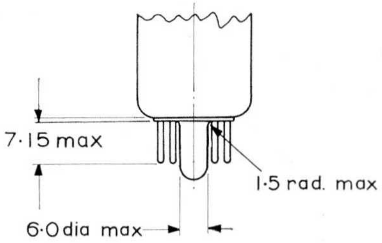
Tube alone	2.2 4.85	kg lb
Deflection angle	90	deg
Light transmission	59	%
Overall length	24.5	cm

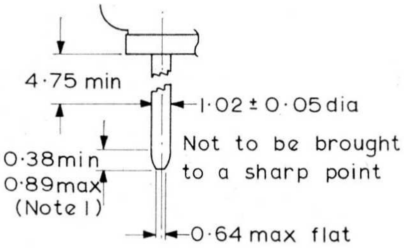


Pin dimensions as in B7G base







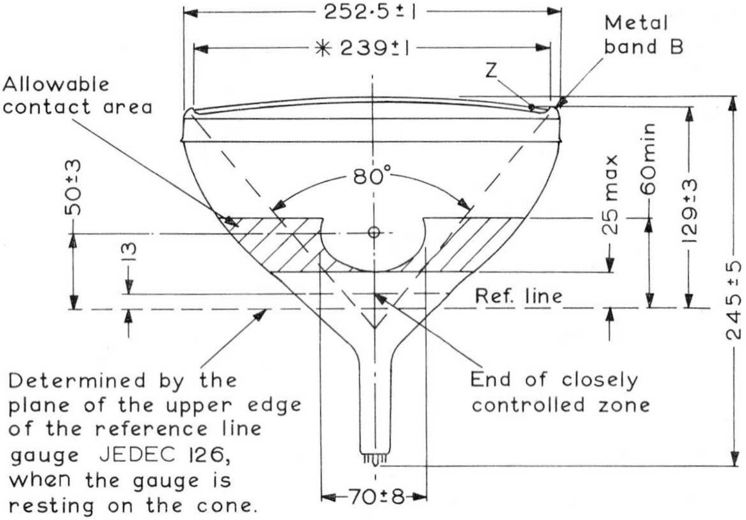


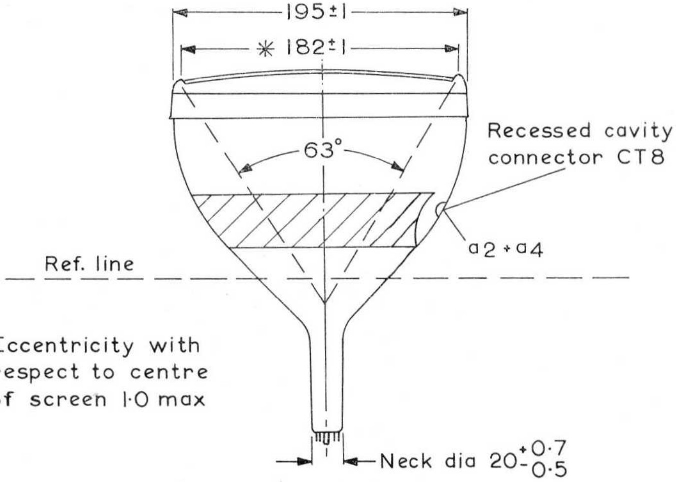
Pin contour

Note 1: This dimension may vary within the limits shown around the periphery of any individual pin

All dimensions in mm B3056

A28-13W (Cont.)

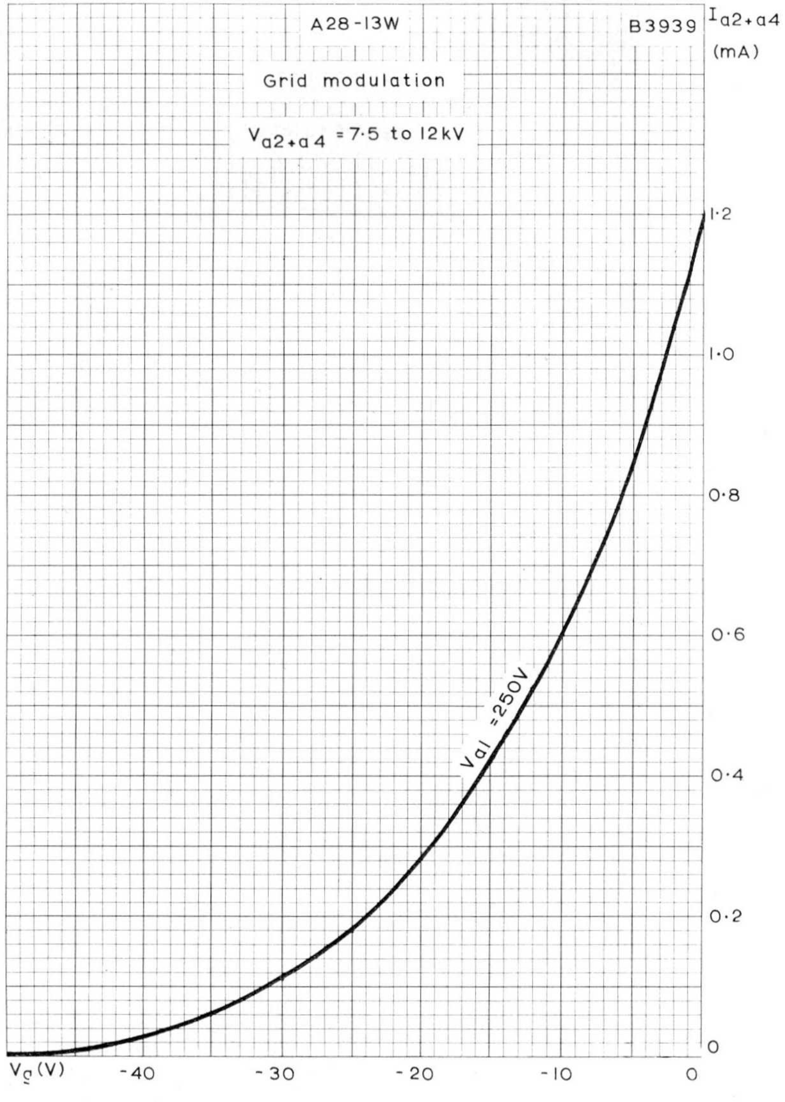




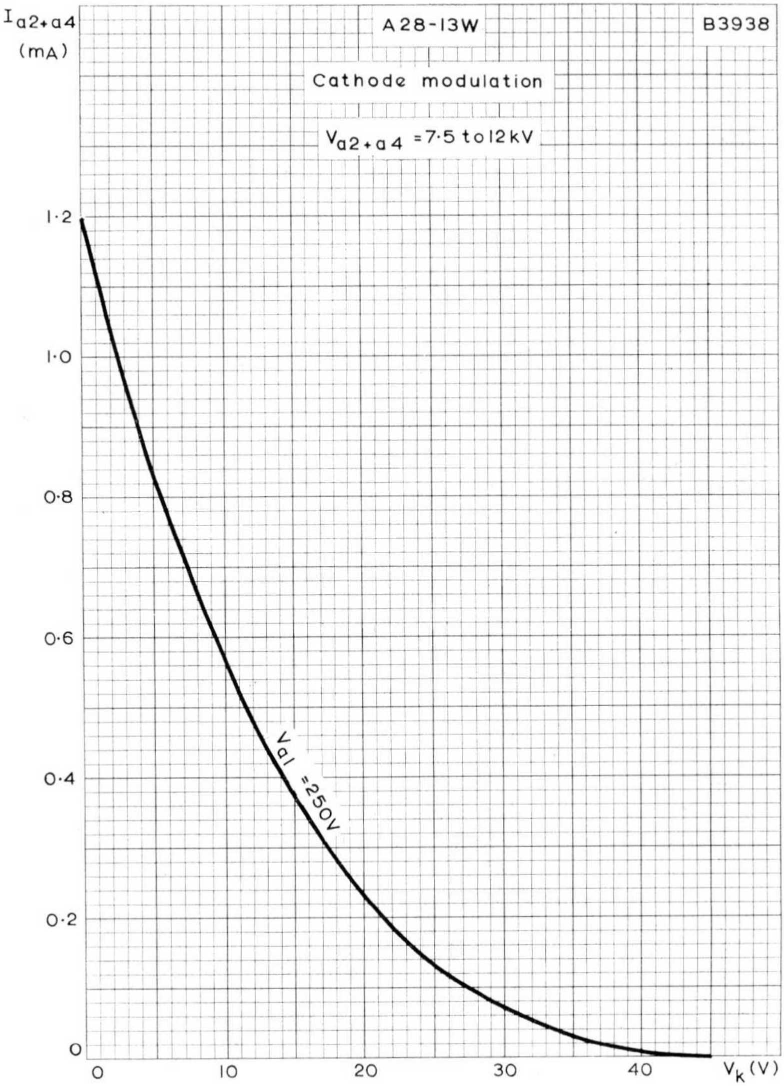
✳ Eccentricity with respect to centre of screen 1·0 max

All dimensions in mm

B3932



FINAL ANODE CURRENT PLOTTED AGAINST GRID VOLTAGE.
GRID MODULATION



FINAL ANODE CURRENT PLOTTED AGAINST CATHODE-TO-GRID VOLTAGE. CATHODE MODULATION

TELEVISION TUBE

A47-11W

47cm (19-in.) direct viewing television tube with metal-backed screen and reinforced envelope. A separate safety screen is not required. This tube is electrically identical to the AW47-91.

HEATER

Suitable for series or parallel operation

V_h	6.3	V
I_h	300	mA

Note—(applies to series operation only). The surge heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on. When used in a series heater chain, a current limiting device may be necessary in the circuit, to ensure that this voltage is not exceeded.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be earthed, and the capacitance of this to the final anode is used to provide smoothing for the e.h.t. supply. The tube marking and warning labels are on the side of the cone opposite the final anode connector and this side should not be used for making contact to the external conductive coating.

CAPACITANCES

c_{g-all}	6.0	pF
c_{k-all}	4.0	pF
$c_{a2+a4-M}$	1000 to 1500	pF
$c_{a2+a4-B}$	250	pF

SCREEN

Metal backed

Fluorescent colour	white	
Light transmission (approx.)	56	%
Useful screen area	see page 29	

FOCUSING

Electrostatic

The range of focus voltages shown in 'OPERATING CONDITIONS' results in optimum overall focus at a beam current of 100μA.

DEFLECTION

Double magnetic

The deflection coils should be designed so that their internal contour is in accordance with JEDEC gauge 126, and should provide a pull-back of 4mm on a nominal tube.

RASTER CENTRING

Centring magnet field intensity	0 to 10	G
Maximum distance of centre of centring field from reference line	57	mm

Adjustment of the centring magnet should not be such that a general reduction in brightness of the raster occurs.

REFERENCE LINE GAUGE

JEDEC 126

OPERATING CONDITIONS

V_{a2+a4}	18	18	kV
V_{a3} (focus electrode control range)	0 to 400	0 to 400	V
V_{a1}	400	500	V
V_g for visual extinction of focused raster	−40 to −77	−50 to −93	V
*V_k for visual extinction of focused raster	36 to 66	45 to 79	V

*For cathode modulation, all voltages are measured with respect to the grid.

DESIGN CENTRE RATINGS

*V_{a2+a4} max. (at $I_{a2+a4} = 0$)	18	kV
V_{a2+a4} min.	13	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
**$+v_{a3(pk)}$ max.	2.5	kV
V_{a1} max.	550	V
V_{a1} min.	350	V
**$-v_{g(pk)}$ max.	400	V
‡$-V_g$ max.	150	V
$\pm I_{a3}$ max.	25	µA
$\pm I_{a1}$ max.	5	µA
†V_{h-k}		
Cathode positive		
d.c. max.	250	V
pk max.	300	V
Cathode negative		
d.c. max.	135	V
pk max.	180	V
R_{h-k} max.	1.0	MΩ
Z_{k-e} max. (f = 50c/s)	100	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50c/s)	500	kΩ

*Adequate precautions should be taken to ensure that the receiver is protected from damage which may be caused by a possible high voltage flashover within the cathode ray tube.

**Maximum pulse duration 22% of a cycle with a maximum of 1.5ms.

‡The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +2V. To ensure long life of the tube it is advisable to limit the positive excursion of the video signal to $+5V_{(pk)}$ max. This may be achieved automatically by the series connection of a 10kΩ resistor.

†In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible and must not exceed $20V_{r.m.s.}$

During a warming-up period not exceeding 15 secs, $v_{h-k(pk)}$ max. (cathode positive) is allowed to rise to 410V.

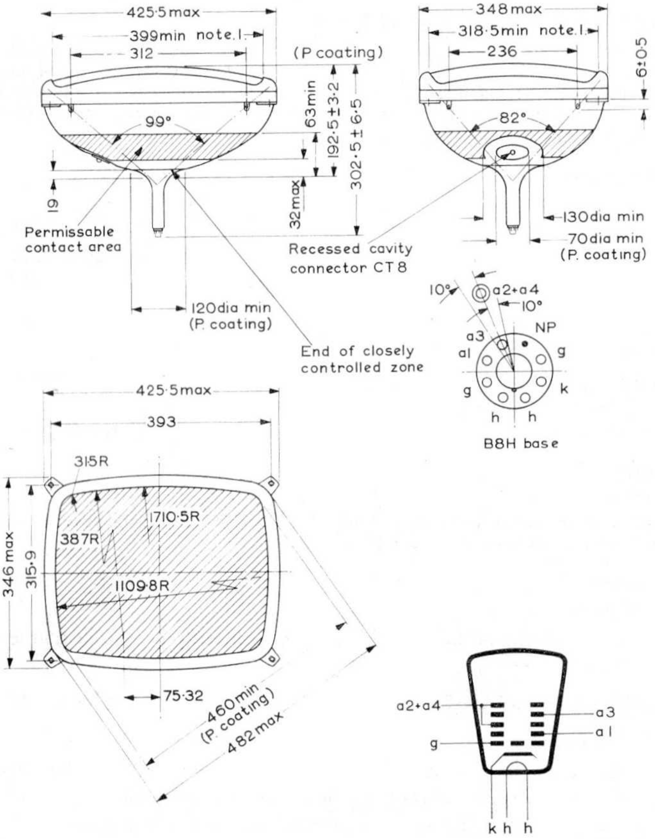
Note – The metal band (B) must be connected to the chassis via a 2MΩ resistor, soldering tags are provided for this purpose.

The mounting lugs will not necessarily be in electrical contact with the metal band.

MOUNTING POSITION Any

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely. The bottom circumference of the base shell will fall within a circle of 40mm diameter which is centred upon the perpendicular from the centre of the face.

This tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the base pins whilst handling the tube.
It is advisable to keep this pin protector on the base until it can be replaced by the socket after installation of the tube in any equipment.



All dimensions in mm

B1119

A59-11W

TELEVISION TUBE

59cm (23-in.) direct viewing television tube with metal-backed screen and reinforced envelope. A separate safety screen is not required. This tube is electrically identical to the AW59-91.

HEATER

Suitable for series or parallel operation.

V_h	6.3	V
I_h	300	mA

Note—(applies to series operation only). The surge heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on. When used in a series heater chain, a current limiting device may be necessary in the circuit, to ensure that this voltage is not exceeded.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be earthed, and the capacitance of this to the final anode is used to provide smoothing for the e.h.t. supply. The tube marking and warning labels are on the side of the cone opposite the final anode connector and this side should not be used for making contact to the external conductive coating.

CAPACITANCES

c_{g-all}	6.0	pF
c_{k-all}	4.0	pF
$c_{a2+a4-M}$	1700 to 2500	pF
$c_{a2+a4-B}$	350	pF

SCREEN

Metal backed

Fluorescent colour	White	
Light transmission (approx.)	53	%
Useful screen area	see page 32	

FOCUSING

Electrostatic

The range of focus voltages shown in 'OPERATING CONDITIONS' results in optimum overall focus at a beam current of 100μA.

DEFLECTION

Double magnetic

The deflection coils should be designed so that their internal contour is in accordance with JEDEC gauge 126.

REFERENCE LINE GAUGE .. .. JEDEC 126

RASTER CENTRING

Centring magnetic field intensity	0 to 10	G
Maximum distance of centre of centring field from reference line	57	mm

Adjustment of the centring magnet should not be such that a general reduction in brightness of the raster occurs.

OPERATING CONDITIONS

V_{a2+a4}	18	18	kV
V_{a3} (focus electrode control range)	0 to 400	0 to 400	V
V_{a1}	400	500	V
V_g for visual extinction of focused raster	−40 to −77	−50 to −93	V
*V_k for visual extinction of focused raster	36 to 66	45 to 79	V

*For cathode modulation, all voltages are measured with respect to the grid.

DESIGN CENTRE RATINGS

*V_{a2+a4} max.	18	kV
V_{a2+a4} min.	13	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
**$+v_{a3(pk)}$ max.	2.5	kV
V_{a1} max.	550	V
V_{a1} min.	350	V
**$-v_{g(pk)}$ max.	400	V
†$-V_g$ max.	150	V
$\pm I_{a3}$ max.	25	μA
$\pm I_{a1}$ max.	5	μA
‡V_{h-k}		
Cathode positive		
d.c. max.	250	V
pk max.	300	V
Cathode negative		
d.c. max.	135	V
pk max.	180	V
R_{h-k} max.	1.0	MΩ
Z_{k-e} max. (f = 50c/s)	100	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50c/s)	500	kΩ

*Adequate precautions should be taken to ensure that the receiver is protected from damage which may be caused by a possible high voltage flashover within the cathode ray tube.

**Maximum pulse duration 22% of a cycle with a maximum of 1.5ms.

†The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +2V.
The maximum positive excursion of the video signal must not exceed +5V with a series grid resistance of 10kΩ.

‡In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible. During a warming up period not exceeding 15 secs, $v_{h-k(pk)}$ max. (cathode positive) is allowed to rise to 410V.

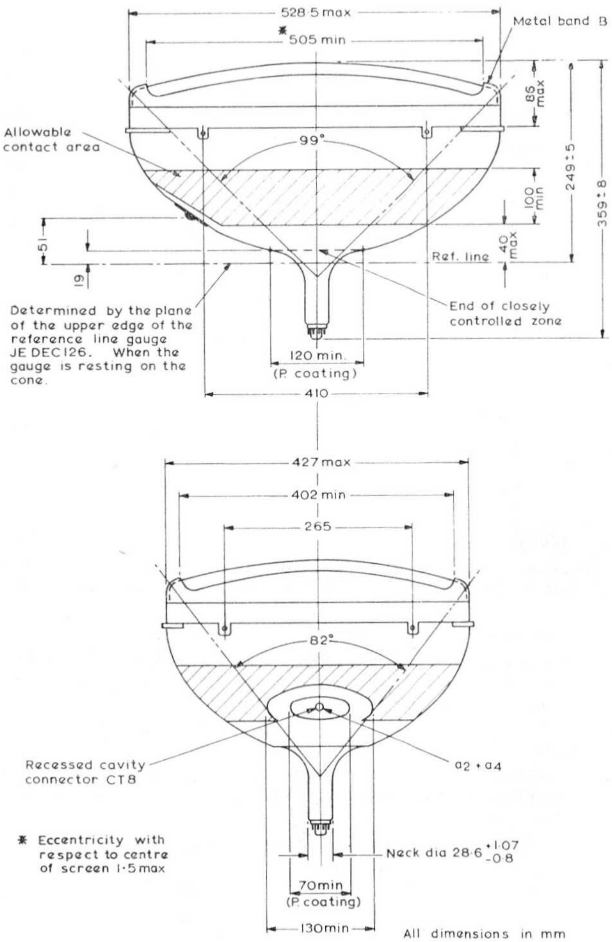
Note—The metal band (B) must be connected to the chassis via a 2MΩ resistor, soldering tags are provided for this purpose.
The mounting lugs will not necessarily be in electrical contact with the metal band.

MOUNTING POSITION .. .. Any

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely. The bottom circumference of the base shell will fall within a circle of 40mm diameter which is centred upon the perpendicular from the centre of the face.

This tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the base pins whilst handling the tube.

It is advisable to keep this pin protector on the base until it can be replaced by the socket after installation of the tube in any equipment.



GERMANIUM DIODE

AA119

Germanium point-contact diode in miniature all-glass construction for use in television sound detector and radio detector circuits.

B206

DIMENSIONS

Max. body length ..	7.6	mm
Max. diameter ..	2.7	mm
Mean lead length ..	27	mm

ABSOLUTE MAXIMUM RATINGS

At T_{amb}	25	60	°C
Maximum reverse voltage			
Peak	45	45	V
Average (averaged over 50ms period or d.c. component)	30	30	V
Maximum forward current			
Peak	100	100	mA
Average (averaged over any 50ms period or d.c. component)	35	15	mA
Surge (occasional overload max. duration 1s)	200	200	mA
Temperature ratings			
T_{stg} max.		75	°C
T_{stg} min.		–55	°C
T_{amb} max.		60	°C
T_{amb} min.		–55	°C
Maximum junction temperature rise above ambient in free air		0.45	°C/mW
Capacitance max.			
(V_R = 2V, f = 470kc/s)		1.0	pF

AA119 (Cont.)

GERMANIUM DIODE

CHARACTERISTICS

At T_{amb}	25		60		°C
	Av.	*Max.*	*Av.*	*Max.*	
Forward voltage at forward current of					
100µA	230	300	160	250	mV
10mA	1.5	2.2	1.4	2.1	V
*30mA	2.8	4.0	2.6	3.8	V
Inverse current at inverse voltage of					
–0.1V	0.35	1.0	4.5	12	µA
–1.5V	0.8	2.8	6.0	25	µA
–10V	4.5	18	16	60	µA
–30V	35	150	60	300	µA
–45V	90	350	170	500	µA

*Measured by pulse method to avoid excessive dissipation.

DYNAMIC CHARACTERISTICS OF AA119 (see Fig. 1).

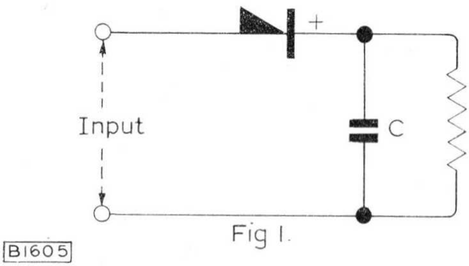
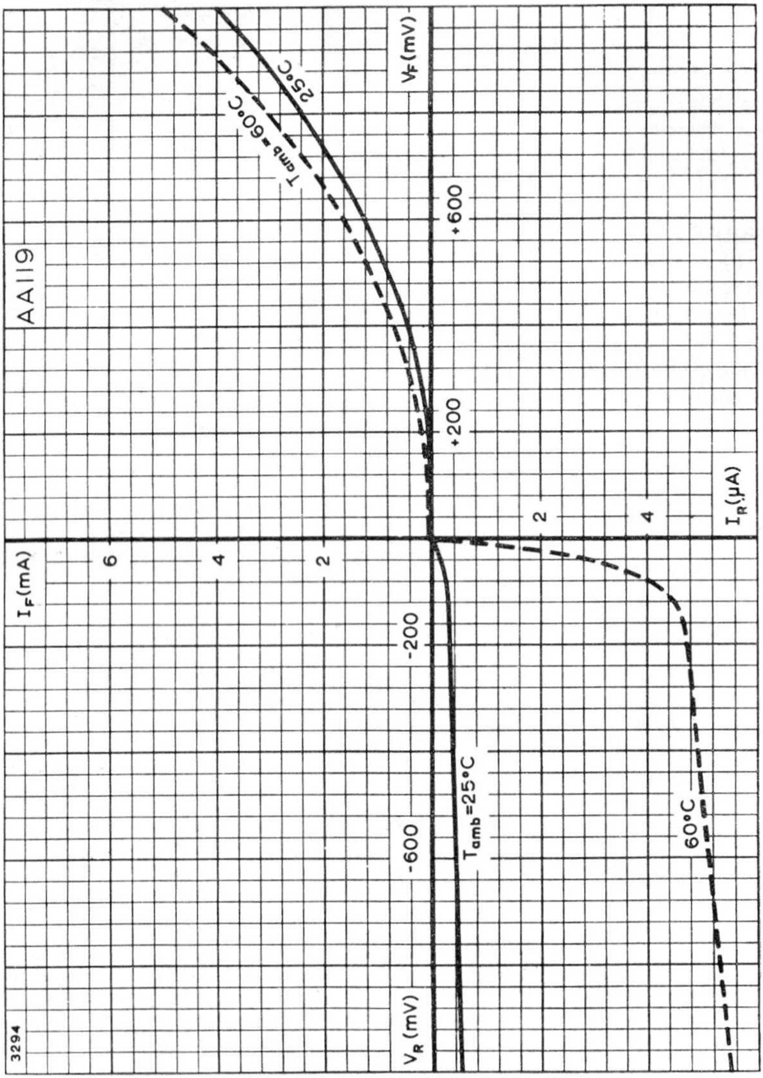


Fig I.

Frequency	0.47	10.7	38.15	Mc/s
$v_{in(pk)}$	1.0	3.0	3.0	V
R	1.0	0.033	0.082	MΩ
C	50	330	33	pF
*η (typical) at 25°C	85	85	85	%
R_d (typical) at 25°C	370	15	30	kΩ

*η = (d.c. output voltage/peak input voltage) × 100.

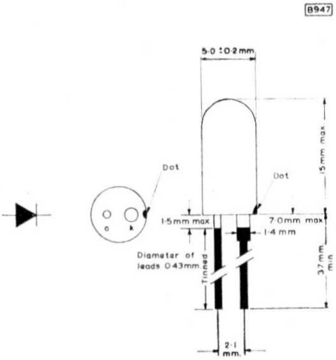


TYPICAL CHARACTERISTICS AT AMBIENT TEMPERATURES OF 25 AND 60°C.

AA129

JUNCTION DIODE

Germanium junction diode intended for use as a bias voltage stabiliser in portable radio receivers using class 'B' output stages.



DIMENSIONS

Max. body length	15	mm
Max. diameter	5.2	mm
Min. lead length	37	mm

CHARACTERISTICS ($T_{amb} = 25°C$)

V_F ($I_F = 5mA$)	175 to 230	mV
Temperature Coefficient ($I_F = 5mA$ approx.)	−2.3	mV/°C

ABSOLUTE MAXIMUM RATINGS

I_{FM} max.	20	mA
T_{stg} max.	+75	°C
T_{stg} min.	−55	°C
T_{amb} max (continuous operation)	75	°C
θ_{j-amb} (free air)	0.4	°C/mW

Figs. 1, 2 and 3 show typical circuit configurations in which the diode may be used. Using the circuit shown on fig. 1, the bias voltage of the output transistors should be set allowing for a.g.c. operation.

Fig. 1

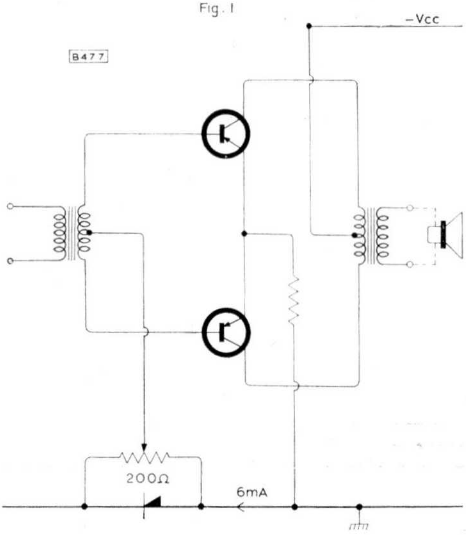


Fig. 2

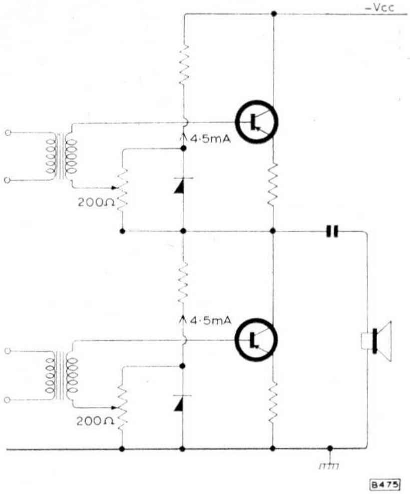
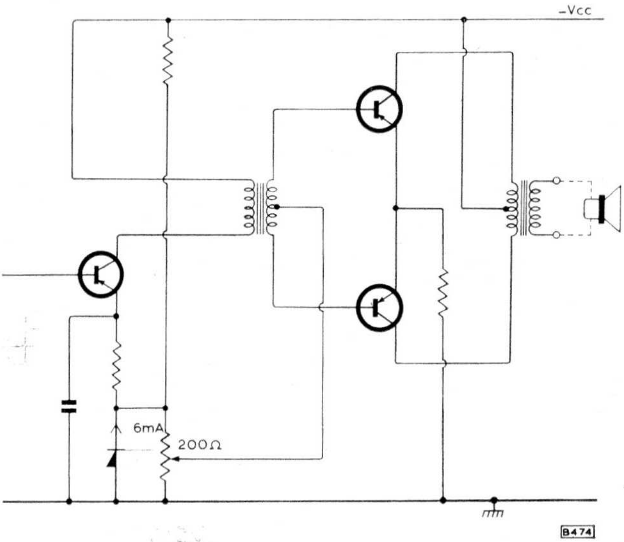
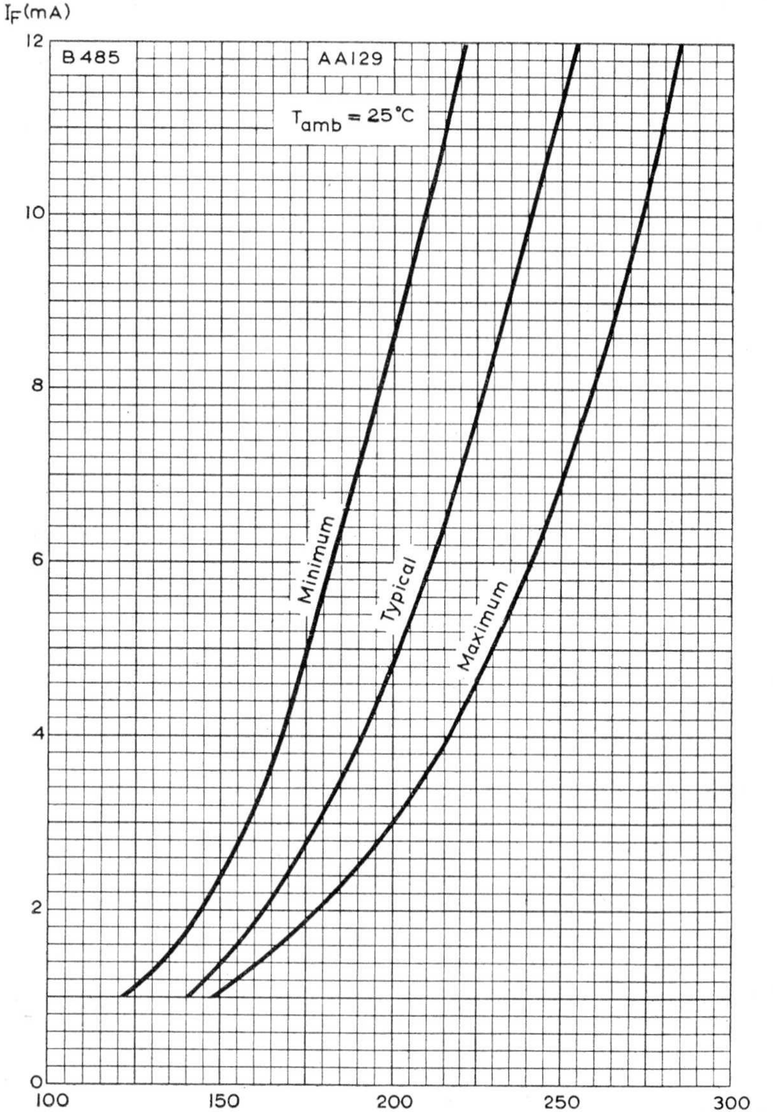


Fig. 3





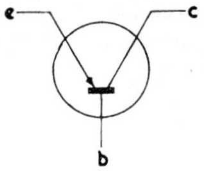
SPREAD OF FORWARD CHARACTERISTIC AT AMBIENT TEMPERATURE OF 25°C

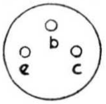
JUNCTION TRANSISTOR

AC125

Germanium p-n-p alloy junction transistor, in metal envelope, for use in pre-amplifier and driver stages.

B229





DIMENSIONS

Max. body length	9.4	mm
Max. diameter	6.1	mm
Min. lead length	38	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage

V_{CB} max. ($I_E = 0$mA)	–32	V
V_{CE} max. ($R_{BE} > 1k\Omega$)	–32	V

Collector current

I_{CM} max.	100	mA
*$I_{C(AV)}$ max.	100	mA

Base Current

I_{BM} max.	5.0	mA
*$I_{B(AV)}$ max.	5.0	mA

Reverse emitter-base voltage

V_{EBM} max.	–10	V
*$V_{EB(AV)}$ max.	–10	V

Total dissipation

P_{tot} max. $\left(\frac{T_j \text{ max.} - T_{amb}}{\theta}\right)$	500	mW

*Averaged over any 20ms period.

Temperature ratings

T_{stg} max.	75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
T_j max. (intermittent operation total duration 200 hours max.)	90	°C
θ_{j-amb} max. (in free air)	0.3	°C/mW
θ_{j-amb} max. (with cooling fin mounted on a heat sink of at least 12.5cm^2)	0.09	°C/mW

CHARACTERISTICS at $T_{amb} = 25°C$		Typ.	Max.	
Collector leakage current	I_{CBO}			
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 25°C$)		5.5	10	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 75°C$)		300	550	μA
Emitter leakage current	I_{EBO}			
($V_{EB} = -5V$, $I_C = 0mA$, $T_j = 75°C$)		—	<550	μA
D.C. current amplification factor	h_{FE}			
($V_{CB} = -5V$, $I_E = 2mA$)		100	—	
($V_{CB} = 0$, $I_E = 50mA$)		95	—	
($V_{CB} = 0$, $I_E = 100mA$)		80	—	
Base voltage	V_{BE}			
($I_E = 2mA$, $V_{CB} = -5V$)		105	—	mV
($I_E = 100mA$, $V_{CB} = 0V$)		—	<400	mV
Frequency at which $\lvert h_{fe} \rvert = 1$	f_1			
($V_{CB} = -2V$, $I_E = 10mA$)		1.7	—	Mc/s
Cut-off frequency	f_{hfe}			
($V_{CB} = -2V$, $I_E = 10mA$)		17	—	kc/s
Base resistance	$\lvert z_{rb} \rvert$			
($V_{CB} = -5V$, $I_E = 1mA$, $f = 0.45Mc/s$)		90	—	Ω
Collector capacitance	c_c			
($V_{CB} = -5V$, $I_E = 0mA$, $f = 0.45Mc/s$)		40	<50	pF
Noise figure				
($V_{CB} = -5V$, $I_E = 0.5mA$, $f = 1kc/s$, input source resistance = 500Ω)		4.0	<10	dB
Small signal characteristics at $T_{amb} = 25°C$				
($V_{CB} = -5V$, $I_E = 2mA$, $f = 1kc/s$)				
Current amplification factor	h_{fe}	125	<170	
Input impedance	h_{ie}	1.7	2.5	kΩ
Voltage feedback ratio	h_{re}	6.5×10^{-4}	8.5×10^{-4}	
Output admittance	h_{oe}	80	<110	μA/V

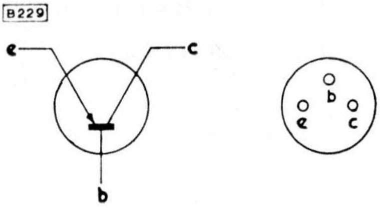
OPERATING NOTES

1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal, or when vertically mounted for 5 seconds up to a point 2mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

JUNCTION TRANSISTOR

AC126

Germanium p-n-p alloy junction transistor, in metal envelope, for use in pre-amplifier and driver stages.



DIMENSIONS

Max. body length ..	9.4	mm
Max. diameter ..	6.1	mm
Min. lead length ..	38	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage

V_{CB} max. ($I_E = 0$mA)	–32	V
V_{CE} max. ($R_{BE} > 1$kΩ)	–32	V

Collector current

I_{CM} max.	100	mA
*$I_{C(AV)}$ max.	100	mA

Base current

I_{BM} max.	5.0	mA
*$I_{B(AV)}$ max.	5.0	mA

Reverse emitter-base voltage

V_{EBM} max.	–10	V
*$V_{EB(AV)}$ max.	–10	V

Total dissipation

P_{tot} max. $\left(\frac{T_j \text{ max.} - T_{amb}}{\theta}\right)$	500	mW

*Averaged over any 20ms period.

Temperature ratings

T_{stg} max.	75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
T_j max. (intermittent operation total duration 200 hours max.)	90	°C
θ_{j-} max. (in free air)	0.3	°C/mW
θ_{j-amb} max. (with cooling fin mounted on a heat sink of at least 12.5cm^2)	0.09	°C/mW

AC126 (Cont.)

JUNCTION TRANSISTOR

CHARACTERISTICS at $T_{amb} = 25°C$

		Typ.	Max.	
Collector leakage current	I_{CBO}			
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 25°C$)		5.5	10	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 75°C$)		300	550	μA
Emitter leakage current	I_{EBO}			
($V_{EB} = -5V$, $I_C = 0mA$, $T_j = 75°C$)		—	550	μA
D.C. current amplification factor	h_{FE}			
($V_{CB} = -5V$, $I_E = 2mA$)		220	—	
($V_{CB} = 0V$, $I_E = 50mA$)		135	—	
($V_{CB} = 0V$, $I_E = 100mA$)		105	—	
Base voltage	V_{BE}			
($I_E = 2mA$, $V_{CB} = 5V$)		105	—	mV
($I_E = 100mA$, $V_{CB} = 0V$)		—	400	mV
Frequency at which $\lvert h_{fe}\rvert = 1$	f_1			
($V_{CB} = -2V$, $I_E = 10mA$)		2.3	—	Mc/s
Cut-off frequency	f_{hfe}			
($V_{CB} = -2V$, $I_E = 10mA$)		17	—	kc/s
Base resistance	$\lvert z_{rb}\rvert$			
($V_{CB} = -5V$, $I_E = 1mA$, $f = 0.45Mc/s$)		90	—	Ω
Collector capacitance	c_c			
($V_{CB} = -5V$, $I_E = 0mA$, $f = 0.45Mc/s$)		40	50	pF
Noise figure				
($V_{CB} = -5V$, $I_E = 0.5mA$, $f = 1kc/s$, input source resistance $= 500Ω$)		4.0	10	dB
Small signal characteristics at $T_{amb} = 25°C$				
($V_{CB} = -5V$, $I_E = 2mA$, $f = 1kc/s$)				
Current amplification factor	h_{fe}	180	300	
Input impedance	h_{ie}	2.4	3.8	kΩ
Output admittance	h_{oe}	100	170	μA/V

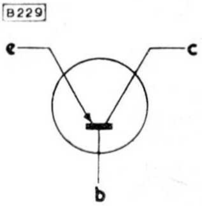
OPERATING NOTES

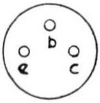
1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 2mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

JUNCTION TRANSISTOR

AC127

High-gain, germanium n-p-n alloy junction transistor intended for use in medium power n-p-n, p-n-p complementary push-pull output stages.





DIMENSIONS

Max. body length	..	9.4	mm
Max. diameter	..	6.48	mm
Min. lead length	..	38	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages component tolerances and ambient temperature must also be taken into account.

Collector voltage

V_{CB} max. ($I_E = 0$mA)	+32	V
V_{CE} max. ($R_{BE} > 70\Omega$)	+32	V

Collector current

I_{CM} max.	500	mA
*$I_{C(AV)}$ max.	500	mA

Base current

I_{BM} max.	25	mA
*$I_{B(AV)}$ max.	25	mA

Reverse emitter-base voltage

V_{EBM} max.	+10	V
*$V_{EB(AV)}$ max.	+10	V

Total dissipation

P_{tot} max. $= \left(\frac{T_j \text{ max.} - T_{amb}}{\theta}\right)$	280	mW

*Averaged over any 20ms period.

Temperature ratings

T_j max.	90	°C
θ_{j-amb} (in free air)	0.37	°C/mW

AC127 (Cont.)

JUNCTION TRANSISTOR

CHARACTERISTICS at T_{amb} = 25°C

		Min.	*Typ.*	*Max.*	
Collector leakage current	I_{CBO}				
(V_{CB} = +10V, I_E = 0mA, T_{amb} = 25°C)		—	6.5	15	µA
(V_{CB} = +10V, I_E = 0mA, T_{amb} = 75°C)		—	350	650	µA
Emitter leakage current	I_{EBO}				
(V_{CB} = +5V, T_j = 75°C)		—	—	550	µA
Collector knee voltage	$V_{CE(knee)}$				
(I_C = 300mA, see Fig. 1)		—	—	500	mV

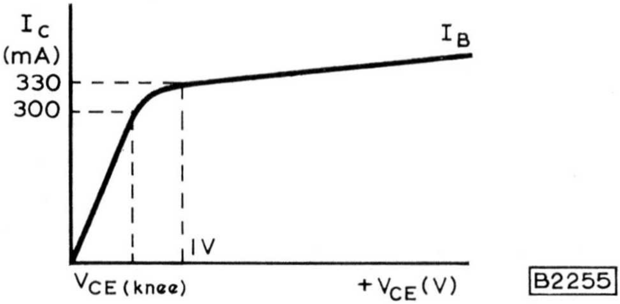


Fig. 1

I_B adjusted such that I_C = 330mA and V_{CE} = +1V.

		Min.	*Typ.*	*Max.*	
Base voltage	V_{BE}				
(V_{CB} = +5V, I_E = 2mA)		—	120	—	mV
(V_{CB} = 0V, I_E = 300mA)		—	—	800	mV
Frequency at which $\lvert h_{fe} \rvert = 1$	f_1	1.5	2.5	—	Mc/s
Current amplification factor	h_{FEL}				
(V_{CB} = 0V, I_E = 20mA)		—	120	—	
(V_{CB} = 0V, I_E = 50mA)		—	115	—	
(V_{CB} = 0V, I_E = 200mA)		—	90	—	
(V_{CB} = 0V, I_E = 300mA)		—	75	—	
Cut-off frequency	f_{hfe}				
(V_{CB} = +2V, I_E = 10mA)		10	20	—	kc/s
Noise figure					
(R_s = 500Ω, V_{CB} = +5V, I_E = 0.5mA, f = 1kc/s)		—	4.0	10	dB
Intrinsic base impedance	$\lvert z_{rb} \rvert$				
(V_{CB} = +5V, I_E = 1mA, f = 0.45Mc/s)		—	70	—	Ω
Collector depletion capacitance	c_{tc}				
(V_{CB} = 5V, I_E = 0mA, f = 0.45Mc/s)		—	70	—	pF

OPERATING NOTES

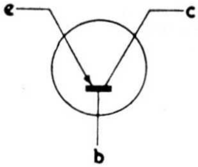
1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal, or when vertically mounted for 5 seconds up to a point 2mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

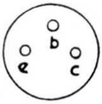
JUNCTION TRANSISTOR

AC128
2-AC128

High gain, germanium p-n-p alloy junction transistor, for use in class 'A' and class 'B' output stages.

B229





DIMENSIONS

Max. body length	9.4	mm
Max. diameter	6.1	mm
Min. lead length	38	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CB} max. ($I_E = 0$mA)	−32	
V_{CE} max. ($R_B \leqslant 400\Omega$)	−32	V
Collector current		
I_{CM} max.	1.0	A
*$I_{C(AV)}$ max.	1.0	A
Base current		
I_{BM} max.	40	mA
*$I_{B(AV)}$ max.	40	mA
Emitter current		
I_{EM} max.	520	mA
*$I_{E(AV)}$ max.	520	mA
Reverse emitter-base voltage		
V_{EBM}	−10	V
*$V_{EB(AV)}$	−10	V
Total dissipation		
P_{tot} max. $\left(\frac{T_j \text{ max.} - T_{amb}}{\theta}\right)$	700	mW

*Averaged over any 20ms period.

Temperature ratings		
T_j max.	90	°C
T_j max. (intermittent operation total duration 200 hours max.)	100	°C
T_{stg} max.	75	°C
T_{stg} min.	−55	°C
θ_{j-case}	0.04	°C/mW
θ_{j-amb} (in free air)	0.29	°C/mW
θ_{j-amb} (with cooling fin, in free air)	0.14	°C/mW

AC128
2-AC128 (Cont.)

CHARACTERISTICS at $T_{amb} = 25°C$

		Min.	*Typ.*	*Max.*	
Collector leakage current	I_{CBO}				
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 25°C$)		—	—	10	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 85°C$)		—	—	750	μA
Emitter leakage current	I_{EBO}				
($V_{EB} = -5V$, $I_C = 0mA$, $T_j = 75°C$)		—	—	500	μA
Collector knee voltage	$V_{CE(knee)}$				
($I_c = 1A$; see Fig. 1)		—	—	600	mV

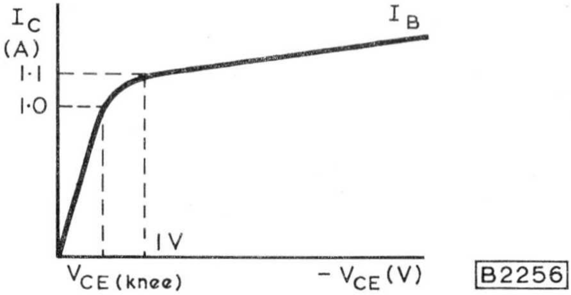


Fig. 1

I_B is adjusted such that $I_C = 1.1A$ and $V_{CE} = -1V$.

		Min.	*Typ.*	*Max.*	
Base voltage	V_{BE}				
($I_E = 3mA$, $V_{CB} = 0V$)		—	130	—	mV
($I_E = 50mA$, $V_{CB} = 0V$)		—	—	−300	mV
($I_E = 300mA$, $V_{CB} = 0V$)		—	—	−450	mV
($I_E = 500mA$, $V_{CB} = 0V$)		—	—	−550	mV
Frequency at which $\|h_{fe}\| = 1$	f_1				
($V_{CB} = -2V$, $I_E = 10mA$)		1.0	1.5	—	Mc/s
Cut-off frequency	f_{hfe}				
($V_{CB} = -2V$, $I_E = 10mA$)		10	15	—	kc/s
Base resistance	$r_{bb'}$				
($V_{CB} = -5V$, $I_E = 1mA$)		—	25	—	Ω
Collector capacitance	c_{tc}				
($V_{CB} = -5V$, $I_E = 0$)		—	100	—	pF

JUNCTION TRANSISTOR

AC128
2-AC128

LARGE SIGNAL CHARACTERISTICS

Current amplification factor $h_{FEL} = \frac{I_C - I_{CBO}}{I_B + I_{CBO}}$

	Min.	*Typ.*	*Max.*
($I_E = 50mA$, $V_{CB} = 0V$)	55	90	175
($I_E = 300mA$, $V_{CB} = 0V$)	60	90	175
($I_E = 1A$, $V_{CB} = 0V$)	45	80	165
Ratio of h_{fe} at $V_{BB} = -10V$, $I_C = 500mA$, $R_L = 16\Omega$			
$\frac{h_{fe} \text{ at } I_C = 500mA}{h_{fe} \text{ max.}}$		0.5	0.6

CHARACTERISTICS OF MATCHED PAIR 2-AC128

	Min.	*Typ.*	*Max.*
Ratio of h_{FE} of the two transistors at			
$I_C = 50mA$, $V_{CB} = 0V$		1.1	1.25 : 1
$I_C = 300mA$, $V_{CB} = 0V$		1.1	1.25 : 1

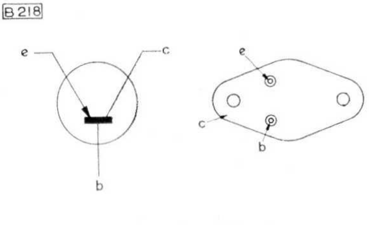
OPERATING NOTES

1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal, or when vertically mounted for 5 seconds up to a point 2mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

AD140
2-AD140

AUDIO POWER TRANSISTOR

Germanium junction, power transistor of the p-n-p alloy type. Intended for use as an amplifier in the output stages of receivers and amplifiers operating from either battery or a.c. mains.



TO-3 Construction

DIMENSIONS

Max. seated height ..	7.0	mm
Max. lead length ..	13	mm
Max. width	26.2	mm
Max. overall length	39.5	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must be taken into account.

Collector voltage		
V_{CB} max. ($I_E = 0$)	–55	V
V_{CE} max. ($I_C = 0.5A$, $+V_{BE} = 2V$)	–55	V
V_{CE} max. ($I_C = 3.0A$, $+V_{BE} = 2V$)	–40	V
Collector current		
I_{CM} max.	3.0	A
*$I_{C(AV)}$ max.	3.0	A
Emitter current		
I_{EM} max.	3.5	A
*$I_{E(AV)}$ max.	3.5	A
Reverse emitter-base voltage		
V_{EBM} max.	–10	V
*$V_{EB(AV)}$ max.	–10	V
Base current		
I_{BM} max.	500	mA
*$I_{B(AV)}$ max.	500	mA

*Averaged over any 20ms period.

Total dissipation		
At $T_{case} \leqslant 37.5°C$	35	W
At $T_{case} \geqslant 37.5°C$	See page 51	

$$\left(P_{tot} \text{ max.} = \frac{T_j \text{ max.} - T_{case}}{\theta_{j-case}}\right)$$

Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	90	°C
†T_j max. (intermittent operation total duration 200 hours)	100	°C
θ_{j-case}	<1.5	°C/W

†Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

For full information on calculating junction temperature see operating notes.

AUDIO POWER TRANSISTOR

AD140
2-AD140

CHARACTERISTICS at $T_{case} = 25°C$

		Typical production spread *Min.*	*Typ.*	*Max.*	
Common base					
Collector leakage current	I_{CBO}				
($V_{CB} = -500mV$, $I_E = 0mA$)		—	—	100	µA
($V_{CB} = -14V$, $I_E = 0mA$, $T_j = 100°C$) ..		—	—	10	mA
Common emitter					
Base input voltage	V_{BE}				
($V_{CE} = -14V$, $I_C = 30mA$)		−100	—	—	mV
($V_{CB} = 0V$, $I_C = 1A$)		—	—	−750	mV
($V_{CB} = 0V$, $I_C = 3A$)		—	—	−1.2	V
Collector knee voltage .. .. (See Fig. 1)	V_{CE} (knee)	—	−400	−800	mV

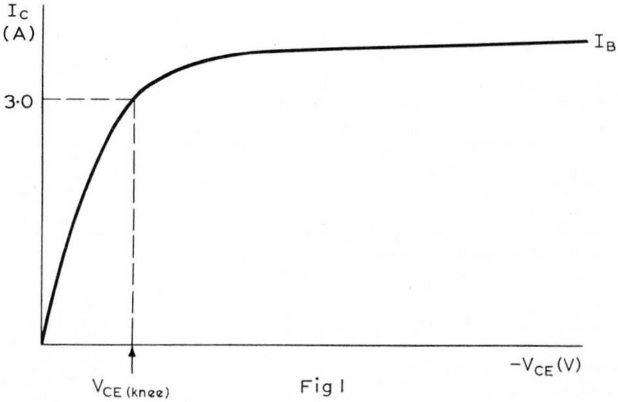


Fig I

I_B adjusted such that I_C = 3·3A with V_{CE} = - 1V

9607

LARGE SIGNAL CHARACTERISTICS

Current amplification factor $h_{FEL} = \dfrac{I_C - I_{CBO}}{I_B + I_{CBO}}$

	Min.	Typ.	Max.	
($V_{CE} = -1V$, $I_C = 1A$)	30	—	100	
$\dfrac{h_{FE} \text{ at } I_C = 1.0A,\ V_{CB} = 0V}{h_{FE} \text{ at } I_C = 100mA,\ V_{CB} = -14V}$ ..	0.5	—	—	
f_{hfe}	3.0	4.5	—	kc/s

CHARACTERISTICS OF MATCHED PAIR (measured at $T_{case} = 25°C$)

Ratio of the current amplification factor of 2-AD140 at $I_C = 3A$ .. .. .. 1.25 : 1

AD140
2-AD140 (Cont.)

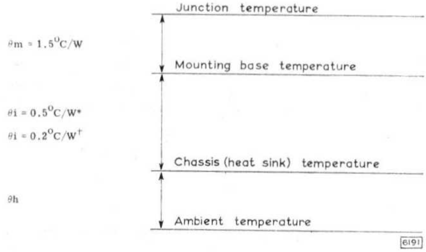
AUDIO POWER TRANSISTOR

OPERATING NOTES

1. Dissipation and heatsink considerations.
   The maximum total dissipation (P_{tot} max. $= (V_{CE} \times I_C) + (V_{BE} \times I_B)$ is given by the relationship:

$$P_{tot}\text{ max.} = \frac{T_j\text{ max.} - T_{amb}}{\theta_m + \theta_i + \theta_h}$$

   Where $\theta_m + \theta_i + \theta_h$ is equal to the junction temperature rise per watt above ambient. The various components of the rise of junction temperature above ambient are illustrated below:



   *With mica insulation.

   †Mounted directly on to a chassis with thin film of silicone grease between contacting surfaces.

   θ_h depends on the cooling conditions under which the transistor is used i.e. dimensions, position and surface conditions of heat sink etc., a good air-cooled heat sink will have an approximate value of $\theta_h = 2.2$°C/W. ($7'' \times 7'' \times 1/16''$ blackened aluminium).

   θ_h can be determined for a given collector dissipation and ambient temperature by measuring the mounting base temperature.

$$\theta_h = \frac{T_{case} - T_{amb}}{P_{tot}} - \theta_i\,^{\circ}C/W$$

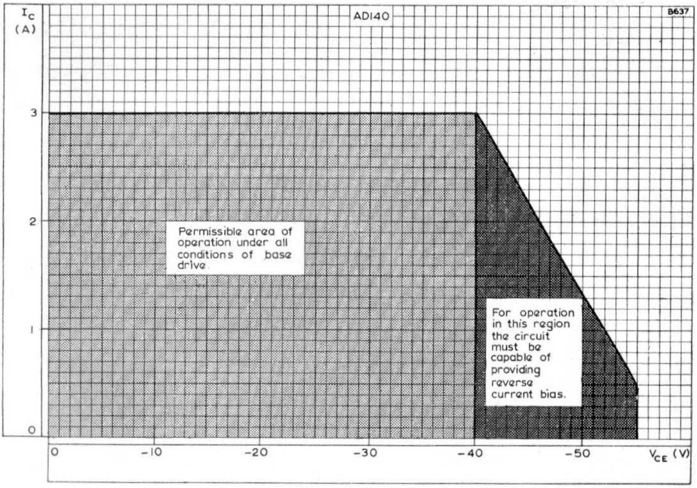
   The following example illustrates the temperatures which occur at various points on the transistor at $P_c = 8W$, $T_j = 90^{\circ}C$, $\theta_h = 2.2^{\circ}C/W$.

   Transistor with mica insulation
   Junction temperature = 90°C
   Mounting base temperature = $90-(8 \times 1.5) = 78^{\circ}C$
   Chassis (heat sink) temperature = $78-(8 \times 0.5) = 74^{\circ}C$
   Ambient temperature = $74-(8 \times 2.2) = 56.4^{\circ}C$

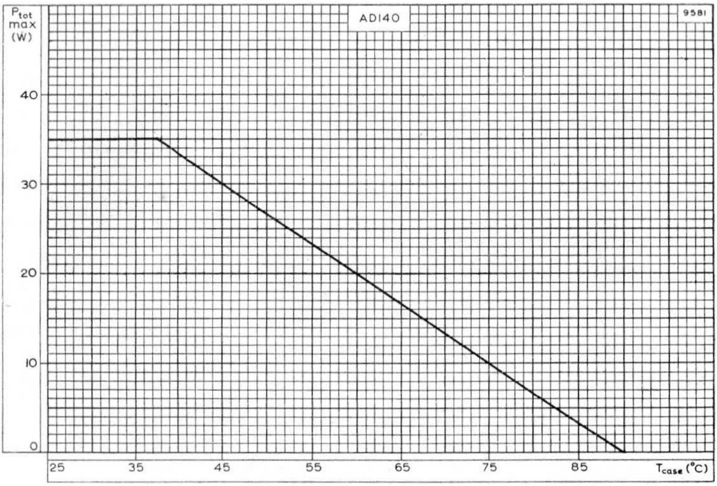
   The suitability of any design can be checked by measuring with a thermocouple the mounting base temperature of the transistor operating at the selected collector dissipation and maximum ambient temperature. The point defined by the mounting base temperature and the total dissipation must lie below the line of the curve on page 45 which results in $T_j < 90^{\circ}C$. If the point lies above the line the design is inadmissible and the dissipation must be reduced or the heat sink improved. The selected total dissipation should be the maximum attained by any transistor in the design being checked.

2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 2mm from the seal.

3. Care must be taken to ensure good thermal contact between the transistor and heat sink. Burrs or thickening at the edges of the four holes must be removed and the transistor bolted down on a plane surface.



COLLECTOR CURRENT PLOTTED AGAINST ABSOLUTE MAXIMUM COLLECTOR-EMITTER VOLTAGE



MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST CASE TEMPERATURE

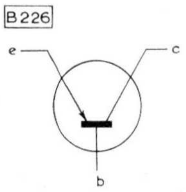
AF102

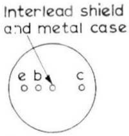
R.F. JUNCTION TRANSISTOR

R.F. junction transistor of the p-n-p alloy-diffused type intended as an r.f. amplifier or mixer oscillator in television receivers at frequencies up to 260Mc/s.

DIMENSIONS

Max. body length ..	9.5	mm
Max. diameter ..	9.1	mm
Min. lead length ..	37	mm





Construction TO-7

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CBM} max.	−25	V
V_{CB} max.	−25	V
Collector current		
I_{CM} max	10	mA
$I_{C(AV)}$ max.	10	mA
Emitter current		
I_{EM} max.	10	mA
$I_{E(AV)}$ max.	10	mA
Reverse emitter current		
I_{EM} max.	1.0	mA
$I_{E(AV)}$ max.	1.0	mA
Total dissipation	50	mW
$P_{tot}\text{ max.} = \dfrac{T_j\text{ max.} - T_{amb}}{\theta_{j-amb}}$	See page 55	
Temperature ratings		
T_{stg}	−55 to +75	°C
T_j max. (Continuous operation)	75	°C
†T_j max. (Intermittent operation total duration = 200 hours max.)	90	°C
θ_{j-amb}	0.6	°C/mW

†Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

R.F. JUNCTION TRANSISTOR

AF102

CHARACTERISTICS at $T_{amb} = 25°C$

		Typical production spreads			
		Min.	*Typ.*	*Max.*	
Collector leakage current ($V_{CB} = -12V$, $I_E = 0mA$)	I_{CBO}	—	—	10	μA
Emitter leakage current ($V_{EB} = -300mV$, $I_C = 0mA$)	I_{EBO}	—	—	50	μA
Base current ($V_{CB} = -12V$, $I_C = 1mA$)	I_B	—	—	50	μA
Base input voltage ($V_{CB} = -12V$, $I_C = 1mA$)	V_{BE}	-220	—	-360	mV
Frequency at which $\|h_{fe}\| = 1$ ($V_{CB} = -12V$, $I_E = 1mA$)	f_1	—	180	—	Mc/s
Current amplification factor ($V_{CE} = -12V$, $I_C = 1mA$, $f = 1kc/s$)	h_{fe}	20	—	—	
Intrinsic base impedance ($V_{CB} = -12V$, $I_E = 1mA$, $f = 2Mc/s$)	$\|z_{rb}\|$	—	10	—	Ω
Noise figure ($V_{CE} = -12V$, $I_C = 1mA$, $R_S = 30Ω$, $f = 200Mc/s$)		—	6	7.5	dB

y-parameters
Common base

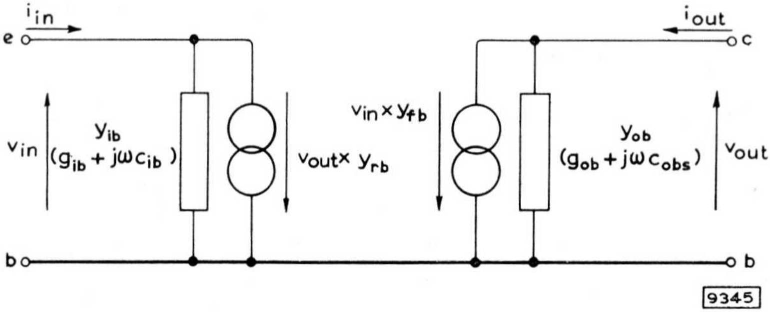


Fig. 1

	V_{CB}	-9.0	9.0	V
Measured at:	I_E	1.5	1.5	mA
	f	50	200	Mc/s
Input conductance (with output short circuited to a.c.)	g_{ib}	50	30	mmho
Input capacitance (with output short circuited to a.c.)	c_{ib}	-36	-20	pF

AF102 (Cont.)

R.F. JUNCTION TRANSISTOR

Transfer admittance (with output short circuited to a.c.)	$\lvert y_{fb} \rvert$	47	30	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fb}	145	90	deg
Output conductance (with input short circuited to a.c.)	g_{ob}	30	300	µmho
Output capacitance (with input short circuited to a.c.)	c_{obs}	2.0	2.0	pF
Feedback admittance (with input short circuited to a.c.)	$\lvert y_{rb} \rvert$	100	400	µmho
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{rb}	–90	–90	deg

Common emitter

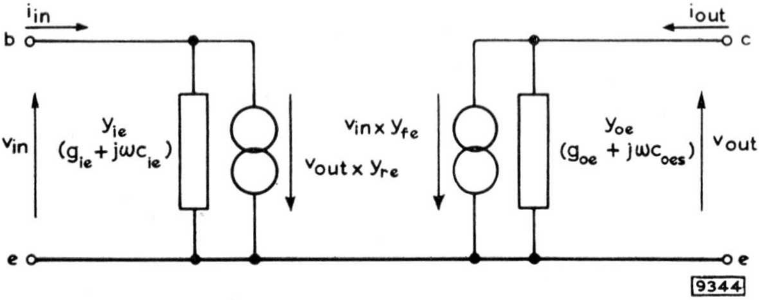


Fig. 2

Measured at $V_{CE} = -12V$, $I_C = 1mA$, f = 450kc/s

Feedback capacitance (with input short circuited to a.c.)	c_{re}	–0.8	pF

Measured at $V_{CE} = -12V$, $I_C = 1mA$ f = 35Mc/s

Output conductance (with input short circuited to a.c.)	g_{oe}	10	µmho
Output capacitance (with input short circuited to a.c.)	c_{oes}	2.0	pF

R.F. JUNCTION TRANSISTOR **AF102**

DYNAMIC CHARACTERISTICS in measuring circuit at f = 200Mc/s

	Min.	*Typ.*	
*Power gain $\left(\frac{V_{out}}{V_{in}}\right)^2 \cdot \frac{4R_S}{R_L}$	10	13	dB

*The insertion losses of both tuned circuits are inclusive.

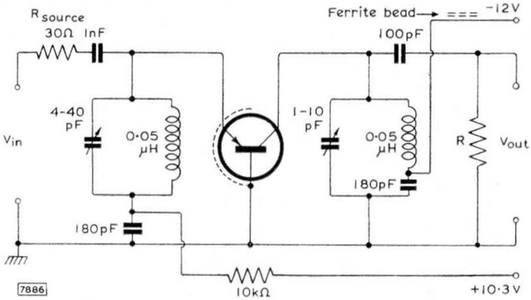
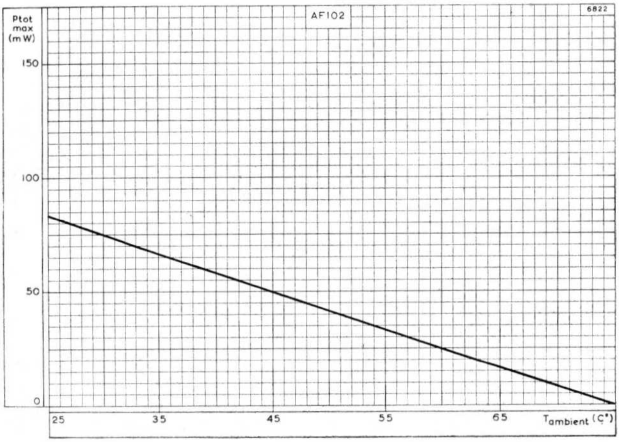


Fig. 3

R is chosen so that the total impedance of the output tuned circuit is 2.0kΩ.

OPERATING NOTES

1. The transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

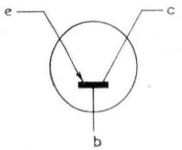


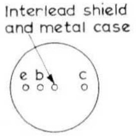
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AF114 AF115 AF116 AF117

Germanium junction transistors of the p-n-p alloy diffused type in TO-7 construction intended for use in a.m./f.m. and a.m. receivers.

B226





DIMENSIONS

Max. body length	9.5	mm
Max. diameter	9.1	mm
Min. lead length	37	mm

Application		**Typical Power Gain** (dB)	at	f (Mc/s)
AF114	R.F. amplifier a.m./f.m. receivers	14		100
AF115	Mixer/oscillator a.m./f.m. and short wave a.m. receivers	13		100
AF116	I.F. amplifier f.m. receivers	25		10.7
AF117	Mixer oscillator i.f. amplifier, m.w. and l.w. a.m. receivers	42		0.45

Unless otherwise shown data is applicable to all types

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CB} max.	–20	V
†V_{CE} max.	–20	V

†This value applies when $\frac{R_B}{R_E} < 100$

Collector current		
I_{CM} max.	10	mA
*$I_{C(AV)}$ max.	10	mA
Emitter current		
I_{EM} max.	11	mA
*$I_{E(AV)}$ max.	11	mA
Base current		
I_{BM} max.	1.0	mA
*$I_{B(AV)}$ max.	1.0	mA
Reverse emitter current		
I_{EM} max.	1.0	mA
*$I_{E(AV)}$ max.	1.0	mA
Total dissipation (at $T_{amb} = 45°C$)	50	mW

*Averaged over any 50ms period.

Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
‡T_j max. (continuous operation)	75	°C
θ_{j-amb}	$\leqslant$0.6	°/mWC

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

AF114 AF115
AF116 AF117

CHARACTERISTICS at $T_{amb} = 25°C$

		Typical production spread			
		Min.	*Typ.*	*Max.*	
Common base					
Collector leakage current ($V_{CB} = -6V$, $I_E = 0mA$)	I_{CBO}	—	1.2	8.0	μA
Common emitter					
Base current ($V_{CB} = -6V$, $I_E = 1mA$)	I_B	—	7.0	25	μA
Base voltage ($V_{CB} = -6V$, $I_E = 1mA$)	V_{BE}	−210	−270	−330	mV
Small signal characteristics					
Frequency at which $\|h_{fe}\| = 1$ ($V_{CB} = -6V$, $I_E = 1mA$)	f_1	—	75	—	Mc/s
Current amplification factor ($V_{CE} = -6V$, $I_E = 1mA$, $f = 1kc/s$)	h_{fe}	40	150	—	

		AF114	**AF115**	**AF116**	**AF117**	
Typical intrinsic base impedance $\|Z_{rb}\|$		20	25	27	35	Ω
Noise figure ($V_{CE} = -6V$, $I_E = 1mA$)						
$R_s = 500Ω$, $f = 1Mc/s$	Typ.	—	1.5	1.5	1.5	dB
	Max.	—	3.0	3.0	3.0	dB
$R_s = 200Ω$, $f = 10.7Mc/s$	Typ.	—	3.0	3.0	—	dB
	Max.	—	—	4.5	—	dB
$R_s = 60Ω$, $f = 100Mc/s$	Typ.	8.0	9.5	—	—	dB
	Max.	9.5	—	—	—	dB
Conversion noise ($V_{CE} = -6V$, $I_E = 1mA$)						
$R_s = 2.0kΩ$, $f = 200kc/s$	Typ.	—	4.0	—	4.0	dB
	Max.	—	7.0	—	7.0	dB
$R_s = 500Ω$, $f = 1Mc/s$	Typ.	—	3.0	—	3.0	dB
	Max.	—	5.0	5.0	5.0	dB
Dynamic performance						
		f = 100	100	10.7	0.45	Mc/s
Power gain $\left(\frac{V_{out}}{V_{in}}\right)^2 \cdot \frac{4R_s}{R_L}$	Min.	12.5	10	19	40	dB
	Typ.	14	13	25	42	dB

Typical y-parameters

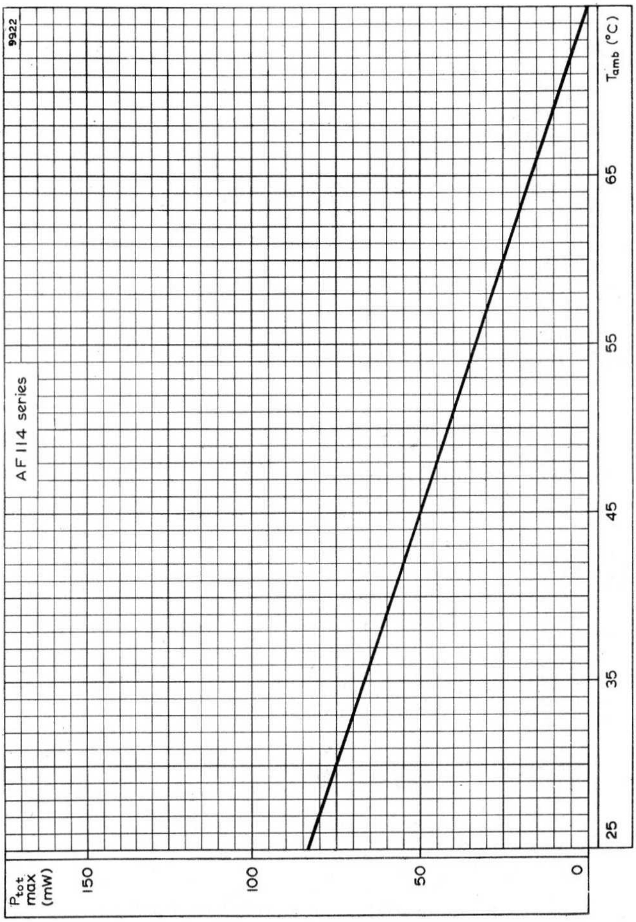
The y-parameters are measured with an effective lead length of 5mm.

	Common Base			Common Emitter						
	measured at $V_{CB} = -6V$, $I_E = 1mA$			measured at $V_{CE} = -6V$, $I_E = 1mA$						
		AF114	**AF115**		**AF114**	**AF115**	**AF116**		**AF117**	
		f = 100	100		f = 36	10.7	0.45	10.7	0.45	Mc/s
Input conductance (with output short circuited to a.c.)	g_{ib}	15	15	g_{ie}	10	1.3	0.25	1.7	0.25	m℧
Input capacitance (with output short circuited to a.c.)	c_{ib}	−5.0	−5.0	c_{ie}	45	65	70	60	70	pF
Transfer admittance (with output short circuited to a.c.)	$\|y_{fb}\|$	16	15	$\|y_{fe}\|$	68	34	37	32	37	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fb}	95	95	ϕ_{fe}	305	335	0	335	0	deg
Output conductance (with input short circuited to a.c.)	g_{ob}	300	350	g_{oe}	360	25	1.0	40	1.0	μ℧
Output capacitance (with input short circuited to a.c.)	c_{obs}	2.5	2.5	c_{oes}	3.1	3.0	4.0	3.5	4.0	pF
Feedback admittance (with input short circuited to a.c.)	$\|y_{rb}\|$	450	450	$\|y_{re}\|$	230	80	4.0	100	4.0	μ℧
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{rb}	250	250	ϕ_{re}	260	260	270	260	270	deg

AF114 AF115 AF116 AF117

OPERATING NOTES

1. The transistors may be soldered into the circuit but heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 245°C for a maximum of 5 seconds up to a point 1.5mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

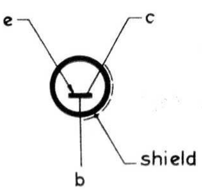


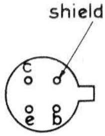
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AF124 AF125 AF126 AF127

JUNCTION TRANSISTORS

B225





Germanium junction transistors of the p-n-p alloy diffused type intended for use in a.m./f.m. and a.m. receivers. TO-18 construction.

DIMENSIONS

Max. body length	5.3	mm
Max. diameter	4.8	mm
Min. lead length	12.7	mm

Application

		Typical Power Gain (dB)	at f (Mc/s)
AF124	R.F. amplifier a.m./f.m. receivers	14	100
AF125	Mixer oscillator a.m./f.m. and short wave receivers	13	100
AF126	I.F. amplifier f.m. receivers	25	10.7
AF127	Mixer oscillator i.f. amplifier m.w. and l.w. a.m. receivers	42	0.45

Unless otherwise shown data is applicable to all types

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CB} max.	−20	V
*V_{CE} max.	−20	V
*This value applies when $\frac{R_B}{R_E} < 100$		
Collector current		
I_{CM} max.	10	mA
*$I_{C(AV)}$ max.	10	mA
Emitter current		
I_{EM} max.	11	mA
*$I_{E(AV)}$ max.	11	mA
Base current		
I_{BM} max.	1.0	mA
*$I_{B(AV)}$ max.	1.0	mA
Reverse emitter current		
I_{EM} max.	1.0	mA
*$I_{E(AV)}$ max.	1.0	mA
Total dissipation (at $T_{amb} = 30°C$)	60	mW
*Averaged over any 50ms period.		
Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	−55	°C
‡T_j max. (continuous operation)	75	°C
θ_{j-amb}	$\leqslant$0.75	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

AF124 AF125 AF126 AF127

CHARACTERISTICS at $T_{amb} = 25°C$

		Typical production spread Min.	Typ.	Max.	
Common base					
Collector leakage current ($V_{CB} = -6V$, $I_E = 0mA$)	I_{CBO}	—	1.2	8.0	μA
Common emitter					
Base Current ($V_{CB} = -6V$, $I_E = 1mA$)	I_B	—	7.0	25	μA
Base voltage ($V_{CB} = -6V$, $I_E = 1mA$)	V_{BE}	–210	–270	–330	mV
Small signal characteristics					
Frequency at which $\|h_{fe}\| = 1$ ($V_{CB} = -6V$, $I_E = 1mA$)	f_1	—	75	—	Mc/s
Current amplification factor ($V_{CE} = -6V$, $I_E = 1mA$, $f = 1kc/s$)	h_{fe}	—	150	—	

		AF124	**AF125**	**AF126**	**AF127**	
Typical Intrinsic base impedance	$\|Z_{rb}\|$	20	25	27	35	Ω
Noise figure ($V_{CE} = -6V$, $I_E = 1mA$)						
$R_s = 500\Omega$, $f = 1Mc/s$	Typ.	—	1.5	1.5	1.5	dB
	Max.	—	3.0	3.0	3.0	dB
$R_s = 200\Omega$, $f = 10.7Mc/s$	Typ.	—	3.0	3.0	—	dB
	Max.	—	—	4.5	—	dB
$R_s = 60\Omega$, $f = 100Mc/s$	Typ.	8.0	9.5	—	—	dB
	Max.	9.5	—	—	—	dB
Conversion Noise ($V_{CE} = -6V$, $I_E = 1mA$)						
$R_s = 2.0k\Omega$, $f = 100kc/s$	Typ.	—	4.0	—	4.0	dB
	Max.	—	7.0	—	7.0	dB
$R_s = 500\Omega$, $f = 1Mc/s$	Typ.	—	3.0	3.0	3.0	dB
	Max.	—	5.0	5.0	5.0	dB
Dynamic Performance						
	f =	100	100	10.7	0.45	Mc/s
Power gain $\left(\frac{V_{out}}{V_{in}}\right)^2 \cdot \frac{4R_s}{R_L}$	Min.	12.5	10	19	40	dB
	Typ.	14	13	25	42	dB

Typical y-parameters

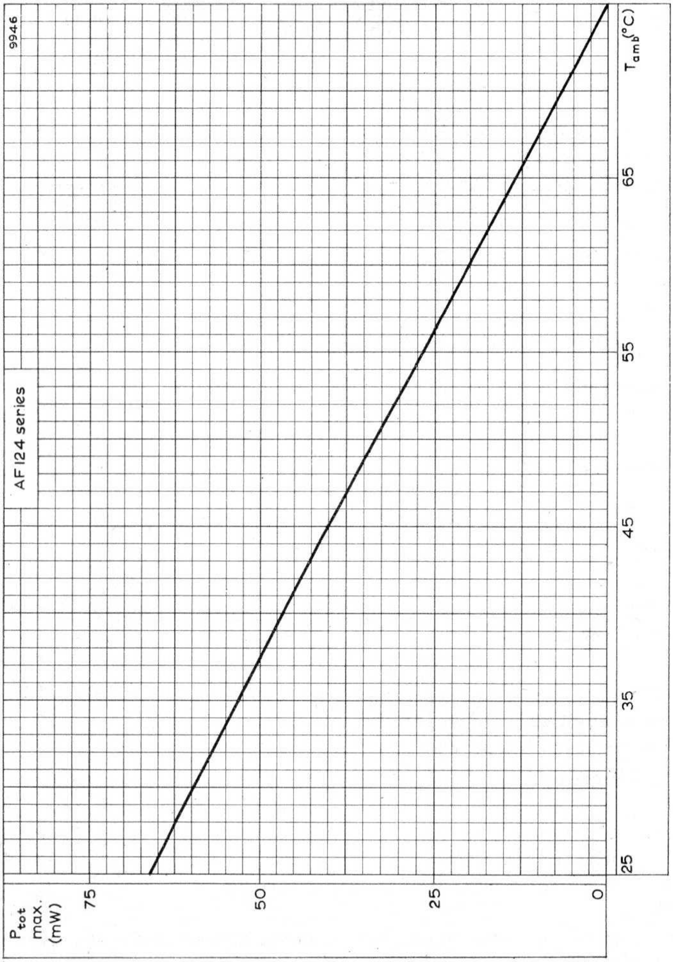
The y-parameters were measured with an effective lead length of 5mm.

	Common Base			Common emitter					
	measured at $V_{CB} = -6V$, $I_E = 1mA$			measured at $V_{CE} = -6V$, $I_E = 1mA$					
		AF124	AF125		AF125	AF126		AF127	
		f = 100	100		10.7	0.45	10.7	0.45	Mc/s
Input conductance (with output short circuited to a.c.)	g_{ib}	15	15	g_{ie}	1.3	0.25	1.7	0.25	m℧
Input capacitance (with output short circuited to a.c.)	c_{ib}	−5.0	−5.0	c_{ie}	65	70	60	70	pF
Transfer admittance (with output short circuited to a.c.)	$\|y_{fb}\|$	16	15	$\|y_{fe}\|$	34	37	32	37	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fb}	95	95	ϕ_{fe}	335	0	335	0	deg
Output conductance (with input short circuited to a.c.)	g_{ob}	300	350	g_{oe}	25	1.0	40	1.0	μ℧
Output capacitance (with input short circuited to a.c.)	c_{obs}	2.5	2.5	c_{oes}	3.0	4.0	3.5	4.0	pF
Feedback admittance (with input short circuited to a.c.)	$\|y_{rb}\|$	450	450	$\|y_{re}\|$	80	4.0	100	4.0	μ℧
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{rb}	250	250	ϕ_{re}	300	270	260	270	deg

AF124 AF125 AF126 AF127

OPERATING NOTES

1. The transistors may be soldered into the circuit but heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

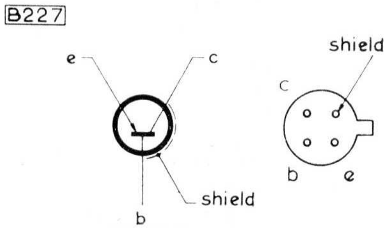


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AF178

R.F. TRANSISTOR

Germanium junction transistor of the p-n-p alloy-diffused type in TO-12 construction. Intended for use as a mixer or oscillator at frequencies up to 220Mc/s.



TO-12 Construction

DIMENSIONS

Max. body length	6·60	mm
Max. body diameter	8·50	mm
Min. lead length	12·7	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CB} max.	–25	V
†V_{CE} max.	–25	V
†This value applies when $\frac{R_B}{R_E} < 100$		
Collector current		
I_{CM} max.	10	mA
*$I_{C(AV)}$ max.	10	mA
Emitter current		
I_{EM} max.	10	mA
*$I_{E(AV)}$ max.	10	mA
Base current		
I_{BM} max.	2.0	mA
*$I_{B(AV)}$ max.	2.0	mA
Reverse emitter current		
I_{EM} max.	1.0	mA
*$I_{E(AV)}$ max.	1.0	mA
Total dissipation (see curve on page 66)	75	mW
*Averaged over any 20ms period.		
Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
‡T_j max. (intermittent operation total duration 200 hours)	90	°C
θ_{j-amb} max	0.6	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

R.F. TRANSISTOR

AF178

CHARACTERISTICS (at $T_{amb} = 25°C$)

		Typical production spread			
		Min.	*Typ.*	*Max.*	
Common base					
Collector leakage current ($V_{CB} = -12V$, $I_E = 0mA$)	I_{CBO}	—	—	10	µA
Reverse emitter-base voltage ($I_C = 0mA$)	V_{EB}	–300	—	—	mV
Common emitter					
Base current ($V_{CB} = -12V$, $I_E = 1mA$)	I_B	—	—	50	µA
Base input voltage ($V_{CB} = -12V$, $I_E = 1mA$)	V_{BE}	–220	—	–360	mV
Small signal characteristics					
Frequency at $\|h_{fe}\| = 1$ ($V_{CB} = -12V$, $I_E = 1mA$)	f_1	—	180	—	Mc/s
Current amplification factor ($V_{CE} = -12V$, $I_E = 1mA$, $f = 1kc/s$)	h_{fe}	20	—	—	
Typical intrinsic base impedance ($V_{CB} = -12V$, $I_E = 1mA$, $f = 2Mc/s$)	$\|Z_{rb}\|$	—	10	—	Ω
Noise figure ($V_{CE} = -12V$, $I_E = 1mA$, $f = 200Mc/s$, $R_s = 30\Omega$)		—	6.0	7.5	dB

y-parameters

Common base

Measured at $V_{CB} = -12V$, $I_E = 1mA$, $f = 200Mc/s$

Input conductance (with output short circuited to a.c.)	g_{ib}	30	mmho
Input capacitance (with output short circuited to a.c.)	c_{ib}	–12	pF
Transfer admittance (with output short circuited to a.c.)	$\|y_{fb}\|$	25	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fb}	90	deg
Output conductance (with input short circuited to a.c.)	g_{ob}	300	µmho
Output capacitance (with input short circuited to a.c.)	c_{obs}	1.8	pF
Feedback admittance (with input short circuited to a.c.)	$\|y_{rb}\|$	400	µmho
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{rb}	270	deg

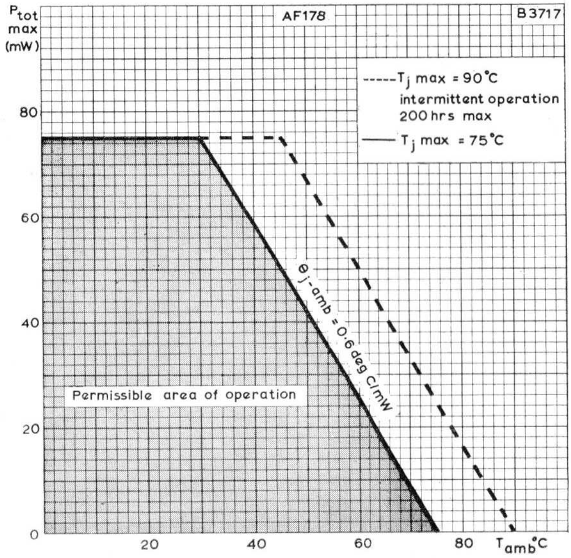
y-parameters (contd.)

Common emitter

Measured at $V_{CE} = -12V$, $I_E = 1mA$, f = 450kc/s			
Feedback capacitance (with input short circuited to a.c.)	c_{re}	–800	mpF
Measured at $V_{CE} = -12V$, $I_E = 1mA$, f = 35Mc/s			
Output conductance (with input short circuited to a.c.)	g_{oe}	10	μmho
Output capacitance (with input short circuited to a.c.)	c_{oes}	2	pF

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by use of a thermal shunt.
2. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
3. Transistors may be dip soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The temperature of the envelope in contact with the board must not exceed 115°C for two minutes. These recommendations apply to a transistor mounted flush on a board with punched through holes or spaced 1.5mm above a board with plated through holes.

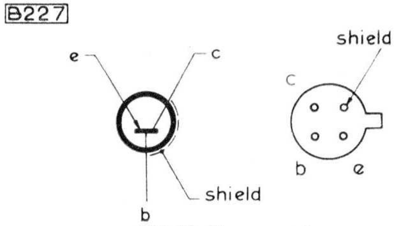


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

R.F. TRANSISTOR

AF179

Germanium junction transistor of the p-n-p alloy-diffused type in TO-12 construction. Intended for use as a large signal i.f. amplifier in a television receiver.



TO-12 Construction

DIMENSIONS

Max. body length	6·35	mm
Max. body diameter	8·15	mm
Min. lead length	12·7	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage

V_{CB} max.	−25	V
†V_{CE} max.	−25	V

†This value applies when $\frac{R_B}{R_E} < 100$

Collector current

I_{CM} max.	15	mA
*$I_{C(AV)}$ max.	10	mA

Emitter current

I_{EM} max.	15	mA
*$I_{E(AV)}$ max.	10	mA

Base Current

I_{BM} max.	2.0	mA
*$I_{B(AV)}$ max.	2.0	mA

Reverse emitter current

I_{EM} max.	10	mA
*$I_{E(AV)}$ max.	10	mA

Total dissipation (see curve on page 69)	140	mW

*Averaged over any 20ms period

Temperature ratings

T_{stg} max.	+75	°C
T_{stg} min.	−55	°C
T_j max. (continuous operation)	75	°C
‡T_j max. (intermittent operation total duration 200 hours)	90	°C
θ_{j-amb}	$\leqslant$0.32	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependant on the type of application.

CHARACTERISTICS (at T_{amb} = 25°C unless otherwise specified)

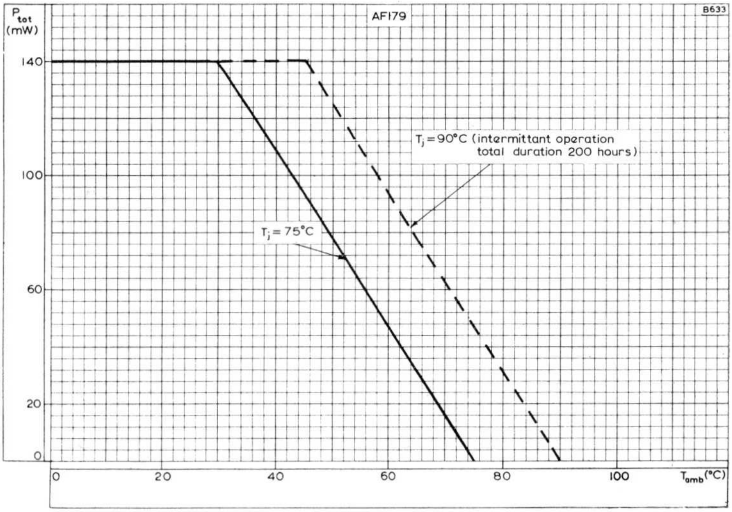
		Typical production spread			
		Min.	*Typ.*	*Max.*	
Common base					
Collector leakage current	I_{CBO}				
(V_{CB} = –10V, I_E = 0mA)		—	—	8	μA
(V_{CB} = –10V, I_E = 0mA, T_j = 75°C)		—	—	150	μA
Common emitter					
Base current	I_B				
(V_{CE} = –10V, I_E = 3mA)		—	40	100	μA
(V_{CE} = –6V, I_E = 5mA)		—	16	40	μA
Base input voltage	V_{BE}				
(V_{CE} = –10V, I_E = 3mA)		-290	—	–370	mV
y-parameters					
Common emitter					
Measured at V_{CE} = –14V, I_E = 6·5mA, f = 35Mc/s					
Input conductance (with output short circuited to a.c.)	g_{ie}		6.5	11	mmho
Input capacitance (with output short circuited to a.c.)	c_{ie}		35	40	pF
Transfer admittance (with output short circuited to a.c.)	$\lvert y_{fe} \rvert$		80	140	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fe}		322	317	deg
Output conductance (with input short circuited to a.c.)	g_{oe}		100	150	μmho
Output capacitance (with input short circuited to a.c.)	c_{oes}		1.8	1.8	pF
Feedback admittance (with input short circuited to a.c.)	$\lvert y_{re} \rvert$		100	100	μmho
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{re}		260	260	deg
Measured at V_{CE} = –10V, I_E = 1mA, = 450kc/s					
Feedback capacitance (with input short circuited to a.c.)	c_{re}		–450		mpF

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by use of a thermal shunt.

2. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

3. Transistors may be dip soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The temperature of the envelope in contact with the board must not exceed 115°C for two minutes. These recommendations apply to a transistor mounted flush on a board with punched through holes or spaced 1.5mm above a board with plated through holes.

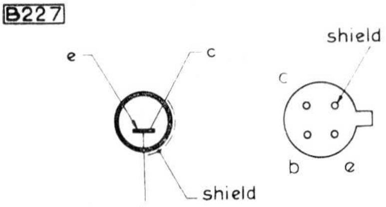


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AF180

R.F. TRANSISTOR

Germanium junction transistor of the p-n-p alloy-diffused type in TO-12 construction. Intended for use as a forward bias r.f. amplifier in television tuners at frequencies up to 220Mc/s.



TO-12 Construction

DIMENSIONS

Max. body length	6·60	mm
Max. body diameter	8·50	mm
Min. lead length	12·7	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variation in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage

V_{CB} max.	–25	V
†V_{CE} max.	–25	V

†This value applies when $\frac{R_B}{R_E} < 100$

Collector current

I_{CM} max.	25	mA
*$I_{C(AV)}$ max.	25	mA

Emitter current

I_{EM} max.	25	mA
*$I_{E(AV)}$ max.	25	mA

Base current

I_{BM} max.	3.0	mA
*$I_{B(AV)}$ max.	3.0	mA

Reverse emitter current

I_{EM} max.	1.0	mA
$I_{E(AV)}$ max.	1.0	mA
Total dissipation (see curve on page 73)	156	mW

*Averaged over any 20ms period

Temperature ratings

T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
‡T_j max. (intermittent operation total duration 200 hours)	90	°C
θ_{j-amb}	$\leqslant$0.32	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

R.F. TRANSISTOR

AF180

TYPICAL PERFORMANCE

common base

($V_{CB} = -10V$, $I_E = 3.5mA$, $R_s = 40\Omega$, $R_L = 1k\Omega$)

Power gain	f = 200Mc/s	14dB (excluding coil losses)
Noise factor	f = 200Mc/s	6dB
Control range	f = 50Mc/s	48dB (over current range 3.5 to <14mA)
	f = 200Mc/s	63dB (over current range 3.5 to <12mA)

Interfering signal for 1% cross modulation (source e.m.f. in 75Ω)

f = 50Mc/s	100mV (for control range = 40dB)
f = 200Mc/s	50mV (for control range = 34dB)

Recommended d.c. operating condition

$V_{CC} = -12V$, total emitter + collector series resistance = 510Ω

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise specified)

		Typical production spread *Typ.*	*Max.*	
Common base				
Collector leakage current	I_{CBO}			
($V_{CB} = -10V$, $I_E = 0mA$)		—	10	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 60°C$)		—	100	μA
Noise figure				
($V_{CB} = -10V$, $I_E = 3.5mA$, $R_s = 40\Omega$)				
f = 50Mc/s		4.0	—	dB
f = 200Mc/s		6.0	—	dB
Common emitter				
Base current	I_B			
($V_{CE} = -10V$, $I_E = 3.5mA$)		—	150	μA
($V_{CE} = -5V$, $I_E = 14mA$)		—	1.0	mA
Base input voltage	V_{BE}			
($V_{CE} = -10V$, $I_E = 3.5mA$)		−300	—	mV
($V_{CE} = -5V$, $I_E = 14mV$)		−350	—	mV

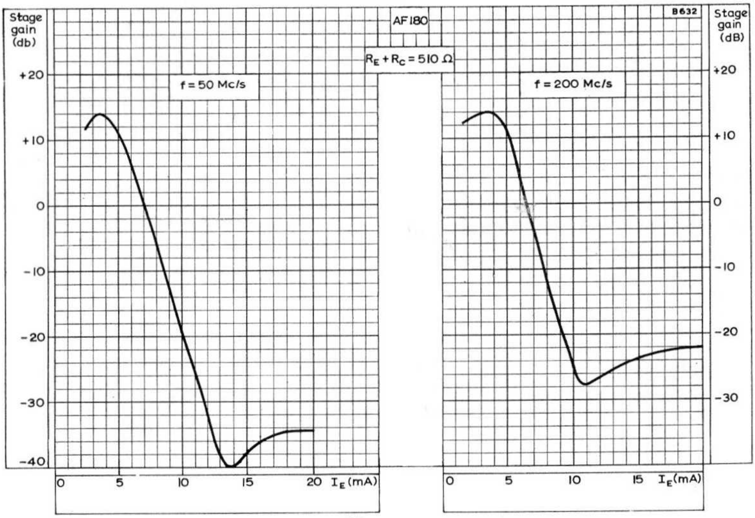
y-parameters

Measured at $V_{CB} = -10V$, $I_E = 3.0mA$

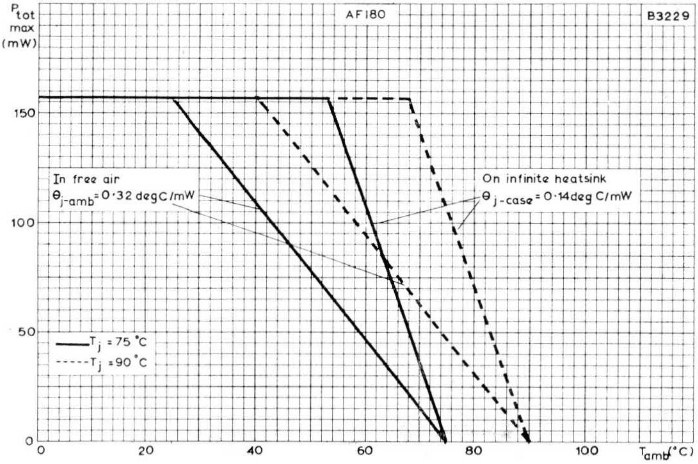
		Common base			*Common emitter*		
	f =	50	200		50	200	Mc/s
Input conductance (with output short circuited to a.c.)	g_{ib}	63	30	g_{ie}	11	27	mmho
Input capacitance (with output short circuited to a.c.)	c_{ib}	−80	−24	c_{ie}	36	2.0	pF
Transfer admittance (with output short circuited to a.c.)	$\|y_{fb}\|$	87	50	$\|y_{fe}\|$	70	35	mA/V
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fb}	150	95	ϕ_{fe}	320	255	deg
Output conductance (with input short circuited to a.c.)	g_{ob}	20	140	g_{oe}	50	280	µmho
Output capacitance (with input short circuited to a.c.)	c_{obs}	3.0	3.0	c_{oes}	3.0	3.0	pF
Feedback admittance (with input short circuited to a.c.)	$\|y_{rb}\|$	40	140	$\|y_{re}\|$	100	412	µmho
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{rb}	200	240	ϕ_{re}	270	256	deg
Measured at $V_{CB} = -10V$, $I_E = 1mA$, f = 450kc/s							
Feedback capacitance (with input short circuited to a.c.)				c_{re}	−250		mpF

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by use of a thermal shunt.
2. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
3. Transistors may be dip soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The temperature of the envelope in contact with the board must not exceed 115°C for two minutes. These recommendations apply to a transistor mounted flush on a board with punched through holes or spaced 1.5mm above a board with plated through holes.



TYPICAL CONTROL CURVES AT 50Mc/s AND 200Mc/s.
STAGE GAIN PLOTTED AGAINST EMITTER CURRENT



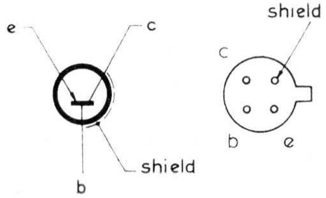
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AF181

R.F. TRANSISTOR

Germanium junction transistor of the p-n-p alloy-diffused type in TO-12 construction. Intended for use as a forward bias i.f. amplifier in television receivers.

B227



TO-12 Construction

DIMENSIONS

Max. body length	6·60	mm
Max. body diameter	8·50	mm
Min. lead length	12·7	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage		
V_{CB} max.	–30	V
†V_{CE} max.	–30	V

†This value applies when $\frac{R_B}{R_E} < 100$

Collector current		
I_{CM} max.	20	mA
*$I_{C(AV)}$ max.	20	mA
Emitter current		
I_{EM} max.	20	mA
*$I_{E(AV)}$ max.	20	mA
Base current		
I_{BM} max.	2.0	mA
*$I_{B(AV)}$ max.	2.0	mA
Reverse emitter current		
I_{EM} max.	1.0	mA
*$I_{E(AV)}$ max.	1.0	mA
Total dissipation (see curve on page 77)	156	mW

*Averaged over any 20ms period

Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
‡T_j max. (intermittent operation total duration 200 hours)	90	°C
θ_{j-amb}	≤0.32	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

DYNAMIC PERFORMANCE OF CONTROLLED STAGE

f = 35Mc/s, V_{CE} = –10V, I_E = 3mA

*Maximum unilateralised gain	35	dB
Control range	56	dB

$$* \quad \frac{|Y_{fe}|^2}{4g_{ie} \cdot g_{oe}}$$

CHARACTERISTICS (at T_{amb} = 25°C unless otherwise specified)

		Typical production spread *Typ.*	*Max.*	
Common base				
Collector leakage current	I_{CBO}			
(V_{CB} = –10V, I_E = 0mA, T_j = 75°C)		70	250	µA
(V_{CB} = –6V, I_E = 0mA)		—	7·0	µA
Common emitter				
Base current	I_B			
(V_{CE} = –10V, I_E = 3mA)		50	150	µA
(V_{CE} = –6V, I_E = 10mA)		235	400	µA
Base input voltage	V_{BE}			
(V_{CE} = –10V, I_E = 3mA)		–360	–400	mV
(V_{CE} = –6V, I_E = 3·5mA)..		—	–420	mV

Recommended d.c. operating condition at T_{amb} = 45°C

V_{CC} = –12V, R_E = 330Ω, R_C = 180Ω, R_B(series) <1kΩ

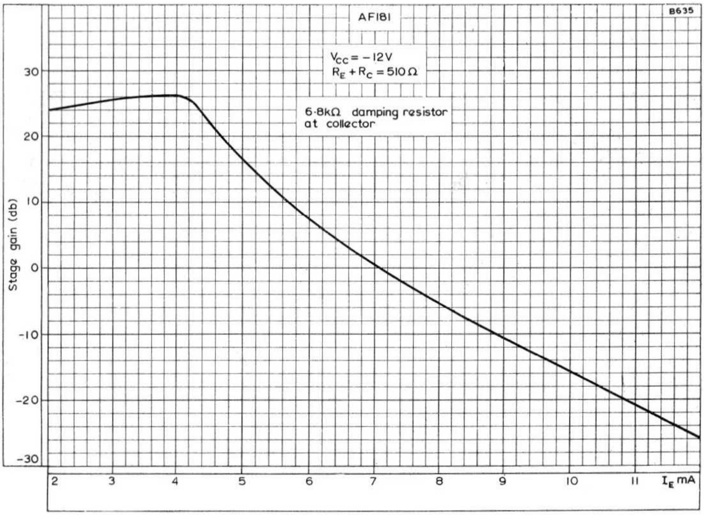
y-parameters

Common emitter

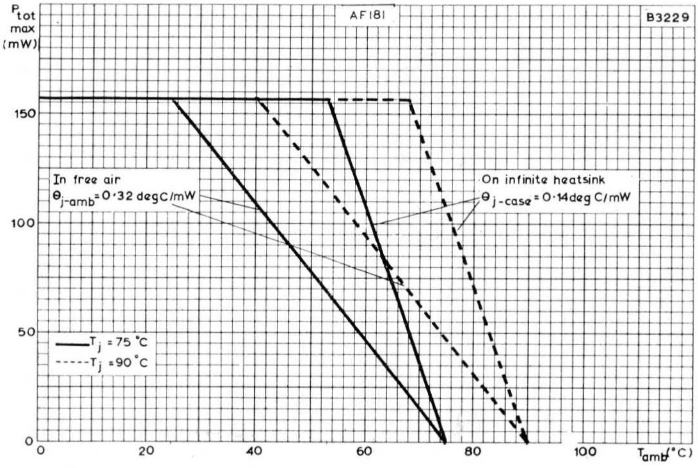
Measured at $V_{CE} = -10V$, f = 450kc/s	I_E =	3	mA
Input conductance (with output short circuited to a.c.)	g_{ie}	10	mmho
Input capacitance (with output short circuited to a.c.)	c_{ie}	45	pF
Transfer admittance (with output short circuited to a.c.)	$\|y_{fe}\|$	85	mmho
Phase angle of transfer admittance (with output short circuited to a.c.)	ϕ_{fe}	–40	deg
Output conductance (with input short circuited to a.c.)	g_{oe}	60	μmho
Output capacitance (with input short circuited to a.c.)	c_{oes}	3.0	pF
Feedback admittance (with input short circuited to a.c.)	$\|y_{re}\|$	75	μmho
Phase angle of feedback admittance (with input short circuited to a.c.)	ϕ_{re}	–90	deg
Measured at $V_{CE} = -10V$, $I_E = 1mA$, f = 450kc/s			
Feedback capacitance (with input short circuited to a.c.)	c_{re}	–400	mpF

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by use of a thermal shunt.
2. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
3. Transistors may be dip soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The temperature of the envelope in contact with the board must not exceed 115°C for two minutes. These recommendations apply to a transistor mounted flush on a board with punched through holes or spaced 1.5mm above a board with plated through holes.



TYPICAL GAIN CONTROL CURVE.
STAGE GAIN PLOTTED AGAINST EMITTER CURRENT

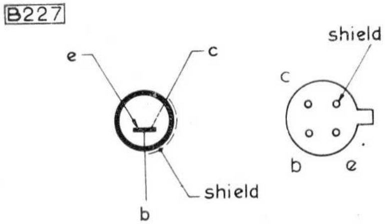


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST
AMBIENT TEMPERATURE

AF186

GERMANIUM P-N-P
U.H.F. TRANSISTOR

Germanium junction transistor of the p-n-p alloy-diffused type in a TO-18 type construction. Intended for use as an amplifier with forward bias control or as a self-oscillating mixer in u.h.f. tuners at frequencies up to 900Mc/s. The AF186 is supplied in pairs, each pair consisting of a preamplifier (white dot) and a mixer/oscillator (green dot).



TO–18 Construction

DIMENSIONS

Max. body length	10.29	mm
Max. diameter	4.8	mm
Min. lead length	12.7	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings.

In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperatures must also be taken into account.

Collector voltage		
V_{CB} max. ($I_E = 0$mA)	–25	V
V_{CE} max. (cut-off)	–25	V
Collector current		
I_{CM} max.	15	mA
*$I_{C(AV)}$ max.	15	mA
Emitter current		
I_{EM} max.	15	mA
*$I_{E(AV)}$ max.	15	mA
Reverse emitter current		
$-I_{EM}$ max.	1.0	mA
Total dissipation	90	mW

*Averaged over any 20ms period.

Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	75	°C
‡T_j max. (Intermittent operation total duration 200 hours)	90	°C
θ_{j-amb}	<0.5	°C/mW

‡Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

GERMANIUM P-N-P U.H.F. TRANSISTOR

AF186

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise specified)

		Typical production spread			
		Min.	*Typ.*	*Max.*	
Collector leakage current	I_{CBO}				
($V_{CB} = -10V$, $I_E = 0mA$)		—	—	3.5	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 75°C$)		—	—	60	μA
Emitter breakdown voltage	BV_{EBO}				
($I_{EBO} = 50μA$)		300	—	—	mV
Base current	I_B				
($V_{CB} = -10V$, $I_E = 2mA$)		—	—	100	μA
Emitter to base voltage	V_{EB}				
($V_{CB} = -10V$, $I_E = 2mA$)		–270	—	–390	mV

Recommended d.c. operating condition as a r.f. amplifier (at $T_{amb} = 45°C$) $V_{CC} = -12V$, $I_E = 2mA$, total emitter+collecter series resistance = 820Ω.

y-parameters

Characteristics unless otherwise shown, power gain and noise figures are measured in the common base configuration at $V_{CB} = -10V$, $I_E = 2mA$ and with a lead length of 3mm.

		R.F. amplifier	*Mixer/Oscillator*	
Base current	I_B			
($V_{CB} = -5V$, $I_E = 10mA$)		<500	—	μA
Emitter to base voltage	V_{EB}			
($V_{CB} = -5V$, $I_E = 10mA$)		400	—	mV
f = 35Mc/s				
Output conductance	g_{ob}	—	30	μmho
Output capacitance	c_{obs}	—	1.4	pF
f = 500Mc/s				
Input conductance	g_{ib}	17	17	mmho
Input capacitance	c_{ib}	–4.2	–4.2	pF
Transfer admittance	$\|Y_{fb}\|$	23	23	mmho
Phase angle of transfer admittance	ϕ_{fb}	90	90	deg
Output conductance	g_{ob}	340	340	μmho
Output capacitance	c_{obs}	1.4	1.4	pF
Feedback admittance	$\|Y_{rb}\|$	310	310	μmho
Phase angle of feedback admittance	ϕ_{rb}	250	250	deg
Power gain ($R_s = 50Ω$, $R_L = 500Ω$)		10.5	10.5	dB
Noise figure ($R_s = 50Ω$)		7.0	—	dB

y-parameters

f = 800Mc/s

		R.F. amplifier	*Mixer/Oscillator*	
Input conductance	g_{ib}	12	—	mmho
Input capacitance	c_{ib}	−2.0	—	pF
Transfer admittance	$\lvert Y_{fb}\rvert$	16	—	mmho
Phase angle of transfer admittance	ϕ_{fb}	55	—	deg
Output conductance	g_{ob}	625	—	µmho
Output capacitance	c_{obs}	1.4	—	pF
Feedback admittance	$\lvert Y_{rb}\rvert$	330	—	µmho
Phase angle of feedback admittance	ϕ_{rb}	250	—	deg
Power gain ($R_s = 50\Omega$, $R_L = 500\Omega$)		9.0	—	dB
Noise figure ($R_s = 50\Omega$)		8.5	—	dB

f = 900Mc/s

Input conductance	g_{ib}	—	12	mmho
Input capacitance	c_{ib}	—	−2	pF
Transfer admittance	$\lvert Y_{fb}\rvert$	—	15	mmho
Phase angle of transfer admittance	ϕ_{fb}	—	40	deg
Output conductance	g_{ob}	—	625	µmho
Output capacitance	c_{obs}	—	1.4	pF
Feedback admittance	$\lvert Y_{rb}\rvert$	—	330	µmho
Phase angle of feedback admittance	ϕ_{rb}	—	240	deg
Power gain ($R_s = 50\Omega$, $R_L = 500\Omega$)		—	7.5	dB

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.

2. Care should be taken not to bend the leads nearer than 1.5 mm from the seal.

3. Transistors may be dip soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The temperature of the envelope in contact with the board must not exceed 115°C for two minutes. These recommendations apply to a transistor mounted flush on a board with puched through holes or spaced 1.5mm above a board with plated through holes.

TELEVISION TUBE

AW47-91

47cm (19-in.) direct viewing television tube with metal-backed grey glass screen. This tube is electrostatically focused and has a 110° deflection angle. An ion trap magnet is not required.

HEATER

Suitable for series or parallel operation.

V_h	6.3	V
I_h	300	mA

Note—(applies to series operation only). The surge heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on. When used in a series heater chain a current limiting device may be necessary in the circuit to ensure that this voltage is not exceeded.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be earthed and the capacitance of this to the final anode is used to provide smoothing for the e.h.t. supply. The tube marking and warning labels are on the side of the cone opposite the final anode connector and this side should not be used for making contact to the external conductive coating.

CAPACITANCES

c_{g-all}	6.0	pF
c_{k-all}	4.0	pF
$c_{a2+a4-M}$	1150	pF

SCREEN

Metal backed

Fluorescent colour		White
Light transmission	75	%
Useful screen area	See drawings on page 83	

FOCUSING

Electrostatic

The range of focus voltage shown in operating conditions results in optimum overall focus at a beam current of 100μA.

DEFLECTION

Double magnetic

The spread in the cone length can be obtained from the outline drawing.

The deflection coils should be designed so that their internal contour is in accordance with JETEC gauge 126.

REFERENCE LINE GAUGE

JETEC 126

RASTER CENTRING

Centring magnet field intensity	0 to 10	G
Maximum distance of centre of centring field from reference line	57	mm

Adjustment of the centring magnet should not be such that a general reduction in brightness or shading of the raster occurs.

AW47-91 (Cont.)

TELEVISION TUBE

OPERATING CONDITIONS

v_{a2+a4}	16	kV
V_{a3} (focus electrode control range)	0 to 400	V
V_{a1}	400	V
†V_g for visual extinction of focused raster	−40 to −77	V
†V_k for visual extinction of focused raster	36 to 66	V

†For grid modulation all voltages are measured with respect to the cathode; for cathode modulation, all voltages are measured with respect to the grid.

DESIGN CENTRE RATINGS

‡V_{a2+a4} max.	18	kV
V_{a2+a4} min.	13	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
**$+v_{a3(pk)}$ max.	2.5	kV
V_{a1} max.	550	V
$v_{a1(pk)}$ min.	400	V
**$-v_{g(pk)}$ max.	400	V
*$-V_g$ max.	150	V
$\pm I_{a3}$ max.	25	µA
$\pm I_{a1}$ max.	15	µA
†V_{h-k}		
Cathode positive		
d.c. max.	200	V
pk max.	300	V
Cathode negative		
d.c. max.	125	V
pk max.	250	V
R_{h-k} max.	1.0	MΩ
Z_{k-e} max. (f = 50c/s)	100	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50c/s)	500	kΩ

‡Adequate precautions should be taken to ensure that the receiver is protected from damage which may be caused by a possible high voltage flashover within the cathode ray tube.

**Maximum pulse duration 22% of a cycle with a maximum of 1.5ms.

*The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +1V. The maximum positive excursion of the video signal must not exceed +2V and at this voltage the grid current may be expected to be approximately 2mA.

†In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible ($<20V_{r.m.s.}$).
During a warming-up period not exceeding 45s, $v_{h-k(pk)}$ max. (cathode positive) is allowed to rise to 410V.

AW47-91

MOUNTING POSITION

Any

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely. The bottom circumference of the base shell will fall within a circle of 40mm which is centred upon the perpendicular from the centre of the face. This tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the base pins whilst handling the tube.

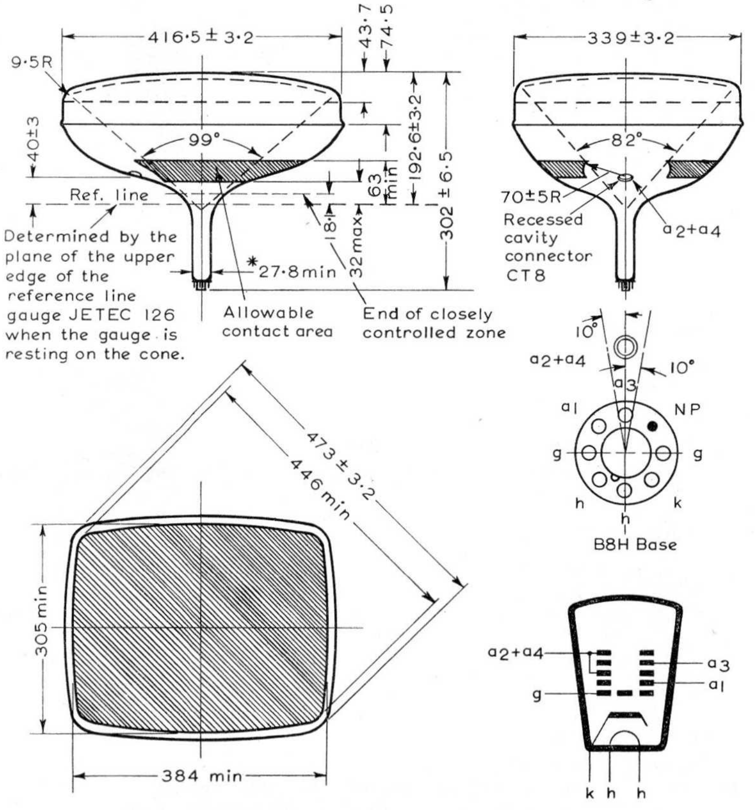
It is advisable to keep this pin protector on the base until it can be replaced by the socket after installation of the tube in an equipment.

WARNING

X-ray shielding is advisible to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operated above 16kV.

WEIGHT

Tube alone	7	kg
	15	lb



All dimensions in mm

*The maximum value is determined by the reference line gauge

8807

AW59-91

TELEVISION TUBE

59cm (23-in.) direct viewing television tube with metal-backed grey glass screen. This tube is electrostatically focused and has a 110° deflection angle. An ion trap magnet is not required.

HEATER

Suitable for series or parallel operation

V_h	6.3	V
I_h	300	mA

Note—(applies to series operation only). The surge heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on. When used in a series heater chain, a current limiting device may be necessary in the circuit, to ensure that this voltage is not exceeded.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be earthed, and the capacitance of this to the final anode is used to provide smoothing for the e.h.t. supply. The tube marking and warning labels are on the side of the cone opposite the final anode connector and this side should not be used for making contact to the external conductive coating.

CAPACITANCES

c_{g-all}	6.0	pF
c_{k-all}	4.0	pF
$c_{a2+a4-M}$	2100	pF

SCREEN

Metal backed

Fluorescent colour	White	
Light transmission (approx.)	75	%
Useful screen area	see page 86	

FOCUSING

Electrostatic

The range of focus voltages shown in "OPERATING CONDITIONS" results in optimum overall focus at a beam current of 100μA.

DEFLECTION

Double magnetic.

The deflection coils should be designed so that their internal contour is in accordance with JEDEC gauge 126, and should provide a pull-back of 4mm on a nominal tube.

REFERENCE LINE GAUGE

JEDEC 126

RASTER CENTRING

Centring magnet field intensity	0 to 10	G
Maximum distance of centre of centring field from reference line	57	mm

Adjustment of the centring magnet should not be such that a general reduction in brightness of the raster occurs.

OPERATING CONDITIONS

*V_{a2+a4} max.	18	kV
V_{a3} (focus electrode control range)	0 to 400	V
V_{a1}	400	V
V_g for visual extinction of focused raster	−40 to −77	V
*V_k for visual extinction of focused raster	36 to 66	V

*For cathode modulation, all voltages are measured with respect to the grid.

DESIGN CENTRE RATINGS

*V_{a2+a4} max. (at $I_{a2+a4=0}$)	18	kV
V_{a2+a4} min.	13	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
†$+v_{a3(pk)}$ max.	2.5	kV
V_{a1} max.	550	V
$v_{a1(pk)}$ min.	400	V
†$-v_{g(pk)}$ max.	400	V
‡$-V_g$ max.	150	V
$\pm I_{a3}$ max.	25	µA
$\pm I_{a1}$ max.	5	µA
§V_{h-k}		
Cathode positive		
d.c. max.	250	V
pk max.	300	V
Cathode negative		
d.c. max.	135	V
pk max.	180	V
R_{h-k} max.	1.0	MΩ
Z_{k-e} max. (f = 50c/s)	100	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50c/s)	500	kΩ

*Adequate precautions should be taken to ensure that the receiver is protected from damage which may be caused by a possible high voltage flashover within the cathode ray tube.

†Maximum pulse duration 22% of a cycle with a maximum of 1.5ms.

‡The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +1V. To ensure long life of the tube it is advisable to limit the positive excursion of the video signal to $+5V_{(pk)}$ max. This may be achieved automatically by the series connection of a 10kΩ resistor.

§In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible ($<20V_{r.m.s.}$).

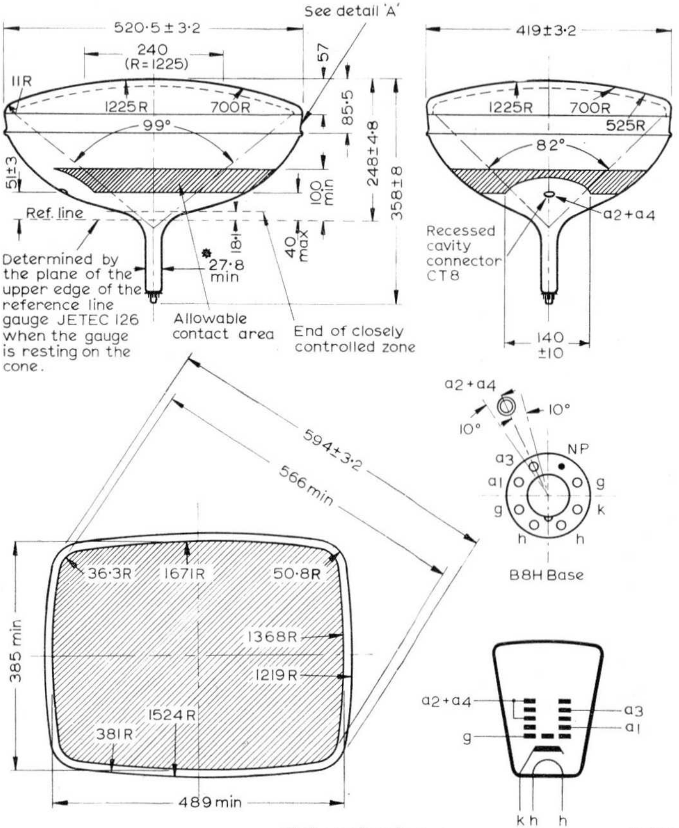
During a warming up period not exceeding 15 secs, $v_{h-k(pk)}$ max. (cathode positive) is allowed to rise to 410V.

MOUNTING POSITION

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely. The bottom circumference of the base shell will fall within a circle of 40mm diameter which is centred upon the perpendicular from the centre of the face.
This tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the base pins whilst handling the tube.
It is advisable to keep this pin protector on the base until it can be replaced by the socket after installation of the tube in any equipment.

WARNING

X-ray shielding is advisable to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operated above 16kV.



All dimensions in mm

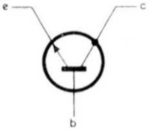
9432

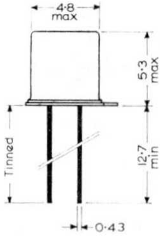
* The maximum value is determined by the reference line gauge

SILICON PLANAR TRANSISTOR

BC107

Silicon n-p-n planar transistor for use in low noise input stages.





TO-18

DIMENSIONS

Max. body length	5.3	mm
Max. body diameter	4.8	mm
Min. lead length	12.7	mm

ABSOLUTE MAXIMUM RATINGS

Collector voltage		
V_{CB} max.	+32	V
V_{CE} max.	+32	V
V_{EB} max.	+5.0	V
Collector current		
I_{CM} max.	30	mA
$I_{C(AV)}$ max.	30	mA
Base current		
I_{BM} max.	5.0	mA
Total dissipation		
P_{tot} max. (In free air $T_{amb} = 25°C$)	300	mW
Temperature ratings		
T_{stg} max.	175	°C
T_{stg} min.	–55	°C
T_j max.	175	°C

CHARACTERISTICS at $T_{amb} = 25°C$ (unless otherwise stated)

		Typical production spreads		
		Typ.	*Max.*	
Common base				
Collector-base cut-off current	I_{CBO}			
($V_{CB} = +10V$, $I_E = 0mA$)		—	10	nA
($V_{CB} = +10V$, $I_E = 0mA$, $T_j = 175°C$)		—	2.0	μA
Emitter cut-off current	I_{EBO}			
$V_{EB} = +5V$, $I_C = 0mA$		—	10	nA

BC107 (Cont.)

SILICON PLANAR TRANSISTOR

		Min.	Typ.	Max.	
Small signal forward current transfer ratio	h_{fe}				
V_{CB} = +5V, I_E = 2mA		—	260	—	
Base emitter voltage	V_{BE}				
V_{CB} = +5V, I_E = 10μA		+470	—	+550	mV
V_{CB} = +5, I_E = 10mA		—	—	+800	mV
Base current	I_B				
V_{CB} = +5V, I_E = 10μA		—	90	—	nA
V_{CB} = +5V, I_E = 2mA		—	8.0	—	μA
Noise figure	NF				
V_{CB} = +5V, I_E = 10μA		—	—	4.0	dB
R_s = 10kΩ, f = 10 to 10,000c/s		—	—	4.0	dB
Transition frequency	f_T				
V_{CB} = +5V, I_E = 500μA		—	90	—	Mc/s
V_{CB} = +5V, I_E = 10mA		—	250	—	Mc/s

THERMAL CHARACTERISTIC

θ_{j-amb} max.	0.5	deg.C/W

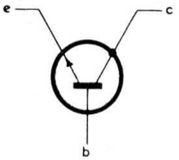
SILICON MESA TRANSISTOR

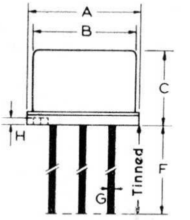
BF109

Silicon n-p-n mesa transistor, intended for application in video output stages.

DIMENSIONS

Max. body length	6.35	mm
Max. body diameter	8.15	mm
Min. lead length	38	mm





TO-5

ABSOLUTE MAXIMUM RATINGS

Collector voltage

V_{CB} max.	+135	V
V_{CE} max.	+135	V
V_{BE} max.	5.0	V

Collector current

I_{CM} max.	50	mA
$I_{C(AV)}$ max.	50	mA

Base current

I_{BM} max.	10	mA
$I_{B(AV)}$ max.	10	mA

Total dissipation

P_{tot} max.	1.2	W

Temperature ratings

T_{stg} max.	+175	°C
T_{stg} min.	–55	°C
T_j max.	+175	°C
θ_{j-case} max.	$\leqslant$6.0	°C/W

CHARACTERISTICS at $T_{amb} = 25°C$

Breakdown voltages

($I_{CBO} = 100\mu A$)	$V_{(BR)CBO}$	$\geqslant$135	V
($I_{EBO} = 100\mu A$)	$V_{(BR)EBO}$	$\geqslant$5.0	V
($I_{CEO} = 4mA$)	$V_{(BR)CEO}$	$\geqslant$110	V

Current amplification factor

($V_{CE} = 10V$, $I_C = 10mA$)	h_{FE}	$\geqslant$20	

Feedback capacitance

($V_{CE} = 10V$, $I_E = 0$, $f = 0.5Mc/s$)	c_{re}	$\leqslant$3.0	pF

Transition frequency

($V_{CE} = 10V$, $I_C = 10mA$)	f_T	$\geqslant$80	Mc/s

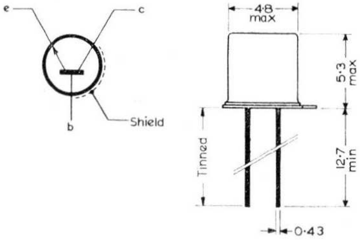
Voltage feedback time constant

($V_{CB} = 10V$, $I_E = 10mA$)	$\vert h_{rb}\vert/2\pi_f$	$\leqslant$350	p

BF115

SILICON EPITAXIAL TRANSISTOR

Silicon n-p-n planar epitaxial transistor, for a.m. and f.m. applications.



SO-12A/SB4-3

DIMENSIONS

Max. body length	5.3	mm
Max. body diameter	4.8	mm
Min. lead length	12.7	mm

ABSOLUTE MAXIMUM RATINGS

Collector voltage		
V_{CB} max.	+50	V
V_{CE} max.	+50	V
Collector current		
I_{CM} max.	30	mA
$I_{C(AV)}$ max.	30	mA
Base current		
I_{BM} max.	21	μA
Total dissipation		
P_{tot} max. (In free air, $T_{amb} \leqslant 45°C$)	145	mW
Temperature ratings		
T_{stg} max.	175	°C
T_j max.	175	°C

CHARACTERISTICS at $T_{amb} = 25°C$ (unless otherwise stated)

		Typical production spreads			
		Min.	*Typ.*	*Max.*	
Collector-base cut-off current	I_{CBO}				
$V_{CB} = 10V$, $I_E = 0$, $T_j = 175°C$		—	500	—	nA
Collector-base breakdown voltage	$V_{(BR)CBO}$				
$I_C = 10\mu A$, $I_E = 0$		50	—	—	V
Emitter-base breakdown current	$V_{(BR)EBO}$				
$I_E = 10\mu A$, $I_C = 0$		5.0	—	—	V
Collector-emitter breakdown voltage	$V_{(BR)CEO}$				
$I_E = 2.0mA$, $I_B = 0$		30	—	—	V

SILICON EPITAXIAL TRANSISTOR

BF115

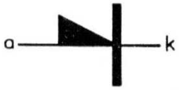
Base emitter voltage	V_{BE}				
$I_E = 1.0$mA, $V_{CB} = 10$V		—	700	—	mV
Transition frequency	f_T				
$I_E = 1.0$mA, $V_{CB} = 10$V, $f = 35$Mc/s		—	230	—	Mc/s
Noise figure	NF				
$I_E = 1.0$mA, $V_{CB} = 10$V $f = 200$kc/s, $R_s = 300\Omega$		—	1.2	—	dB
$I_E = 1.0$mA, $V_{CB} = 10$V, $f = 1.0$Mc/s, $R_s = 50\Omega$		—	3.5	—	dB
$I_E = 1.0$mA, $V_{CB} = 10$V, $f = 1.0$Mc/s, $R_s = 300\Omega$		—	1.2	—	dB
Y-parameters					
Common emitter measured at $I_E = 1.0$mA, $V_{CE} = 10$V, $f = 450$kc/s					
Input conductance	g_{ie}	—	400	—	μmho
Input capacitance	c_{ie}	—	25	—	pF
Feedback admittance	$\|y_{re}\|$	—	1.5	—	μmho
Phase angle of feedback admittance	ϕ_{re}	—	270	—	deg
Output conductance.	g_{oe}	—	4.0	—	μmho
Output capacitance	c_{oe}	—	1.4	—	pF
Transfer admittance	$\|y_{fe}\|$	—	35	—	mmho
Phase angle of transfer admittance	ϕ_{fe}	—	0	—	deg

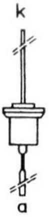
BY100

SILICON JUNCTION RECTIFIER

Silicon diffused junction rectifier for use as a mains rectifier in television receivers.

B230





DIMENSIONS

Max. overall length	68.6	mm
Max. diameter	10.16	mm
Max. body length excluding leads	9.0	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no rectifier exceeds these ratings. In arriving at the actual operation conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Voltage ratings

Maximum recurrent P.I.V.	800	V
Maximum transient peak (max. duration = 10ms)	1.25	kV

Current ratings

Maximum average forward current		
$T_{amb} \leqslant 50°C$	550	mA
$T_{amb} > 50°C$	450	mA
Maximum recurrent peak	5.0	A
Maximum surge (Sine wave operation max. duration = 10ms)	55	A

Temperature ratings

T_{stg} max.	+150	°C
T_{stg} min.	–55	°C
T_{amb} max.	70	°C

CHARACTERISTICS (T_{case} = 25°C)

V_F at I_F = 5.0A	<1.5	V
I_R at V_R = –800V	<10	μA

OPERATING CONDITIONS

For a voltage receiver with three main taps. ($C_{reservoir}$ = 200μF).

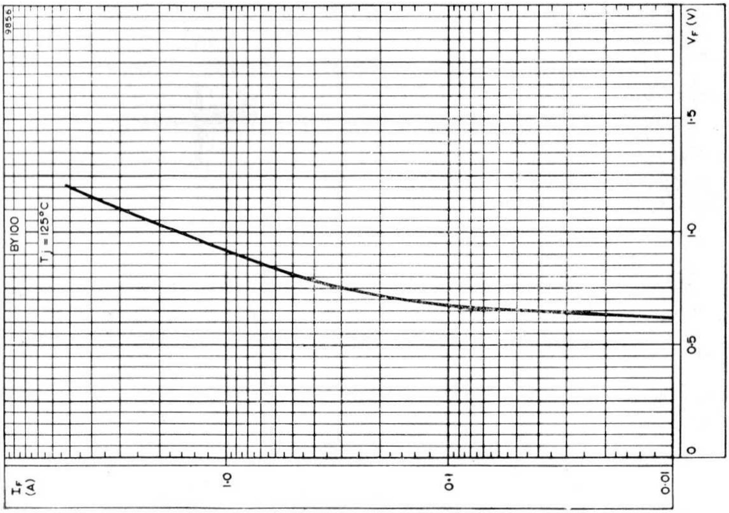
Voltage tap range	I_o = 100	200	350	550 mA
($V_{r.m.s.}$)		R_{lim} (min.) Ω		
200–210	6.0	6.0	6.0	6.0
220–230	39	25	19	15
240–250	90	52	35	26

OPERATING NOTES

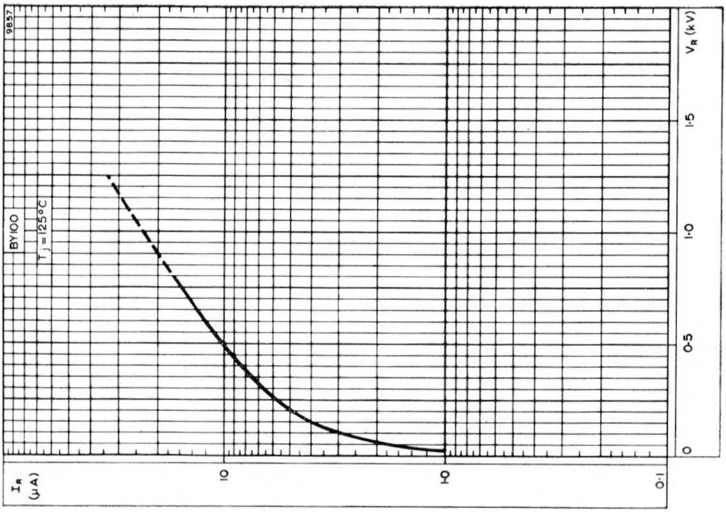
1. Diodes may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Diodes may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

IMPORTANT

The metal envelope of the rectifier is in contact with the metal stud which forms the output electrode of the device. It is thus essential to ensure that this envelope is never connected directly to the receiver chassis. If it is, then the output will be short-circuited to earth.



FORWARD CHARACTERISTIC AT $T_j = 125°C$



REVERSE CHARACTERISTIC AT $T_j = 125°C$

BY114

SILICON JUNCTION RECTIFIER

Silicon double-diffused junction rectifier having a recurrent P.I.V. of 450V. Intended for general purpose rectifier applications.

B230

DIMENSIONS

Max. overall length	68.6	mm
Max. diameter	10.16	mm
Max. body length excluding leads	9.0	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no rectifier exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperatures must also be taken into account.

Voltage ratings

Maximum recurrent P.I.V.	450	V
Maximum transient peak (max. duration = 10ms)	650	V

Current ratings

Maximum average forward current	550 (See page 95)	mA
Maximum recurrent peak	5.0	A
Maximum surge (Sine wave operation max. duration = 10ms)	55	A

Temperature ratings

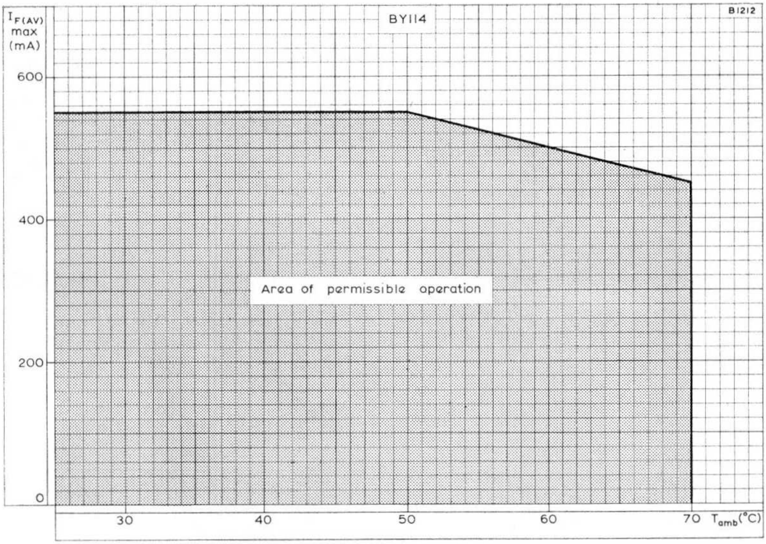
T_{stg} max.	+150	°C
T_{stg} min.	–55	°C
T_{amb} max.	70	°C

CHARACTERISTICS ($T_{case} = 25°C$)

V_F at $I_F = 5.0A$	<1.5	V
I_R at $V_R = 450V$	<10	µA

OPERATING NOTES

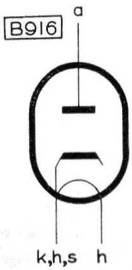
1. Diodes may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Diodes may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

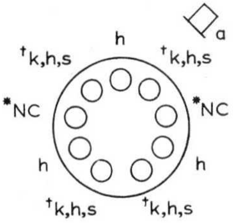


MAXIMUM AVERAGE FORWARD CURRENT PLOTTED AGAINST AMBIENT TEMPERATURE

DY87

HALF-WAVE RECTIFIER





B9A

High voltage half-wave rectifier for television line fly-back e.h.t. supply. It has a chemically treated bulb to prevent flashover under conditions of high humidity.

Pins 1, 4, 6 and 9 may be used to fit an anti-corona shield.
Pins 3 and 7 may only be connected to points in the heater circuit and must not be earthed.

HEATER

V_h	1.4	V
I_h	550	mA
Heater voltage tolerances		
$I_{out} < 200\mu A$	±15*	%
$I_{out} > 200\mu A$	± 7*	%

DIMENSIONS

Max. overall length	74	mm
Max. seated height	67.5	mm
Max. diameter	22	mm

*These tolerances apply when the power supply voltage is at its nominal value and when a valve having average heater characteristics is employed. In addition fluctuations in the mains supply voltage not exceeding ±10% are premissible.

CAPACITANCES

$c_{a-(h+k+s)}$	1.55	pF

DESIGN CENTRE RATINGS

Pulsed input		
*P.I.V. max.	22	kV
‡$i_{a(pk)}$ max.	40	mA
I_{out} max.	500	μA
C max.	2000	pF

*Maximum duration 22% of a line scanning cycle with a maximum of 18μs.

‡Maximum duration 10% of a line scanning cycle with a maximum of 10μs.

WARNING

X-ray shielding is advisable to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operated above 16kV. The level of X-radiation is likely to be considerably higher when the heater circuit of the tube is open.

DOUBLE TRIODE (separate cathodes)

ECC82

HEATER

	Series	Parallel	
V_h	12.6	6.3	V
I_h	150	300	mA

LIMITING VALUES (each section)

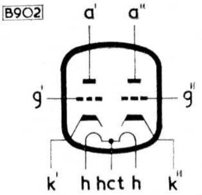
$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	2.75	W
I_k max.	20	mA
*$i_{k(pk)}$ max.	150	mA
$-V_g$ max.	100	V
$-v_{g(pk)}$ max.	250	V
R_{g-k} max. (cathode bias)	3.0	MΩ
R_{g-k} max. (fixed bias)	1.5	MΩ
V_{h-k} max.	180	V

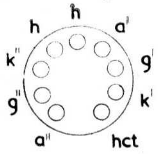
*Max. pulse duration = 200µs.
Duty factor = 3%.

CAPACITANCES

*c_{a-g}	1.5	pF
*c_{g-k}	1.8	pF
$c_{a'-k'}$	370	mpF
$c_{a''-k''}$	250	mpF

*Each section.





B9A

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

CHARACTERISTICS (each section)

V_a	100	250	V
I_a	11.8	10.5	mA
V_g	0	−8.5	V
g_m	3.1	2.2	mA/V
μ	19.5	17	
r_a	6.25	7.7	kΩ
V_g max. ($I_g = \phi+0.3\mu$A)		−1.3	V

OPERATING CONDITIONS (each section)

As an a.f. amplifier

V_b (V)	R_a (kΩ)	I_k (mA)	R_k (kΩ)	$\frac{V_{out}}{V_{in}}$	V_{out}* ($V_{r.m.s.}$)	D_{tot}* (%)	R_g† (kΩ)
400	47	5.0	1.2	13.5	59	6.7	150
350	47	4.3	1.2	13.5	51	6.6	150
300	47	3.7	1.2	13.5	43	6.5	150
250	47	3.0	1.2	13.5	34	6.4	150
200	47	2.4	1.2	13.5	26	6.3	150
150	47	1.8	1.2	13.5	18	6.1	150
100	47	1.2	1.2	13.5	11	5.6	150
400	100	2.6	2.2	14	57	6.2	330
350	100	2.3	2.2	14	49	6.1	330
300	100	2.0	2.2	14	41	6.0	330
250	100	1.6	2.2	14	32	5.9	330
200	100	1.3	2.2	14	25	5.8	330
150	100	1.0	2.2	14	17	5.6	330
100	100	0.7	2.2	14	10	4.8	330
400	220	1.3	3.9	14.5	50	5.1	680
350	220	1.2	3.9	14.5	43	5.0	680
300	200	1.0	3.9	14.5	36	4.9	680
250	220	0.8	3.9	14.5	28	4.8	680
200	220	0.7	3.9	14.5	22	4.7	680
150	220	0.5	3.9	14.5	15	4.4	680
100	220	0.3	3.9	14.5	8.0	4.0	680

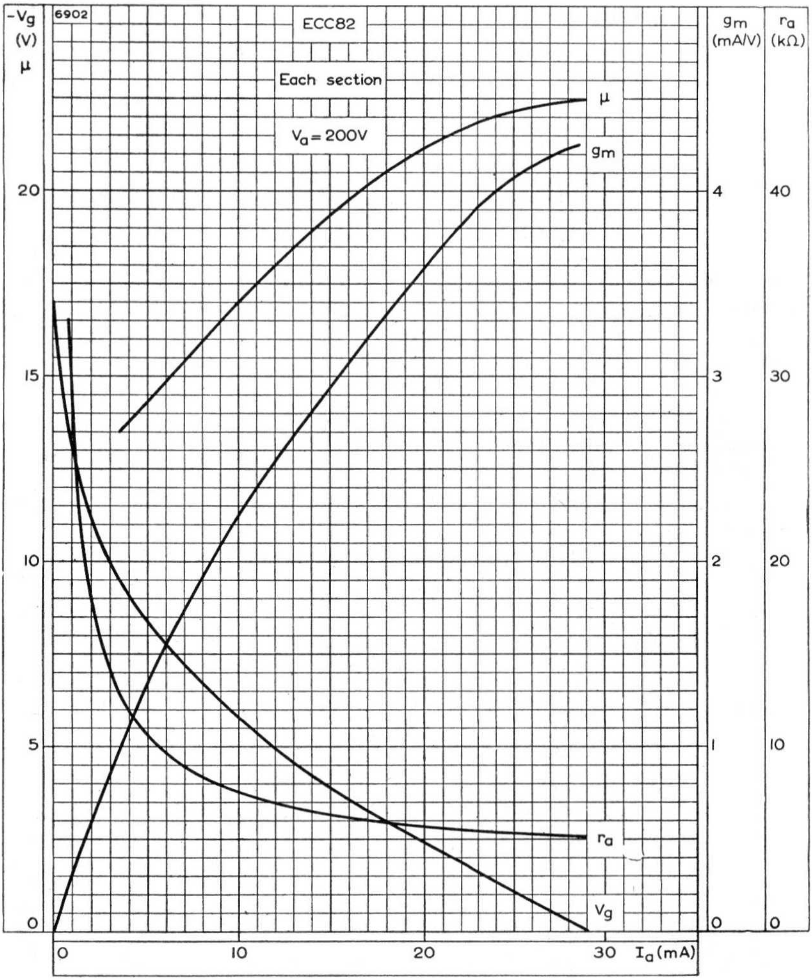
*Output voltage and distortion at start of positive grid current. At lower output voltage, the distortion is approximately proportional to the output voltage.

†R_g = grid resistor of following valve.

OPERATING NOTES

This valve can be used without special precautions against microphony in equipment where the input voltage is not less than 10mV for an output of 50mW (or 100mV for 5W output).

With V_h applied between pin 9 and pins 4 and 5 connected together, and with the centre tap of the heater transformer earthed the section connected to pins 6, 7 and 8 is the most favourable with regard to hum.

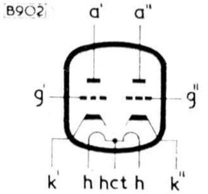


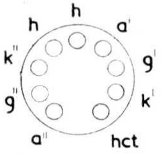
ANODE IMPEDANCE, AMPLIFICATION FACTOR, MUTUAL CONDUCTANCE AND GRID VOLTAGE PLOTTED AGAINST ANODE CURRENT. $V_a = 200V$

DOUBLE TRIODE (separate cathodes)

ECC83

High μ double triode, having separate cathodes, primarily intended for use as a resistance-coupled amplifier or phase inverter.





B9A

HEATER

	Series	Parallel	
V_h	12.6	6.3	V
I_h	150	300	mA

DIMENSIONS

Max overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

CAPACITANCES

$c_{out'}$	330	mpF
$c_{out''}$	230	mpF
$*c_{in}$	1.6	pF
$*c_{a-g}$	1.6	pF
$c_{a'-a''}$	<1.2	pF
$c_{a''-g'}$	<100	mpF
$c_{a'-g''}$	<110	mpF
$c_{g'-g''}$	<10	mpF
$*c_{g-h}$	<150	mpF

*Each section.

LIMITING VALUES (each section)

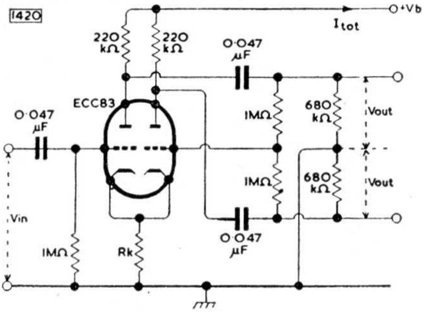
V_a max.	300	V
p_a max.	1.0	W
I_k max.	8.0	mA
$-V_g$ max.	50	V
R_{g-k} max. (fixed bias)	1.0	MΩ
V_{h-k} max.	180	V
†R_{h-k} max.	20	kΩ

CHARACTERISTICS (each section)

V_a	100	250	V
I_a	0.5	1.2	mA
V_g	-1.0	-2.0	V
g_m	1.25	1.6	mA/V
μ	100	100	
r_a	80	62.5	kΩ
V_g max. ($I_g = +0.3\mu A$)		-0.9	V

†When used as a phase inverter immediately preceding the output stage, R_{h-k} max may be 150kΩ.

OPERATING CONDITIONS as a phase inverter



V_b (V)	I_{tot} (mA)	R_k (kΩ)	$V_{out(r.m.s.)}$* (V)	$\frac{V_{out}}{V_{in}}$
350	1.3	1.5	44	65
250	0.8	2.2	23	60

*Output voltage measured at $D_{tot} = 5\%$.

ECC83 (Cont.)

DOUBLE TRIODE

OPERATING CONDITIONS as resistance coupled a.f. amplifier with grid current bias (R_g = 10MΩ)

				Z_s = 0kΩ		Z_s = 220kΩ	
V_b (V)	R_a (kΩ)	R_g.** (kΩ)	I_a (mA)	$\frac{V_{out}}{V_{in}}$	$V_{out(r.m.s.)}$* (V)	$\frac{V_{out}}{V_{in}}$	$V_{out(r.m.s.)}$† (V)
400	47	150	3.5	48	43	33	49
350	47	150	2.8	46	35	33	41
300	47	150	2.2	45	28	32	33
250	47	150	1.7	43	21	31	25
200	47	150	1.2	40	14	30	17
400	100	330	2.1	63	58	42	68
350	100	330	1.7	62	48	42	57
300	100	330	1.4	61	38	41	46
250	100	330	1.1	59	29	41	36
200	100	330	0.8	56	20	39	25
400	220	680	1.2	75	69	49	82
350	220	680	1.0	74	57	48	70
300	220	680	0.8	72	45	47	57
250	220	680	0.6	70	34	46	44
200	220	680	0.4	66	24	44	32

*Output voltage measured at D_{tot} = 5%.

$\frac{V_{out}}{V_{in}}$ measured with $V_{in(r.m.s.)}$ = 100mV

**Grid resistor of following valve.

†When operating this valve with grid current bias and a high source impedance, the second harmonic distortion rises to a peak at quite low levels of output (about 10$V_{r.m.s.}$) and then falls with increasing drive. The third harmonic then begins to rise, and D_{tot} finally reaches 5% at a much higher output level than with zero source impedance. The maximum value of this distortion peak varies inversely with the anode load, being about 5.5% with R_a = 47kΩ, 4.5% with R_a = 100kΩ and 4% with R_a = 220kΩ.

OPERATING CONDITIONS as resistance coupled a.f. amplifier with cathode bias

V_b (V)	R_a (kΩ)	I_a (mA)	R_k (kΩ)	$\frac{V_{out}}{V_{in}}$	$V_{out(r.m.s.)}$* (V)	D_{tot}* (%)	$R_{g'}$† (kΩ)
400	47	2.2	1.0	43	40.5	5.0	150
350	47	1.7	1.2	42	31	5.0	150
300	47	1.3	1.5	40	22	5.0	150
250	47	0.9	2.2	36	12.5	5.0	150
400	100	1.4	1.5	59	59	5.0	330
350	100	1.1	1.8	57	45	5.0	330
300	100	0.88	2.2	55	32.5	5.0	330
250	100	0.6	3.3	50	18·5	5.0	330
400	220	0.88	2.2	71	63	3.7	680
350	220	0.7	2.7	69	60	5.0	680
300	220	0.5	3.9	65	38.5	5.0	680
250	220	0.38	4.7	62	27	5.0	680

*Output voltage measured at D_{tot} = 5% or at start of positive grid current. At lower output voltages the distortion is approximately proportional to the output voltage.

†Grid resistor of following valve.
At lower values of V_b, grid current bias should be used.

TRIODE HEPTODE

ECH84

Triode heptode intended for use as a noise cancelled synchronising pulse separator and time-base oscillator.

HEATER

Suitable for series or parallel operation, a.c. or d.c.

V_h	6.3	V
I_h	300	mA

CAPACITANCES

c_{ah-at}	<250	mpF
c_{ah-gt}	<90	mpF
c_{g1-at}	<80	mpF
c_{g1-gt}	<100	mpF
c_{g3-at}	<130	mpF

Heptode section

c_{a-g1}	<9.0	mpF

Triode section

c_{in}	3.0	pF
c_{a-g}	1.1	pF

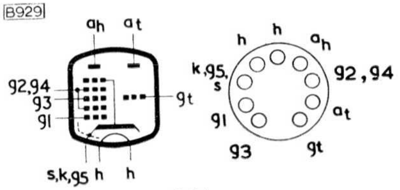
CHARACTERISTICS

Heptode section

V_a	135	V
V_{g3}	0	V
V_{g2+g4}	14	V
V_{g1}	0	V
I_a	1.7	mA
I_{g2+g4}	900	µA
g_m	2.2	mA/V
V_{g3} ($I_a = 20\mu A$)	−2.0	V
V_{g1} ($I_a = 20\mu A$)	−1.9	V

Triode section

V_a	50	V
V_g	0	V
I_a	3.0	mA
g_m	3.7	mA/V
μ	50	
I_a ($V_a = 200V$, $V_g = -11V$)	<100	µA



B9A

DIMENSIONS

Max. overall length	67.5	mm
Max. seated height	60.5	mm
Max. diameter	22.2	mm

DESIGN CENTRE RATINGS

Heptode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.7	W
$V_{g2+g4(b)}$ max.	550	V
V_{g2+g4} max.	250	V
V_{g2+g4} min.	10	V
p_{g2+g4} max.	800	mW
$-v_{g1(pk)}$ max.	150	V
$-v_{g3(pk)}$ max.	150	V
I_k max.	12.5	mA
R_{g1-k} max.	3.0	MΩ
R_{g3-k} max.	3·0	MΩ
V_{h-k} max.	100	V

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.3	W
$-v_{g(pk)}$ max.	200	V
I_k max.	10	mA
R_{g-k} max.	3.0	MΩ

ECL86

TRIODE HEPTODE

Combined high-μ triode and output pentode for use in audio amplifier circuits.

HEATER

V_h	6.3	V
I_h	700	mA

DIMENSIONS

Max. overall length	78.5	mm
Max. seated height	71.5	mm
Max. diameter	22.2	mm

CHARACTERISTICS

Pentode Section

V_a	250	V
V_{g2}	250	V
V_{g1}	−7.0	V
I_a	36	mA
I_{g2}	6.0	mA
g_m	10	m/AV
r_a	48	kΩ
μ_{g1-g2}	21	

Triode Section

V_a	250	V
V_g	−1.9	V
I_a	1.2	mA
g_m	1.6	mA/V
μ	100	
r_a	62	kΩ

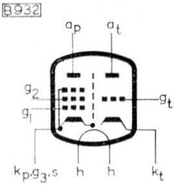
LIMITING VALUES

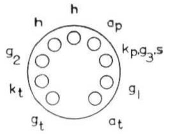
Pentode Section

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	9.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	300	V
p_{g2} max.	1.8	W
I_k max.	55	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	100	V
R_{h-k} max.	20	kΩ

Triode Section

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	500	mW
I_k max.	4.0	mA
R_{g-k} max.	1.0	MΩ
V_{h-k} max.	100	V
R_{h-k} max.	20	kΩ





B9A

OPERATING CONDITIONS

Pentode Section as Single Valve Class 'A' Amplifier

V_a	250	250	250	V
V_{g2}	210	250	250	V
R_k	130	270	170	Ω
I_a	36	26	36	mA
I_{g2}	5.6	4.4	6.0	mA
R_a	7.0	10	7.0	kΩ
P_{out}	4.0	2.8	4.0	W
$V_{in(r.m.s.)}$	3.1	2.7	3.2	V
D_{tot}	10	10	10	%
$V_{in(r.m.s.)}$ (P_{out} = 50mW)	280	280	300	mV

Two Valves in Push-Pull

$V_{a(b)}$	250	300	V
$V_{g2(b)}$	250	300	V
R_k (per valve)	180	290	Ω
R_{a-a}	8.0	9.0	kΩ
$I_{a(o)}$	2 × 35	2 × 31	mA
$I_{g2(o)}$	2 × 5.6	2 × 5.0	mA
$V_{in(g1-g1)r.m.s.}$	10.2	17.4	V
P_{out}	10	14.3	W
D_{tot}	4.5	5.0	%
$V_{in(r.m.s.)}$ (P_{out} = 50mW)	480	520	mV
I_a (max. sig.)	2 × 37.3	2 × 37	mA
I_{g2} (max. sig.)	2 × 9.0	2 × 10.6	mA

Triode Section

As for single section of ECC83.

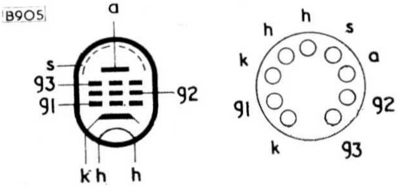
OPERATING NOTES

1. **Microphony**
   This valve may be used without special precautions against microphony in equipment where the input voltage is not less than 4mV for an output of 50mW.
2. **Hum**
   To obtain the minimum value of hum, pin 4 should be earthed.

R.F. PENTODE

EF80

High slope r.f. pentode primarily intended for r.f. or i.f. amplification in television receivers. It is suitable for use as a video amplifier, mixer or synchronising pulse separator.



B9A

HEATER

Suitable for series or parallel operation, a.c. or d.c.

V_h	6.3	V
I_h	300	mA

CAPACITANCES

$c_{in(g1)}$	7.0	pF
$c_{in(g2)}$	5.4	pF
C_{out}	3.1	pF
c_{a-g1}	<7.0	mpF
c_{g2-g1}	2.6	pF
c_{a-k}	<10	mpF
c_{g1-h}	<150	mpF

CHARACTERISTICS

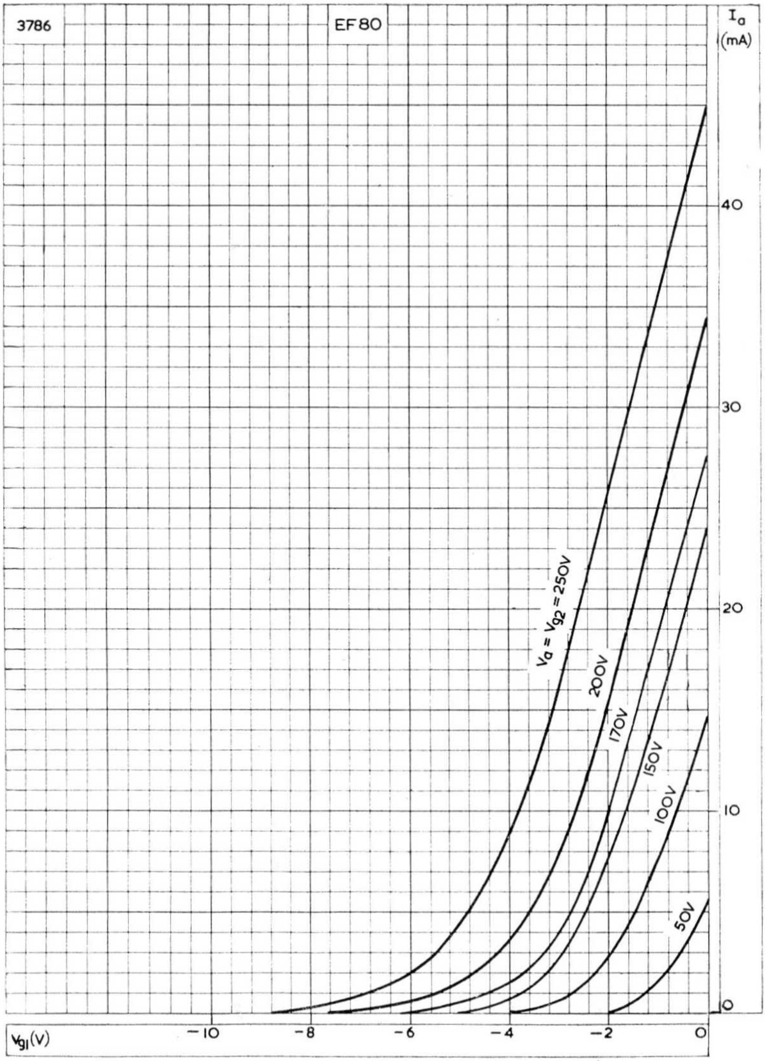
V_a	170	V
V_{g2}	170	V
V_{g3}	0	V
I_a	10	mA
I_{g2}	2.5	mA
V_{g1}	–2.0	V
g_m	7.4	mA/V
r_a	400	kΩ
μ_{g1-g2}	50	
R_{eq}	1.0	kΩ
r_{g1}(f = 50Mc/s)	10	kΩ
V_{g1} max. ($I_{g1} = +0.3\mu A$)	–1.3	V

DIMENSIONS

Max. overall length	67	mm
Max. seated height	60	mm
Max. diameter	22.2	mm

LIMITING VALUES

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	2.5	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	300	V
p_{g2} max.	700	mW
I_k max.	15	mA
R_{g1-k} max.	500	kΩ
V_{h-k} max.	150	V
R_{h-k} max.	20	kΩ

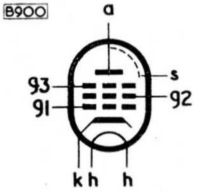


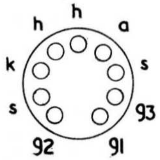
ANODE CURRENT PLOTTED AGAINST CONTROL-GRID VOLTAGE WITH ANODE AND SCREEN-GRID VOLTAGES AS PARAMETER

LOW NOISE A.F. VOLTAGE AMPLIFYING PENTODE

EF86

Low noise pentode intended for use as r.c. coupled a.f. voltage amplifier, particularly in the early stages of high-gain audio amplifiers, microphone pre-amplifiers and magnetic tape recorders.





B9A

HEATER

V_h	6.3	V
I_h	200	mA

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

LIMITING VALUES

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	1.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	200	V
p_{g2} max.	200	mW
I_k max.	6.0	mA
R_{g1-k} max. ($p_a > 200$mW)	3.0	MΩ
R_{g1-k} max. ($p_a < 200$mW)	10	MΩ
R_{h-k} max.	20	kΩ
V_{h-k} max. (cathode positive)	100	V
V_{h-k} max. (cathode negative)	50	V

CAPACITANCES

(Measured without external shield)

c_{out}	5.3	pF
c_{in}	3.8	pF
c_{a-g1}	<50	mpF
c_{g1-h}	<2.5	mpF

CHARACTERISTICS

V_a	250	V
V_{g3}	0	V
V_{g2}	140	V
I_a	3.0	mA
I_{g2}	600	μA
V_{g1}	−2.0	V
g_m	2.0	mA/V
r_a	2.5	MΩ
μ_{g1-g2}	38	

OPERATING CONDITIONS as r.c. coupled a.f. amplifier

Pentode connection

V_b (V)	R_a (kΩ)	R_{g2} (MΩ)	R_k (kΩ)	I_a (mA)	I_{g2} (μA)	$\frac{V_{out}}{V_{in}}$	V_{out}* ($V_{r.m.s.}$)	R_{g1}** (kΩ)
400	100	0.39	1.0	2.6	550	137	95	330
350	100	0.39	1.0	2.3	480	130	81	330
300	100	0.39	1.0	1.95	400	127	68	330
250	100	0.39	1.0	1.6	350	122	53	330
200	100	0.39	1.0	1.35	280	115	38	330
150	100	0.47	1.5	0.8	180	104	26	330
400	220	1.0	2.2	1.2	250	213	80	680
350	220	1.0	2.2	1.1	220	208	70	680
300	220	1.0	2.2	0.9	190	202	59	680
250	220	1.0	2.2	0.8	160	196	48	680
200	220	1.0	2.2	0.7	120	188	37	680
150	220	1.0	2.7	0.5	100	165	26	680

*Output voltage at $D_{tot} = 5\%$

**Grid resistor of following valve.

Triode connection (g_2 connected to a, g_3 to k)

V_b (V)	R_a (kΩ)	I_a (mA)	R_k (kΩ)	$\frac{V_{out}}{V_{in}}$	V_{out}* ($V_{r.m.s.}$)	D_{tot}* (%)	R_{g1}† (kΩ)
400	47	3.5	1.2	27.3	68	5.2	150
350	47	3.0	1.2	27	57	5.0	150
300	47	2.6	1.2	26.7	47	4.6	150
250	47	2.2	1.2	26.5	36.5	4.3	150
200	47	1.8	1.2	25.8	26.5	3.9	150
400	100	1.9	2.2	31.5	77	4.8	330
350	100	1.65	2.2	31	65	4.7	330
300	100	1.45	2.2	30.5	54	4.6	330
250	100	1.2	2.2	30.5	42	4.2	330
200	100	1.0	2.2	30	31	4.0	330
400	220	1.0	3.9	33.2	78	4.3	680
350	220	0.9	3.9	33	66	4.3	680
300	220	0.8	3.9	32.8	54	4.2	680
250	220	0.68	3.9	32.5	43	3.9	680
200	220	0.55	3.9	32	31	3.7	680

*Output voltage and distortion at the start of positive grid current. At lower output voltages the distortion is approximately proportional to the voltage.

†Grid resistor of the following valve.

OPERATING NOTES

1. Hum

When used as a normal voltage amplifier with a line voltage of 250V, an anode load of 100kΩ and a grid resistor of 470kΩ the maximum hum level of the valve alone is 5μV, the average value being about 3μV when operated with one side of the heater earthed. This can be further reduced by centre-tapping the heater to earth. Under these conditions the nominal hum level is 1μV. The low level of hum attained with this valve can be completely masked by that due to an unsuitable valveholder, in which excessive leakage and capacitive coupling between pins will introduce considerable hum.

2. Noise

The low-frequency noise generated by a valve is most conveniently specified as an equivalent voltage on the control grid for a specific bandwidth. For the EF86 under normal conditions, i.e. line voltage of 250V and an anode load of 100kΩ, the equivalent noise voltage is approximately 2μV for the frequency range of 25 to 10,000c/s.

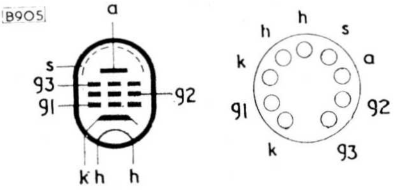
3. Microphony

Care in the design of the valve to ensure that the electrode structure and its mounting are as rigid as possible has reduced the microphony of the EF86 to a very low level. There are no appreciable internal resonances at frequencies below 1,000c/s. At higher frequencies the effect of vibration is usually negligible on account of the damping provided by the chassis and the valveholder. In high-gain applications such as tape recording care should be taken in siting the valve, particularly when a loudspeaker is present in the same cabinet or when a motor is mounted on the same chassis. In such cases a flexible mounting for the valveholder or a separate weighted sub-chassis is advisable.

VARIABLE-MU R.F. PENTODE

EF183

Frame grid variable-mu r.f. pentode for use as a.g.c. controlled i.f. amplifier in t.v. receivers.



B9A

HEATER

V_h	6.3	V
I_h	300	mA

DIMENSIONS

Max. overall length	61.1	mm
Max. seated height	54.1	mm
Max. diameter	22.2	mm

CAPACITANCES

c_{in}	9.5	pF
c_{out}	3.0	pF
c_{a-g1}	5.5	mpF
c_{g1-g2}	2.8	pF

CHARACTERISTICS

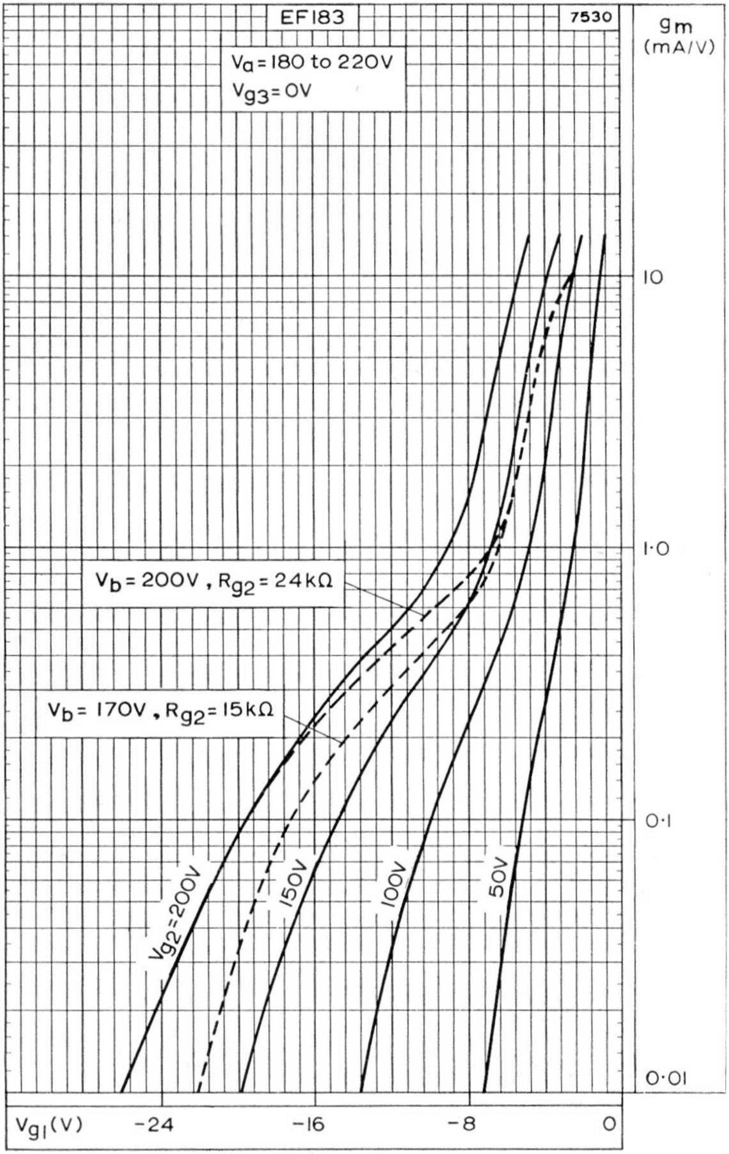
V_a	200	V
V_{g2}	90	V
V_{g3}	0	V
I_a	12	mA
I_{g2}	4.5	mA
V_{g1}	–2.0	V
g_m	12.5	mA/V
r_a	500	kΩ
r_{g1} (f = 40Mc/s)	13	kΩ

OPERATING CONDITIONS

V_b	190	V
R_{g2}	22	kΩ
R_k	120	Ω
I_a	11.7	mA
I_{g2}	4.3	mA
g_m	12.4	mA/V
V_{g1} (for 10 : 1 reduction in g_m)	–5.0	V
V_{g1} (for 100 : 1 reduction in g_m)	–18.5	V

LIMITING VALUES

V_a max.	250	V
p_a max.	2.5	W
V_{g2} max.	250	V
p_{g2} max.	650	mW
I_k max.	20	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	150	V
R_{h-k} max.	20	kΩ



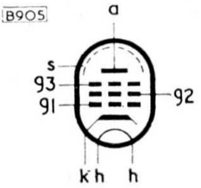
MUTUAL CONDUCTANCE PLOTTED AGAINST CONTROL-GRID VOLTAGE WITH SCREEN-GRID VOLTAGE AS PARAMETER

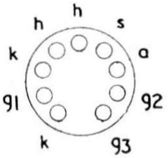
R.F. PENTODE

EF184

Frame-grid sharp cut-off pentode for use as an i.f. amplifier in television receivers.

B905





B9A

HEATER

Suitable for series or parallel operation, a.c. or d.c.

V_h	6.3	V
I_h	300	mA

CHARACTERISTICS

V_a	170	200	V
V_{g2}	170	200	V
V_{g3}	0	0	V
I_a	10	10	mA
I_{g2}	4.1	4.1	mA
V_{g1}	−2.0	−2.5	V
g_m	15.6	15	mA/V
r_a	330	380	kΩ
μ_{g1-g2}	60	60	
r_{g1} (f = 40Mc/s)	9.5	11	kΩ
R_{eq} (f = 40Mc/s)	—	330	Ω

OPERATING CONDITIONS

$V_{a(b)}$	170	200	230	V
$V_{g3(b)}$	0	0	0	V
$V_{g2(b)}$	170	200	230	V
R_k	140	140	140	Ω
R_{g2}	0	7.5	15	kΩ
I_a	10	10	10	mA
I_{g2}	4.1	4.1	4.1	mA
g_m	15.6	15.6	15.6	mA/V
r_a	330	510	680	kΩ
r_{g1} (f = 40Mc/s)	10	10	10	kΩ
R_{eq} (f = 40Mc/s)	300	300	300	Ω

DIMENSIONS

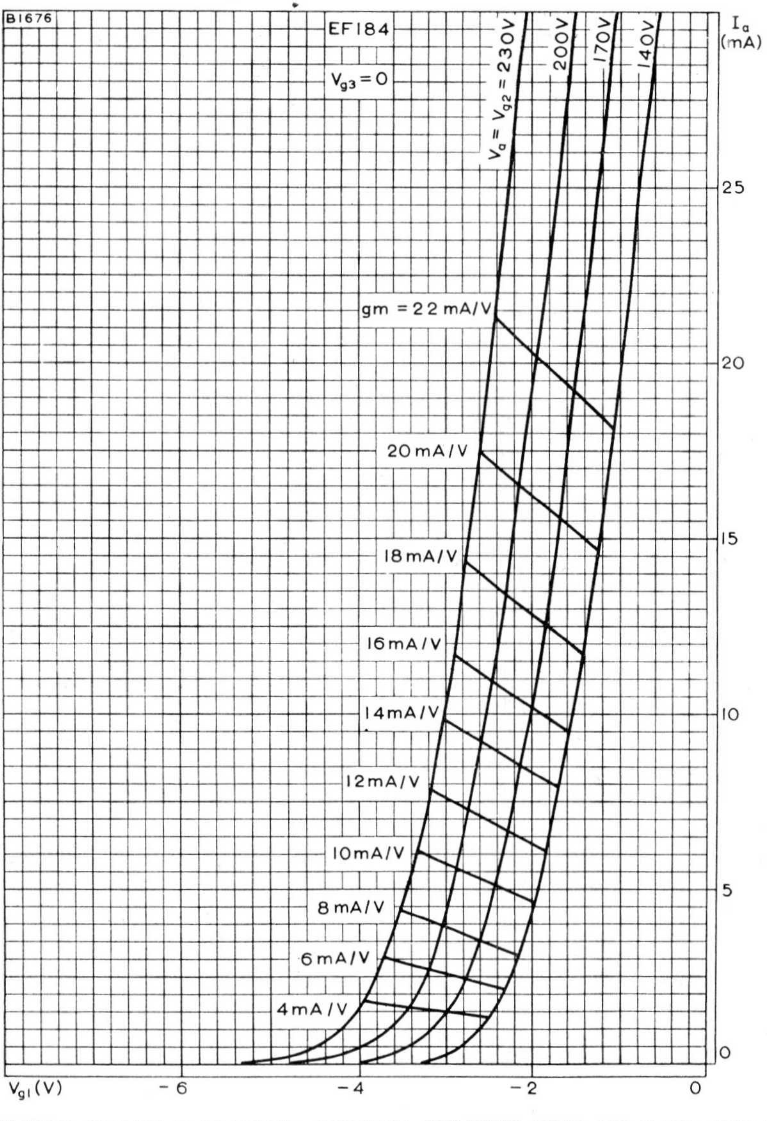
Max. overall length	61.1	mm
Max. seated height	54.7	mm
Max. diameter	22.2	mm

CAPACITANCES

c_{in}	10	pF
c_{out}	3.0	pF
c_{a-g1}	5.5	mpF
c_{g1-g2}	2.8	pF

DESIGN CENTRE RATINGS

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	2.5	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	900	mW
$-v_{g1(pk)}$ max.	50	V
I_k max.	25	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	150	V
R_{h-k} max.	20	kΩ
T_{bulb} max.	180	°C

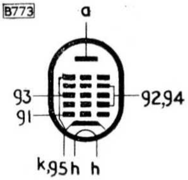


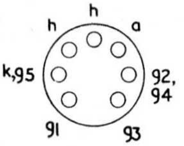
ANODE CURRENT PLOTTED AGAINST CONTROL-GRID VOLTAGE WITH ANODE AND SCREEN-GRID VOLTAGES AS PARAMETER AND WITH MUTUAL CONDUCTANCE CONTOURS

DUAL-CONTROL HEPTODE

EH90

Dual-control heptode for use in television receivers.





B7G

HEATER

V_h	6.3	V
I_h	300	mA

DIMENSIONS

Max. overall length	54.5	mm
Max. seated height	47.5	mm
Max. diameter	19	mm

CAPACITANCES

c_{a-g1}	<70	mpF
c_{a-g3}	<360	mpF
$c_{in(g1)}$	5.5	pF
$c_{in(g3)}$	7.0	pF
c_{out}	7.5	pF
c_{g1-g3}	<220	mpF

CHARACTERISTICS

V_a	10	100	100	V
V_{g2+g4}	30	30	30	V
V_{g1}	0	0	−1.0	V
V_{g3}	0	−1.0	0	V
I_a	2.0	0.8	0.75	mA
I_{g2+g4}	3.5	4.0	1.1	mA
$g_{m(g1-a)}$	—	—	1.2	mA/V
$g_{m(g3-a)}$	—	1.55	—	mA/V
r_a	—	400	900	kΩ
V_{g1} ($I_a = 50\mu A$)	—	—	−2.5	V
V_{g3} ($I_a = 50\mu A$)	—	−2.2	—	V

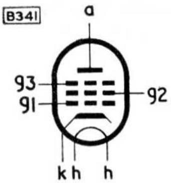
DESIGN CENTRE RATINGS

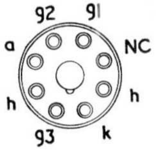
$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	1.0	°C
$V_{g2+g4(b)}$ max.	300	V
V_{g2+g4} max.	100	V
p_{g2+g4} max.	1.0	W
I_k max.	14	mA
R_{g1-k} max.	470	kΩ
R_{g3-k} max.	2.2	MΩ
R_{g3-k} max. ($V_{g2+g4} \leqslant 30V$)	5.0	MΩ
V_{h-k} max. (cathode positive)	200	V
V_{h-k} max. (cathode negative)	100	V

EL34

OUTPUT PENTODE

Output pentode rated for 25W anode dissipation, intended for use in a.c. mains operated equipment.





Octal

HEATER

V_h	6.3	V
I_h	1.5	A

CAPACITANCES

c_{out}	8.4	pF
c_{in}	15.3	pF
c_{a-g1}	<1.0	pF
c_{g1-h}	<1.0	pF
c_{h-k}	11	pF

DESIGN CENTRE RATINGS

$V_{a(b)}$ max.	2.0	kV
V_a max.	800	V
p_a max.	25	W
$V_{g2(b)}$ max.	800	V
V_{g2} max.	500	V
p_{g2} max.	8.0	W
I_k max.	150	mA
R_{g1-k} max.	500	kΩ
V_{h-k} max.	100	V
R_{h-k} max.	20	kΩ

DIMENSIONS

Max. overall length	112	mm
Max. seated height	98	mm
Max. diameter	33.3	mm

CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
V_{g3}	0	V
I_a	100	mA
I_{g2}	15	mA
V_{g1}	−12.2	V
g_m	11	mA/V
r_a	15	kΩ
μ_{g1-g2}	11	

OPERATING CONDITIONS As single valve class "A" amplifier
Pentode Connection

V_a	250	300	V
V_{g2}	250	300	V
V_{g3}	0	0	V
R_k	106	190	Ω
R_a	2.0	3.5	kΩ
I_a	100	83	mA
I_{g2}	15	13	mA
$V_{in(r.m.s.)}$ (P_{out} = 50mW)	500	450	mV
$V_{in(r.m.s.)}$	8.0	8.2	V
*P_{out}	11	11	W
*D_{tot}	10	10	%

*P_{out} and D_{tot} are measured at fixed bias and therefore represent the power output available during the reproduction of speech and music. When a sustained sine wave is applied to the control-grid the bias across the cathode resistor will readjust itself as a result of the increased anode and screen-grid currents. This will result in a reduction in power output of approximately 10%.

OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

Distributed load conditions for maximum output (screen-grid tapping at 20% of primary turns)

V_b	450	V
R_{g2} (per valve)	1.0	kΩ
R_k (per valve)	500	Ω
R_{a-a}	7.0	kΩ
$I_{a(o)}$	2×55	mA
$I_{g2(o)}$	2×9.0	mA
$V_{in(g1-g1)r.m.s.}$	55.2	V
P_{out}	40	W
D_{tot}	4.5	%
$I_{a(max.\ sig.)}$	2×74	mA
$I_{g2(max.\ sig.)}$	2×9.0	mA

Distributed load conditions for minimum distortion (with screen-grid tapping at 43% of primary turns)

V_b	430	430	V
R_{g2} (per valve)	1.0	1.0	kΩ
R_k (per valve)	470	470	Ω
R_{a-a}	6.0	6.0	kΩ
$I_{a(o)}$	2×62.5	2×62.5	mA
$I_{g2(o)}$	2×10	2×10	mA
$V_{in(g1-g1)r.m.s.}$	35	50	V
P_{out}	20	34	W
D_{tot}	0.35	2.5	%
$I_{a\ (max.\ sig.)}$	2×65	2×70	mA
$I_{g2(max.\ sig.)}$	2×10.2	2×14	mA

OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

Triode connection (g_2 connected to a, g_3 to k) with separate cathode bias resistors.

With R_k bypassed

V_b	430	V
V_a	400	V
V_{g3}	0	V
R_k (per valve)	440	Ω
R_{a-a}	5.0	kΩ
$I_{a(o)}$	2 × 70	mA
$V_{in(g1-g1)r.m.s.}$	48	V
P_{out}	19	W
D_{tot}	1.8	%
$I_{a(max.\ sig.)}$	2 × 75	mA

With R_k unbypassed

V_b	430	V
V_a	400	V
V_{g3}	0	V
R_k (per valve)	440	Ω
R_{a-a}	10	kΩ
$I_{a(o)}$	2 × 70	mA
$V_{in(g1-g1)r.m.s.}$	48	V
P_{out}	14	W
D_{tot}	0.4	%
$I_{a(max.\ sig.)}$	2 × 73	mA

OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL WITH CONTINUOUS SINE WAVE DRIVE

Fixed bias

V_b	375	400	V
V_{g3}	0	0	V
R_{g2}	1.0	1.5	kΩ
V_{g1}	−32	−35.5	V
R_{a-a}	3.5	3.5	kΩ
$I_{a(o)}$	2 × 30	2 × 30	mA
$I_{g2(o)}$	2 × 4.4	2 × 4.4	mA
$V_{in(g1-g1)r.m.s.}$	45	50	V
P_{out}	42	51	W
D_{tot}	3.0	1.8	%
$I_{a(max.\ sig.)}$	2 × 98	2 × 106	mA
$I_{g2(max.\ sig.)}$	2 × 19	2 × 21	mA

Cathode bias

Any of the cathode bias conditions published in this data sheet are suitable for continuous sine wave drive.

OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

Fixed bias

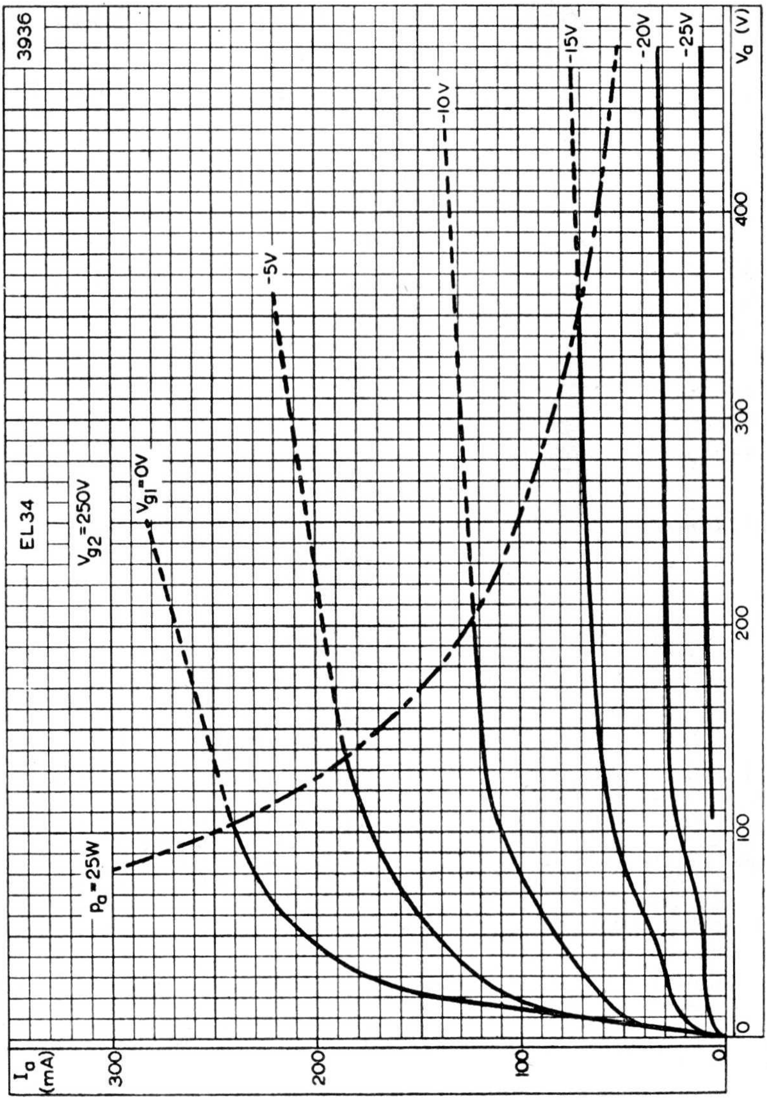
V_b	375	400	V
V_{g3}	0	0	V
*R_{g2}	600	800	Ω
V_{g1}	−33	−36	V
R_{a-a}	3.5	3.5	kΩ
$I_{a(o)}$	2 × 30	2 × 30	mA
$I_{g2(o)}$	2 × 4.7	2 × 4.5	mA
$V_{in(g1-g1)r.m.s.}$	46.7	50	V
P_{out}	48	54	W
D_{tot}	2.8	1.6	%
$I_{a(max.\ sig.)}$	2 × 107.5	2 × 110.5	mA
$I_{g2(max.\ sig.)}$	2 × 23.5	2 × 23	mA

*Screen-grid resistor common to both valves.

Cathode bias

V_b	375	450	V
V_{g3}	0	0	V
*R_{g2}	0.47	1.0	kΩ
R_k (per valve)	260	465	Ω
R_{a-a}	3.5	6.5	kΩ
$I_{a(o)}$	2 × 75	2 × 60	mA
$I_{g2(o)}$	2 × 12.5	2 × 10	mA
$V_{in(g1-g1)r.m.s.}$	40	54	V
P_{out}	35	40	W
D_{tot}	1.7	5.1	%
$I_{a(max.\ sig)}$	2 × 94	2 × 71.5	mA
$I_{g2(max.\ sig.)}$	2 × 19.5	2 × 22	mA

*Screen-grid resistor common to both valves.



ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE WITH CONTROL-GRID VOLTAGE AS PARAMETER

OUTPUT PENTODE

EL84

Output pentode rated for 12W anode dissipation, primarily intended for use in a.c. mains operated equipment.

HEATER

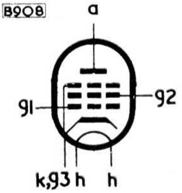
V_h	6.3	V
I_h	760	mA

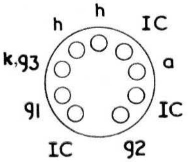
CAPACITANCES

c_{out}	6.5	pF
c_{in}	10.8	pF
c_{a-g1}	$<$500	mpF
c_{g1-h}	$<$250	mpF

LIMITING VALUES

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	12	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	300	V
p_{g2} max.	2.0	W
I_k max.	65	mA
$-V_{g1}$ max.	100	V
R_{g1-k} max. (fixed bias)	300	kΩ
V_{h-k} max.	100	V
R_{h-k} max.	20	kΩ





B9A

DIMENSIONS

Max. overall length	78.5	mm
Max. seated height	71.5	mm
Max. diameter	22.2	mm

CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
I_a	48	mA
I_{g2}	5.5	mA
V_{g1}	-7.3	V
g_m	11.3	mA/V
r_a	38	kΩ
μ_{g1-g2}	19	

OPERATING CONDITIONS as single valve amplifier

Pentode connection

V_a	250	250	V
V_{g2}	250	250	V
R_a	5.2	4.5	kΩ
V_{g1}	-7.3	-7.3	V
I_a	48	48	mA
I_{g2}	5.5	5.5	mA
$V_{in(r.m.s)}$ (P_{out} = 50mW)	300	300	mV
$V_{in(r.m.s.)}$ (D_{tot} = 10%)	4.3	4.4	V
P_{out} (D_{tot} = 10%)	5.7	5.7	W
D_3	9.5	8.0	%
D_2	2.0	5.0	%

Triode connection (g_2 connected to a)

V_a	250	V
R_a	3.5	kΩ
V_{g1}	-9.0	V
$I_{a(o)}$	34	mA
$V_{in(r.m.s.)}$ (P_{out} = 50mW)	1.0	V
$V_{in(r.m.s.)}$	6.0	V
P_{out}	1.5	W
D_{tot}	6.0	%
$I_{a(max. sig.)}$	39	mA

OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

Pentode connection

V_a	250	300	V
V_{g2}	250	300	V
R_k (per valve)	270	270	Ω
R_{a-a}	8.0	8.0	kΩ
$I_{a(o)}$	2 × 31	2 × 36	mA
$I_{g2(o)}$	2 × 3.5	2 × 4.0	mA
$V_{in(g1-g1)r.m.s.}$	16	20	V
P_{out}	11	17	W
D_{tot}	3.0	4.0	%
$I_{a(max.\ sig.)}$	2 × 37.5	2 × 46	mA
$I_{g2(max.\ sig.)}$	2 × 7.5	2 × 11	mA

Distributed load conditions for maximum output (screen-grid tapping at 20% of primary turns)

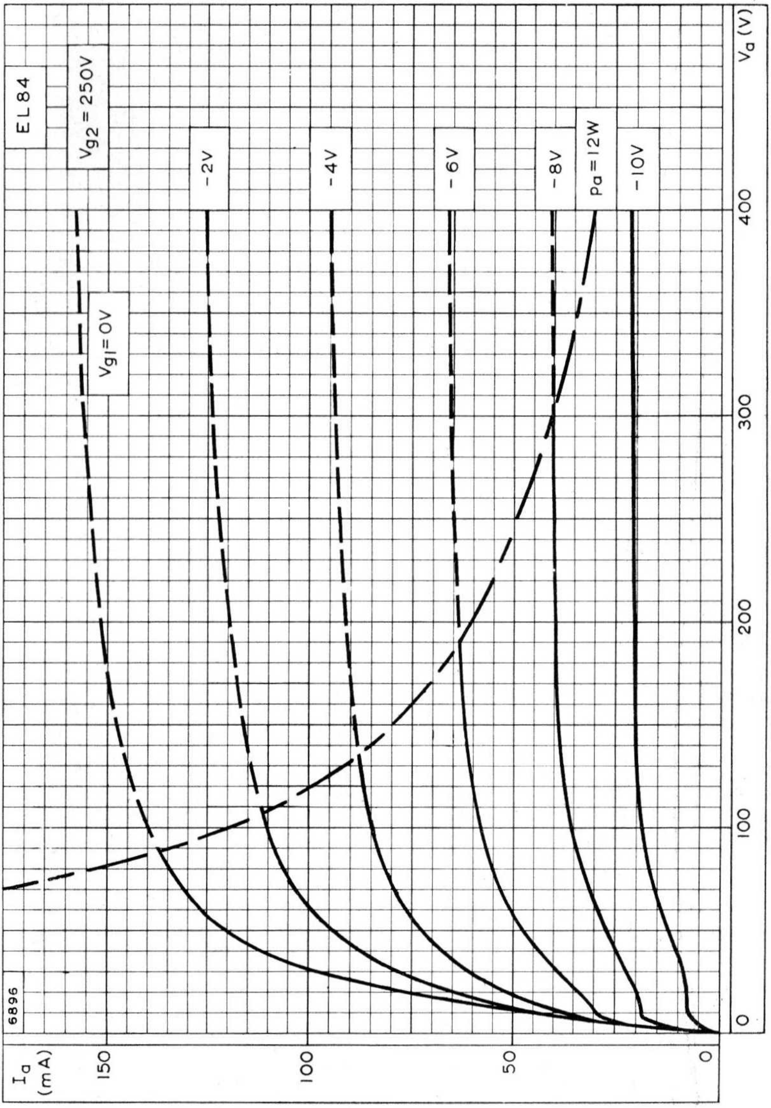
V_a	300	300	V
V_{g2}	300	300	V
R_k (per valve)	390 + 47	270	Ω
R_{a-a}	6.0	8.0	kΩ
$I_{k(o)}$	2 × 28	2 × 40	mA
$V_{in(g1-g1)r.m.s.}$	17	18.3	V
P_{out}	14.4	15.4	W
D_{tot}	0.85	1.17	%
$I_{k(max.\ sig.)}$	2 × 55	2 × 48.5	mA

Distributed load conditions for minimum distortion (screen-grid tapping at 43% of primary turns)

V_a	300	300	V
V_{g2}	300	300	V
R_k (per valve)	390 + 47	270	Ω
R_{a-a}	6.0	8.0	kΩ
$I_{k(o)}$	2 × 28	2 × 40	mA
$V_{in(g1-g1)r.m.s.}$	16.8	16	V
P_{out}	10.1	11	W
D_{tot}	0.72	0.7	%
$I_{k(max.\ sig.)}$	2 × 47	2 × 45	mA

Triode connection (g_2 connected to a)

V_a	250	300	V
R_k (per valve)	560	560	Ω
R_{a-a}	10	10	kΩ
$I_{a(o)}$	2 × 20	2 × 24	mA
$V_{in(g1-g1)r.m.s.}$	16.5	20	V
P_{out}	3.4	5.2	W
D_{tot}	2.5	2.5	%
$I_{a(max.\ sig.)}$	2 × 21.5	2 × 26	mA



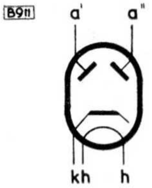
ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE WITH CONTROL-GRID VOLTAGE AS PARAMETER. $V_{g2} = 250V$

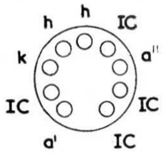
EZ81

FULL-WAVE RECTIFIER

HEATER

V_h	6.3	V
I_h	1.0	A





B9A

LIMITING VALUES

P.I.V. max.	1.3	kV
$i_{a(pk)}$ max.	500	mA
$i_{a(surge)}$ max.	1.8	A
V_{h-k} max. (cathode positive)	500	V

DIMENSIONS

Max. overall length	78.5	mm
Max. seated height	71.5	mm
Max. diameter	22.2	mm

OPERATING CONDITIONS

Capacitor input

$V_{in(r.m.s.)}$	2×250	2×350	2×450	V
R_{lim} (per anode)	150	230	310	Ω
C	50	50	50	μF
I_{out} max.	160	150	100	mA
V_{out}	245	352	497	V

Choke input

$V_{in(r.m.s.)}$	2×250	2×350	2×450	V
L	10	10	10	H
I_{out}	180	180	150	mA
V_{out}	199	288	378	V

CHARACTERISTIC

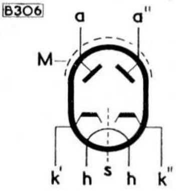
Anode voltage drop (I_{out} = 150mA)	19.8	V

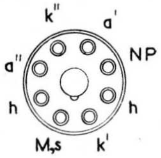
INDIRECTLY HEATED FULL-WAVE RECTIFIER

GZ34

HEATER

V_h	5.0	V
I_h	1.9	A





Octal
Pin No. 1 IC

DIMENSIONS

Max. overall length	86	mm
Max. seated height	72	mm
Max. diameter	38	mm

LIMITING VALUES

P.I.V. max.						1.5	kV
$i_{a(pk)}$ max.						750	mA
C max.						60	μF
$V_{a(r.m.s.)}$	2 × 300	2 × 350	2 × 400	2 × 450	2 × 500	2 × 550	V

Capacitor input

I_{out} max.	250	250	250	250	200	160	mA
R_{lim} min. (per anode)	50	75	100	125	150	175	Ω

Choke input

I_{out} max.	250	250	250	250	250	225	mA
R_{lim} min. (per anode)	0	0	0	0	0	0	Ω

OPERATING CONDITIONS

Capacitor input

$V_{a(r.m.s.)}$ (V)	I_{out} (mA)	C (μF)	R_{lim} (per anode) (Ω)	V_{out} (V)
2 × 300	250	60	75	330
2 × 350	250	60	100	380
2 × 400	250	60	125	430
2 × 450	250	60	150	480
2 × 500	200	60	175	560
2 × 550	160	60	200	640

Choke input

$V_{a(r.m.s.)}$ (V)	I_{out} (mA)	L (H)	R_{lim} (per anode) (Ω)	V_{out} (V)
2 × 300	250	10	0	250
2 × 350	250	10	0	290
2 × 400	250	10	0	330
2 × 450	250	10	0	375
2 × 500	250	10	0	420
2 × 550	225	10	0	465

LCR4

AUDIO TRANSISTOR PACKAGE

Package of four audio transistors consisting of two OC82DM as preamplifier and driver with matched pair of AD140 output transistors. Intended for use in car radio receivers with class 'B' push-pull output stages.

PACKAGE GAIN PRODUCT

Product of the current gain of the OC82DM driver at $V_{CE} = -6V$, $I_C = 2mA$ and the current gain of an AD140 measured at $V_{CE} = -1V$, $I_C = 1A$.

Min.	*Typ.*	*Max.*
4,000	6,000	8,000

OPERATING CONDITIONS FOR THREE STAGE AMPLIFIER WITH A CLASS "B" OUTPUT STAGE intended for use in transistor car and radio receivers

Output stage

With the output transistors mounted on a common heatsink with the thermal resistance quoted, the circuit is thermally stable up to 55°C ambient. The thermal resistance junction to ambient is 2°C/W (max.) higher than twice the values quoted for the heat sink thermal resistance. This includes 0.5°C/W contact thermal resistance.

Driver stage

The driver transistor must be fitted with a cooling fin having an area of 3sq.cm. (material 0.5mm copper strip commercial|half-hard BS899). For the condition $P_{load} = 12W$ the cooling fin should be mounted on a heatsink 5cm × 7cm of 16s.w.g. aluminium.

Driver stage

Thermal resistance of heatsink		6	4	°C/W
Supply voltage	V_{CC}	–14	–14	V
Quiescent current	$I_{C(q)}$	2 × 30	2 × 30	mA
Peak collector current	I_{CM}	0.9	1.9	A
Collector to collector load	R_{c-c}	59	26.4	Ω
Power delivered to transformer primary	P_{load}	6.0	12	W
Distortion	D_{tot}	<10	<10	%
Average feedback from output to driver stage		6.0	6.0	dB
Collector current	I_C	5.0	19	mA

Preamplifier stage

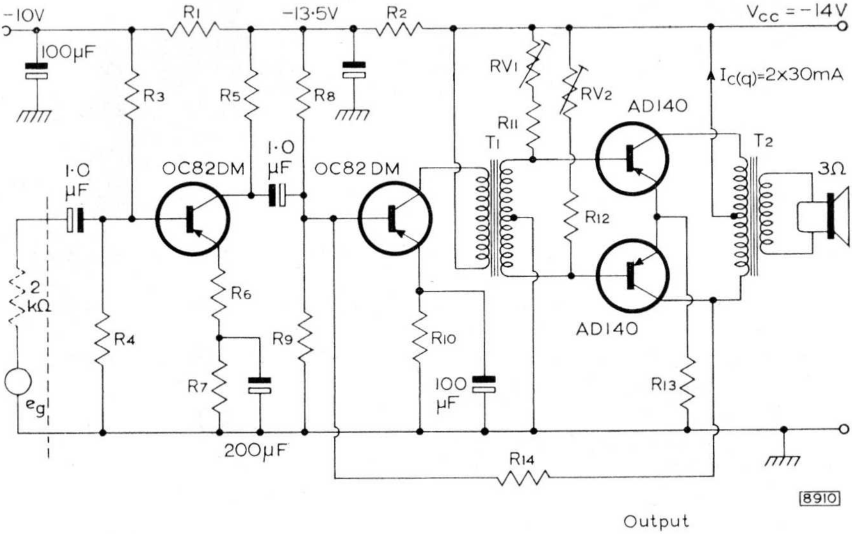
Collector current	C	550	550	μA
Input impedance	R_{in}	>4.0	>4.0	kΩ

†Sensitivity

Input voltage (r.m.s.) for full output	5.5 to 11	19 to 38	mV
Average input voltage (r.m.s.) for $P_{load} = 50mW$	0.7	1.4	mV

†Defined as the open circuit e.m.f. from a generator with a 2kΩ source impedance.

AUDIO TRANSISTOR PACKAGE LCR4



Either OC82DM may be used in the driver stage.

COMPONENT VALUES

R1 R2	Value determined by current requirements of previous stages.

Preamplifier stage

R3	150	kΩ
R4	39	kΩ
R5	5.6	kΩ
R6	82 ± 5%	Ω
R7	3.3	kΩ

Driver and output stage

Power delivered to transformer primary (P_{load})	6.0	12	W
R8	18	4.7	kΩ
R9	4.7	1.2	kΩ
R10	470	120	Ω
R11	330	330	Ω
R12	330	330	Ω
R13	0.5	0.5	Ω
R14	330	100	kΩ
RV1	500	500	Ω
RV2	500	500	Ω

Mullard

TRANSFORMERS

Driver transformer T1

Turns ratio	n	7.0 : 1+1	4.5 : 1+1	
Primary inductance (at specified current)	L_p	3.0	1.0	H
Primary resistance	R_p	<200	<30	Ω
Secondary resistance (per half)	R_s	8±10%	8±10%	Ω

Output transformer T2

Turns ratio	n	2+2 : 1	1.35+1.35 : 1	
Primary inductance (per half)	L_p	32	15	mH
Primary resistance (per half)	R_p	<1.5	<0.6	Ω
Secondary resistance	R_s	<0.3	<0.3	Ω

The secondary of the driver transformer and the primary of the output transformer should be bifilar wound.

The driver transformer inductance is chosen to complement the output transformer performance.

The frequency response of the circuit shown will typically be –3dB at f = 100c/s.

TRANSISTORS 2-OC82DM, 2-AD140

AD140:—

ABSOLUTE MAXIMUM RATINGS

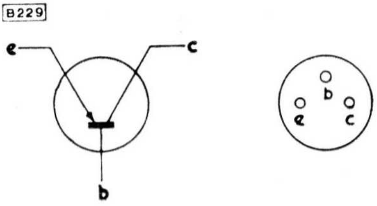
Collector voltage

V_{CB} max. ($I_E = 0$)	–45	V
V_{CE} max. ($I_C = 0.5A$, $+V_{BE} = 2V$)	–45	V
V_{CE} max. ($I_C = 3.0A$, $+V_{BE} = 2V$)	–32	V

For the rest of the data see AD140 on page 48.

OC82DM:—

Junction transistor of the p-n-p alloy type in TO-1 construction intended for use in the pre-amplifier and driver stages of car radio receivers with class 'B' output stages.



TO-1 Construction

DIMENSIONS

Max. body length	9.4	mm
Max. diameter	6.1	mm
Min. lead length	38	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage

Common emitter

V_{CEM} max.	–32	V
*$V_{CE(AV)}$ max.	–16	V

*These figures apply with an external base-ground circuit impedance of less than 3kΩ or providing $+V_{BE} > 500mV$.

OC82DM (Cont.)

Collector current

I_{CM} max.	20	mA
*$I_{C(AV)}$ max.	10	mA

Emitter current

I_{EM} max.	25	mA
*$I_{E(AV)}$ max.	15	mA

Reverse emitter-base voltage

V_{EBM} max.	–3.0	V
*$V_{EB(AV)}$ max.	–3.0	V

Base current

I_{BM} max.	5.0	mA
*$I_{B(AV)}$ max.	5.0	mA

Total dissipation .. .. See curve on page 51

$$P_{tot} \text{ max.} = \frac{T_j \text{ max.} - T_{amb}}{\theta}$$

*Averaged over any 20ms period.

Temperature ratings

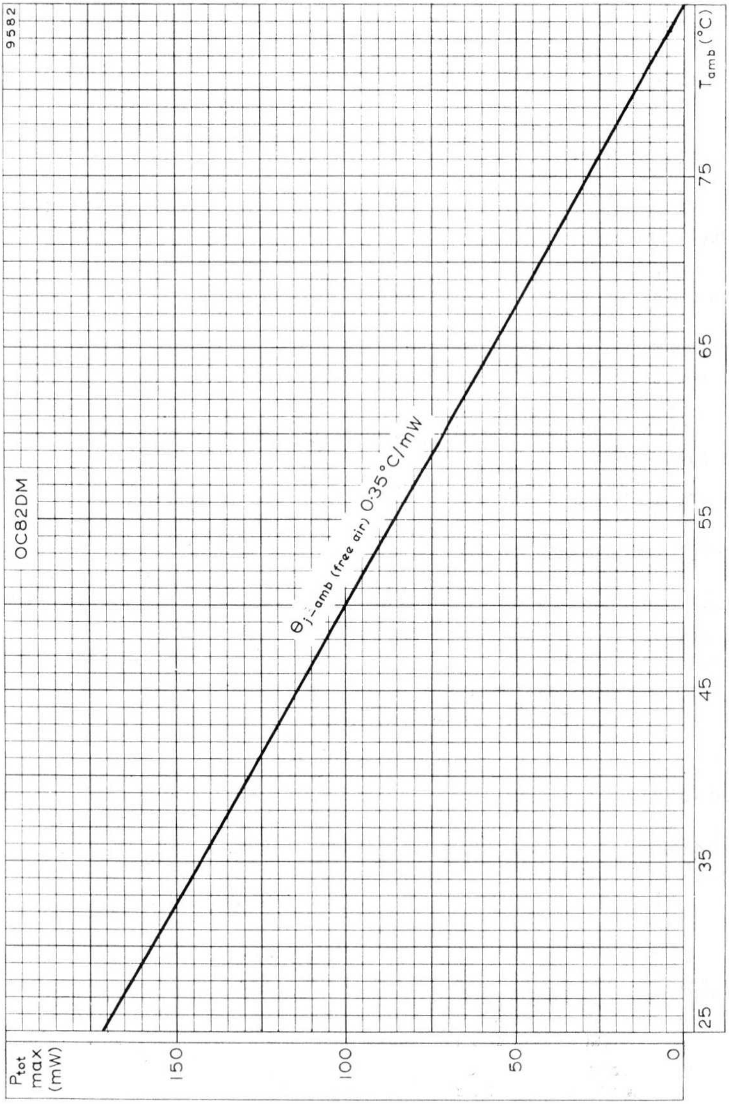
T_{stg} max.	+85	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	85	°C
θ_{j-amb} (without cooling clip in free air)	0.35	°C/mW

CHARACTERISTICS at $T_j = 25$°C

Common base		Typical production spread Min.	Typ.	Max.	
Collector leakage current ($V_{CB} = -10$V, $I_E = 0$mA)	I_{CBO}	—	—	13	µA

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 240°C for a maximum of 10 seconds up to a point 5mm from the seal or when vertically mounted for 5 seconds up to a point 2mm from the seal.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.



MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

AUDIO TRANSISTOR PACKAGE

LFH3

Package of three audio transistors consisting of OC81D driver and matched pair OC81 output types intended for use in the driver and output stages of radio receivers and gramophone amplifiers.

PACKAGE GAIN PRODUCT

Product of the current gain of a matched pair of OC81 and the current gain of an OC81D in a typical driver circuit.

Matched pair of OC81 measured at $I_C = 300$mA and the OC81D driver at $V_{CE} = -7$V, $I_C = 3.0$mA, load resistance 7.5kΩ and input shunt loss of 5.6kΩ.

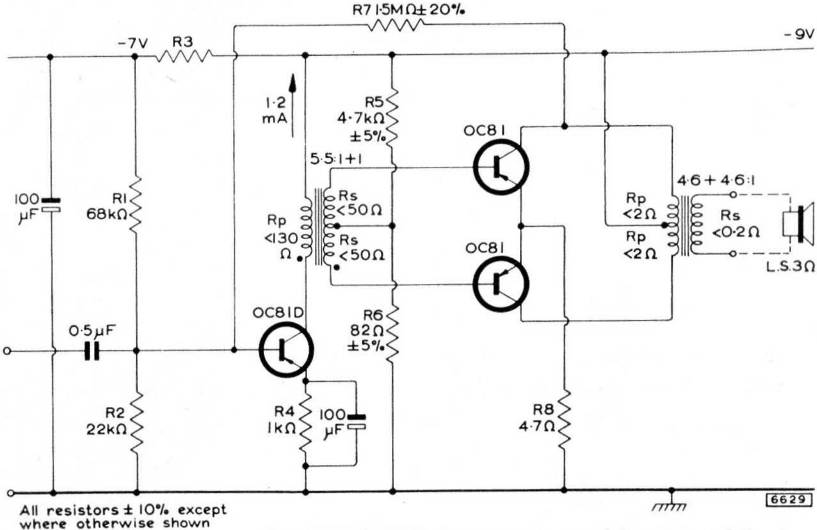
Min.	*Av.*	*Max.*
2100	3600	6200

OPERATING CONDITIONS

(a) Operation at $T_{amb} \leqslant 45$°C in free air.

(b) Operation at $T_{amb} = 55$°C with each output transistor in a standard cooling clip type (a) or extended version of type (b). (See page 133).

COMMON EMITTER 500MW PUSH-PULL AMPLIFIER (Fig. 1)



All resistors ± 10% except where otherwise shown

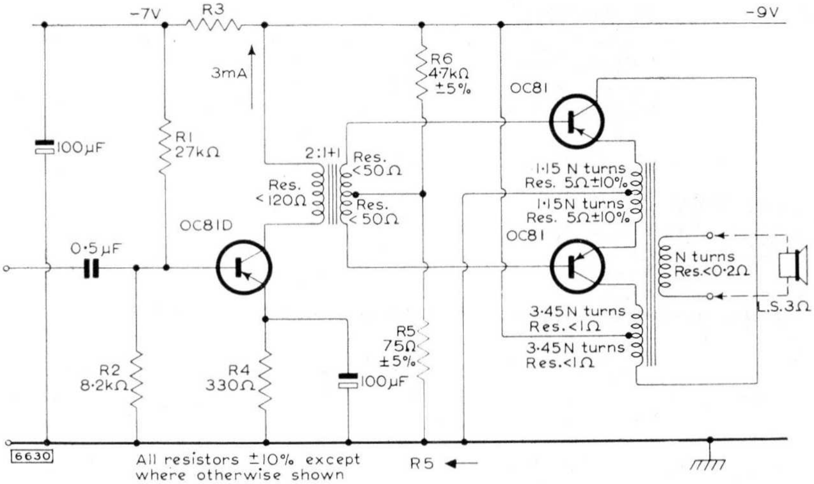
The secondary of the driver transformer and the primary of the output transformer should be bifilar wound.

V_{cc}	−9.0	V
I_{CM}	125	mA
Power delivered to transformer primary (P_{out})	500	mW
D_{tot}	10	%
D_{tot} at $P_{out} = 450$mW	6.0	%
Total negative feedback (av.)	6.0	dB

Input requirements

Spread of input current (r.m.s.) for $P_{out} = 500$mW	6.4 to 10	µA
Average input current (r.m.s.) for $P_{out} = 50$mW	2.4	µA

SPLIT LOAD 540MW PUSH-PULL AMPLIFIER (Fig. 2)

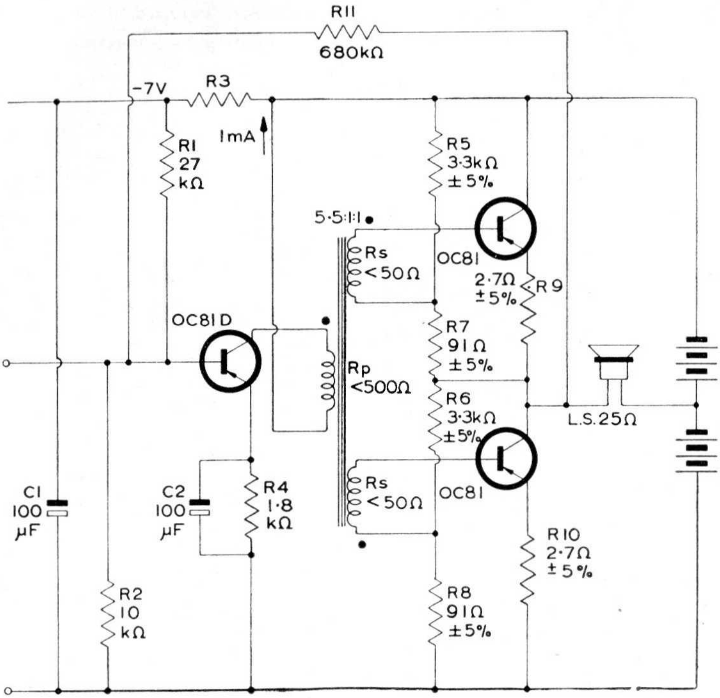


V_{cc}	−9.0	V
I_{CM}	125	mA
Power delivered to transformer primary (P_{out})	540	mW
D_{tot}	10	%
D_{tot} at P_{out} = 450mW	8.0	%

Input requirements

Spread of input current (r.m.s.) for P_{out} = 540mW	5.5 to 17.5	μA
Average input current (r.m.s.) for P_{out} = 50mW	3.0	μA

SINGLE ENDED 500MW PUSH-PULL AMPLIFIER (Fig. 3)



All resistors ± 10% except where otherwise shown.

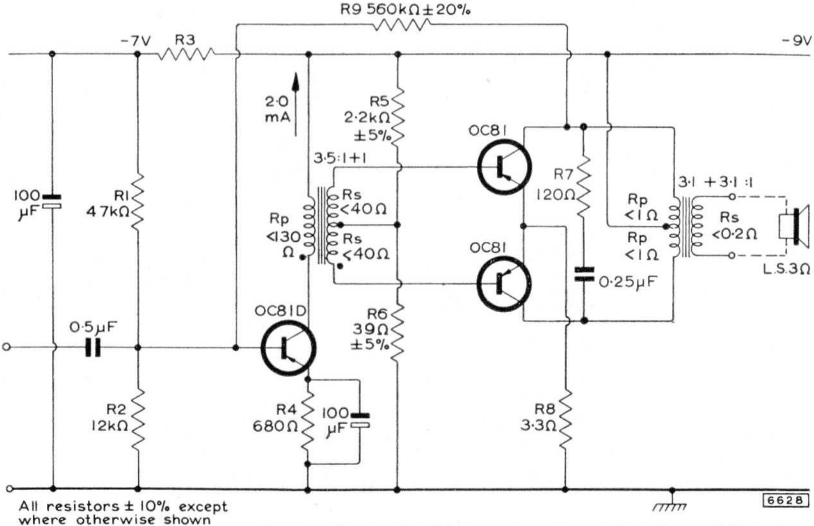
V_{cc}	6.0+6.0	V
I_{CM}	200	mA
Power delivered to load (P_{load})	500	mW
D_{tot}	10	%
D_{tot} at P_{load} = 450mW	5.0	%
Total negative feedback (av.)	6.0	dB

Input requirements

Spread of input current (r.m.s.) for P_{load} = 300mW	10 to 15.5	μA
Average input current (r.m.s.) for P_{load} = 50mW	2.2	μA

COMMON EMITTER 1W PUSH-PULL AMPLIFIER (Fig. 4).

(a) Operation at $T_{amb} \leqslant 45°C$ with each transistor in a standard cooling clip type
(b) mounted on a heatsink 5cm × 7cm of 16 s.w.g. aluminium or equivalent.



The secondary of the driver transformer and the primary of the output transformer should be bifilar wound.

V_{cc}	–9.0	V
I_{CM}	250	mA
Power delivered to transformer primary (P_{out})	1.0	W
D_{tot}	10	%
Total negative feedback (av.)	5.0	dB

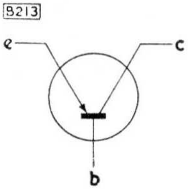
Input requirements

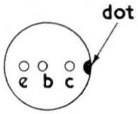
Spread of input current (r.m.s.) for P_{out} = 1W	16.5 to 26.5	µA
Average input current (r.m.s.) for P_{out} = 50mW	5.0	µA

AUDIO TRANSISTOR PACKAGE LFH3

TRANSISTORS OC81D, 2-OC81

OC81D, OC81:—





DIMENSIONS

Max. body length	15.7	mm
Max. diameter	5.9	mm
Min. lead length	37	mm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage	OC81D	OC81	
Common emitter			
V_{CM} max.	−32	−20	V
V_{CE} max. (d.c.)	−16	−10	V

These figures apply with an external base-ground circuit impedance $R_b < 300\Omega$ or $+V_{be} > 500$mV.

Collector current			
†I_{CM} max.	20	500	mA
*$I_{C(AV)}$ max.	10	200	mA
Emitter current			
†I_{EM} max.	25	550	mA
*$I_{E(AV)}$ max.	15	220	mA
Reverse emitter-base voltage			
V_{EMB} max.	−1.0	−3.0	V
Base current			
I_{BM} max.	5.0	50	mA
*$I_{B(AV)}$ max.	5.0	20	mA

Total dissipation

$$P_{tot}\ \text{max.} = \frac{T_j\ \text{max.} - T_{amb}}{\theta}$$

*Averaged over any 20ms period.

†Owing to linearity considerations it is inadvisable to design for peak currents greater than 300mA where low distortion is required.

Temperature ratings

Storage temperature	−55 to +85	°C
Maximum junction temperature Continuous operation	85	°C

Junction temperature rise above ambient θ	OC81D	OC81	
(1) without cooling clip in free air	0.4	0.2	°C/mW
(2) With type (a) or extended type (b) cooling clip. (See outline drawing and page 123)	—	0.15	°C/mW
(3) with standard clip type (b) on a heatsink 5 × 7cm, 16 s.w.g. aluminium	—	0.1	°C/mW

LFH3 (Cont.)

AUDIO TRANSISTOR PACKAGE

CHARACTERISTICS at $T_j = 25$°C

		Typical production spread			
		OC81D	OC81		
Grounded base					
Collector leakage current	I_{CBO}		*Av.*	*Max.*	
($V_{CB} = -10V$, $I_E = 0mA$)		<13	4.5	10	μA
($V_{CB} = -10V$, $I_E = 0mA$, $T_j = 85$°C)		—	300	500	μA
Grounded emitter					
Current amplification factor					
($V_{CE} = -2V$, $I_C = 3mA$)	h_{FEL}	>25	—	—	

			OC81		
Base input voltage		*Min.*	*Av.*	*Max.*	
($V_{CE} = -6V$, $I_C = 2mA$)	V_{BE}	—	−150	—	mV
Collector bottoming voltage					
($I_C = 300mA$, $I_B = 9.0mA$)	V_{CE}	—	−300	−500	mV

LARGE SIGNAL CHARACTERISTICS OF OC81 ($T_j = 25$°C)

Static characteristics

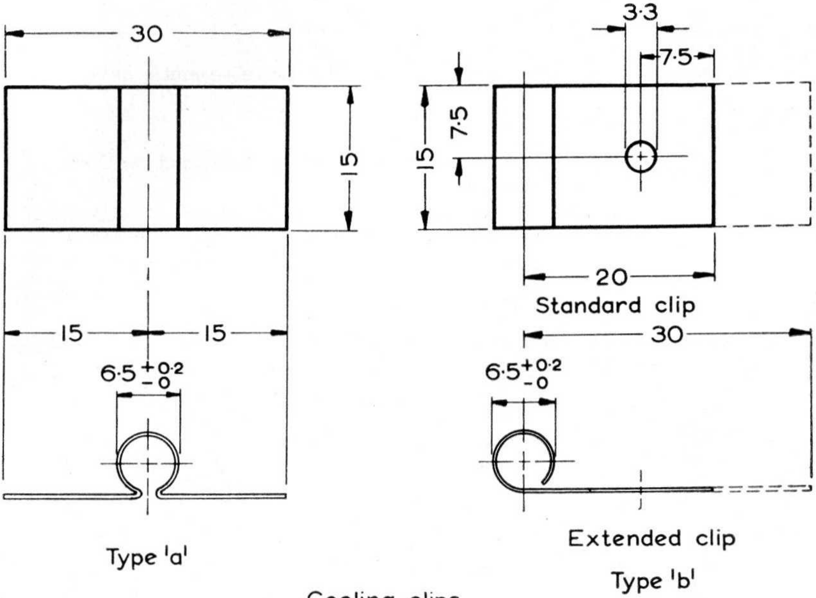
Current amplification factor $h_{FEL} = \frac{I_C - I_{CBO}}{I_B + I_{CBO}}$

at $V_{CE} = -1.0V$, $I_C = 300mA$	h_{FEL}		>45	
h_{FEL} at $I_C = 50mA$ . . . . h_{FEL} at $I_C = 300mA$			<1.6	
Base input voltage		*Av.*	*Max.*	
($V_{CE} = -1V$, $I_C = 300mA$)	V_{BE}	−475	−750	mV

CHARACTERISTICS OF MATCHED PAIR OC81 ($T_j = 25$°C)

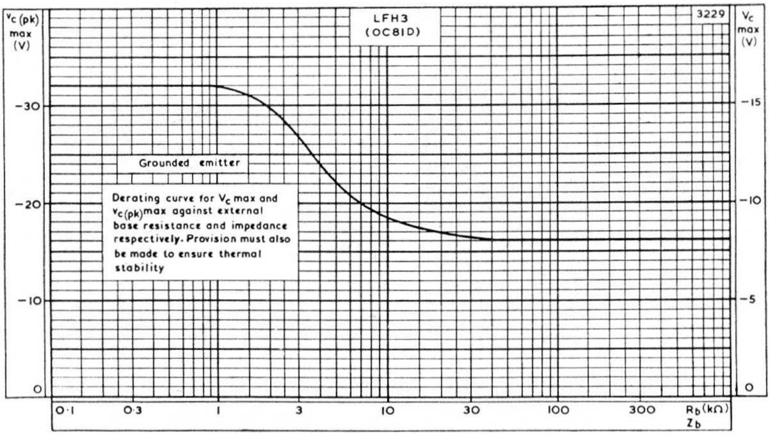
Ratio of the current amplification factors of the two transistors at:

$I_C = 50mA$ . . . . $<1.2 : 1$
$I_C = 300mA$ . . . . $<1.2 : 1$



Cooling clips

Material: 0·5mm copper strip commercial half-hard BS899



MAXIMUM PEAK AND AVERAGE COLLECTOR VOLTAGE PLOTTED AGAINST EXTERNAL BASE-EMITTER IMPEDANCE OR RESISTANCE

LFK3

AUDIO TRANSISTOR PACKAGE

Package of three audio transistors consisting of OC81D driver and complementary matched n-p-n/p-n-p output types AC127 and OC81. Intended for use in transformerless audio amplifiers for portable radio receivers.

PACKAGE GAIN PRODUCT

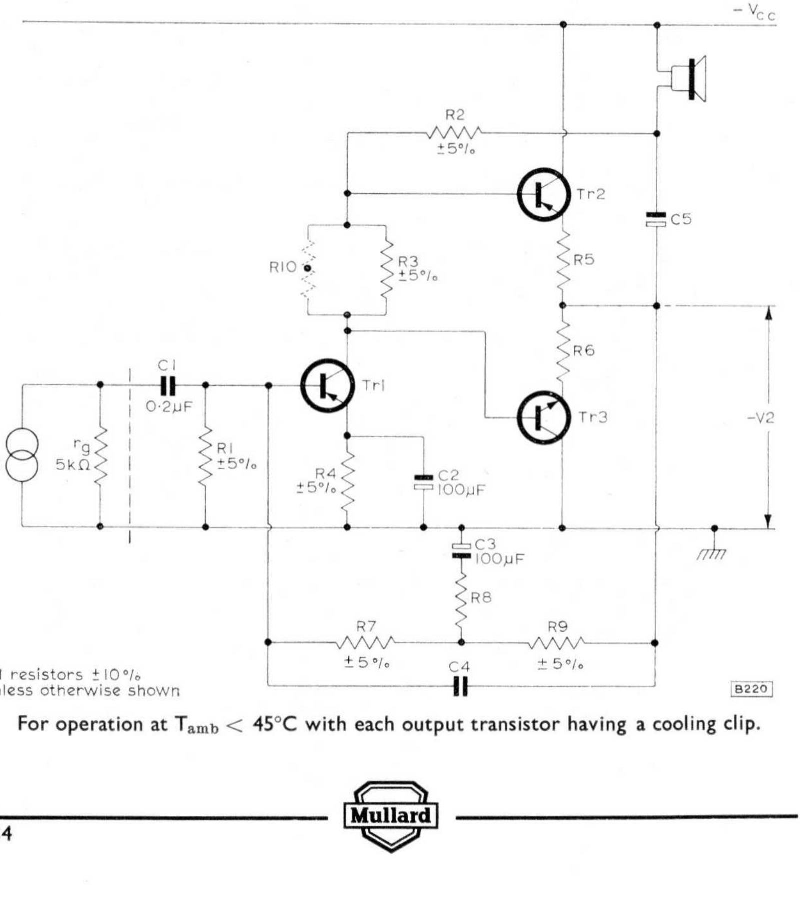
Product of the current gain of a matched pair of AC127/OC81 and the current gain of an OC81D in a typical driver circuit.

Matched pair of AC127/OC81 measured at $I_C = 50\text{mA}$ and the OC81D driver at $V_{CE} = -7\text{V}$, $I_C = 3.0\text{mA}$, load resistance 7.5kΩ and input shunt loss of 5.6kΩ.

Min.	*Typ.*	*Max.*
2600	5000	7600

TWO-STAGE AMPLIFIER WITH P-N-P/N-P-N SINGLE ENDED PUSH-PULL OUTPUT STAGE

Tr1	OC81D
Tr2	OC81
Tr3	AC127



All resistors ±10% unless otherwise shown

For operation at $T_{amb} < 45°C$ with each output transistor having a cooling clip.

OUTPUT STAGE

$-V_{CC}$	9	9	V
P_{out}	200	300	mW
R5, R6	3.3	3.3	Ω
R3 resistive bias	120	56	Ω
$I_{C2(q)}+I_{C3(q)}$	3.0	3.0	mA
R3 preset	500	100	Ω
Thermistor bias			
R10	VA1064	VA1040	
$I_{C2(q)}+I_{C3(q)}$	2.0	2.0	mA
R_{load}	30	15	Ω
I_{CM}	115	200	mA
C5	320	320	μF

DRIVER STAGE

$-V2$	4	4	V
I_C	2.7	3.0	mA
R1	2.7	1.2	kΩ
R2	1.5	0.68	kΩ
R4	220	100	Ω
R7	6.8	3.6	kΩ
R9	6.8	2.2	kΩ
*Average input sensitivity for P_{out} max.	52	100	μA
$P_{out} = 50$mW	24	40	μA
D_{tot} at P_{out} max.	3.5	3.0	%
$P_{out} = 50$mW	1.0	1.0	%

FEEDBACK COMPONENTS

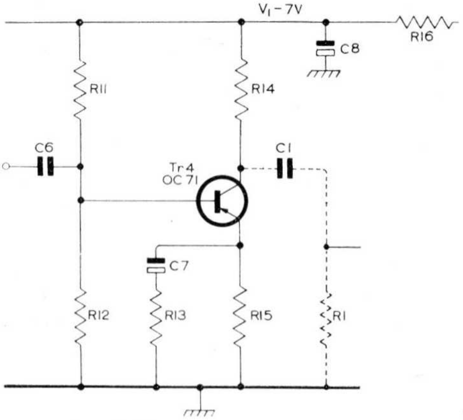
R8	560	220	Ω
C4	390	100	pF

*With 6dB average feedback.

The sensitivity of the two stage amplifier shown is such that to obtain full power output requires the use of a preamplifier. With the preamplifier shown on page 126 the average sensitivity with a 2kΩ source is as shown. The spread in sensitivity is approximately ±3dB.

	$P_{out} = 200$mW	300mW
For $P_{out} = 50$mW	6.9	11.5mV
For P_{out} max.	15	28.5mV

PREAMPLIFIER (for use with 2 stage amplifier)



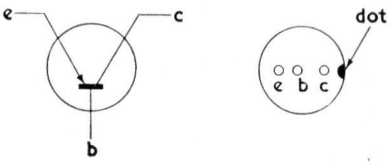
All resistors ±10%

B 219

Tr4	OC71	
I_C	0.6	mA
V1	–7	V
R11	100	kΩ
R12	27	kΩ
R13	120	kΩ
R14	6.8	kΩ
R15	2.2	kΩ
R16	Value will depend on preceeding stages	
C6	0.22	μF
C7	200	μF
C8	100	μF

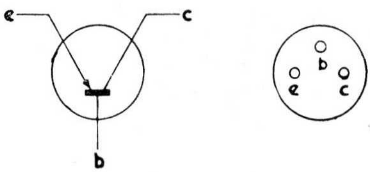
TRANSISTORS OC81D, OC81, AC127

B213



OC81D, OC81

B229



AC127

AUDIO TRANSISTOR PACKAGE

LFK3

DIMENSIONS

Max body length: 15.7mm (AC127: 9.4mm)
Max. diameter: 5.9mm (AC127: 6.1mm)
Min. lead length: 37 mm (AC127: 38 mm)

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Collector voltage	OC81D	OC81	AC127	
Common emitter				
V_{CEM} max.	–15	–15	+15	V
$V_{CE(AV)}$ max.	–15	–15	+15	V
These figures apply with $R_{BE} < 2k\Omega$.				
Reverse emitter-base voltage				
V_{EBM} max.	–1.0	–3.0	+3.0	V
Collector current				
I_{CM} max.	20	200		mA
*$I_{C(AV)}$ max.	10	200		mA
Emitter current				
I_{EM} max.	25	220		mA
*$I_{C(AV)}$ max.	15	220		mA
Base current				
I_{BM} max.	5.0	20		mA
*$I_{B(AV)}$ max.	5.0	20		mA
Total dissipation		See page 140		

$$\left(P_{tot}\text{ max.} = \frac{T_j\text{ max.} - T_{amb}}{\theta}\right)$$

*Averaged over any 20ms period.

Temperature ratings	OC81D	OC81	AC127	
T_{stg} max.	+85	+85	+75	°C
T_{stg} min.	–55	–55	–55	°C
T_j max.	85	85	75	°C
T_j max. (intermittent operation total duration 200 hours max.)	90	90	90	°C
θ_{j-amb}				
without cooling clip in free air	0.4	0.2	0.36	°C/mW
with type (a) or extended type (b) cooling clip (see outline drawing on page 129) ..	—	0.15	—	°C/mW
with cooling clip (see outline drawing on page 129)	—	—	0.22	°C/mW
with standard clip type (b) on a heatsink 5×7cm, 16 s.w.g. aluminium	—	0.1	—	°C/mW
with cooling clip on a heatsink of 12.5cm². .	—	—	0.16	°C/mW

Mullard

LFK3 (Cont.)

AUDIO TRANSISTOR PACKAGE

CHARACTERISTICS ($T_j = 25°C$)

		Typical production spread					
		OC81D	OC81		AC127		
Common base							
Collector leakage current	I_{CBO}		*Typ.*	*Max.*	*Typ.*	*Max.*	
($V_{CB} = 10V$, $I_E = 0mA$)		<13	4.5	10	5.0	10	µA
($V_{CB} = 10V$, $I_E = 0mA$, $T_j = 75°C$)		—	150	250	350	650	µA
Common emitter							
Current amplification factor	h_{fe}						
($V_{CE} = -2V$, $I_C = 3mA$)		>25	—	—	—	—	

		OC81	AC127	
Base input voltage	V_{BE}	*Typ.*	*Typ.*	
($V_{CE} = 6V$, $I_C = 2mA$)		−125	+125	mV
Collector knee voltage	$V_{CE(knee)}$			
($I_C = 200mA$)		−300	+300	mV

LARGE SIGNAL CHARACTERISTICS FOR OC81 and AC127. ($T_j = 25°C$)

Static characteristics

		OC81		AC127		
Current amplification factor	h_{FE}					
($V_{CE} = 1.0V$, $I_C = 200mA$)		>50		>50		
($V_{CE} = 0V$, $I_C = 50mA$)		>65		>65		
Base input voltage	V_{BE}	*Typ.*	*Max.*	*Typ.*	*Max.*	
($V_{CE} = 1V$, $I_C = 100mA$)		−300	−450	+225	+400	mV

CHARACTERISTICS OF MATCHED PAIR AC127/OC81. ($T_j = 25°C$)

Ratio of the current amplification factors of the two transistors at : $I_C = 50mA$ .. .. <1.2 : 1

OPERATING NOTES

1. Transistors may be soldered directly into the circuit but the heat conducted to the junction should be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip soldered at a solder temperature of 245°C for a maximum of 5 seconds up to a point 1.5mm from the seal. The temperature of the envelope in contact with the printed board must not exceed 115°C for two minutes.
3. Care should be taken not to bend the leads nearer than 1.5mm to the seal.

COOLING CLIPS

Type (a)

Intended for operation in free air and not recommended for bolting on to a heatsink.

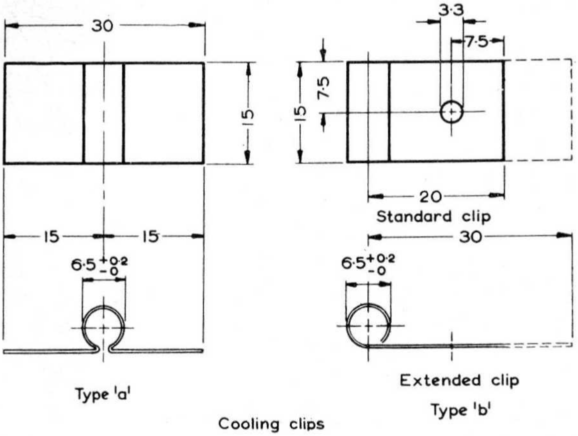
Type (b)

Extended version. (Area 15 × 30mm). Intended for operation in free air but may be bolted on to such materials as paxolin without deterioration in the thermal resistance.

Standard version. (Area 15 × 20mm). Intended to be bolted on to a heatsink.

COOLING CLIPS

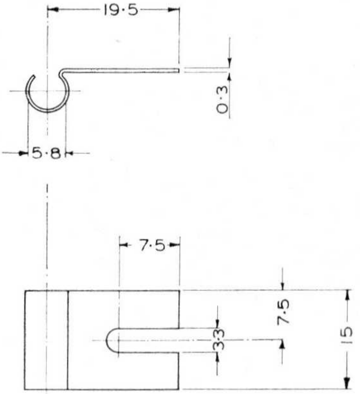
OC81
OC81D



Cooling clips

Material: 0·5mm copper strip commercial half-hard BS899

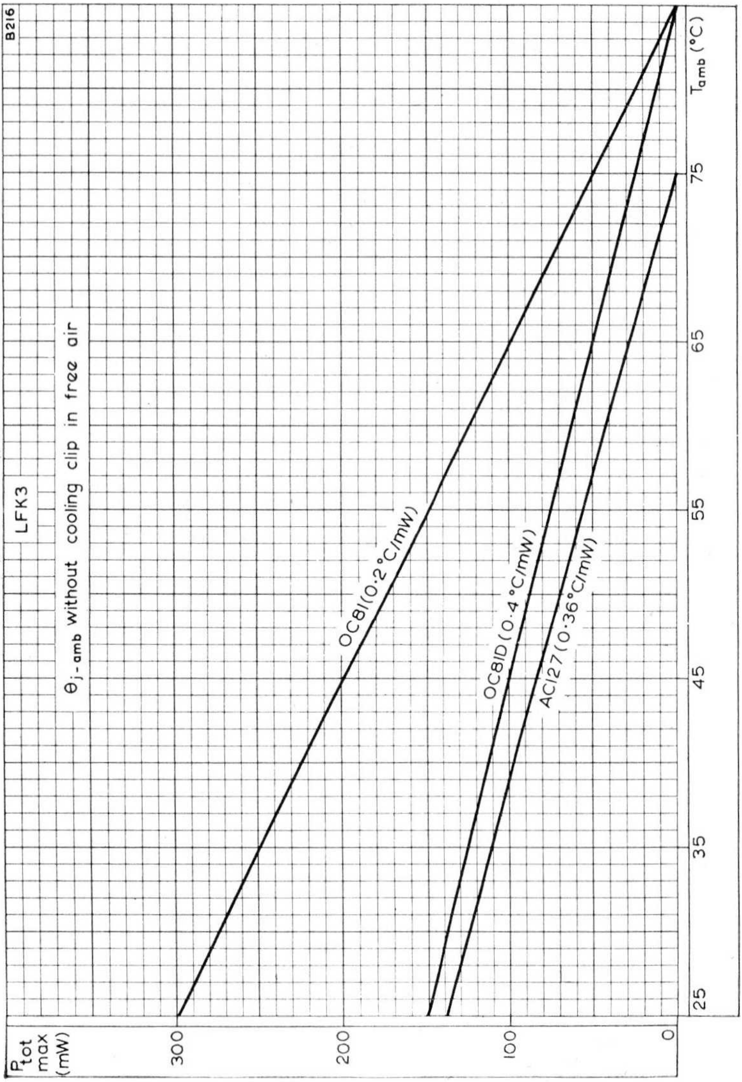
AC127



Dimensions of cooling fin

B218

Material: Cadmium plated steel



MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

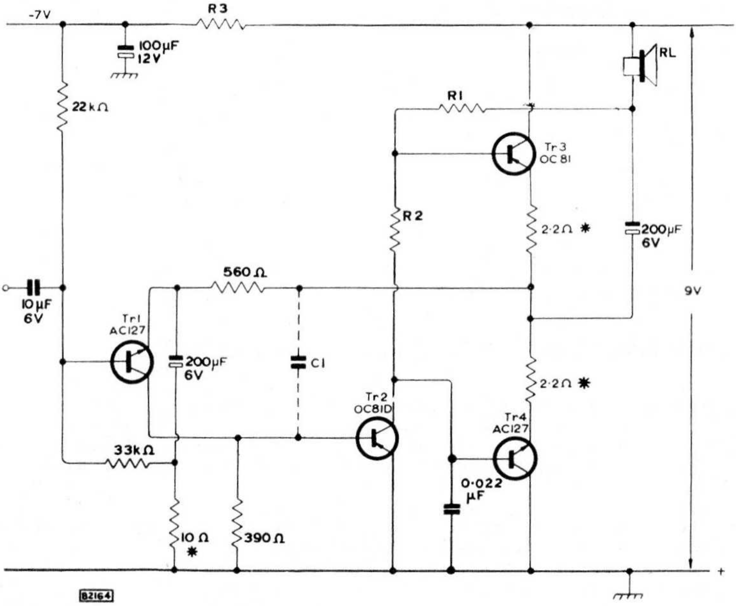
AUDIO TRANSISTOR PACKAGE LFK4

A package of four audio transistors, comprising an AC127 pre-amplifier, an OC81D driver and a complementary n-p-n/p-n-p matched pair of OC81/AC127, intended for use in transformerless audio amplifier stages in portable receivers.

THREE STAGE AMPLIFIER WITH CLASS "B" N-P-N/P-N-P OUTPUT STAGE

A simple d.c. coupled circuit, using a minimum of components and offering low driver current is illustrated below.

The achievable output with 9V supply is approximately 700mW, while at 12V about 1W may be obtained. The circuit as specified is for operation from a 9V battery, but may be operated with suitable modifications from a 12V supply.



All resistance values ±5%, except those marked* which may be ±10%.

LFK4 (Cont.)

CIRCUIT VALUES AND PERFORMANCE

The performances quoted are based on the series resistance of the 200μF capacitors being less than 2Ω. With each transistor mounted in a cooling clip (as shown page 131) bolted to a heatsink of 1mm thick aluminium, 12.5sq.cm area, the circuit is thermally stable up to 45°C ambient.

Loudspeaker impedance	Z_L	10	15	Ω
	R_1	680	1000	Ω
	R_2	47	68	Ω
	C_1	8200	6800	pF
Quiescent driver current	$I_{C}2_{(q)}$	6.2	4.2	mA
Total quiescent current	$I_{C(q)tot}$	9.8	7.8	mA
P_{out} (D_{tot} = 5%)		500	400	mW

DRIVE REQUIREMENTS

Loudspeaker resistance	10	15	Ω
Input voltage (r.m.s.) (e.m.f. from a generator with 2.0kΩ source impedance)			
For 50mW	16	17	mV
For 400mW	—	60	mV
For 500mW	62	—	mV

The value of C_1 given introduces a treble cut having a value of –3db at 4kc/s.

R_3 should be chosen to give the voltage shown taking into account the total current consumption of preceding stages.

TRANSISTORS. OC81, OC81D, AC127. For data see LFK3.

SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, the transistors may be soldered directly into a circuit, but the heat conducted to the junction should be minimised by the use of a heat shunt.
2. These transistors may be dip-soldered at a solder temperature of 245°C for a maximum time of 5 seconds. The case temperature during dip-soldering may exceed the maximum storage temperature for a period not exceeding 2 minutes, provided that it at no time exceeds 115°C. These recommendations apply to a transistor mounted flush on a board with punched-through holes or spaced 1.5mm above the board with plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seals.

MARKING

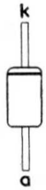
The complementary matched output pair are identified by means of an orange dot on the top.

GERMANIUM DIODE

OA90

Germanium diode of all-glass construction intended for industrial applications.

B2O6



DIMENSIONS

Max. overall length	66.5	mm
Max. diameter	3.5	mm
Max. body length without leads	7.6	mm

ABSOLUTE MAXIMUM RATINGS ($T_{amb} = 75°C$)

Maximum inverse voltage

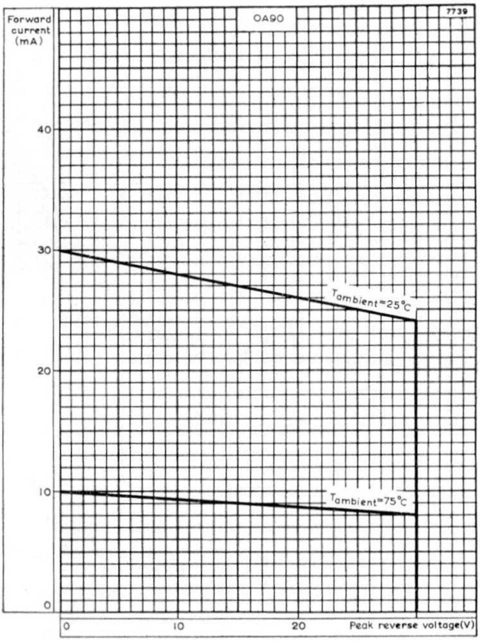
Peak	30	V
Average (averaged over any 50ms period or d.c. component) ..	20	V
Surge (in video detector applications)	40	V

Maximum forward current

Peak	45	mA
*Average (averaged over any 50ms period or d.c. component) ..	10	mA
Surge (occasional overload max. duration 1.0s)	200	mA

Temperature ratings	$T_{storage}$	$T_{ambient}$	
Maximum	+90	+75	°C
Minimum	–55	–55	°C
Junction temperature rise above ambient in free air		0.4	°C/mW

*The maximum forward current is 10mA at 75°C and when the inverse voltage over any part of the cycle is zero. For other values of inverse voltage and temperature see curve below.



OA90 (Cont.)

GERMANIUM DIODE

CHARACTERISTICS

Typical production spread

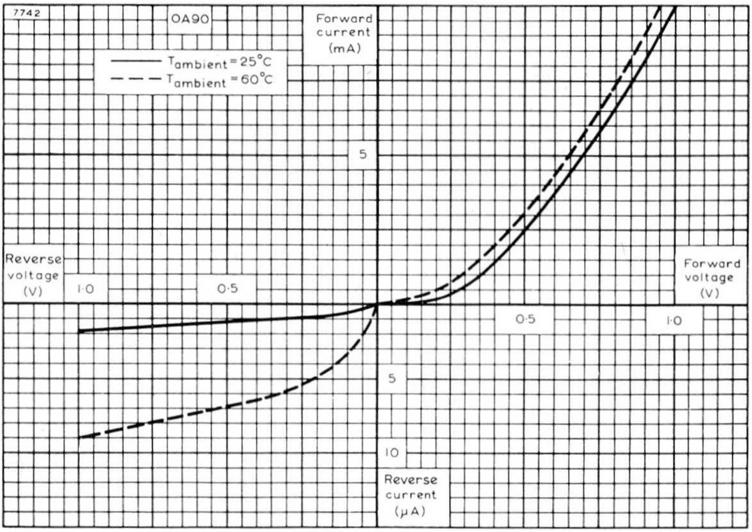
At T_{amb}	25			60			°C
	Min.	*Typ.*	*Max.*	*Min.*	*Typ.*	*Max.*	
Forward voltage at forward current of							
100µA	100	180	250	50	120	200	mV
10mA	0.5	1.0	1.5	0.4	0.95	1.4	V
30mA	1.1	2.0	3.2	1.0	1.95	3.1	V

	Typ.	*Max.*	*Typ.*	*Max.*	
Reverse current at reverse voltage of					
1.5V	2.4	10	11	40	µA
10V	20	135	45	270	µA
20V	90	450	140	650	µA
30V	0.3	1.1	0.4	1.5	mA

DYNAMIC CHARACTERISTICS at $T_{amb} = 25°C$

f	30	40	40	40	Mc/s
$v_{in(pk)}$	5.0	5.0	1.4	0.5	V
R	3.9	3.0	3.0	3.0	kΩ
C	10	10	10	10	pF
*η	60	63	54	34	%
R_d	2.9	2.4	2.8	3.7	kΩ

*η = (d.c. output voltage/peak input voltage) × 100.



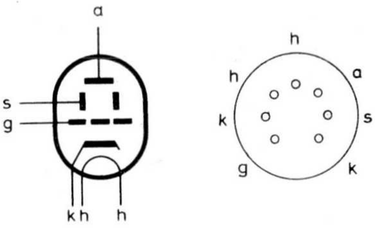
LOW LEVEL CHARACTERISTICS AT AMBIENT TEMPERATURES OF 25 AND 60°C.

Mullard

R.F. TRIODE

PC900

Triode with low anode-to-grid capacitance intended for use as an r.f. amplifier in v.h.f. television receivers.



B7G

HEATER

Suitable for series operation a.c. or d.c.

I_h	300	mA
V_h	4.0	V

DIMENSIONS

Max. overall length	41.9	mm
Max. seated height	34.9	mm
Max. diameter	19	mm

CAPACITANCES (with external shield)

c_{a-g}	350	mpF
$c_{a-k+h+s}$	3.0	pF
$c_{g-k+h+s}$	4.5	pF
c_{a-k}	80	mpF
c_{g-k}	3.3	pF
c_{g-h}	<70	mpF
c_{k-h}	2.3	pF

CHARACTERISTICS

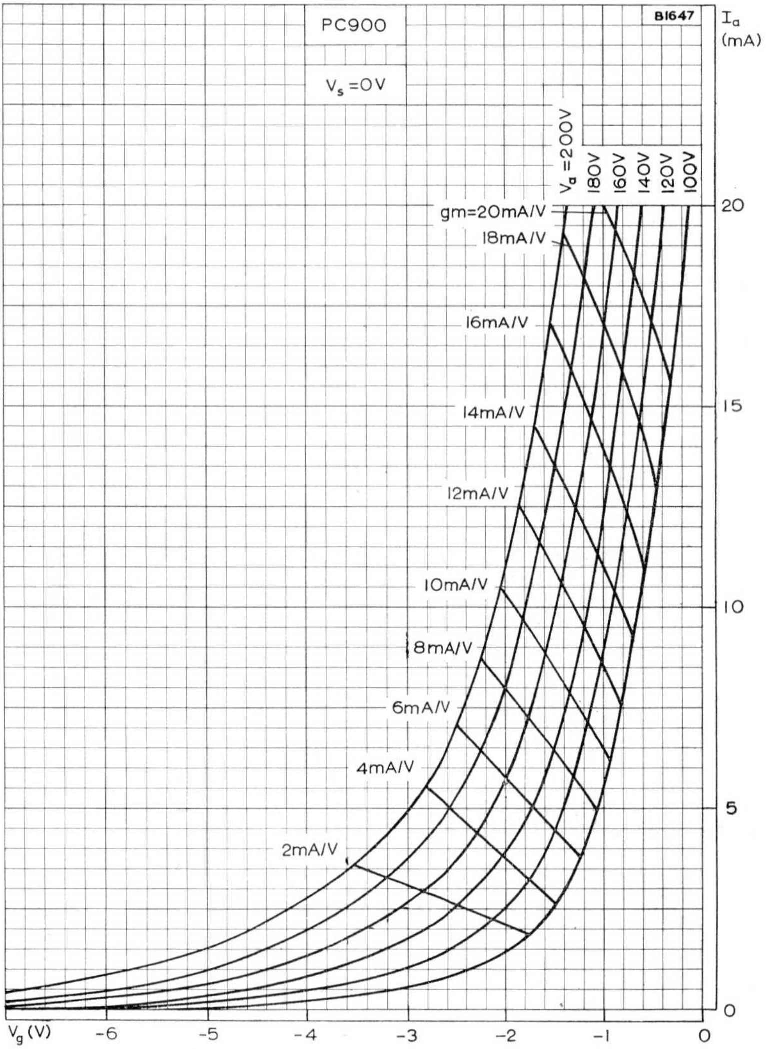
V_a	135	V
I_a	11.5	mA
V_g	–1.0	V
g_m	14.5	mA/V
μ	72	
r_a	5.0	kΩ

DESIGN CENTRE RATINGS

$V_{a(b)}$ max.	550	V
V_a max.	200	V
p_a max.	2.2	W
I_k max.	20	mA
$-V_g$ max.	50	V
R_{g-k} max.	1.0	MΩ
V_{h-k} max.	100	V

OPERATING CONDITIONS

	1	2	3	
V_b	135	200	200	V
R_a	1.0	4.7	5.6	kΩ
R_k	0	0	82	Ω
I_a	17	17	11.5	mA
I_g	10	10	0	μA
V_g	–0.5	–0.5	1.0	V
g_m	20	20	14.5	mA/V
μ	80	80	72	
V_g for 10 : 1 reduction in g_m	–2.4	–3.3	–3.8	V
V_g for 100 : 1 reduction in g_m	–5.3	–7.7	–8.1	V



ANODE CURRENT PLOTTED AGAINST GRID VOLTAGE WITH ANODE VOLTAGE AS PARAMETER

R.F. DOUBLE TRIODE

PCC89

Variable-mu double triode primarily intended for use as a cascode r.f. amplifier at frequencies up to 220Mc/s in television receivers with series connected heaters.

HEATER

I_h	300	mA
V_h	7.5	V

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

CAPACITANCES (shielded*)

$c_{a'-a''}$	<15	mpF
$c_{g'-a''}$	<5.0	mpF

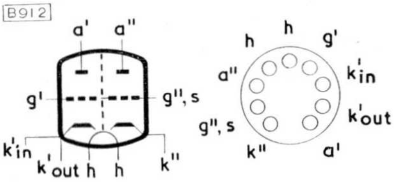
Grounded cathode section

$c_{a'-g'}$	1.9	pF
$c_{in'}$	3.8	pF
$c_{out'}$	2.5	pF
$c_{g'-h}$	<300	mpF

Grounded grid section

$c_{a''-g''}$	4.1	pF
$c_{a''-k''}$	<200	mpF
$c_{k''-g''+h+s}$	6.3	pF
$c_{a''-g''+h+s}$	4.5	pF
$c_{h-k''}$	2.9	pF

*Shield connected to same terminal as g″



B9A

LIMITING VALUES

(each section unless otherwise specified)

V_a max.	130	V
p_a max.	1.8	W
I_k max.	18	mA
$-V_g$ max.	50	V
$R_{g'-k'}$ max.	1.0	MΩ
$R_{g''-k''}$	500	kΩ
$V_{h-k'(r.m.s.)}$ max.	50	V
$V_{h-k''}$ max. (cathode positive)	200	V
R_{h-k} max.	20	kΩ

CHARACTERISTICS (each section)

V_a	90	V
I_a	15	mA
V_g	-1.2	V
g_m	12.3	mA/V
μ	36	
r_a	2.9	kΩ

The triode on pins 6, 7, 8 and 9 should have grounded cathode connection and that on pins 1, 2 and 3 should have grounded grid connection. It is recommended that pins 7 and 8 should be strapped.

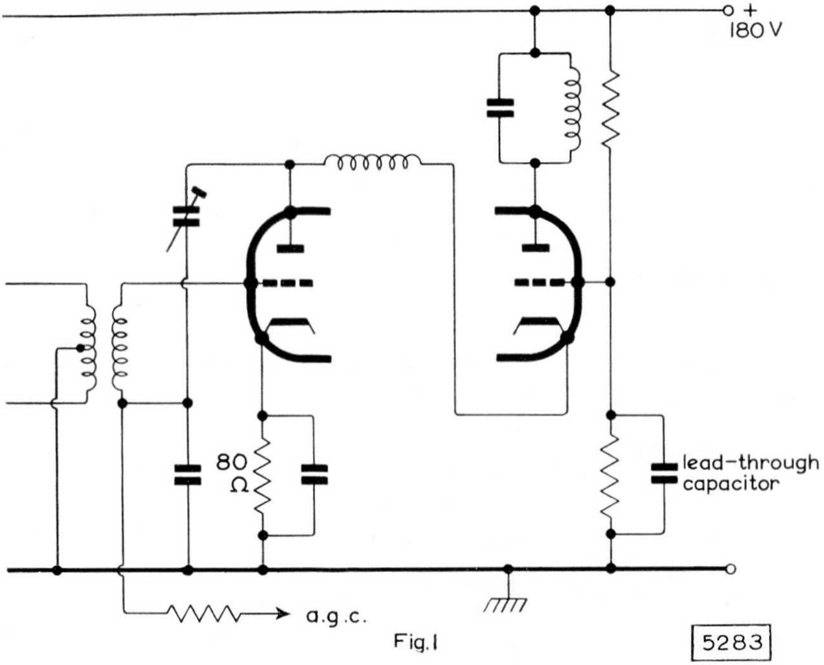
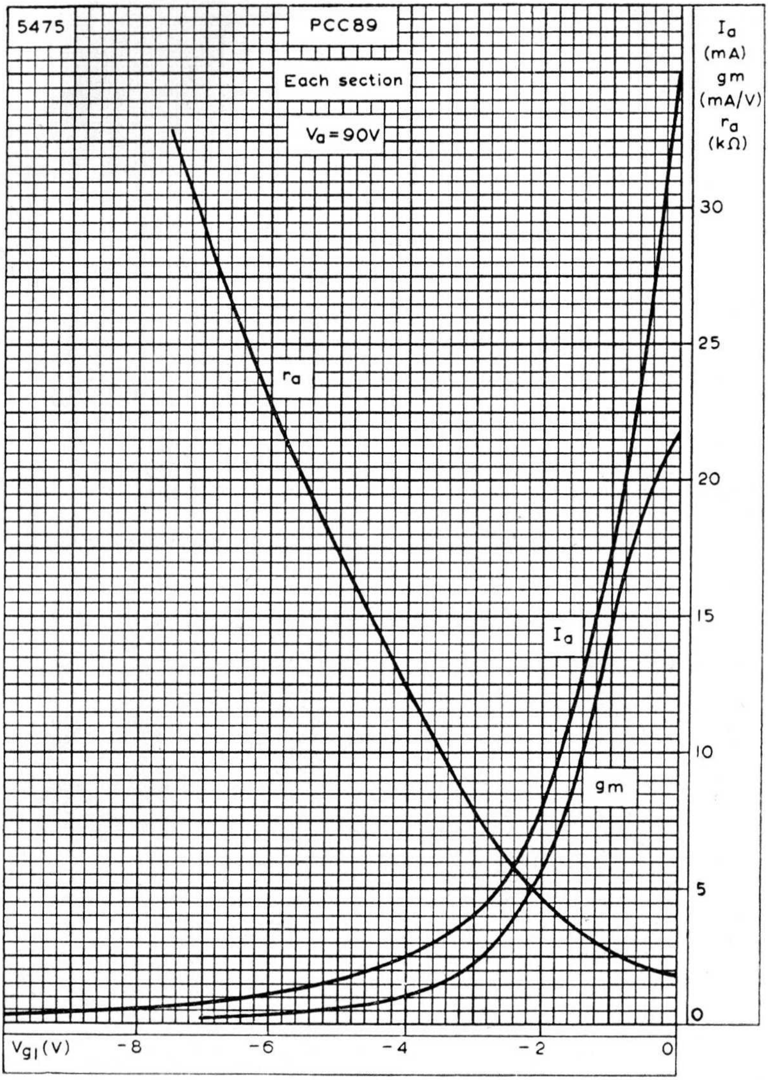


Fig. 1

CHARACTERISTICS (cascode—see Fig. 1)

V_b	180	V
I_a	15	mA
g_m	12	mA/V
$*V_{g'}$	−9.0	V
Noise factor	5.5	dB

*For 100 : 1 reduction in cascode slope.

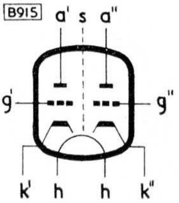


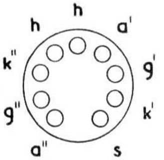
ANODE CURRENT, MUTUAL CONDUCTANCE AND ANODE IMPEDANCE PLOTTED AGAINST GRID VOLTAGE

PCC189

V.H.F. DOUBLE TRIODE

Variable-mu, low noise v.h.f. frame grid double triode with high mutual conductance for use as a cascode amplifier.





B9A

HEATER

I_h	300	mA
V_h	7.6	V

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

CAPACITANCES Shielded

$c_{a'-a''}$	<15	mpF
$c_{g'-a''}$	<4.0	mpF

Grounded cathode section

$c_{a'-g'}$	1.9	pF
$c_{g'-k'+h+s}$	3.5	pF
$c_{a'-k'+h+s}$	2.3	pF
$c_{g'-h}$	<280	mpF

Grounded grid section

$c_{a''-g''}$	1.9	pF
$c_{k''-g''+h+s}$	6.0	pF
$c_{a''-g''+h+s}$	4.0	pF
$c_{k''-h}$	3.0	pF
$c_{a''-k''}$	170	mpF

CHARACTERISTICS (each section)

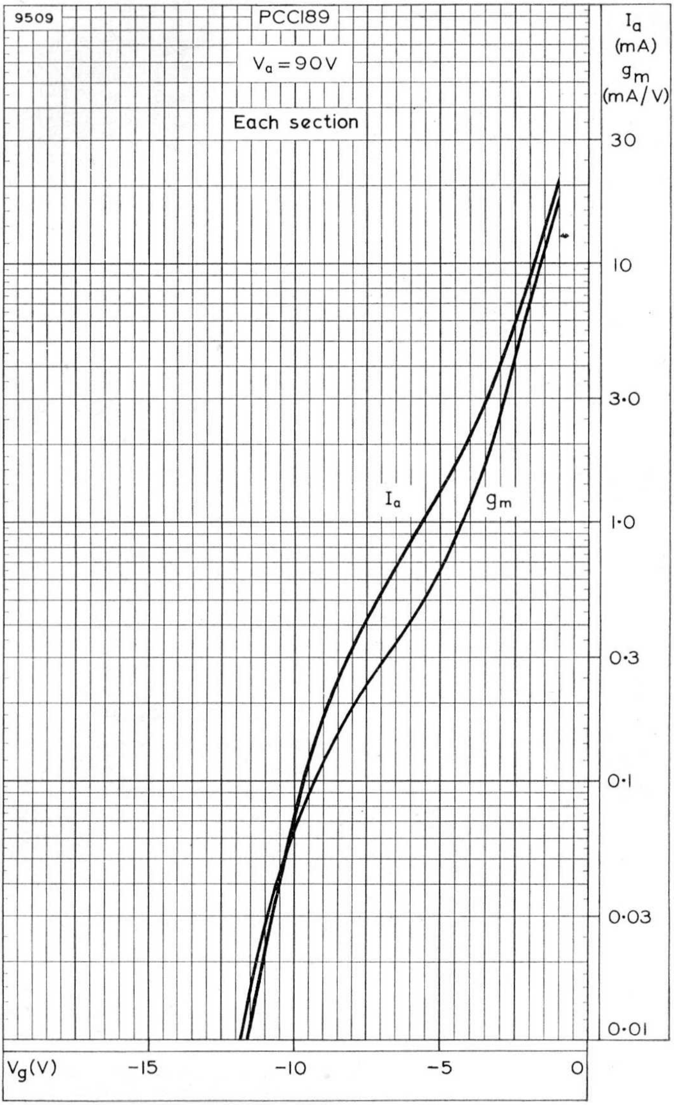
V_a	90	V
V_g	−1.4	V
I_a	15	mA
g_m	12.5	mA/V
r_a	2.5	kΩ
μ	34	
V_g (for 20 : 1 reduction in g_m)	−5.0	V
V_g (for 100 : 1 reduction in g_m)	−9.0	V

DESIGN CENTRE RATINGS (each section)

$V_{a(b)}$ max.	550	V
V_a max.	130	V
p_a max.	1.8	W
I_k max.	22	mA
$-V_g$ max.	50	V
$R_{g'-k}$ max.	1.0	MΩ
$R_{g''-k}$ max.	500	kΩ
$V_{h-k'}$ max.	80	V
$V_{h-k''}$ max. (cathode positive)	180	V
R_{h-k} max.	20	kΩ

NOTE

In order not to exceed the maximum permissible anode voltage when the cascode amplifier is controlled, it is necessary to use a voltage divider or the grid of the grounded grid section.

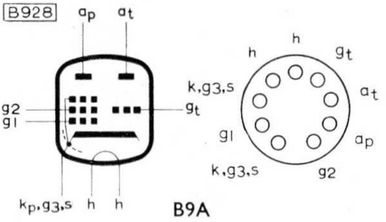


ANODE CURRENT AND MUTUAL CONDUCTANCE PLOTTED AGAINST GRID VOLTAGE

PCF86

TRIODE PENTODE

Combined triode and high slope frame grid r.f. pentode for use as a frequency changer at frequencies up to 220Mc/s in television tuners.



HEATER

Suitable for series operation, a.c. or d.c.

I_h	300	mA
V_h	8.0	V

CAPACITANCES

(measured without an external shield)

c_{ap-at}	125	mpF
c_{ap-gt}	14	mpF
c_{g1-at}	$<$10	mpF
c_{g1-gt}	$<$10	mpF

Pentode section

c_{a-g1}	12	mpF
c_{g1-g2}	1.7	pF
c_{in}	5.8	pF
c_{out}	3.5	pF

Triode section

c_{g-k+h}	2.4	pF
c_{a-k+h}	1.1	pF
c_{a-g}	2.0	pF

CHARACTERISTICS

Pentode section

V_a	170	V
V_{g2}	150	V
I_a	10	mA
I_{g2}	3.3	mA
g_m	12	mA/V
r_a	$>$350	kΩ
μ_{g1-g2}	70	
V_{g1}	−1.2	V
R_{eq}	1.0	kΩ

Triode section

V_a	100	V
I_a	14	mA
g_m	5.7	mA/V
μ	17	
V_g	−3.0	V

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

OPERATING CONDITIONS

As a frequency changer

Pentode section

V_a	190	V
$V_{g2(b)}$	190	V
R_{g2}	18	kΩ
R_{g1}	100	kΩ
I_a	8.5	mA
I_{g2}	2.7	mA
$V_{osc(r.m.s.)}$	2.3	V
g_c	4.5	mA/V

LIMITING VALUES

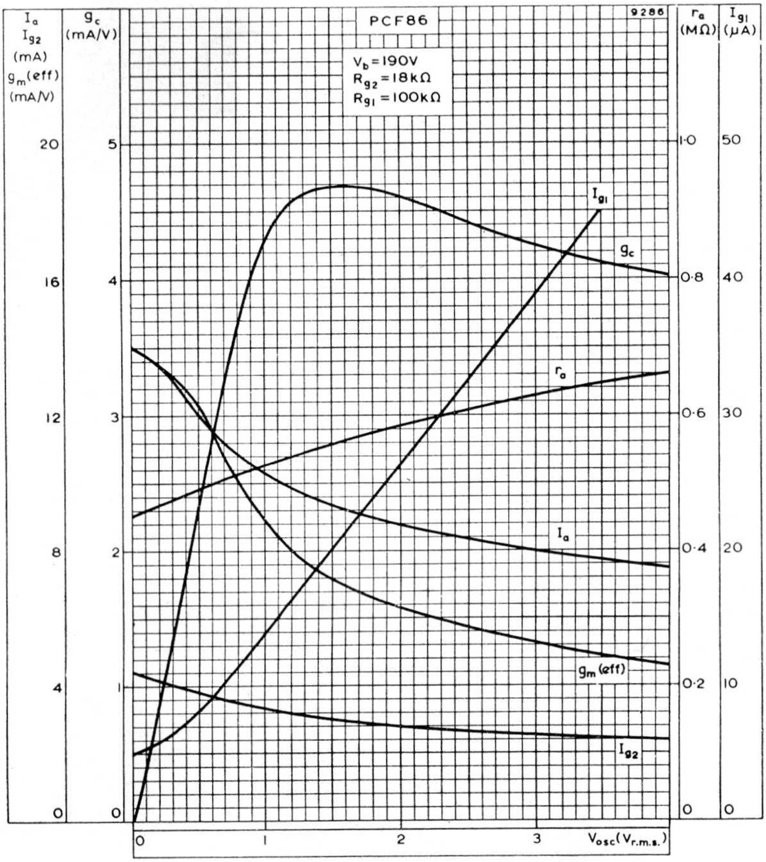
Pentode section

V_a max.	250	V
p_a max.	2.0	W
V_{g2} max.	150	V
p_{g2} max.	500	mW
I_k max.	18	mA
R_{g1-k} max.	250	kΩ

Triode section

V_a max.	125	V
p_a max.	1.5	W
I_k max.	15	mA
R_{g-k} max.	500	kΩ
*V_{h-k} max.	100	V

*To fulfil hum requirements on a.m. sound, it will be necessary for V_{h-k} to be less than $50V_{r.m.s.}$ For intercarrier receivers V_{h-k} should not exceed $75V_{r.m.s.}$



PERFORMANCE CURVES FOR USE AS A FREQUENCY CHANGER

PCF801

TRIODE PENTODE

Combined triode and frame-grid, variable-mu pentode for use as a frequency changer and i.f. amplifier at frequencies up to 200Mc/s in television receivers.

HEATER

Suitable for series operation a.c. or d.c.

I_h	300	mA
V_h	8.0	V

DIMENSIONS

Max. overall length	50.6	mm
Max. seated height	43.6	mm
Max. diameter	22.2	mm

CAPACITANCES

c_{ap-at}	$<$25	mpF
c_{ap-gt}	$<$10	mpF
c_{g1-at}	$<$10	mpF
c_{g1-gt}	$<$10	mpF

Pentode section (with external shield)

c_{a-g1}	9.0	mpF
c_{a-g1} max.	12	mpF
c_{g1-g2}	1.6	pF
c_{in}	6.2	pF
c_{out}	3.7	pF

Triode section

c_{a-g}	1.8	pF
c_{in}	3.3	pF
c_{out}	1.7	pF

OPERATING CONDITIONS AS FREQUENCY CHANGER

Pentode section

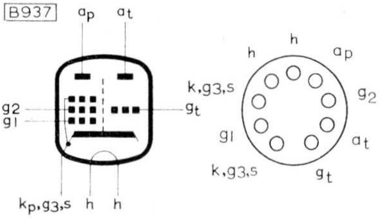
V_b	200	200	V
R_a	2.7	4.7	kΩ
R_{g2}	27	27	kΩ
R_{g1}	0.1	1.0	MΩ
I_a	10	9.3	mA
I_{g2}	3.0	2.9	mA
I_{g1}	8.0	2.3	μA
V_{g1}	–1.4	*	V
$V_{osc(r.m.s.)}$	1.6	1.6	V
g_c	5.0	4.7	mA/V

*With grid current bias.

DESIGN CENTRE RATINGS

Pentode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	2.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	450	mW
I_k max.	18	mA
$-V_{g1}$ max.	50	V
R_{g1-k} max.	1.0	MΩ



B9A

CHARATERISTICS

Pentode section

V_a	170	V
V_{g2}	120	V
I_a	10	mA
I_{g2}	3.0	mA
g_m	11	mA/V
r_a	$\geqslant$350	kΩ
μ_{g1-g2}	55	
V_{g1}	–1.4	V
R_{eq}	1.5	kΩ

Triode section

V_a	100	V
I_a	15	mA
g_m	9.0	mA/V
μ	20	
V_g	–3.0	V

OPERATING CONDITIONS

as i.f. amplifier

Pentode section

V_b	200	200	V
R_a	2.7	4.7	kΩ
R_{g2}	27	27	kΩ
R_{g1}	0.1	1.0	MΩ
I_a	10	13	mA
I_{g2}	3.0	3.7	mA
V_{g1}	–1.4	*	V
g_m	11	14.5	mA/V
V_{g1} (for 100 : 1 reduction in g_m)	–12	—	V
R_{in} ($f = 50$Mc/s)	10	10	kΩ

*With grid current bias.

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	125	V
p_a max.	1.5	W
I_k max.	20	mA
$-V_g$ max.	50	V
R_{g-k} max.	500	kΩ
*V_{h-k} max.	100	V

*To fulfil hum requirements on a.m. sound, it will be necessary for V_{h-k} to be less than 50$V_{r.m.s.}$

TRIODE PENTODE

PCF802

Triode pentode for use in line oscillator circuits, the pentode section as an oscillator and the triode section as a reactance valve.

HEATER

Suitable for series operation a.c. or d.c.

I_h	300	mA
V_h	9.0	V

CAPACITANCES

Pentode section

c_{a-g1}	50	mpF
c_{g1-h}	<100	mpF
c_{in}	5.4	pF

Triode section

c_{a-g}	1.5	pF
c_{g-h}	<100	mpF
c_{in}	2.4	pF

DESIGN CENTRE RATINGS

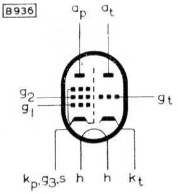
Pentode section

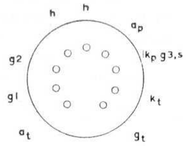
$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.2	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	800	mW
I_k max.	15	mA
*$i_{k(pk)}$ max.	50	mA
R_{g1-k} max.	560	kΩ
†V_{h-k} max.	100	V
†Z_{g1-k} (f = 50c/s) max.	300	kΩ

*t_p max. = 30µs, duty factor max. -0.3.

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.5	W
I_k max.	10	mA
R_{g-k} max.	3.0	MΩ
†V_{h-k} max.	100	V
†Z_{g-k} (f = 50c/s) max.	50	kΩ





B9A

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

CHARACTERISTICS

Pentode section

V_a	100	V
V_{g2}	100	V
I_a	6.0	mA
I_{g2}	1.7	mA
V_{g1}	-1.0	V
g_m	5.5	mA/V
μ_{g1-g2}	47	
r_a	400	kΩ
V_a	200	V
V_{g2}	200	V
I_a	10	µA
V_{g1}	<-16	V

Triode section

V_a	200	V
I_a	3.5	mA
V_g	-2.0	V
g_m	3.5	mA/V
μ	70	
r_a	20	kΩ

†To avoid hum interference the a.c. component of V_{h-k} should not exceed 65V at the specified value of Z_{g1-k}.

PCH200

TRIODE HEPTODE

Triode heptode intended for use as a noise-cancelled synchronising pulse separator and clipper.

HEATER

Suitable for series or parallel operation, a.c. or d.c.

I_h	300	mA
V_h	9.0	V

CAPACITANCES

c_{ah-at}	<150	mpF
c_{g1-at}	<10	mpF
c_{g1-gt}	<10	mpF
c_{g3-at}	<30	mpF

Heptode section

c_{out}	6	pF
c_{a-g1}	<100	mpF
c_{a-g3}	<250	mpF
c_{g1-g3}	300	mpF

Triode section

c_{in}	3.5	pF
c_{out}	2.2	pF
c_{a-g}	1.8	pF

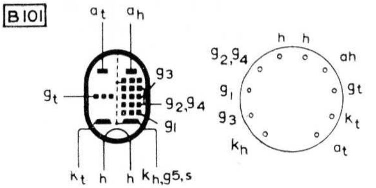
CHARACTERISTICS

Heptode section

V_a	14	V
V_{g2+g4}	14	V
I_a	800	μA
I_{g2+g4}	900	μA
I_{g3}	1.0	μA
I_{g1}	30	μA
V_{g3} ($I_a = 20\mu A$, $I_{g1} = 30\mu A$)	−2.0	V
V_{g1} ($I_a = 20\mu A$, $V_{g3} = +25V$)	−2.0	V
V_{g3} max. ($I_{g3} = 0.3\mu A$)	<−1.3	V
V_{g1} max. ($I_{g1} = 0.3\mu A$)	<−1.3	V

Triode section

V_a	100	V
I_a	9.5	mA
V_g	−1.0	V
g_m	8.5	mA/V
μ	48	



B10B

DIMENSIONS

Max. overall length	56	mm
Max. seated height	49	mm
Max. diameter	22.2	mm

OPERATING CONDITIONS

V_a	1	14	V
V_{g2+g4}	14	14	V
I_a	>200	800	μA
I_{g3}	1.0	1.0	μA
I_{g1}	30	30	μA

DESIGN CENTRE RATINGS

Heptode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.0	W
$V_{g2+g4(b)}$ max.	550	V
V_{g2+g4} max.	50	V
V_{g2+g4} min.	10	V
p_{g2+g4} max.	500	mW
$-v_{g1(pk)}$ max.	150	V
$-v_{g3(pk)}$ max.	150	V
I_k max.	12.5	mA
R_{g1-k} max.	3.0	MΩ
R_{g3-k} max.	3.0	MΩ
V_{h-k} max.	100	V

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.5	W
$-v_{g(pk)}$ max.	200	V
I_k max.	20	mA
R_{g-k} max.	3.0	MΩ
V_{h-k} max.	100	V

TRIODE PENTODE (separate cathodes)

PCL84

Combined triode and output pentode for use in television receivers with the triode as keyed a.g.c. valve, sync-separator, sync-amplifier or for use in noise suppression circuits and the pentode section as video output valve.

HEATER

I_h	300	mA
V_h	15	V

DIMENSIONS

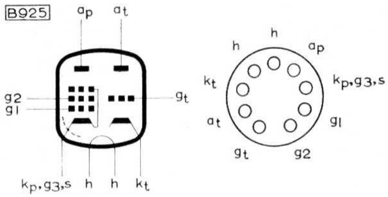
Max. overall length	67.5	mm
Max. seated height	60.5	mm
Max. diameter	22.2	mm

CAPACITANCES

c_{at-g1}	<10	mpF
c_{gt-g1}	<10	mpF
Pentode section		
c_{in}	8.7	pF
c_{out}	4.2	pF
c_{a-g1}	<100	mpF
Triode section		
c_{g-k}	3.8	pF
c_{a-k}	2.3	pF
c_{a-g}	2.7	pF
c_{g-h}	<100	mpF

CHARACTERISTICS
Triode section

V_a	200	V
V_g	−1.7	V
I_a	3.0	mA
g_m	4.0	mA/V
r_a	16.2	kΩ
μ	65	



B9A

LIMITING VALUES
Pentode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	4.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	1.7	W
I_k max.	40	mA
R_{g1-k} max. (fixed bias)	1.0	MΩ
V_{h-k} max.	200	V

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	1.0	W
$i_{k(pk)}$ max.	160	mA
I_k max.	12	mA
R_{g-k} max. (fixed bias)	1.0	MΩ
V_{h-k} max. (cathode negative)	150	V
*$v_{h-k(pk)}$ max. (cathode positive)	350	V

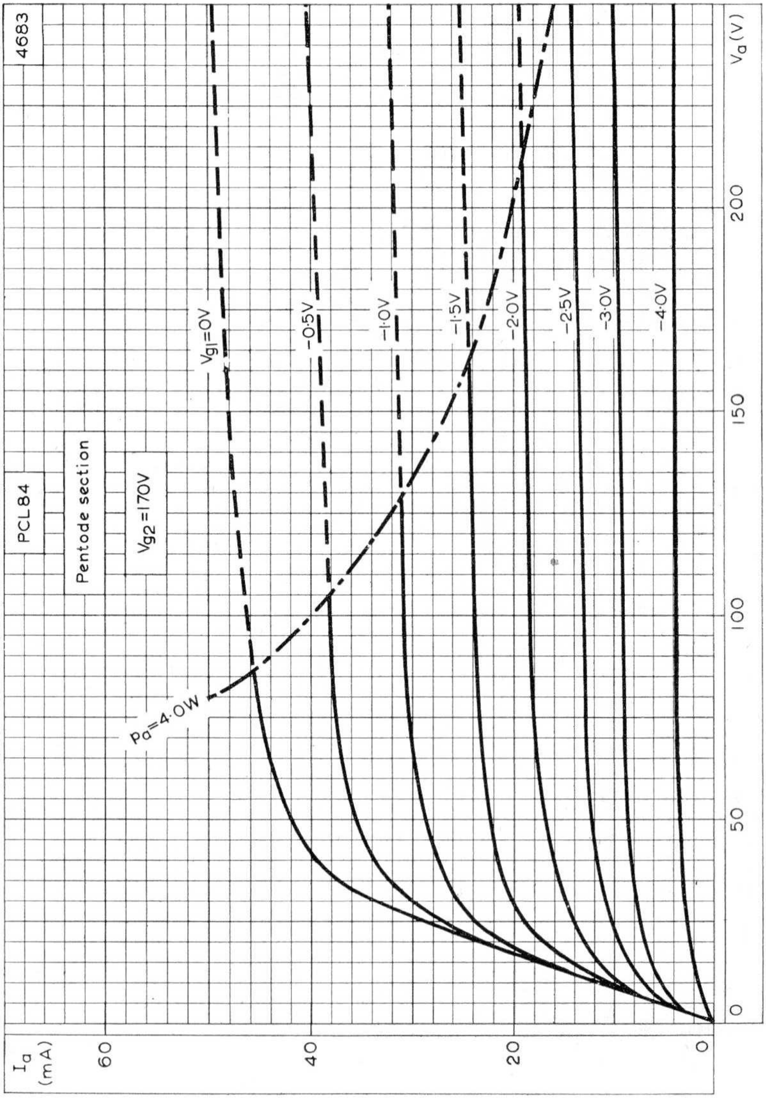
*Max. d.c. component = 200V

CHARACTERISTICS
Pentode Section

V_a	170	200	220	V
V_{g2}	170	200	220	V
V_{g1}	−2.1	−2.9	−3.4	V
I_a	18	18	18	mA
I_{g2}	3.0	3.0	3.0	mA
g_m	11	10.4	10	mA/V
r_a	100	130	150	kΩ
μ_{g1-g2}	36	36	36	

PENTODE SECTION AS VIDEO OUTPUT VALVE

$V_b = V_{g2}$	170	200	220	V
V_{g1}	−2.0	−2.8	−3.3	V
R_a	3.0	3.0	3.0	kΩ
I_a	18	18	18	mA
I_{g2}	3.2	3.1	3.1	mA
g_m	10.4	10	9.7	mA/V



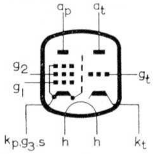
ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE WITH CONTROL-GRID VOLTAGE AS PARAMETER. $V_{g2} = 170V$

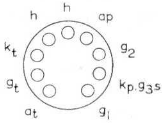
TRIODE PENTODE

PCL85

Combined triode pentode with separate cathodes for use as a field oscillator and field output valve in television receivers employing 110° tubes.

B931





B9A

HEATER

I_h	300	mA
V_h	18	V

CAPACITANCES

c_{ap-gt}	<40	mpF
c_{at-g1}	<80	mpF
c_{gt-g1}	<30	mpF
c_{at-ap}	130	mpF
Pentode section		
c_{in}	12.5	pF
c_{out}	9.0	pF
c_{a-g1}	450	mpF
c_{g1-h}	<200	mpF
Triode section		
c_{a-k+h}	350	mpF
c_{g-k+h}	2.8	pF
c_{a-g}	1.9	pF
c_{g-h}	<140	mpF

DIMENSIONS

Max. overall length	78.5	mm
Max. seated height	71.5	mm
Max. diameter	22.2	mm

CHARACTERISTICS

Pentode Section

V_a	50	65	170	V
V_{g2}	170	210	170	V
I_a	200	285	41	mA
I_{g2}	35	45	2.7	mA
V_{g1}	−1.0	−1.0	−15	V
g_m	—	—	7.25	mA/V
μ_{g1-g2}	—	—	7.0	
r_a	—	—	25	kΩ

Triode Section

V_a	100	V
I_a	5.0	mA
V_g	−0.85	V
g_m	5.7	mA/V
μ	60	
r_a	11	kΩ

TYPICAL OPERATION

Pentode Section as field output valve

Stabilised circuits

See nomogram on page 150.

Non-stabilised circuits

To allow for valve spread and deterioration during life the field output circuit should be designed around the following values:

V_a min.	55	V
V_{g2}	170	V
$i_{a(pk)}$	130	mA

PCL85 (Cont.)

TRIODE PENTODE

LIMITING VALUES

Pentode section

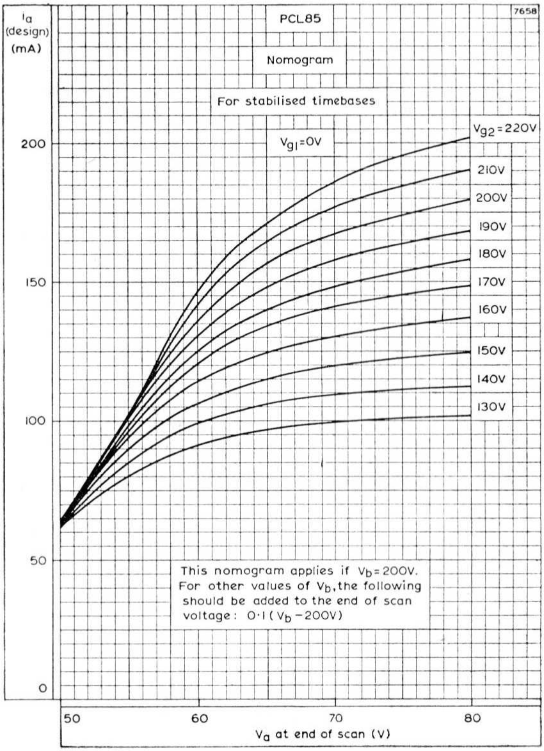
$V_{a(b)}$ max.	550	V
V_a max.	250	V
*+$v_{a(pk)}$ max.	2.0	kV
p_a max.	7.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	2.0	W
I_k max.	75	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	220	V
R_{h-k} max.	20	kΩ

*Max. pulse duration 7% of one cycle with a maximum of 1.4ms.

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	500	mW
I_k max.	15	mA
*$i_{k(pk)}$ max.	200	mA
R_{g-k} max.	1.0	MΩ
V_{h-k} max.	220	V
R_{h-k} max.	20	kΩ
T_{bulb} max.	240	°C

*Max. pulse duration 3% of one cycle with a maximum of 200µs.



This nomogram applies if V_b=200V. For other values of V_b, the following should be added to the end of scan voltage: 0·1(V_b−200V)

NOMOGRAM

PCL86

TRIODE PENTODE

Combined high-μ triode and output pentode for use in the audio amplifier stage of television receivers.

HEATER

I_h	300	mA
V_h	13.3	V

CAPACITANCES

c_{ap-gt}	<6.0	mpF
c_{at-g1}	<200	mpF
c_{gt-g1}	<20	mpF
c_{at-ap}	<150	mpF

Pentode section

c_{in}	10	pF
c_{a-g1}	<400	mpF
c_{g1-h}	<240	mpF

Triode section

c_{in}	2.3	pF
c_{out}	2.5	pF
c_{a-g}	1.4	pF
C_{g-h}	<6.0	mpF

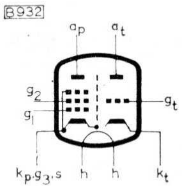
CHARACTERISTICS

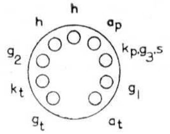
Pentode section

V_a	230	V
V_{g2}	230	V
V_{g1}	−5.7	V
I_a	39	mA
I_{g2}	6.5	mA
g_m	10.5	mA/V
r_a	45	kΩ
μ_{g1-g2}	21	
$-V_{g1}$ max. ($I_{g1} = +0.3\mu A$)	1.3	V

Triode section

V_a	230	V
V_g	−1.7	V
I_a	1.2	mA
g_m	1.6	mA/V
μ	100	
r_a	62	kΩ
$-V_{g1}$ max. ($I_{g1} = +0.3\mu A$)	1.3	V





B9A

DIMENSIONS

Max. overall length	78.5	mm
Max. seated height	71.5	mm
Max. diameter	22.2	mm

LIMITING VALUES

Pentode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	9.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max.	1.8	W
I_k max.	55	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	100	V
R_{h-k} max.	20	kΩ

Triode section

$V_{a(b)}$ max.	550	V
V_a max.	250	V
p_a max.	500	mW
I_k max.	4.0	mA
R_{g-k} max.	1.0	MΩ
V_{h-k} max.	100	V
†R_{h-k} max.	20	kΩ

†When used as a phase inverter immediately preceding the output stage, R_{h-k} max. may be 120kΩ.

OPERATING CONDITIONS AS SINGLE VALVE AMPLIFIER

Pentode section

V_a	230	200	V
V_{g2}	230	200	V
V_{g1}	−5.7	−4.7	V
R_k	125	115	Ω
I_a	41	34	mA
I_{g2}	10.5	9.0	mA
R_a	5.1	5.6	kΩ
P_{out}	4.1	3.1	W
$V_{in(r.m.s.)}$	3.6	3.2	V
D_{tot}	10	10	%
$V_{in(r.m.s.)}$ (P_{out} = 50mW)	300	290	mV

OPERATING CONDITIONS FOR TRIODE SECTION AS RESISTANCE COUPLED A.F. AMPLIFIER

Grid current bias (R_g = 10MΩ)

				Z_s = 0kΩ		Z_s = 220kΩ	
V_b (V)	R_a (kΩ)	R_g† (kΩ)	I_a (mA)	$\frac{V_{out}}{V_{in}}$	$V_{out(r.m.s.)}$* (V)	$\frac{V_{out}}{V_{in}}$	$V_{out(r.m.s.)}$** (V)
230	47	150	1.37	40	15	32	18
170	47	150	0.82	36	9	29	11
230	100	330	0.90	57	22	45	26
170	100	330	0.58	53	13	42	16
230	220	680	0.57	72	26	55	33
170	220	680	0.37	67	15	52	21

*Output voltage measured at D_{tot} = 5%.

$\frac{V_{out}}{V_{in}}$ measured with $V_{in(r.m.s.)}$ = 100mV.

†Grid resistor of following valve.

**When operating this valve with grid current bias and a high source impedance, the second harmonic distortion rises to a peak at quite low levels of output (about 10$V_{r.m.s.}$) and then falls with increasing drive. The third harmonic then begins to rise, and D_{tot} finally reaches 5% at a much higher output level than with zero source impedance. The maximum value of this distortion peak varies inversely with the anode load, being about 5.5% with R_a = 47kΩ, 4.5% with R_a = 100kΩ and 4% with R_a = 220kΩ.

OPERATING NOTES

1. **Microphony**

   This valve may be used without special precautions against microphony in equipment where the input voltage is not less than 10mV for an output of 50mW.

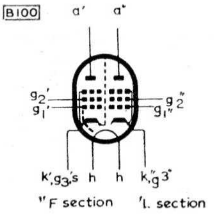
2. **Hum**

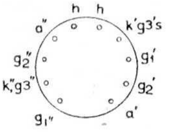
   To obtain the minimum value of hum, the a.c. voltage between pin 4 and triode cathode should not exceed 30V.

DOUBLE PENTODE

PFL200

Double pentode for video output plus synch. separator, a.g.c. amplifier or i.f. amplifier applications.





B10B

The output section (L) is indicated by single primes and the amplifier section (F) by double primes.

HEATER

I_h	300	mA
V_h	16.5	V

DIMENSIONS

Max. overall length	72.8	mm
Max. seated height	58.8	mm
Max. diameter	22.2	mm

CAPACITANCES (unshielded)

$c_{a'-a''}$	<150	mpF
$c_{g1'-g1''}$	<10	mpF
$c_{a'-g1''}$	<100	mpF
$c_{g1'-a''}$	<5.0	mpF
$c_{in'}$	12	pF
$c_{out'}$	7.0	pF
$c_{a'-g1'}$	95	mpF
$c_{in''}$	10	pF
$c_{out''}$	6.5	pF
$c_{a''-g1''}$	140	mpF
$c_{g1''-h}$	<150	mpF

CHARACTERISTICS

Output section

V_a	170	V
V_{g2}	170	V
I_a	30	mA
I_{g2}	6.5	mA
V_{g1}	−2.6	V
g_m	21	mA/V
μ_{g1-g2}	32	
r_a	>40	kΩ

Amplifier section

V_a	50	V
V_{g2}	75	V
I_a	5.0	mA
I_{g2}	1.6	mA
V_{g1}	−0.65	V
g_m	6.8	mA/V
μ_{g1-g2}	34	
r_a	110	kΩ

DESIGN CENTRE RATINGS

Output section

V_a max.	250	V
V_{g2} max.	250	V
p_a max.	5.0	W
p_{g2} max.	2.5	W
I_k max.	60	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	200	V

Amplifier section

V_a max.	250	V
V_{g2} max.	250	V
p_a max.	1.5	W
p_{g2} max.	0.5	W
I_k	15	mA
R_{g1-k} max.	1.0	MΩ
V_{h-k} max.	200	V

PL500

LINE OUTPUT PENTODE

Output pentode primarily intended for use in the line timebase of television receivers.

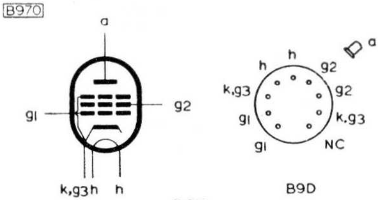
HEATER

Suitable for series operation a.c. or d.c.

I_h	300	mA
V_h	27	V

DESIGN CENTRE RATINGS

$V_{a(b)}$ max.	550	V
V_a max.	250	V
$v_{a(pk)}$ max.	7.0	kV
p_a max. ($p_{g2} \leqslant 4W$)	12	W
p_a max. ($p_{g2} = 5W$)	8.0	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	250	V
p_{g2} max. ($p_a \leqslant 8W$)	5.0	W
p_{g2} max. ($p_a = 12W$)	4.0	W
I_k max.	250	mA
R_{g1-k} max.	500	kΩ
R_{g1-k} max. (line timebase applications)	2.2	MΩ



B9D

DIMENSIONS

Max. overall length	104.2	mm
Max. seated height	95.5	mm
Max. diameter	30.2	mm

CAPACITANCE

c_{g1-h}	<200	mpF

DYNAMIC CHARACTERISTICS

V_a	75	V
V_{g2}	200	V
V_{g1}	−10	V
I_a	440	mA
I_{g2}	30	mA

OPERATION AS A LINE OUTPUT VALVE

Stabilised circuits (operating above the knee)

V_b	170		200			230			V
*R_{g2} min.	1.2		1.5			2.2			kΩ
V_{g2}	130	150	130	150	170	150	170	190	V
**V_a (end of scan)	62	66	65	69	73	72	76	80	V
†V_{g1} (end of scan)	−6	−7	−6	−7	−8	−7	−8	−9	V
††$i_{a(pk)}$	250	310	250	310	360	310	360	420	mA

Non-stabilised circuits (operating below the knee)

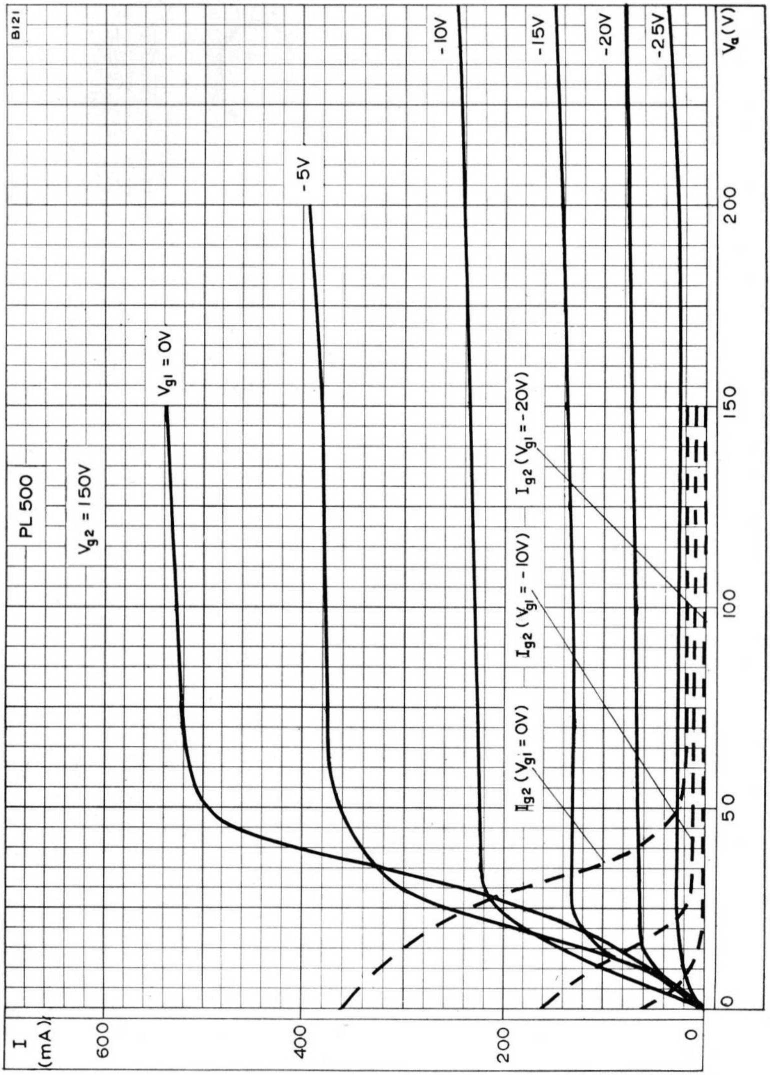
V_b	190	230	V
R_{g2} min.	2.2	2.2	kΩ
†V_{g1} (end of scan)	+1.0	+1.0	V
$i_{a(pk)}$	230	320	mA

*Minimum values of R_{g2} required to prevent excessive screen-grid dissipation during the warming-up period.

**Minimum voltage at the end of scan. These values apply at nominal mains voltage. At mains voltage 10% below nominal, the valve will still operate above the knee.

†The minimum value of V_{g1} for cut-off during the flyback period is −120V.

††To allow for valve spread and deterioration during life, and a 10% fall in mains voltage, the given values of $i_{a(pk)}$ should not be exceeded under the specified conditions at nominal mains voltage.



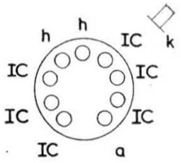
ANODE AND SCREEN-GRID CURRENTS PLOTTED AGAINST ANODE VOLTAGE WITH CONTROL-GRID VOLTAGE AS PARAMETER. $V_{g2} = 150V$

PY88

BOOSTER DIODE

Booster diode with a maximum peak inverse voltage of 6.6kV, intended for use in transformerless television receivers with 110° deflection angle cathode ray tubes.

B9O1



B9A

HEATER

I_h	300	mA
V_h	30	V

LIMITING VALUES

*P.I.V. max.	6.6	kV
*$i_{a(pk)}$ max.	550	mA
$I_{a(av)}$ max.	220	mA
$V_{h-e(r.m.s.)}$ max.	220	V
*$v_{h-k(pk)}$ max. (cathode positive)	6.6	kV

*Maximum pulse duration 22% of a cycle with a maximum of 18µs.

DIMENSIONS

Max. overall length	89	mm
Max. seated height	82	mm
Max. diameter	22.2	mm

CAPACITANCES

c_{a-k}	8.6	pF
c_{h-k}	2.0	pF

625-LINE VALVE TELEVISION RECEIVER CNU16

The CNU16 is a 625-line television receiver designed for v.h.f. transmissions using negative modulation. The significant features of the receiver are:

(i) High sensitivity through the use of two frame-grid valves (EF183 and EF184) in the i.f. amplifier,
(ii) Locked-oscillator f.m. sound demodulator using an EH90 valve,
(iii) Automatic contrast and brightness control with an ORP12 cadmium sulphide photoconductive cell,
(iv) Fully stabilised deflection, a.g.c., and brightness control circuits which minimise the effects of mains potential variations,
(v) Dual-mode line flywheel synchronising system,
(vi) Line-gated field pulse separator which improves the h.f. noise immunity and interlace.

CIRCUIT DESCRIPTION

The complete circuit diagram for the receiver is shown in Fig. 1. at the back of the book.

I.F., Sound and Video Amplifiers

The aerial input is applied to a conventional turret tuner using a PCC88 valve as a cascode r.f. amplifier and a PCF80 as a mixer. The gain of the cascode stage is controlled by a delayed a.g.c. potential to obtain the best noise factor with weak signals. The output of the tuner is applied to a three-stage i.f. amplifier. The input circuit incorporates three trap circuits. These are for the adjacent sound channel, 40·4Mc/s, the sound channel, 33·4Mc/s, and the adjacent vision channel, 31·9Mc/s. The first valve of the i.f. stage V_3 (Fig. 1a), is a variable-mu type and its gain is controlled by the a.g.c. circuit. The output from the video detector feeds an inductive peaking circuit L_8 and a bandpass circuit T_4 (Fig. 1d) tuned to 5·5Mc/s , which acts as a trap circuit in addition to providing the sound take-off. The 5·5Mc/s intercarrier sound signal is fed to the sound i.f. amplifier by a low-impedance link circuit.

The sound signal is amplified by V_9 (Fig. 1c) and applied to the first control grid of V_{10} which operates as a locked-oscillator detector. The audio output from the anode circuit of V_{10} drives the output stage V_{11B} directly through the volume control. This stage is conventional and employs 10dB of negative feedback.

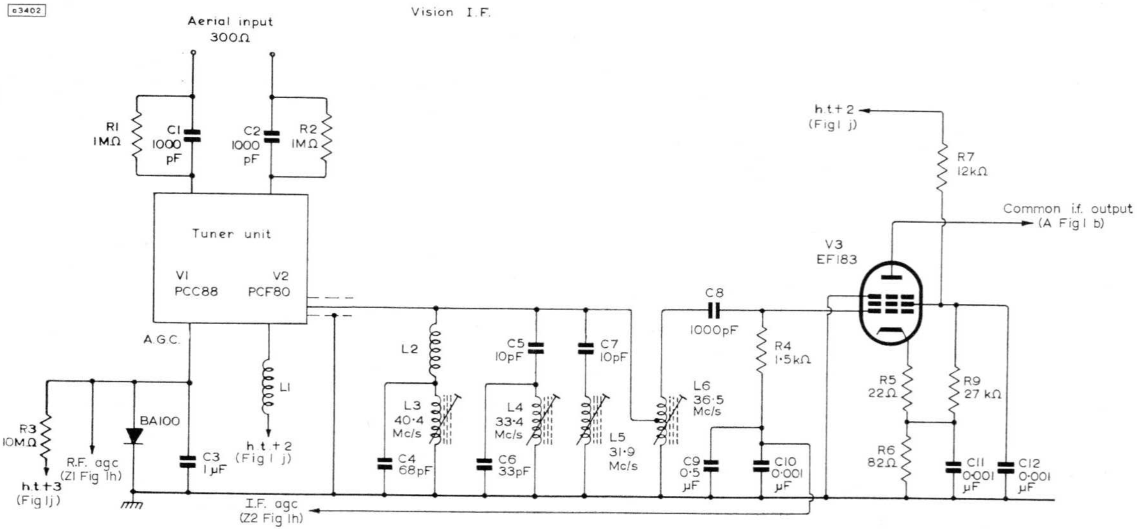


Fig. 1a (above)—VISION I.F. AMPLIFIER

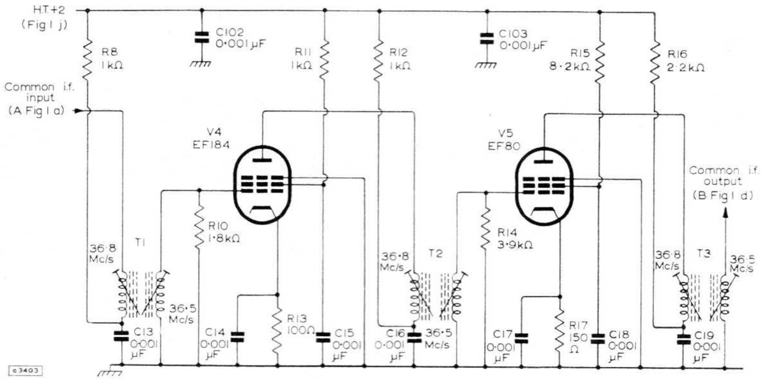


Fig. 1b (right)—VISION I.F. AMPLIFIER (*contd.*)

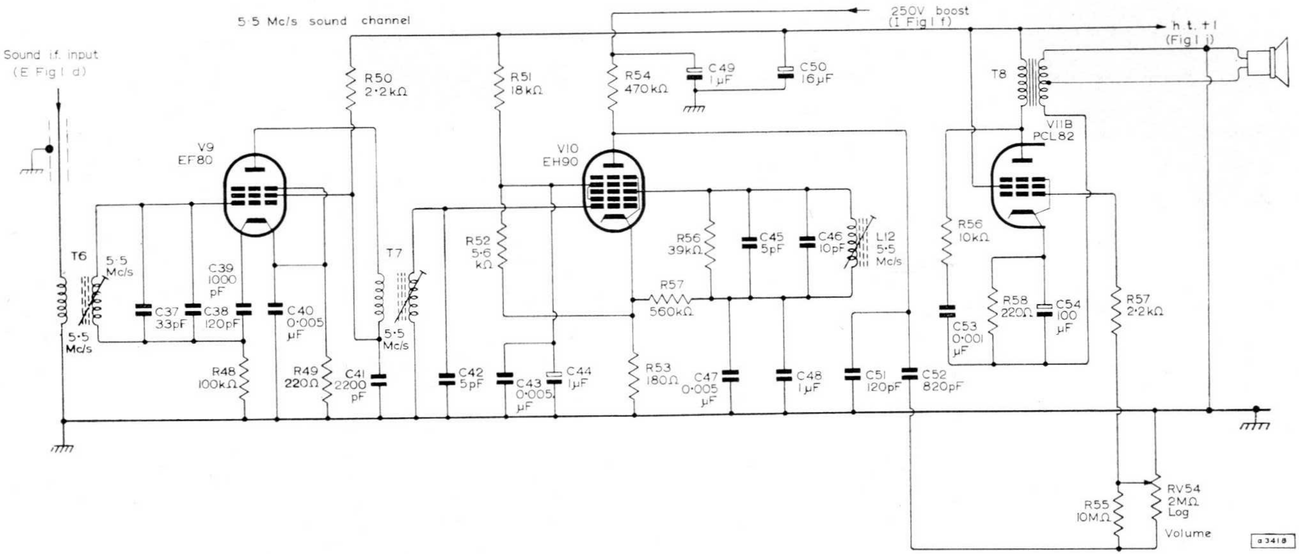


Fig. 1c—AUDIO AMPLIFIER AND OUTPUT CIRCUIT

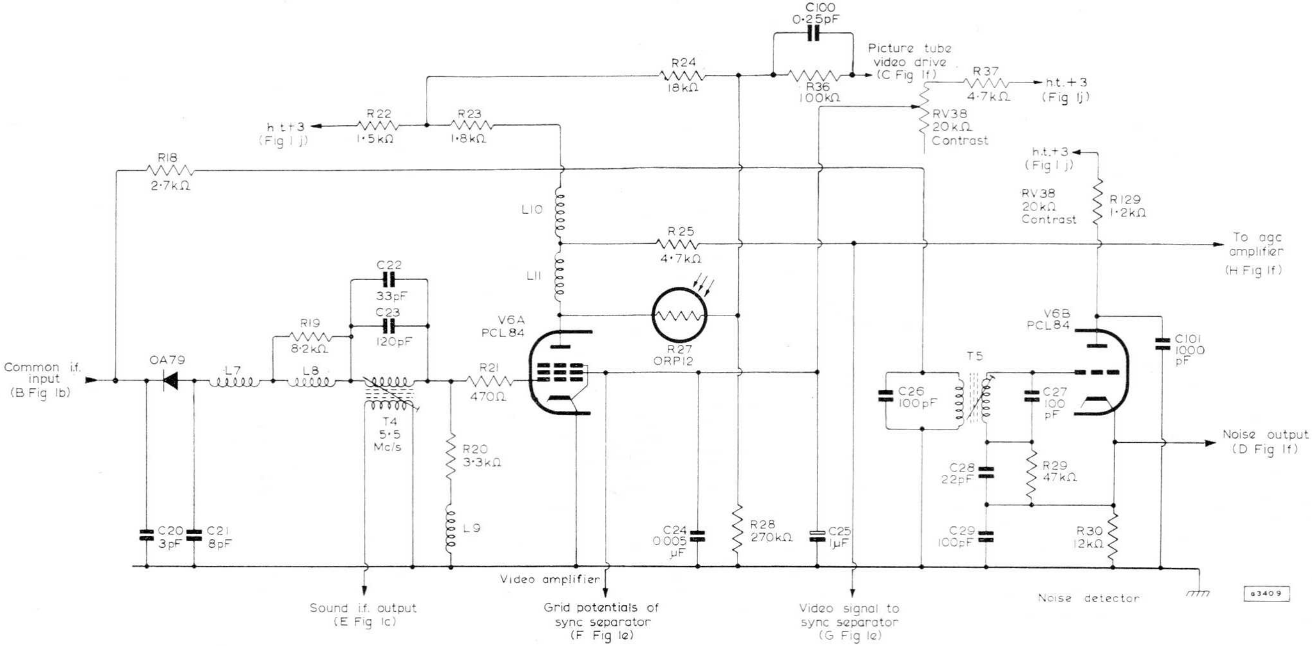


Fig. 1d—VIDEO AMPLIFIER AND NOISE DETECTOR

The video output amplifier V_{6A} (Fig. 1d) uses anode compensation and its screen-grid potential is variable (RV_{38}) to form the contrast control. The cathode of the picture tube is driven from the anode circuit of V_{6A} through a parallel RC network, R_{36} and C_{100} to prevent excessive beam current being drawn. A photoconductive cell, type ORP12 (operating as a light-dependent resistor R_{27}), is incorporated in this circuit so that the picture contrast and brightness is automatically adjusted for changes in ambient illumination.

Noise Detector and Synchronising Pulse Separator Circuits

The synchronising and a.g.c. valves are prevented from conducting on noise pulses by applying negative-going pulses to the control grids. The noise pulses are obtained from a separate noise detector (Fig. 1d) coupled by a bandpass transformer T_5 to the output of the last i.f transformer. The bandpass transformer has a bandwidth of about 1·5Mc/s spaced approximately 3·5Mc/s from the vision carrier frequency. The negative-going output produced at the cathode of the noise detector V_{6B} consists of h.f., video and noise pulses only. Since the noise pulses are derived from the frequency-selective noise detector, no preset controls are required to set the clipping levels.

The video signal from the anode of the video amplifier V_{6A} is coupled to the second control grid of V_{8A} (Fig. 1e) by a conventional double-time-constant network, R_{59}, R_{60}, C_{55} and C_{56}. To ensure optimum operating conditions for the separator valve with different manual contrast control settings, the potentials for the control grid and the screen grids are taken from the slider of the contrast control.

Experiments have shown that it is often advantageous to obtain the field synchronising pulse after the first synchronising pulse separator stage. Residual noise pulses can be amplified by the second clipper which tends to neutralise the effects of noise gating. The separated synchronising pulses are therefore integrated by R_{64} and C_{58}, and applied to a diode separator circuit. The output from this circuit is used to trigger the field blocking oscillator directly. The triode V_{7B} (Fig. 1e) operates as a second clipper to provide the required drive for the line phase detector, V_{8B}, and the diode coincidence detector in the cathode circuit.

An auxiliary direct-synchronisation circuit is automatically switched into operation whenever the line oscillator synchronisation is lost, as, for example, when changing channels. Negative-going separated synchronising pulses are developed across R_{70} in the cathode circuit of the second clipper V_{7B} and applied to the coincidence-detector diode together with the positive flyback pulses through C_{66}. When the oscillator is correctly synchronised, these pulses are coincident and the diode conducts, charging C_{66} negatively. This negative potential is filtered by R_{68} and C_{62} and then applied to the grid of the gate valve V_{11A} (Fig. 1g). The cathode of this valve is connected to the cathode of the second clipper V_{7B}. When

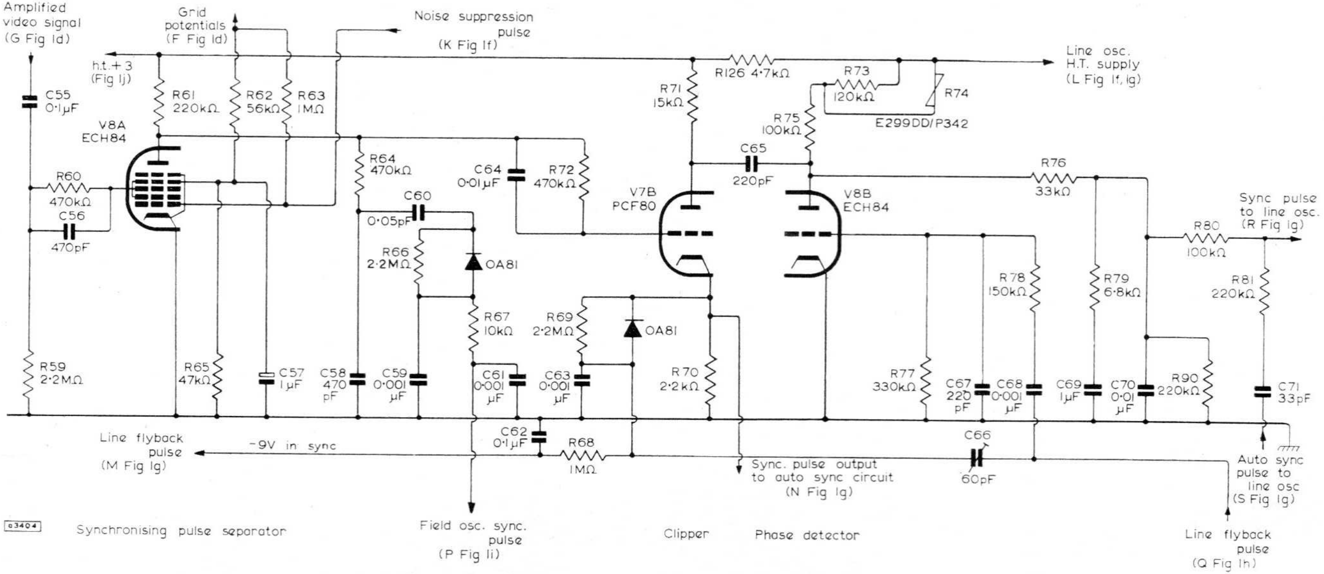


Fig. 1e—SYNCHRONISING PULSE SEPARATOR AND PHASE DETECTOR

synchronism is lost, the gate valve conducts and amplified synchronising pulses are developed at its anode. These pulses are applied to the oscillator via the isolating components C_{71} and R_{81} (Fig. 1e). As soon as the oscillator synchronises, the negative d.c. output from the coincidence detector is developed cutting off the gate valve and the flywheel circuit resumes control. The time-constant of R_{68} and C_{62} prevents the circuit operating on spurious noise inputs.

A.G.C. Circuit

A pentode valve V_{7A} (Fig. 1f) is used in the a.g.c. circuit with the video signal d.c. coupled to the screen grid, the screen grid acting as a second control grid. The first control grid is held so that grid current flows except when negative-going noise pulses cut the valve off, the noise pulses being derived from the noise detector.

The a.g.c. circuit is operated by a floating d.c. potential obtained by rectifying the line flyback pulse by the v.d.r., R_{131} (Fig. 1h). The a.g.c. amplifier V_{7A} operates as a controlled d.c. restorer to the floating potential. As it is driven harder into conduction by the tips of the synchronising pulses, the negative d.c. potential developed across the v.d.r. increases. This d.c. potential is used as the a.g.c. control bias. A d.c. delay potential is applied to the cathode of the a.g.c. amplifier to prevent it conducting before the video signal has reached its required amplitude. This bias is preset by RV_{34} to allow for component tolerances. The a.g.c. potential depends on the line timebase to operate the amplifier but is independent of the synchronisation.

The delay potential applied to the a.g.c. amplifier and the potential of the brightness control are stabilised by the v.d.r., R_{35}. This minimises variations in both brightness and contrast caused by mains potential variations. When switching off, the v.d.r. also tends to hold the grid of the picture tube positive and this ensures that the e.h.t. capacitance is rapidly discharged, thus preventing burning of the screen.

Line Timebase

A stabilising tuned circuit is connected in series with one of the coupling capacitors of the multivibrator. This method of connection allows a large-amplitude sine wave to be developed at the grid of V_{12B} (Fig. 1g) and at the same time the tuned circuit is not damped since V_{12B} is cut off when V_{12A} is conducting. The frequency stability of this circuit is therefore very good, a $\pm 10\%$ mains variation causing only a ± 10c/s change in the free-running frequency.

The output from V_{12B} anode drives the line output valve V_{14} (Fig. 1h). A pulse from the output transformer primary winding is rectified by a v.d.r. R_{130} and the negative d.c. potential is used to control the conduction of the output valve. A preset resistor, RV_{110}, is used to set the boost potential to allow for component tolerances.

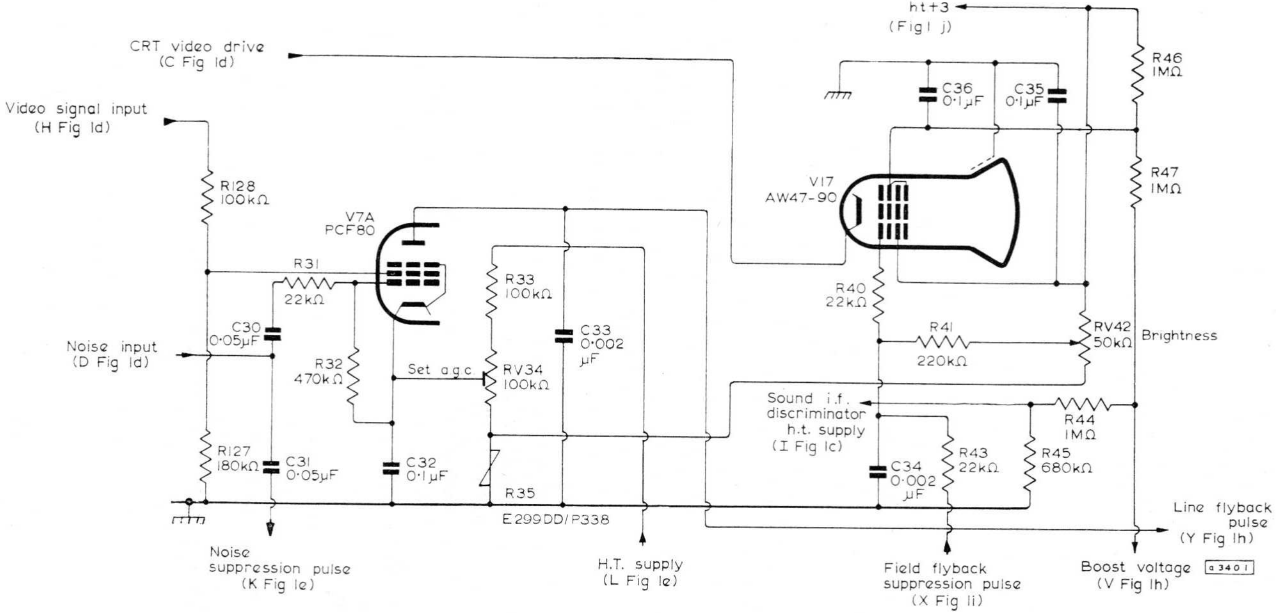


Fig. 1f—A.G.C. AMPLIFIER

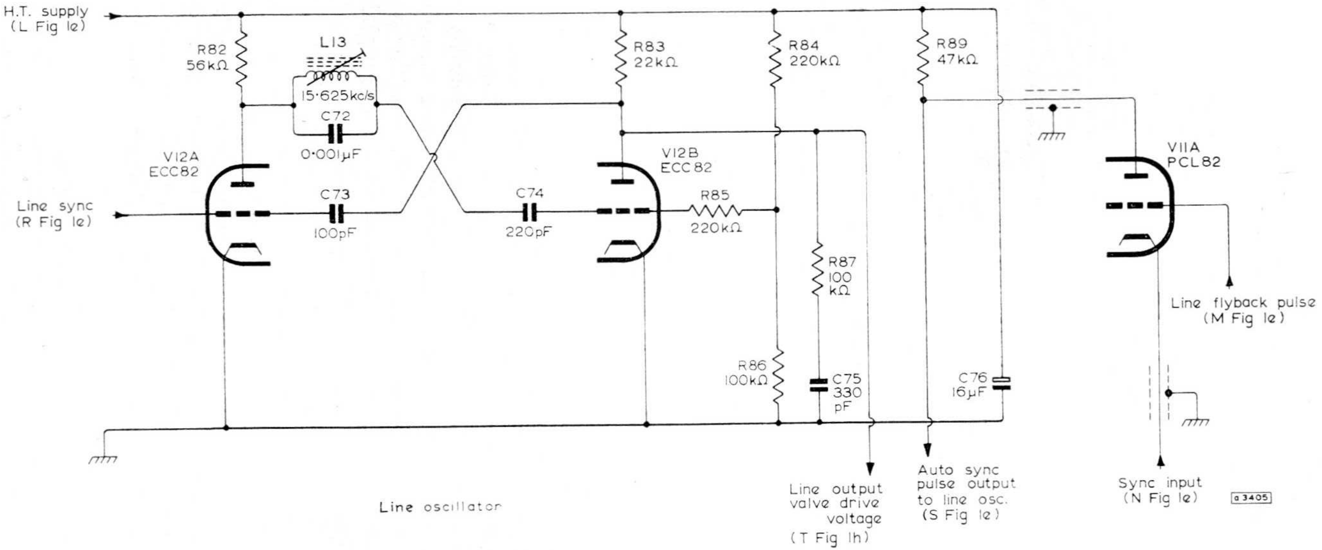


Fig. 1g—LINE OSCILLATOR CIRCUIT

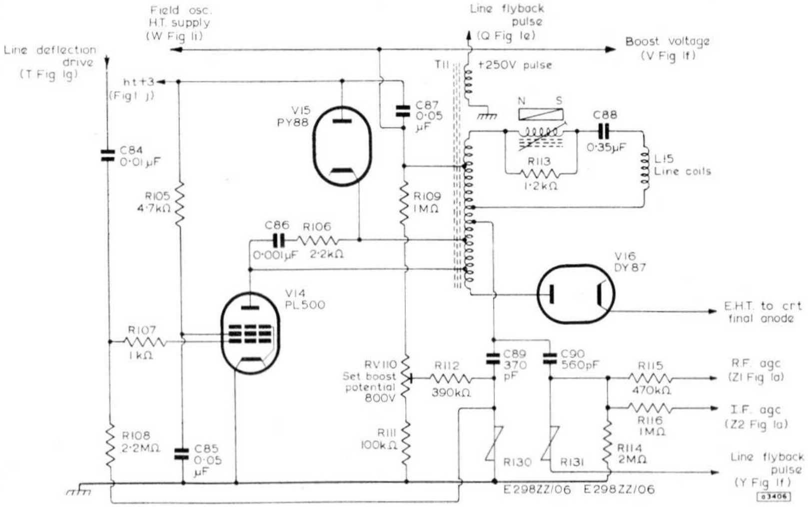


Fig. 1h—LINE OUTPUT CIRCUIT

Field Timebase

A conventional field timebase (Fig. 1i) is used in which a cathode-coupled blocking oscillator produces the positive-going sawtooth drive for the output pentode, and voltage feedback is used for linearity correction. Variations in mains supply potential normally cause variations in the amplitude of the drive waveform and also vary the available peak current from the output valve through the variation of the screen-grid potential. The required drive to the output valve is substantially constant, however, since the cathode bias tends to stabilise the working point of the valve. Provided the output stage has been designed to operate from the minimum h.t. potential, the picture height is substantially independent of mains supply potential if the sawtooth drive has a constant amplitude. This may be achieved simply by operating the oscillator from the stabilised boost potential. A further stage of stabilisation is provided by the v.d.r., R_{95}. Temperature compensation is provided by the thermistor R_{104}.

Power Supply

A silicon rectifier BY100 (Fig. 1j) is used for the power supply with a shunt capacitor C_{91} to protect the rectifier from impulsive disturbances in the mains. The smoothing choke, L_{16}, is wound in two sections. For a.c.

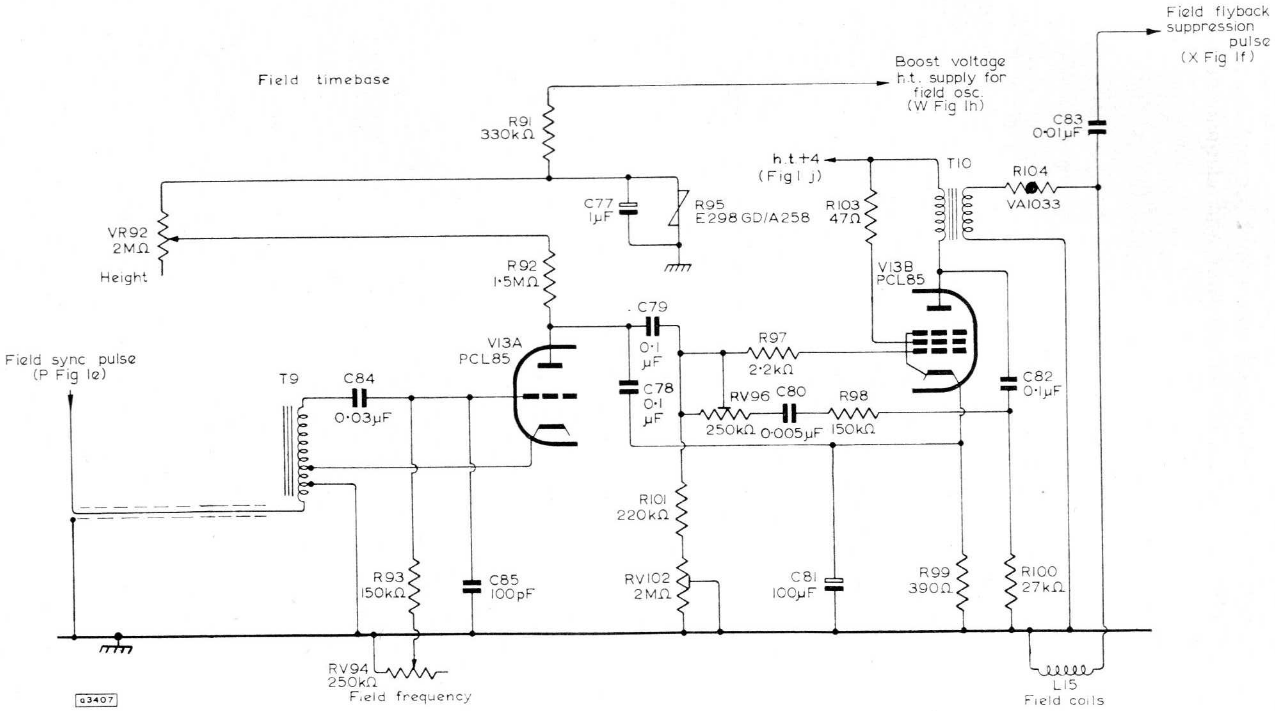


Fig.1i—FIELD TIMEBASE CIRCUIT

operation the two sections are in series and for d.c. operation they are connected in parallel. The individual smoothing for various circuits in the receiver is provided to give low visible hum and adequate decoupling.

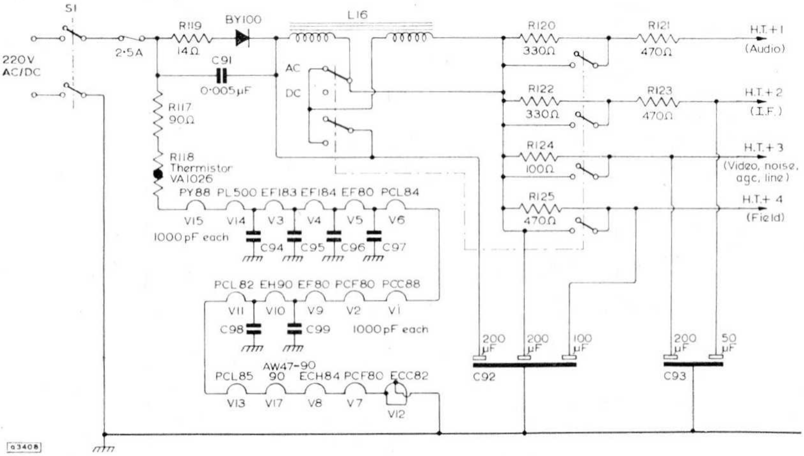


Fig. 1j—POWER SUPPLY CIRCUIT

625-LINE HYBRID TELEVISION RECEIVER CHA19

Transistors are becoming available in quantities and with a performance that makes their use in television receivers an attractive proposition. The high-power stages in a television receiver, however, require types that, at present, are not in this category. With r.f. and i.f. transistors, amplifiers can be designed having a performance similar to or better than that of their valve counterparts, while with u.h.f. transistors, amplifiers with a performance markedly superior to that of their valve counterparts can be designed. Thus, a hybrid receiver employing transistors for the small-signal amplifiers and valves for the power circuits is a practical proposition.

One of the problems of a hybrid television circuit is that of obtaining an economical power supply for the transistors. This may affect the number of transistors employed and preclude using transistors for certain stages because of excessive current consumption. In the sound channel, for example, transistors may be used for the i.f. and audio stages, but a transistor sound output stage will require a large current which may increase the cost of the transistor power supply.

The hybrid television receiver CHA19 described in this section is designed for v.h.f. operation with 625-line standard and negative modulation. Other features of the receiver are:

(*a*) Synchronising tip a.g.c. is employed so that the full d.c. component of the video signal is retained.

(*b*) Noise protection of the synchronising pulse separator and a.g.c. amplifier is provided by a frequency-selective noise-gated circuit.

(*c*) Automatic synchronisation of both line and field timebases is employed and no customer-operated hold controls are necessary.

(*d*) A high-level contrast control is employed so that the input to the synchronising pulse separator is held constant at all contrast settings.

The receiver is in part similar to that described in the Mullard Dual-standard Hybrid Television Receiver booklet published in May 1963. The transition from transistor to valve circuits is carried out at the video and sound detectors respectively so that all the low-level signal amplifying stages are transistorised and valves are only retained for the video and audio amplifiers, the synchronising pulse separator and the timebase circuits. The vertical synchronising circuit, is, however, transistorised. The complete circuit diagram for the receiver is given at the back of the book.

When valve and transistor circuits for a television receiver are considered, it will be apparent that transistors in uncontrolled stages, that is, constant current stages, can be operated directly from a 220V supply with a high value of emitter resistor. However, when there are large changes in the transistor operating currents, a low-impedance, low-voltage supply for the controlled transistors is essential. Receiver CHA19 operates from 220V a.c. supply only and the valve complement is such that no heater dropper is necessary. A series diode reduces the power in the heater chain and the d.c. component of the heater current is employed to drive the transistor circuits. A major advantage of this circuit technique is that the total power dissipated in the receiver is considerably reduced.

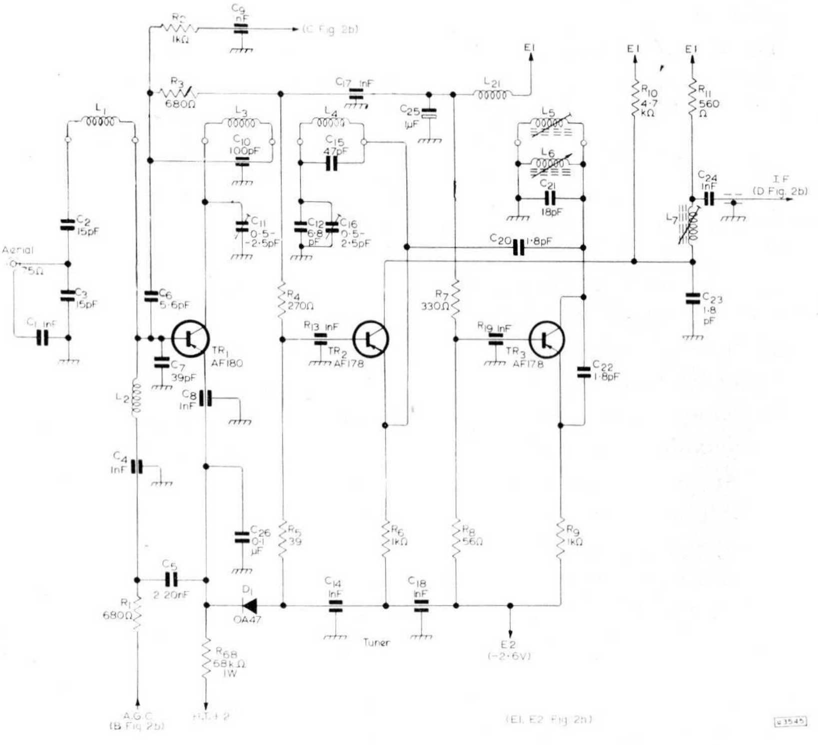


Fig. 2a—V.H.F. TUNER

CIRCUIT DESCRIPTION

The complete circuit diagram is shown in Fig. 2 at the back of the book.

V.H.F. Tuner

The r.f. amplifier (Fig. 2a) employs an AF180 in the common-emitter configuration with the a.g.c. potential applied to its base. The emitter is connected via a high-value resistor R_{68} to the 220V h.t. line. When the a.g.c. potential drives the base of the transistor negative, the emitter potential follows the base potential and there is no appreciable increase of transistor current. When the a.g.c. potential reaches approximately −2·6V, the diode D_1 conducts and clamps the emitter to −2·6V (potential E_2). Any further increase of a.g.c. potential increases the r.f. transistor current, thus reducing its gain by forward a.g.c. action.

An AF178 is used as the oscillator. The outputs from the r.f. amplifier and the oscillator are applied to the emitter of the mixer transistor TR_2 (AF178) connected in the common-base configuration. The i.f. output is taken from the collector circuit to the i.f. amplifier. Incorporated in the coupling circuit between the tuner and the i.f. amplifier are trap circuits tuned to 40·4Mc/s (adjacent sound), 31·9Mc/s (adjacent vision), and 33·4Mc/s (sound).

Vision I.F. Amplifier

The vision i.f. amplifier (Fig. 2b) employs an AF179 and two AF181. The first i.f. transistor TR_4 is gain-controlled by a negative-going a.g.c. potential applied to its base. As the signal level increases, the current in this transistor is increased and the gain falls by forward a.g.c. action. Excessive transistor dissipation is prevented by resistors R_{15}, R_{16} and R_{17}. Fixed neutralisation is used in each i.f. stage.

The video output signal is developed across a 2·7kΩ load resistor, R_{37}, and applied to the video amplifier valve. A bandpass circuit tuned to 38·9Mc/s is loosely coupled to the collector of the output transistor. This circuit drives the noise detector, and negative gated noise pulses are produced and applied to the noise amplifier TR_8 (OC44). The amplified output pulses are applied as gating signals to the synchronising pulse separator and a.g.c. valves.

Video Amplifier and A.G.C. Circuit

The video amplifier (Fig. 2c) is the video pentode of the PFL200, the h.f. pentode of which is used as the a.g.c. gate. The video signal from the anode of the amplifier is applied to the cathode of the picture tube via a high-level contrast control. The low-potential end of this control is connected to a d.c. potential equal to the black level of the video signal. Hence variation of picture contrast does not significantly vary the black level of the displayed picture.

The a.g.c. amplifier is driven at its cathode by the negative-going video signal developed at the cathode of the video amplifier valve. Negative-

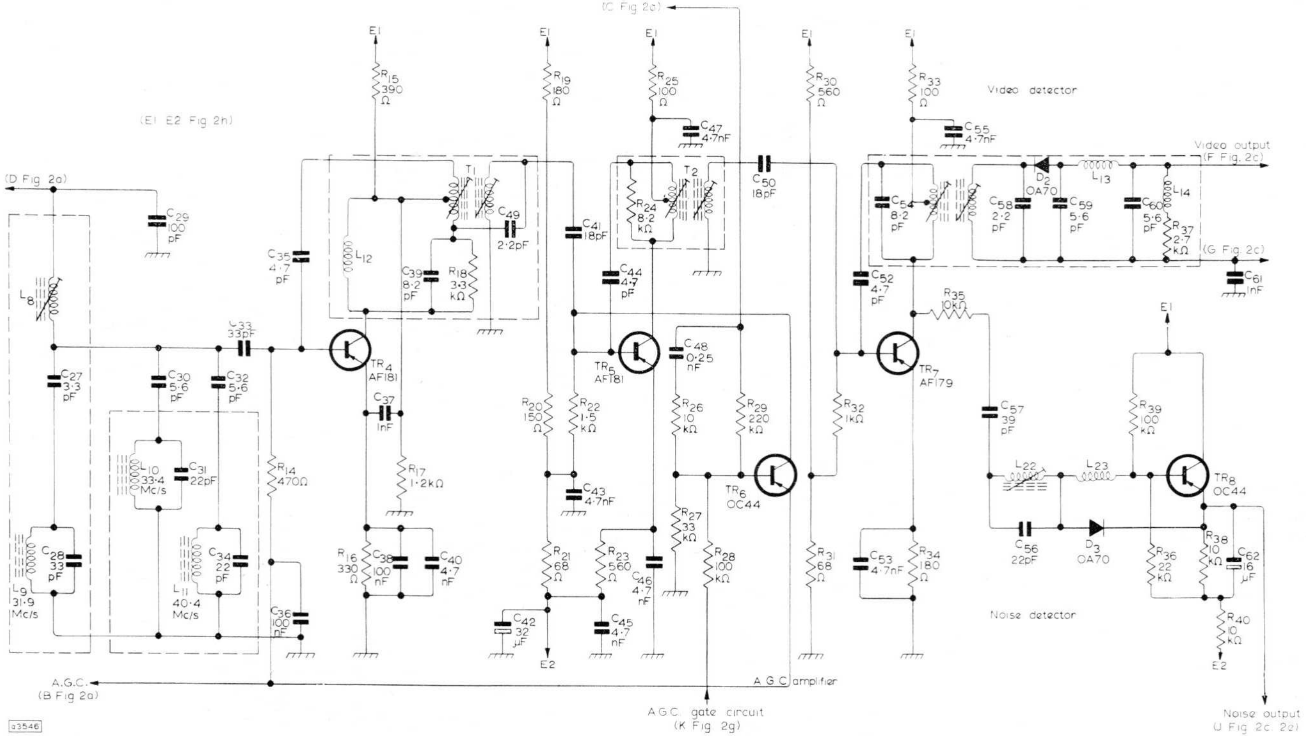


Fig. 2b—VISION I.F. AMPLIFIER AND NOISE DETECTOR

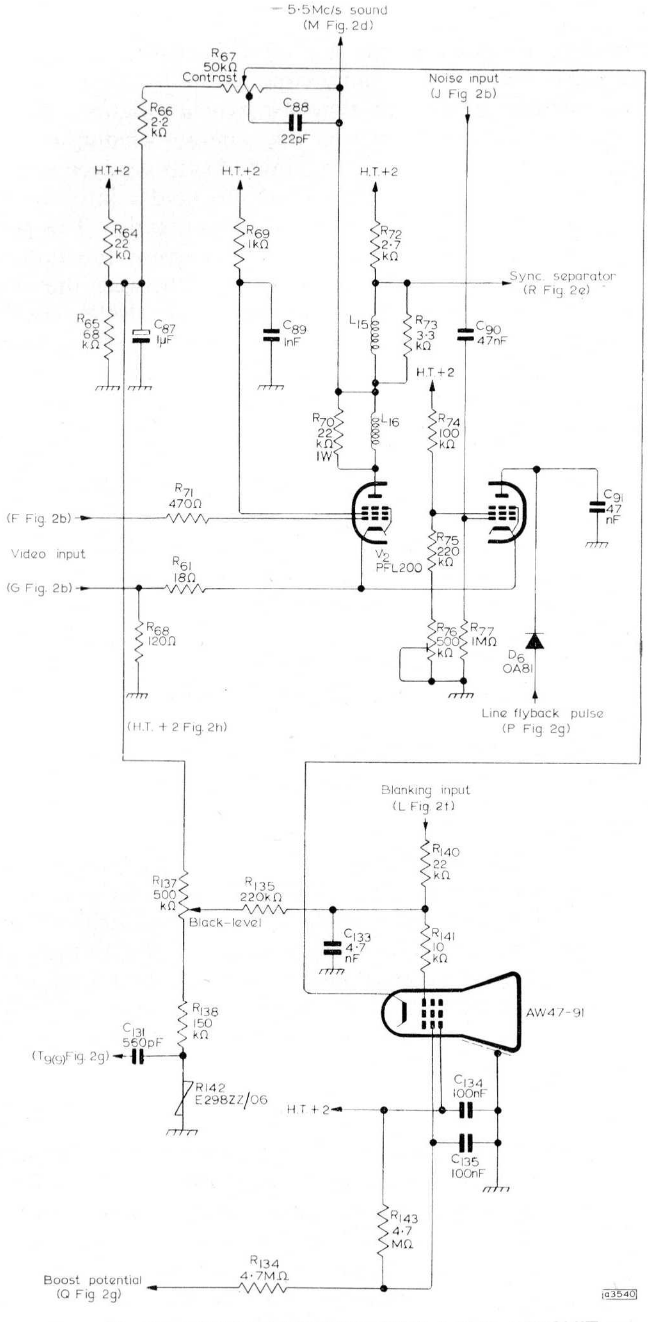


Fig. 2c—VIDEO AMPLIFIER AND A.G.C. CIRCUIT

going interference or noise pulses are applied to the control grid to prevent the valve being driven into conduction by them. The a.g.c. current is independent of the line timebase synchronisation. A pulse of about 85V amplitude is obtained from the separate winding on the line output transformer and rectified by the diode D_6 to produce a 'floating' d.c. potential. As the a.g.c. amplifier is driven harder into conduction by the video signal, the mean anode potential goes negative. This potential is applied to the a.g.c. amplifier TR_6. This transistor functions as an emitter follower and provides an impedance match between the relatively high-impedance valve circuit and the low-impedance controlled transistors. The rate of control of the i.f. amplifier is determined largely by the emitter resistance R_{16} in the emitter circuit of the first i.f. transistor. To reduce the rate of control of the r.f. amplifier d.c. feedback is taken from its collector circuit and applied to the base of the a.g.c. amplifier transistor TR_6.

Sound Amplifier

The 5·5Mc/s intercarrier sound signal is taken from the anode circuit of the video amplifier (Fig. 2d) and applied via a bandpass coupling to the base circuit of the sound i.f. amplifier TR_9 (AF116). This transistor functions as a limiting amplifier and drives a conventional ratio detector. The audio signal is applied, through the 50μs de-emphasis network, to the volume control. A conventional audio amplifier circuit is used, employing 10dB of feedback.

The audio output stage operates from the unsmoothed h.t. with a hum-cancelling winding on the primary of the output transformer.

Synchronising Circuits

A triode heptode type PCH200 (Fig. 2e) is used as a synchronising pulse separator and second clipper stage. The heptode is noise-gated at its first control grid. This valve has a triode section with a separate cathode. The triode control grid can therefore be directly coupled to the anode of the heptode. The vertical synchronising pulse is developed across a parallel RC network in the triode cathode circuit, and the line synchronising pulse across a critically damped tuned circuit in the triode anode circuit.

Field Timebase

The vertical timebase employs a PCL85 in a conventional self-oscillating circuit (Fig. 2f), the flyback pulse at the anode of the pentode section being applied by a shaping network to the control grid of the triode section. Synchronisation of the oscillator is effected by converting the synchronising pulse into a sawtooth waveform, the synchronising sawtooth being applied to the cathode of the oscillator valve. In this way the conflicting requirements of the synchronising and feedback circuits are separated.

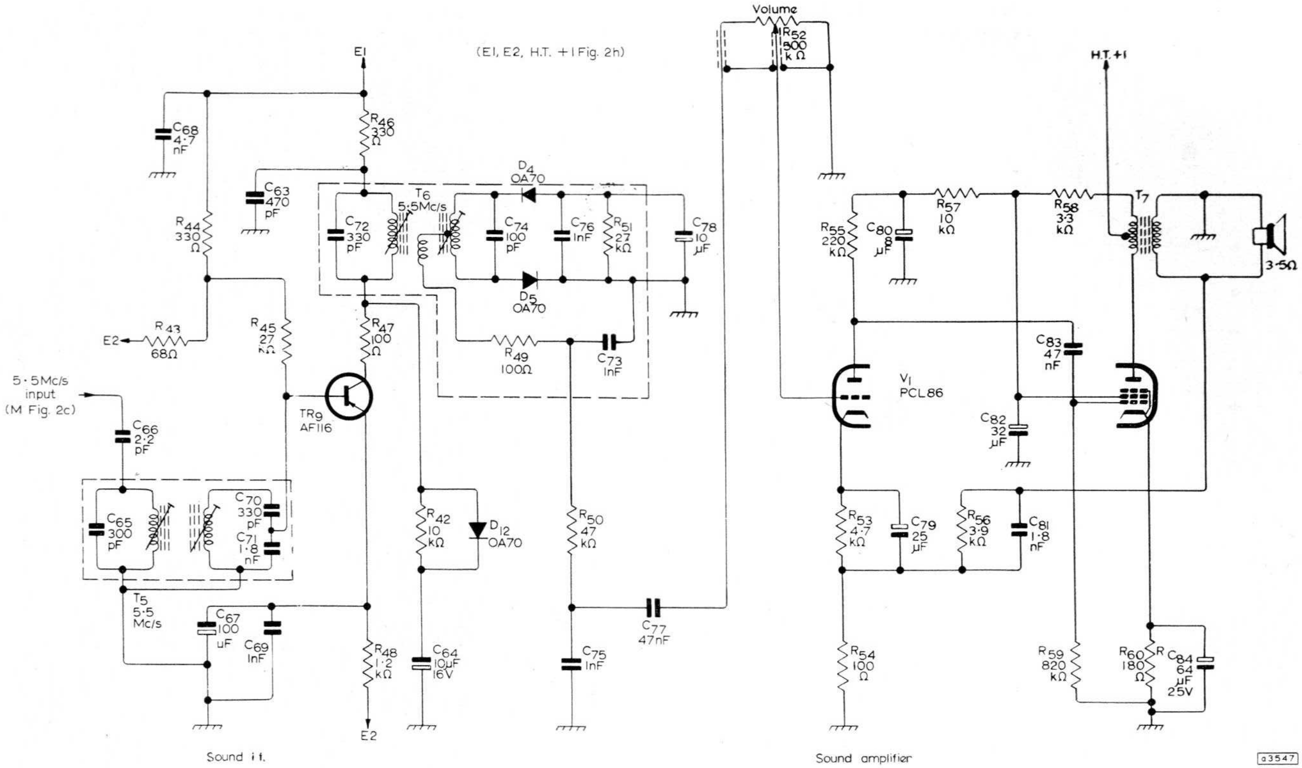


Fig. 2d—SOUND I.F. STAGE AND AMPLIFIER

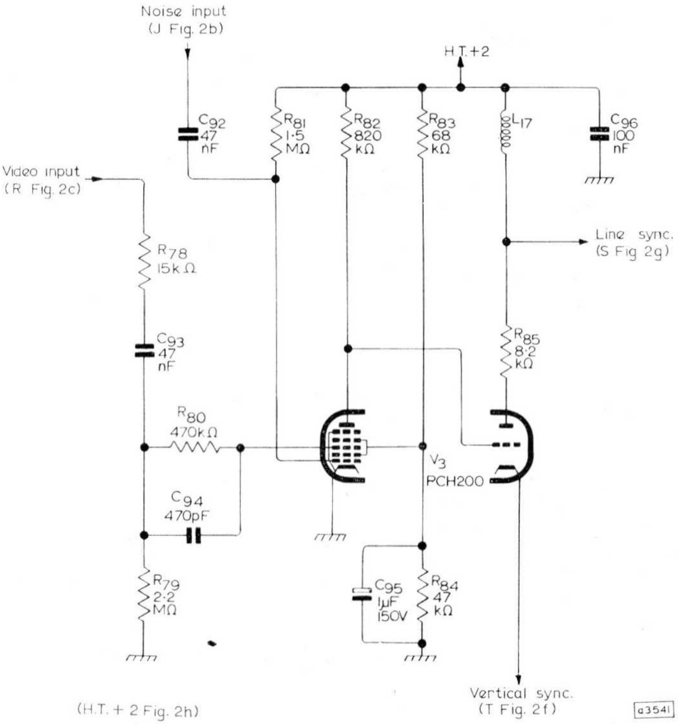


Fig. 2e—SYNCHRONISING PULSE SEPARATOR

During the scanning period the charge capacitance, formed by the series connected capacitors C_{103} and C_{104}, charges positively. The upper capacitor C_{103} is discharged by the valve when it is triggered by the flyback pulse and the lower capacitor C_{104} is discharged by the transistor when it is triggered by the negative-going synchronising pulse. Because of the sawtooth shape of the synchronising waveform the timebase synchronises on the fast retrace produced by the synchronising pulse. The exact instant of synchronisation, however, occurs when the negative-going synchronising sawtooth passes the conduction point of the valve. Because of the shape of the synchronising waveform, the oscillator frequency may be fast or slow with respect to the synchronising frequency. Since the free-running frequency is substantially the same as its synchronised frequency the momentary absence of a synchronising pulse does not disturb the oscillator frequency and picture 'rolling' is minimised. The locking range of the circuit is sufficiently large (some ±10c/s) to enable the normal customer-operated hold control to be dispensed with.

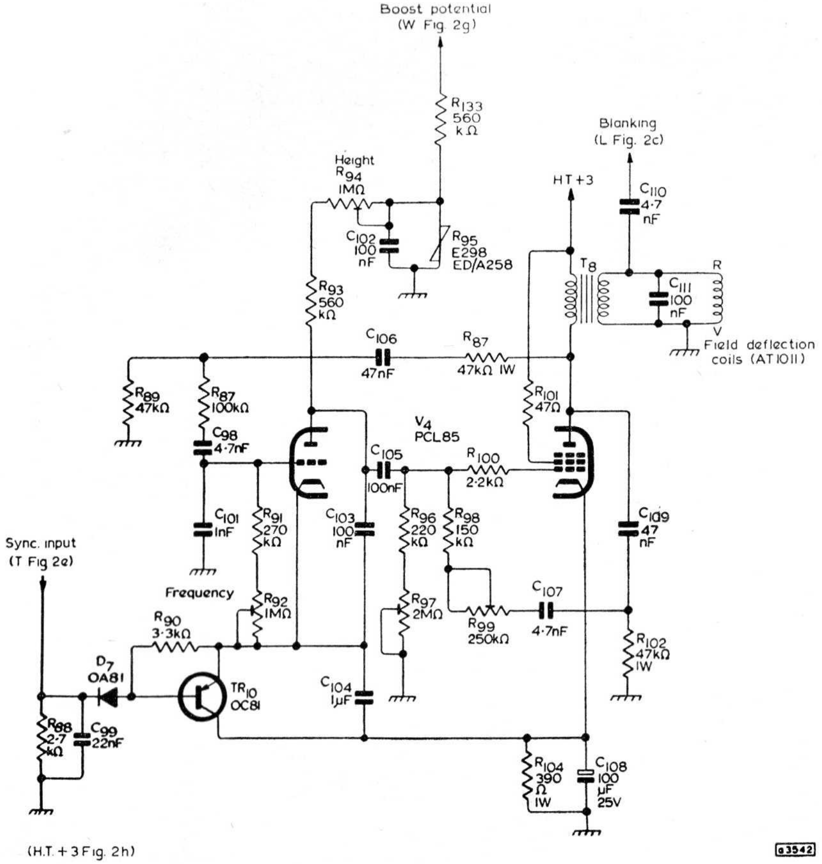


Fig. 2f—FIELD TIMEBASE

Initial Frequency Adjustment

To adjust the free-running frequency the vertical synchronising pulse must be suppressed without disturbing the normal d.c. potential of the vertical synchronising circuit. This may be achieved either by decoupling the anode of the heptode V_3 to earth with a large capacitor (220nF) or by joining together the collector and emitter of the vertical synchronising transistor TR_{10}. The free-running frequency can then be adjusted to its correct value by varying R_{92}.

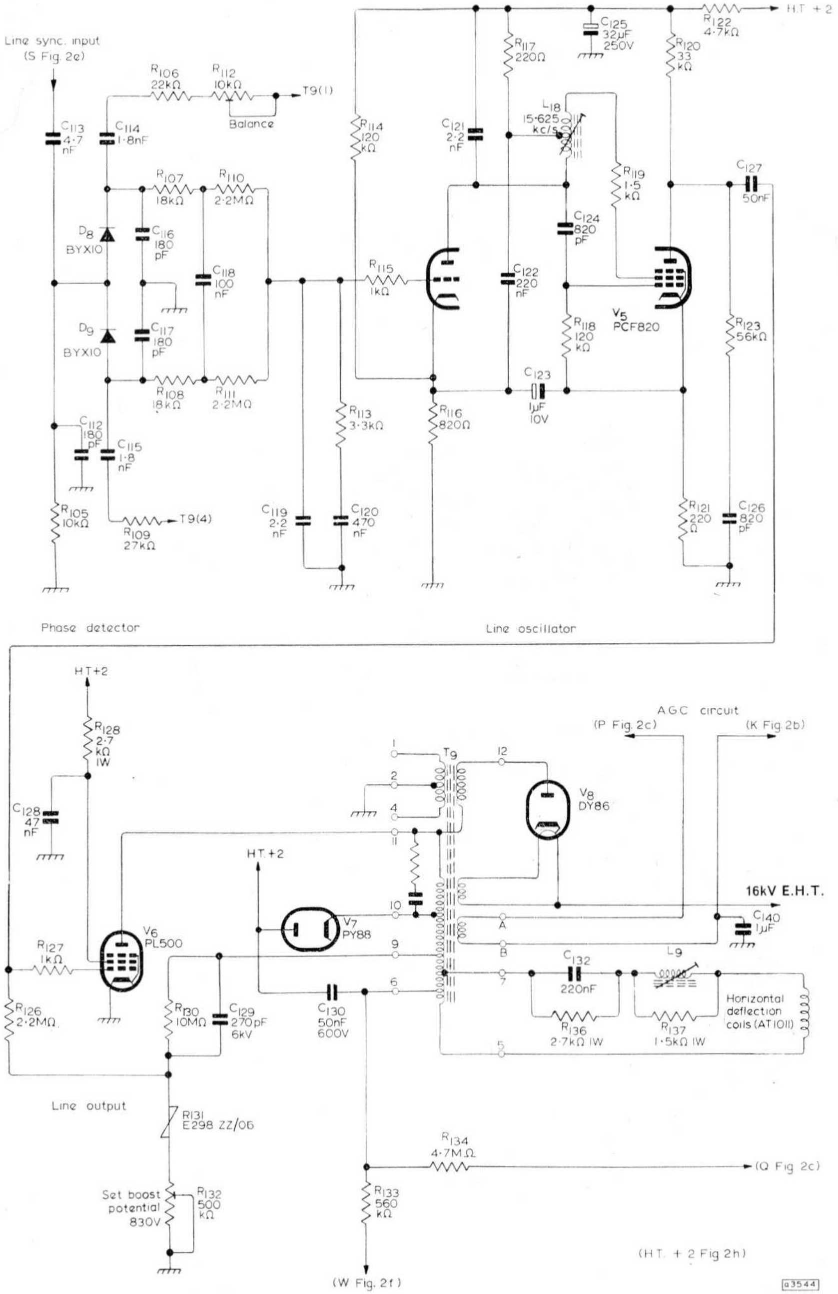


Fig. 2g—PHASE DETECTOR, LINE OSCILLATOR AND LINE OUTPUT STAGE

Line Timebase

The synchronising pulse developed in the anode circuit of the second clipper valve is used as the reference waveform for the self-locking fly-wheel circuit. Push-pull gating pulses from the line output transformer are applied to the diodes (Fig. 2g), causing them to conduct. The d.c. output is used after filtering to control the frequency of the sine-wave oscillator. When the timebase is not in synchronism, the phase detector operates as a frequency discriminator giving a d.c. output proportional to the frequency difference. This circuit has a wide locking range (about ±700c/s) together with good noise immunity, and no customer-operated frequency control is required. The line output stage is a conventional above-the-knee circuit employing v.d.r. stabilisation.

Initial Frequency Adjustment

The initial adjustment of the line oscillator and the balancing of the phase detector has to be carried out in two parts. The first part is to short-circuit the control grid of the reactance triode of V_5 to earth and then adjust the line frequency to its correct value by varying the choke L_{18}. Secondly, the short-circuit has to be removed from the control grid and a short-circuit introduced between the junction of the phase detector diodes D_8 and D_9 and earth. The line frequency can then be readjusted to its correct value by varying the balancing control R_{112}.

Power Supply

A conventional half-wave rectifier and RC smoothing are employed for the required +220V h.t. supply for the valve circuits (Fig. 2h). A diode is connected in series with the heater chain to modify the heater waveform

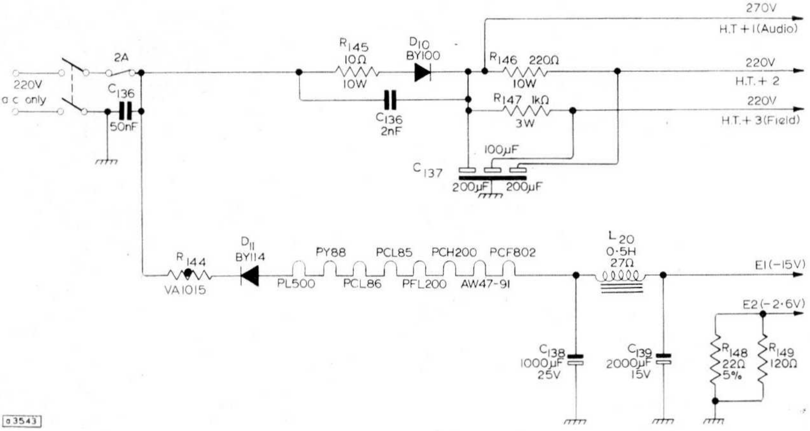


Fig. 2h—POWER SUPPLY CIRCUIT

to a half sine-wave. With an r.m.s. current equal to 300mA, the d.c. component is 190mA. The transistor circuits are connected in series with the low-potential end of the heater chain. The a.c. component is bypassed by the capacitor C_{138}. The d.c. component is filtered by L_{20} and C_{139}, and applied to the transistor circuits. Because of the necessity of providing a 2·6V delay potential the transistor circuits operate between potentials of −15V and −2·6V. The total transistor circuit current is increased to 190mA by employing low-resistance networks for the base divider chains in the transistor stages. In this way the total current is distributed over several networks and an individual component failure will not result in an excessive rise in the transistor supply potential.

F.M./A.M. BATTERY-OPERATED RADIO RECEIVER

The circuit diagram for a battery-operated f.m./a.m. receiver is shown in Fig. 3. Provision is made for reception of f.m. transmissions and transmissions in the long and medium waveband. Switching between f.m. and a.m. operation has been reduced to a minimum.

For f.m. operation, a tuner, i.f. amplifier and a conventional asymmetrical discriminator are used. For a.m. operation, the tuner transistors, types AF102 and AF115, are inoperative. The first AF116, which functions as the first i.f. amplifier during f.m. reception, operates as a self-oscillating mixer for a.m. reception. The second and third AF116 provide two stages of i.f. amplification during a.m. reception. To minimise switching, the f.m. and a.m. i.f. transformers are connected in series.

CIRCUIT DESCRIPTION

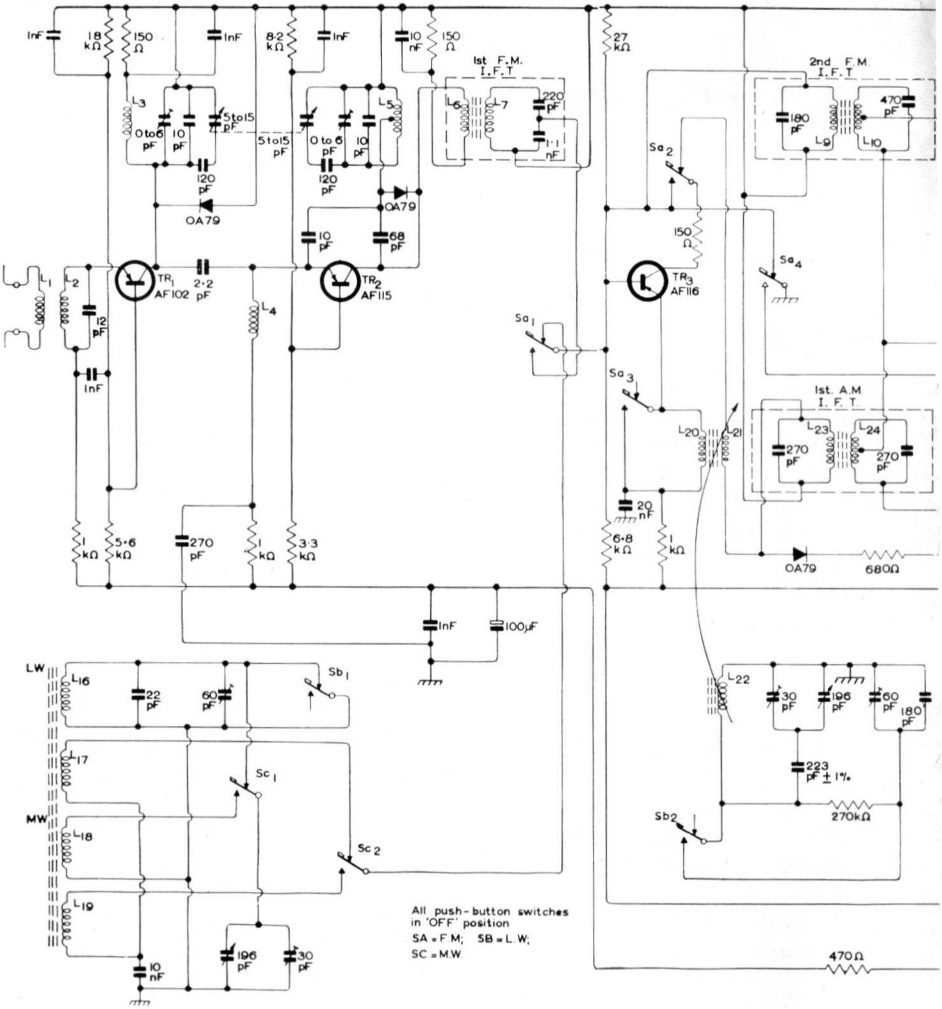
R.F. Stage

At frequencies in the region of 100Mc/s, the internal feedback in a transistor tends to become negative for a common-emitter configuration, but positive for a common-base configuration. This causes the gain with the common-base connection to be slightly greater than that obtainable with the common-emitter connection. The common-base configuration is therefore used, but the circuit is designed so that the stage remains stable under all operating conditions, including when the aerial is disconnected, the stability factor for a nominal AF102 being approximately 2·5.

The noise factor of the AF102 at 100Mc/s reaches a minimum when the emitter current is 1·4mA. For optimum noise and gain performance at this value of current, the source conductance should be inductive, and with the circuit of Fig. 3, it is almost optimum over the entire frequency band.

The source admittance is obtained by means of the input transformer which couples the 75Ω aerial to the transistor input terminals. This transformer is designed so that the insertion loss is very low. Maximum gain and signal-to-noise ratio are thus obtainable and fixed tuning can be used.

The bandwidth of the inter-stage circuit is 1Mc/s, and the total output conductance of the r.f. stage is made up of the output conductance, -23μmho, of the AF102, the input conductance, 100μmho, of the mixer stage and the conductance, 80μmho, of the collector circuit coil.

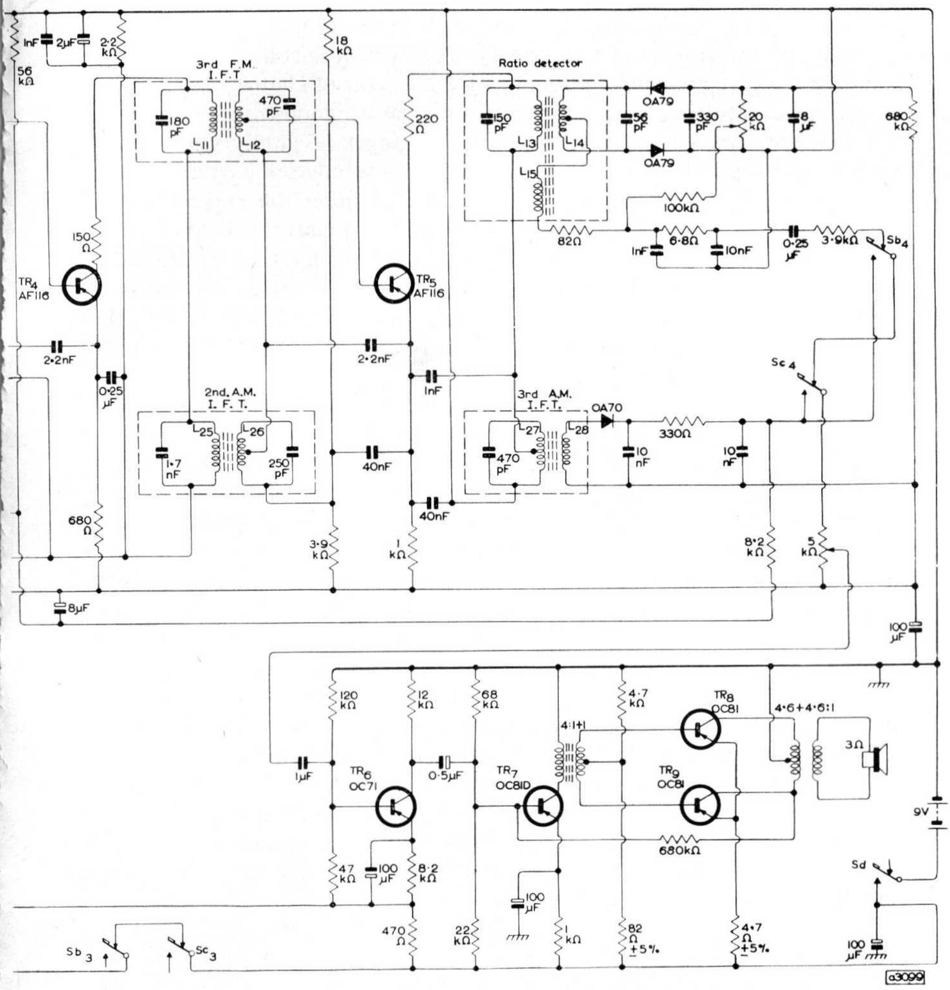


All push-button switches in 'OFF' position
SA = F.M; SB = L.W;
SC = M.W.

Fig. 3—F.M./A.M

F.M. Mixer Stage

The collector of the r.f. stage is coupled to the emitter of the mixer stage by a 2·2pF capacitor which provides an impedance match between the low output conductance of the r.f. stage and the high input conductance of the mixer. The coil in the emitter circuit of the mixer transistor provides a d.c. path for the emitter current, and forms with the 270pF bypass capacitor a series resonant circuit at 10·7Mc/s. This circuit acts as an i.f. trap at 10·7Mc/s and also prevents feedback at the intermediate frequency from the collector.



BATTERY-OPERATED RADIO RECEIVER

At frequencies of about 100Mc/s, the transistor output current lags behind the input current by approximately 90 degrees. In the oscillator circuit used in Fig. 3, this phase lag is corrected by the 10pF feedback capacitor connected between the tuned circuit and the transistor emitter. No further phase compensation is required, and the frequency of oscillation is the same as the resonant frequency of the tuned circuit.

At this resonant frequency, small errors in the phase are corrected by the tuned circuit with a minimum amount of frequency deviation, so giving the best possible frequency stability. Also the frequency stability is improved by connecting, by way of a 68pF coupling capacitor, the collector of the transistor to a tap on the oscillator coil. This minimises the effect on the resonant frequency of the circuit of changes in transistor capacitance resulting from changes in operating conditions.

Oscillator frequency drift results from changes in supply voltage. This drift is produced by the variations of both the emitter current and the collector voltage. Greater drift is produced if either the emitter current or the collector voltage is varied while the other quantity is held constant. The rate of change of drift with line voltage can therefore be altered by varying the current for which the oscillator is designed. The value of 1·7mA gives the minimum rate of change with a number of AF115. For a reduction in oscillator supply voltage from −7 to −4V, the drift is 70kc/s with a typical AF115.

In addition to the frequency drift caused by variation in the supply voltage, the frequency of oscillation can also be influenced by large input signals. With input signals in excess of 0·5mV at the aerial terminals, the magnitude of the r.f. signal reaching the mixer is sufficient to affect the operating condition of the transistor, so that any variation in the amplitude of the incoming signal would produce frequency modulation of the signal applied to the i.f. amplifier. This effect is considerably reduced by including a limiting diode in the collector circuit which limits the 10·7Mc/s component at the mixer collector. An additional limiting diode is connected to the collector of the r.f. stage. With these diodes, the frequency drift for 10mV aerial terminal voltage is reduced from 180kc/s to 15kc/s. With a 50mV input signal, the frequency drift is 30kc/s. In addition the a.m./f.m. suppression at these levels is considerably improved.

The oscillator drive voltage at the emitter of the AF115 is approximately 200mV over the band. This value is optimum for conversion gain. The oscillator continues to work when the line voltage is reduced from −7 to −4V. Oscillator radiation voltage is about 300μV across a 75Ω load at the aerial terminal.

A.M. Mixer Stage

The a.m. mixer stage operates at an emitter current of 1mA and is fed from an aerial source impedance of 600Ω at 1Mc/s in the medium waveband and 1kΩ at 200kc/s in the long waveband. The oscillator coil is designed so that oscillation is still maintained when the line voltage has fallen to 50% of its nominal value, except at the low-frequency end of the long waveband, where the figure is 60%. At the same time, an adequate margin of safety against squegging is obtained. This can be verified by ensuring that, at all frequencies, the emitter bypass capacitance can be increased to at least twice its nominal value before squegging occurs.

Since the output resistance of an AF116 transistor at a frequency of 470kc/s is very high, a high-impedance i.f. transformer can be used with advantage for maximum gain. However, it is found that with mixer collector loads in excess of 6kΩ, instability can occur when the receiver is tuned to the second or third harmonics of the intermediate frequency and large signals or interference pulses are applied which drive the mixer transistor into bottoming. To prevent the collector of the mixer transistor from bottoming, in this design the a.g.c. diode is used.

F.M. I.F. Amplifier

The f.m. i.f. amplifier uses three conventional common-emitter stages, and double-tuned transformers are used to obtain the best compromise between the flatness of the response curve in the pass band and the adjacent channel selectivity. The overall bandwidth required in the i.f. amplifier is ±100kc/s at −3dB and ±300kc/s at −40dB. This can be achieved by using three critically coupled double-tuned transformers each having a bandwidth of ±100kc/s at −1dB. To obtain this bandwidth at 10·7Mc/s, each coil requires a working Q-factor of 52.

It is considered that the improvement in gain arising from full or partial neutralisation is insufficient to warrant the extra complexity of the circuit. The gain obtainable without neutralisation is 20·75dB. This value assumes that there is no leakage inductance associated with the i.f. transformers. In practice, however, a leakage reactance of about 4Ω referred to the secondary tap must be expected, and to allow for the effect of this on the amplifier stability, the stages are designed for a gain of 20dB. To achieve this gain and the required working Q-factor of 52, an undamped coil Q-factor of 68·4 is required with a tuning capacitor of 180pF. This value of capacitance applies to the primaries of the transformers. A similar value could be used on the secondaries, but to minimise leakage inductance, the value on the secondary is increased to 470pF and the secondary tapping point is adjusted to obtain a ratio of 6·46 : 1 for the total primary turns to the secondary tap.

In addition to the use of a large value of secondary tuning capacitance to reduce leakage inductance, the coil-connecting leads should be kept as short as possible. It follows that since this precaution is necessary in the construction of the transformers, similar precautions will be necessary in the layout of the circuit.

The above considerations apply to the second and third i.f. transformers, which operate between similar transistors. The primary of the first i.f. transformer, however, is fed from the mixer stage, and stability conditions are less severe at 10·7Mc/s in this stage. It is possible therefore to raise the impedance of the first i.f. transformer primary and to obtain a better power match to the mixer output resistance, thus obtaining greater gain. This is achieved by increasing the undamped Q-factor of the coil to 90 and reducing the tuning capacitance to 68pF. The operating Q-factor of the transformer, and therefore also its bandwidth, is the same as for the remaining coils.

A.M. I.F. Amplifier

The design of the a.m. i.f. amplifier follows the conventional one of using two transistors in the common-emitter configuration. As the feedback capacitance in the transistors is small, neutralisation is not required. Two double-tuned transformers and one single-tuned transformer provide the necessary bandwidth and adjacent channel selectivity. The transformer impedances are chosen so that they are low compared with the input and output resistances of the transistor. This arrangement is made possible by the high intrinsic gain of the AF116, and it leads to a close control of performance from one amplifier to another.

The single-tuned transformer is placed in the collector circuit of the last i.f. transistor, where it is used to supply the power to the detector needed to operate the a.g.c. system.

Combination of A.M. and F.M. I.F. Stages

In combining the 470kc/s and 10·7Mc/s stages inductive tapping is used for the a.m. and f.m. transformers to allow optimum design at 470kc/s. Inductive tapping at 10·7Mc/s has the disadvantage, however, that the phase advance associated with the unavoidable leakage inductance adds to the phase lag associated with the forward and reverse transfer admittances of the transistor and detracts from the stability of the stage. A leakage inductance of 4Ω referred to the secondary tap can be tolerated if the stage gain is reduced by approximately 0·75dB. The gain then becomes 20dB per stage, which is acceptable.

Freedom of design between the f.m. and a.m. circuits is maintained since independent bypass capacitors are used for both circuits. The value of the bypass capacitor at the bottom of the f.m. input coil is made large enough for f.m. operation but is small enough to make only a small contribution to the tuning of the a.m. transformer. A much larger value, such as 0·1μF, can be used for the a.m. bypass capacitor. A similar arrangement is used in the collector circuit. The circuit has the advantage of placing no limitation on the degree of d.c. stabilisation that can be employed and it permits standardisation of coil design with a.m.-only receivers, which normally also use inductive tapping.

The above reasoning only applies to the second and third f.m. transformers which are used in conjunction with the 470kc/s transformers. The first f.m. i.f. transformer, which is connected to the mixer stage, may be either inductively or capacitively tapped. It is advantageous to use a capacitive tap since stray inductance introduced by switching already exists, and further leakage inductance is undesirable.

A.M. Detector and A.G.C. Circuit

The a.m. detector has the normal load resistance of 5kΩ. This allows a reasonable a.c./d.c. load ratio for the detector and provides sufficient power for the automatic gain control applied to the first i.f. amplifier.

The damping diode across the primary of the first i.f. transformer is forward-biased when the current in the controlled i.f. stage is reduced to a low value by the a.g.c. action. In the absence of strong signals, this damping diode is reverse-biased and has a negligible effect on performance.

Ratio Detector

The primary circuit of the ratio detector is designed to give a suitable collector load impedance for the last i.f. transistor. A balancing circuit is included to permit precise balance of the diode characteristics. A sample of the direct voltage across the load is fed back through the 100kΩ resistor to bias the diodes with a voltage proportional to the signal amplitude. After alignment of the i.f. amplifier, the ratio-detector secondary is tuned for the best ratio-detector curve at a low signal level, and then the balancing control is adjusted to give equal positive and negative excursions of the curve at high signal levels. The r.f. bypass capacitor (330pF) of the tertiary winding may then require adjusting to remove overall curvature on the straight part of the curve, as this value of capacitance is dependent on the mechanical construction used. Similarly, the value of the resistor between the tertiary winding and the r.f. bypass capacitor should be adjusted for best linearity and a.m. rejection once the layout has been finalised.

Audio Amplifier

The requirements for the audio amplifier in a transistor portable f.m./a.m. receiver are similar to those for a.m.-only receivers. Class B operation is still required in the interests of battery economy. Some improvements in the distortion and frequency response are desirable, however. These can be obtained by slightly increasing the standing current in the push-pull output stage to reduce cross-over distortion, and by using more negative feedback. In this design, a 500mW output stage is used as this is considered to be optimum for a portable receiver.

Since a three-stage amplifier is used, it is necessary to give some consideration to the noise performance of the pre-amplifier stage. A low operating current is required for low noise, and as the signal levels in this pre-amplifier are relatively small, a current of 0·25mA is adequate.

TEN-WATT VALVE HIGH-QUALITY STEREOPHONIC AMPLIFIER

This section describes a seven-valve, high-quality amplifier which uses one EF86 and two ECL86 in each channel and produces a maximum audio output of 10W from each channel. The distortion is very low (typically 0·2% at full output), and good hum and noise performance is ensured by the use of the EF86 in the first stage.

The overall negative feedback at 1kc/s is approximately 20dB. Particular care has been taken to ensure that at least 17dB is effective over the full audio range of 30c/s to 20kc/s.

CIRCUIT DESCRIPTION

The circuit diagram of the amplifier is given in Fig. 4. Only one channel is shown: except for the loudspeaker phase-reversal switch, the other channel is identical. The circuit is conventional and only the salient features will be discussed in detail.

The phase characteristic of the amplifier is an important consideration in the application of negative feedback. As the frequency response and the gain of each stage are related, the phase characteristic depends on the choice of individual stage gains. With the correct choice of stage gains, complicated feedback networks are avoided, and a good margin of stability is achieved.

Input Stage

The input stage uses one EF86 and has a voltage gain of approximately 120 times. The stage is capacitively coupled to the phase splitter.

Phase Splitter

The phase splitter uses the triode sections of two ECL86 in a long-tailed pair. Fixed bias to the grids is provided by a potential divider across the h.t. supply. The voltage gain is approximately 24 times between the input of the stage and the control grid of each pentode section.

The long-tailed pair is chosen because of its low distortion (less than 1%, mainly third harmonic, at 7V output) and its excellent amplitude and phase-balance characteristics. However, the residual unbalance with the nominal values of resistance in Fig. 4 is about 2%, and this and the spread in values of the high-stability anode resistors (2% tolerance) will make a contribution to the distortion of the complete amplifier.

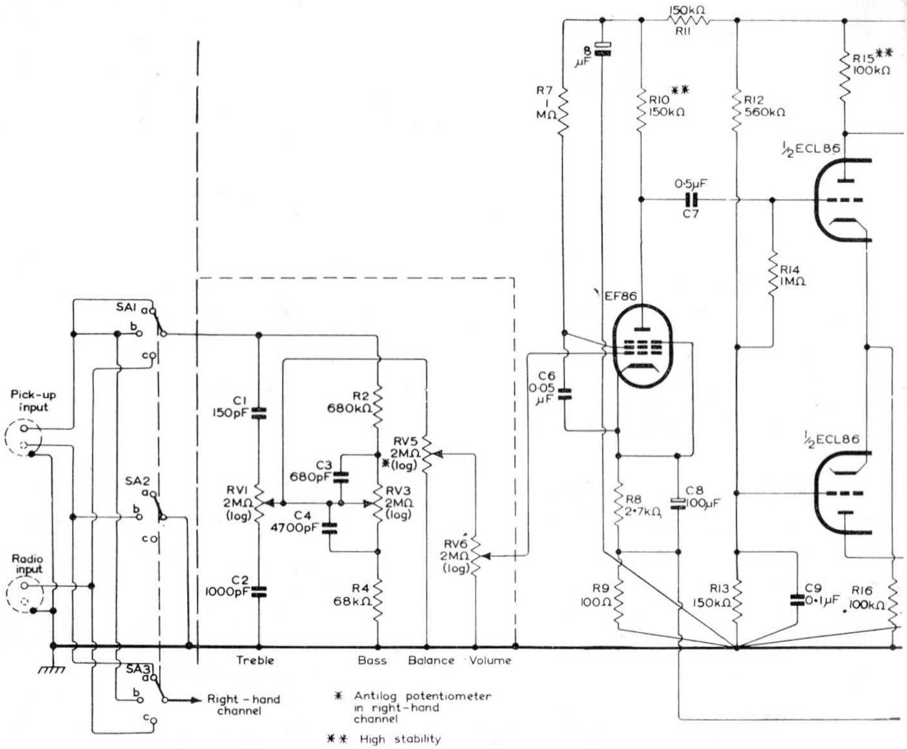


Fig. 4—TEN-WATT VALVE

Output Stage

The push-pull output stage of Fig. 4 uses the pentode sections of the two ECL86 operating under class AB conditions with distributed loading.

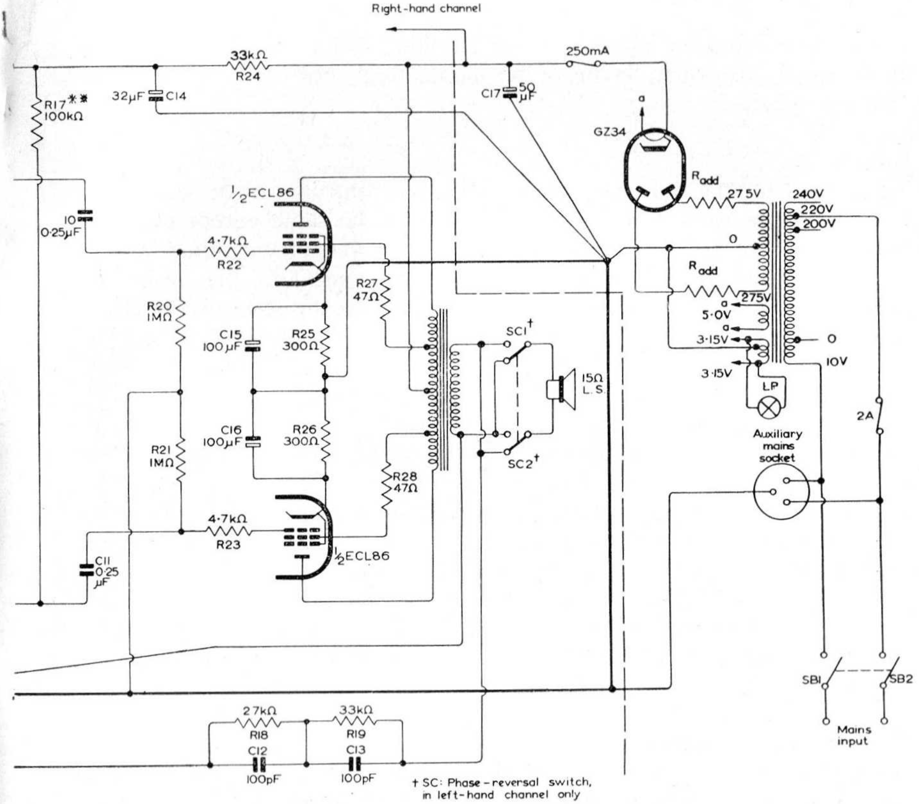
The output transformer should be of the construction normally used in high-quality amplifiers. In particular it should be free from any pronounced resonances. The turns ratio should be such that the anode-to-anode load is 9kΩ after allowing for the winding resistances.

Negative Feedback

Negative feedback of about 20dB is taken from the secondary winding of the output transformer to the cathode circuit of the input stage.

Low-frequency Stability

Coupling time-constants and screen-grid and cathode bypass time-constants which are considerably greater than the transformer time-constant ensure low-frequency stability. The loop phase shift when the l.f. loop gain is unity is 300 degrees.



HIGH-QUALITY STEREOPHONIC AMPLIFIER

The frequency response curve of the amplifier with feedback is flat to within ±3dB between 4c/s and 60kc/s. A hump of 1dB occurs at 12c/s and will increase if the value of any of the coupling or bypass capacitors is decreased, or if the value of transformer primary inductance is increased. A large change in any of these values will produce instability.

High-frequency Stability

A phase-advance network in the feedback loop ensures high-frequency stability. This amplifier has a good margin of stability. The phase change when the h.f. loop gain is unity is about 35 degrees, and the loop gain at zero phase change is −17dB. The stability is much better with normal loudspeaker loads. A capacitance of 0·5µF can be placed across a 15Ω resistive load without causing instability. The capacitance required to cause instability with normal loudspeaker loads would be smaller because of speaker resonances.

The high-frequency stability of the amplifier will require reappraisal if an output transformer having a resonance frequency lower than about 110kc/s is used.

Controls

The circuit for the tone, volume and balance controls can be seen from Fig. 4. The network for the other channel is the same except that the balance-control potentiometer should obey a reverse-logarithmic law.

Simple passive tone-control networks are used, and the design is straightforward. The ranges of control relative to the response at 1kc/s are:

Bass: +12 to −12dB at 30c/s
Treble: +12·5 to −12dB at 15kc/s

Dual-ganged, 10% log-law potentiometers are commonly used in tone-control circuits. The tolerance on the angular position corresponding to 10% resistance is wide with these potentiometers, and this results in a similar tolerance on the location of the 'flat-response' position of the tone controls. Closer angular tolerance on the 10% resistance value can be obtained if 5% log-law potentiometers are used.

Either 5% or 2% log-law and reverse-log-law ganged potentiometers can also be used for the balance control. These cause a lower loss in the central position than the 10% log-law and reverse-log-law potentiometers.

Switched Tone Controls

Because of the coarseness of matching (20%) of ganged potentiometers, the tone-control characteristics of the two channels may not be identical, but identical responses can be obtained if switched controls rather than the continuously variable controls are used. Resistor values are given in Fig. 5 for switched tone controls; the resistances have been chosen to give equal increments (in dB) of boost and cut.

Power Supply

The valve complement of the amplifier is two EF86, four ECL86 and a rectifier valve. The h.t. supply requirement, and therefore the choice of rectifier, depends on whether the output stage is designed for full-dissipation operation (full power with sine-wave drive) or for low-dissipation operation (speech or music signals only).

The h.t. line voltage should be such that the quiescent anode-to-cathode voltage for the pentode sections of the ECL86 is 300V. Care should be taken to ensure that the maximum anode voltage rating of the valve (300V) is not exceeded.

A value of limiting resistance $R_{lim(min)}$ is required at each anode of the rectifier, and unless this value is provided by the winding resistances of the mains transformer, some value of resistance R_{add} must be included in each anode circuit of the rectifier. The value of R_{add} is given by the standard equation:

$$R_{lim(min)} = R_s + n^2 R_p + R_{add} ,$$

where R_s is the resistance of half the secondary winding of the mains transformer, R_p is the resistance of the primary winding and n is the ratio of half the number of turns on the secondary winding to the whole number of turns on the primary winding.

Full-dissipation Operation

The cathode resistance required for the pentode section of each ECL86 is 300Ω. The quiescent current drain of the amplifier is 140mA, and the current drain with full drive is 160mA. Reference to the rating chart of the EZ81 published in the Mullard Technical Handbook shows that a current drain of 160mA at 300V is excessive for operation with a capacitive input filter. The EZ81 is therefore unsuitable as the rectifier and the GZ34 is thus the recommended rectifier. The required value of $R_{lim(min)}$ is 50Ω per anode.

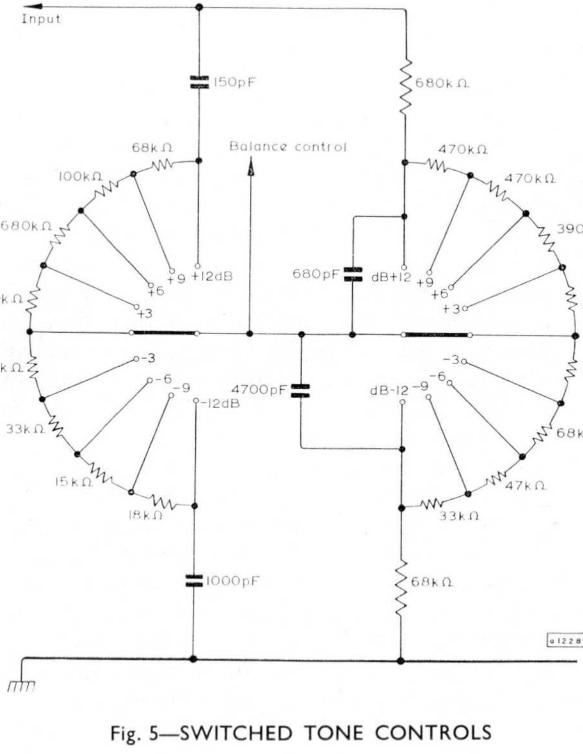


Fig. 5—SWITCHED TONE CONTROLS

The heater supply requirements for an amplifier using a GZ34 rectifier are:

6·3V, centre-tapped, 3·2A
5·0V, 2A

If an indicator lamp is included in the amplifier, the current requirement at 6·3V becomes 3·35A.

Low-dissipation Operation—Speech or Music Signals Only

The cathode resistance required for the pentode section of each ECL86 is 470Ω. The quiescent current drain of the amplifier is 105mA, and the current drain at full drive (music) is 120mA. Thus for speech or music operation only, the EZ81 can be used, provided that current is not required for ancillary equipment. The required value of $R_{lim(min)}$ for the EZ81 is 190Ω. Whether the GZ34 or the EZ81 is used, the line voltage must be adjusted so that the quiescent anode-to-cathode voltage of the pentode sections is 300V. The heater supply requirements for an amplifier using the EZ81 rectifier are:

6·3V, centre-tapped, 3·2A (plus optional 0·15A)
6·3V, 1A

Earthing

Care in the routing of earth returns and in the wiring layout is necessary to attain a low level of hum and also to minimise second harmonic distortion resulting from common-impedance coupling. For instance, at full sine-wave output, the peak current in each output pentode section is about 120mA, the peak from each valve occurring once in every cycle of the input signal. These pulses of current combine in the common h.t. and earth lines to form a steady current with a ripple content which has twice the frequency of the input signal and a peak-to-peak amplitude of 82mA. If any voltage produced by either the current in one output pentode section or the current in the common line is injected into the input circuits, it will produce an output at even multiples (mainly twice) of the input frequency. This, of course, is experienced as distortion. The voltage developed across a resistance of only 0·01Ω in the common earth return will, if fed back to the input, result in approximately 10% second-harmonic distortion (in the absence of negative feedback).

The earth returns of each stage are grouped together, the h.t. supply decoupling capacitors being included with the appropriate stage. The input stage is connected to the chassis at the input socket. The phase splitter and output stage returns are taken to the reservoir capacitor, which is also connected to the chassis at the input socket.

Magnetic fields caused by the flow of the output-stage current in wiring loops can also induce voltages in the input circuit and can thus cause second-harmonic distortion. The layout of the wiring and the location of the cathode bypass capacitors should be arranged so that magnetic coupling with the input circuit is avoided.

PERFORMANCE

The sensitivity of each channel in the basic amplifier for an output power of 10W is 2·3mV without feedback and 23mV with feedback. The sensitivity of the complete amplifier, including tone controls, is 250V.

At 50mW output with feedback, the response is flat to within ±3dB from 4c/s to 60kc/s; at 10W output, it is flat from 12c/s to 50kc/s.

The small amount of ringing on the pulse waveform is attributable to the very short rise time of the edges of the pulses. No ringing occurs on pulses with rise times longer than 5μs, and since those of transients present in music are considerably longer than this, the response of the amplifier is more than adequate for music reproduction.

Harmonic Distortion

The values of distortion of the amplifier are slightly higher than would be expected from the output stage alone because of the distortion and unbalance introduced by the phase splitter. Since the distortion in the phase splitter can either add to or subtract from the distortion in the output stage, the distortion was measured again with the ECL86 interchanged. The total harmonic distortion is likely to vary from amplifier to amplifier but should not exceed 0·4% at 10W. A typical value of total distortion is 0·2% at 10W.

Output Impedance

The output impedance of the amplifier measured at the 15Ω terminals for an output of 1W at 1kc/s is 1·4Ω. This low value is maintained over a frequency range of 30c/s to 15kc/s.

Hum and Noise

The combined hum and noise level in the amplifier with the input short-circuited at the control grid of the EF86 is typically 75dB below 10W for the audio bandwidth of 20c/s to 20kc/s. The hum and noise with a 470kΩ resistor connected across the input is −65dB.

With the input short-circuited, the level of hum alone is typically −76dB. Most of this derives from ripple on the h.t. line. The contribution of hum from a.c. heating in the EF86 is −86dB and is negligible. The change in the hum level when a 470kΩ resistor is connected across the input is also negligible.

The level of noise with the input short-circuited is −80dB. With a 470kΩ resistor connected across the input, the level rises to the predictable value of −66dB. This figure is determined entirely by the Johnson noise in the 470kΩ resistor; the contribution of the EF86 is negligible in comparison.

TEN-WATT TRANSISTOR HIGH-QUALITY AMPLIFIER

Part 1—10W Class AB Amplifier

INTRODUCTION

Eight transistors are used in the power amplifier illustrated in Fig. 6. The Mullard OC71 and OC81 form a two-transistor input stage. Two AF118 comprise the phase splitter which feeds two OC81Z driver transistors and two AD140 power transistors in a push-pull output stage. The 'π-mode' of class AB operation is used in the output stage. This differs from normal class AB operation in that the total current in the stage remains constant with varying levels of drive.

The rated output of the amplifier into a 15Ω load is 10W at 0·06% total harmonic distortion. The sensitivity for this output is 140μA r.m.s. The performance of the amplifier compares favourably with that of established Mullard valve amplifiers such as the 'Five-Ten' and ECL86 ten-watt circuits.

π-mode Class AB Operation

The class AB amplifier shown in Fig. 6 operates in the 'π-mode', which differs from the normal class AB mode in that the total current remains constant with drive. Increasing the level of drive will cause the operating point of the transistors to change first from class A to class AB and then to class B. Up to 40% of full power, the transistors operate in class A push-pull, but as the drive is increased further the operating conditions change and the transistors work in class AB until, at full power, the conditions are such that the transistors operate in class B mode. (The 'π' itself is obtained from the relationship $i_{pk} = \pi I_q$ between peak and quiescent currents when the transistors work in class B.)

The advantages of the π-mode of operation are:

(i) Crossover distortion such as that associated with class B is absent.

(ii) Regulation is not important since the current drain from the power supply is constant. Adequate smoothing of the power supply can be obtained by simple R-C filtering.

(iii) Short-circuiting of the output terminals will not damage the transistors.

(iv) Distortion at normal listening levels is very low since the transistors operate in class A at low power levels.

(v) With the use of emitter-loaded operation, the distortion of the amplifier over the full power range can be controlled to specific limits by a suitable choice of driver-stage source impedance.

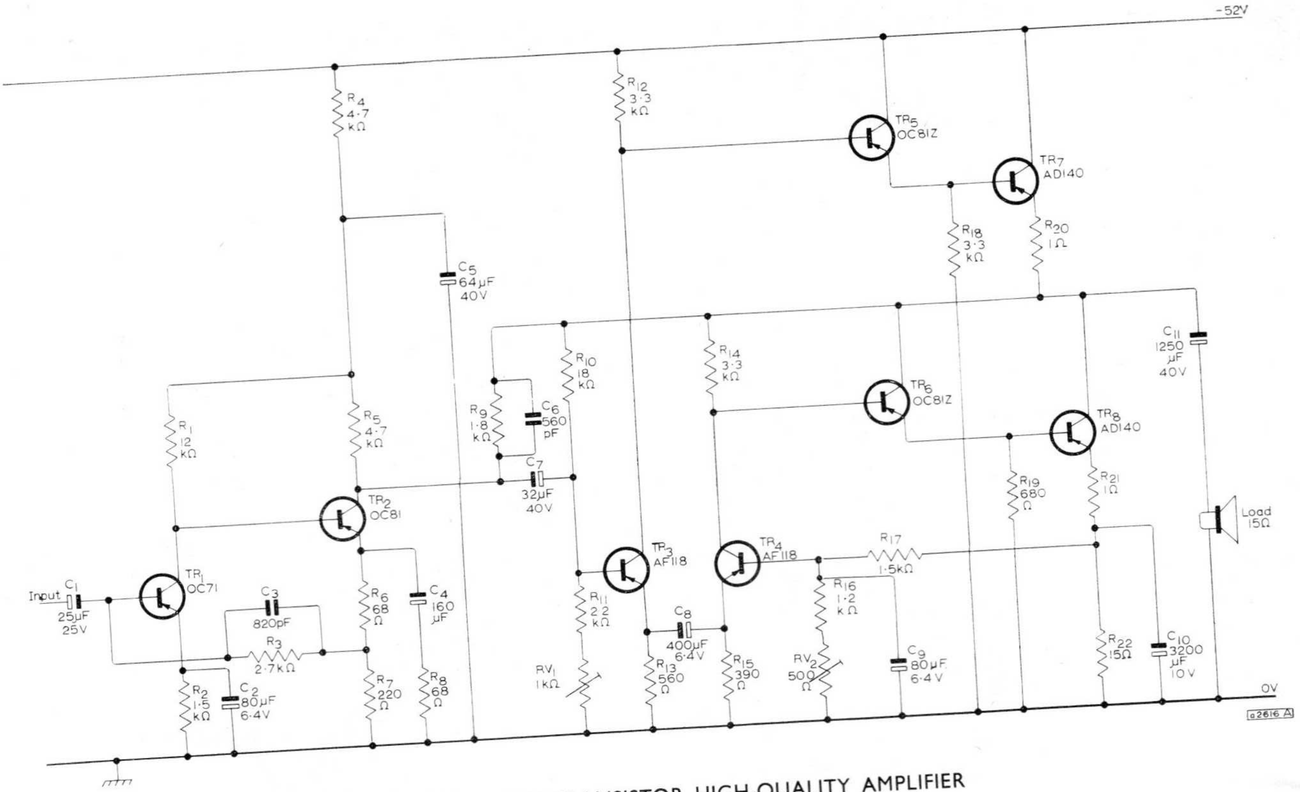


Fig. 6—TEN-WATT TRANSISTOR HIGH-QUALITY AMPLIFIER

CIRCUIT DESCRIPTION

Output Stage

The output transistors TR_7 and TR_8 of the amplifier circuit of Fig. 6 require to be driven from a low-impedance source. To provide this, the two driver transistors TR_5 and TR_6 are connected in the common-collector configuration. This configuration is comparable with the cathode-follower connection of valves, and affords an impedance transformation by virtue of its high input and low output impedances. Use of these driver transistors simplifies the design of the phase splitter; without the impedance transformation, a high-power phase splitter would be needed.

Phase Splitter

A modified long-tailed-pair arrangement of transistors TR_3, TR_4 is used as the phase splitter because of the symmetry of output and low distortion afforded by this configuration. In a conventional long-tailed-pair circuit, the collector resistors are equal, and a shared emitter resistor is used. The disadvantage of this is that the collector currents can vary because of production spreads in transistor characteristics and temperature variations. This disadvantage is overcome by using separate emitter resistors (R_{13} and R_{15}) and by capacitance-coupling of the emitters, as in Fig. 6.

Stability of the collector currents is further improved by directly coupling the phase splitter to the output stage through R_{10} and R_{17} and by applying overall d.c. feedback, by way of R_9, C_6 and R_{16}, C_9. Thus the midpoint voltage (−29V) is defined by the one feedback loop (R_9, C_6) and the quiescent current through the output transistors by the other (R_{16}, C_9). Setting-up adjustments to the midpoint voltage and quiescent current can be made by means of the preset variable resistors RV_1 and RV_2 in the base circuits of TR_3 and TR_4 respectively.

The collector resistors R_{12} and R_{14} are chosen to give the low impedance necessary for class AB operation. They must be matched to within 5% in order to minimise even-harmonic distortion. The voltages across these resistors are such that the emitter-to-collector voltages of the output transistors are slightly higher than the values required for a maximum output of 10W. This is to ensure that the phase splitter is not cut off when the output stage is driven to 10W. Hence at this power, the phase splitter is not working in the non-linear low-current region.

The loudspeaker load in Fig. 6 is placed in the emitter circuit of TR_7, and the phase-splitter output from TR_3 is applied between the base of the driver transistor TR_5 and chassis. This is necessary for the class AB operation. The drive for TR_8 obtained from the collector of TR_4 is applied between the base of the driver transistor TR_6 and the live end of the load.

Negative Feedback

Overall negative feedback of 44dB is applied from the output to the base of the input transistor of the phase splitter. As the three stages within the loop are directly coupled, except for the emitters of the phase splitter, low-frequency instability cannot occur. The high-frequency stability of the three stages is no problem as the phase splitter uses alloy-diffused transistors with very high cut-off frequencies. The overall negative feedback is applied by R_9 and C_6, the latter removing overshoot to give good pulse response.

Input Stage

The phase splitter is driven by a two-stage current amplifier. Negative feedback is applied by way of R_3, C_3 over this two-stage amplifier to minimise distortion and to obtain the correct sensitivity.

PERFORMANCE

In the design of the 10W amplifier illustrated in Fig. 6, the objective has been that a minimum of audible deterioration should be incurred in the quality of the reproduced programme material. Such deterioration can result from one or more of several causes, the important ones being:

(i) Non-linearity distortion, introduced by the curvature of the voltage/current characteristic of the output stage in the region of transfer of conduction from one transistor of the push-pull pair to the other. Two main forms of non-linearity distortion are harmonic and intermodulation distortion.

(ii) Inadequate frequency response.

(iii) Poor transient response, indicating high- or low-frequency instability.

The performance of the amplifier is therefore expressed principally in terms of these characteristics.

Non-linearity Distortion

It is desirable in assessing non-linearity distortion to establish a close correlation between the measured values and the unpleasantness of 'crossover' distortion. To do this for the 10W amplifier, the variation of gain along the transfer characteristic is measured. Two signals, one at 10kc/s and one at 100c/s, whose amplitudes are in the ratio 1 : 10, are applied simultaneously to the amplifier.

From the output, the 100c/s is filtered out, and the 10kc/s signal observed on an oscilloscope. The variation of amplitude of the 10kc/s signal corresponds to the variation of gain along the transfer characteristics. The maximum variation of gain—the maximum 'gain deviation'—correlates well with the unpleasantness of crossover distortion. Extensive tests have shown that the maximum gain deviation method can be extended to all forms of non-linearity distortion, provided the transfer characteristic is not frequency-dependent. However, when the transfer characteristic is frequency-dependent (for example, when the negative feedback is less at high frequencies than at low frequencies) some method of measuring the high-frequency intermodulation distortion is necessary. A sensitive method is to pass 'white noise' (that is, all frequencies) confined to the high-frequency band, for example 16kc/s to 20kc/s, through the amplifier and measure the resultant noise below the h.f. band, for example, below 10kc/s.

The overall feedback has been chosen to reduce the gain deviation and h.f. intermodulation distortion to acceptable levels. The intermodulation distortion measured by the gain deviation method is less than 1·5% at 10W, and the h.f. intermodulation distortion is 60dB below the level of the 'white-noise' signal.

The harmonic distortion in the mid- and low-frequencies has also become extremely low: the class AB amplifier has 0·06% total harmonic distortion at 10W output at a frequency of 1kc/s.

Frequency Response

If the frequency range of a sound-reproducing system over which the output relative to that at 1kc/s does not fall below half (−3dB) corresponds with the normal audible frequency range (30c/s to 15kc/s), the quality of reproduction will not be impaired. This gives the minimum bandwidth requirement for an output at 1kc/s of 1W. The peak power of musical instruments is in the low- and mid-frequency ranges, however, so that the upper limit of the response at the rated output at 1kc/s need not be greater than about 10kc/s.

At 1W output, the response is flat to within 3dB from 16c/s to 60kc/s; at 10W, the response is flat to within 3dB from 16c/s to 20kc/s.

Transient Response

An important requirement is that the amplifier shall have a good margin of stability. The high-frequency stability is conveniently checked by observing the pulse response of the amplifier. The pulse should show very little ringing with resistive, resistive-capacitive, and inductive-capacitive loads.

The feedback capacitor C_6 determines the upper limit of the frequency response and the rise time of the amplifier. If this is chosen to give adequate margins of stability with the above types of load, then the correct pulse response will be obtained. The rise time of the amplifier is about 8μs. It is desirable to restrict the high-frequency response of the amplifier to about 20kc/s. If C_6 is made 4700pF, then the upper −3dB point becomes 20kc/s but the rise time becomes 20μs. The stability margin is, of course, considerably increased.

Stability

The low-frequency stability was checked by driving the amplifier with square waves of one second duration. The output indicated good low-frequency stability.

Output Impedance

The output impedance of the amplifier is less than 0·2Ω over the frequency range 30c/s to 10kc/s.

Sensitivity
The sensitivity of the amplifier is 140μA r.m.s. for the rated output of 10W.

Input Impedance
The input impedance of the amplifier is very low, and is of the order of 20Ω.

Part 2—Pre-amplifier

INTRODUCTION

Three OC75 transistors are used in the pre-amplifier circuit of Fig. 7, and by virtue of the design of the first stage, the noise level is well below typical user requirements. A further lowering of the noise level by half (3dB) can be achieved by the use of an AC107 in the first and third stages.

The circuit is suitable for most crystal and ceramic pick-up heads. In the magnetic pick-up position, the circuit gives correct equalisation for a pick-up head of 500mH inductance. Other values of inductance require a different resistance in the input circuit. In the radio input position, the input resistance is 100kΩ and the sensitivity 100mV. Other values of input resistance and sensitivity can be obtained by altering resistor values.

Alteration of the resistor values in the radio input position enables an equalised tape input to be accommodated in that position. The equalised tape input can be also accommodated by replacing one or other of the pick-up inputs. Fig. 8a gives the arrangement for the combination of radio, equalised tape and magnetic pick-up; Fig. 8b offers the combination of radio, tape and crystal pick-up.

Bass and treble tone controls are provided in the circuit of Fig. 7, and simple h.f. and l.f. filters are incorporated.

GENERAL CIRCUIT CONSIDERATIONS

The number of amplifying stages, the location of volume control and tone controls, and the signal levels throughout the pre-amplifier are governed by a number of conflicting requirements.

An important requirement is that all amplifying stages preceding the volume control should be capable of handling signals much greater than the nominal input level. This is necessary because of the wide variations of recording levels and sensitivities of pick-ups; and it is common practice to design the 'pre-volume-control' stages to handle an increase of input level by a factor of at least 10 without excessive distortion. Obviously it is easier to obtain large dynamic ranges if the signal levels are very low. However, too low a signal level would make the noise contributed by the circuit very much more troublesome. Thus the location of the volume control is a compromise between dynamic range and noise.

The noise requirements are as follows. First, the noise introduced by the pre-amplifier should be well below the noise present with the programme material—for example, recorded noise. This requires careful design of the input stage, and again the operating conditions of the input transistor are a compromise between noise and dynamic range. The second requirement is that with the volume control turned down fully, the noise from the system under typical user conditions should be inaudible. To meet this condition, the volume control should be as late in the system as possible. This, however, conflicts with the dynamic range requirements and in practice a compromise is adopted.

Tone controls generally introduce a loss, with a factor of 10 or more being common. Placing the tone controls before the volume control increases the signal handling problems of the pre-volume-control stages. If the tone control is placed immediately after the volume control then the signal level after the tone controls may be so low that the noise of the stage following a tone control becomes a problem. A better solution is to follow the volume control by a single stage of amplification and then the tone control circuits.

PRE-AMPLIFIER CIRCUIT

The pre-amplifier circuit is shown in Fig. 7. The transistors TR_1 and TR_2 forming the input amplifier are directly coupled with overall d.c. feedback via R_9 to stabilise operating conditions. The undecoupled emitter resistor R_{12} presents a high impedance to the collector of TR_1. The voltage gain of TR_1 is therefore high, enabling high-impedance feedback networks to be used for equalisation.

In the magnetic pick-up position, R_6 in conjunction with the pick-up inductance gives h.f. 'roll-off'. The value of R_6 should be chosen to suit the individual pick-up:

L_s :	200	300	400	500	600	700	mH
R_6 :	2·7	4·7	5·6	6·8	8·2	10	kΩ

A bass-lift equalisation characteristic is provided by the feedback components R_3 and C_3. Resistor R_4 across C_3 restricts the otherwise excessive gain at very low frequencies.

In the crystal pick-up position, equalisation is provided by the network R_2 C_2 C_1. The component values are suitable for pick-ups with capacitances greater than 500pF. The lower cut-off frequency is about 80c/s—this is equivalent to using a 5MΩ load across the pick-up in conventional valve circuits.

In the radio position, the gain is determined by the feedback resistor R_1 and the input resistance by R_5. These can be chosen to suit individual requirements. The input impedance with the values given in Fig. 7 is 100kΩ, and is therefore suitable for valve tuner units. (If a transistor tuner unit is to be used, an impedance of about 10kΩ is required. R_5 should therefore be reduced to 10kΩ, and R_1 should be reduced to 820Ω to maintain correct sensitivity.)

In the equalised tape input position (Fig. 8), the values of R_X and R_Y must be chosen to suit the particular tape input used.

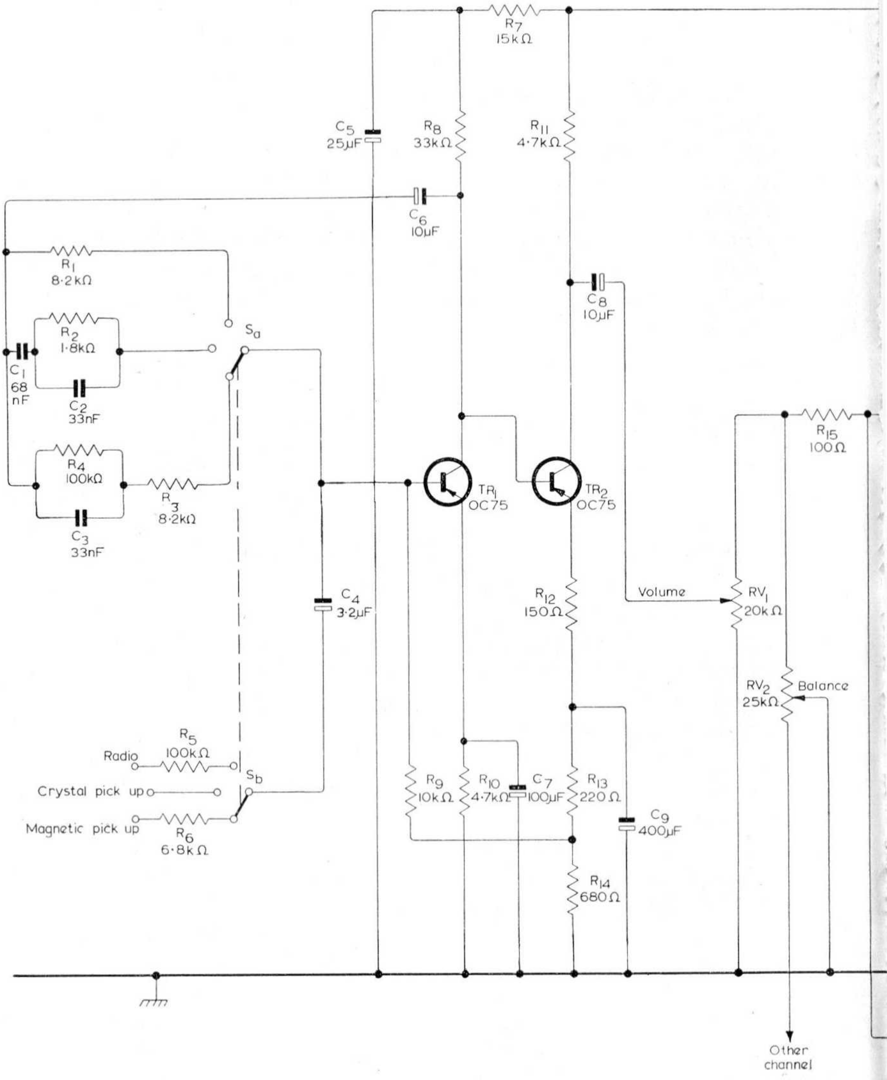
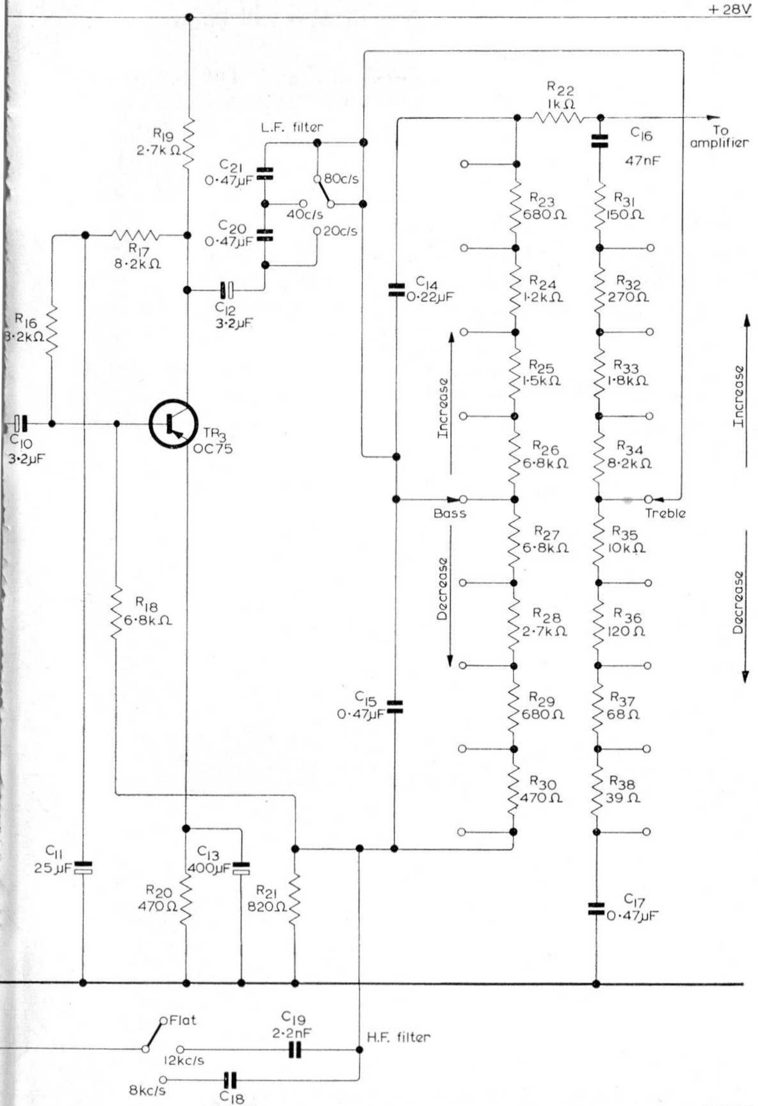


Fig. 7—TRANSISTOR

The input amplifier is followed by the volume and the balance controls. These are followed by the amplifying stage consisting of transistor TR_3, which feeds the tone control network. Overall negative feedback is applied via resistor R_{18} to reduce distortion.

Switched bass and treble tone controls are provided. By the use of



PRE-AMPLIFIER

switching, it is easier to maintain identical responses between both channels of a stereo system than when continuously variable controls are used. Also the values of resistance for equal increments of boost or cut are such that conventional potentiometers will not be suitable because the tone control circuit is part of the feedback network. If sufficient feedback is used to reduce distortion, and passive tone control circuits with conventional potentiometers are used, then the loss of gain will be greater and an extra stage may be necessary.

Simple h.f. and l.f. filters are incorporated in Fig. 7. The lowest bass cut-off frequency of the pre-amplifier is about 20c/s. This can be increased by decreasing the value of the coupling capacitor C_{12} by switching-in series capacitors. A suitable value for the series capacitors is 0·47μF. The inclusion of one of these raises the lower cut-off frequency to 40c/s; the inclusion of two raises it to 80c/s.

The h.f. response can be reduced by shunting the feedback resistor R_{18} with suitable capacitors. Switching-in a 3·3nF capacitor gives a treble cut-off frequency of 8kc/s; inclusion of a 2·2nF capacitor gives a cut-off frequency of 12kc/s.

The sensitivity of the pre-amplifier in the magnetic pick-up position is 5mV for an output current of 140μA. This current of 140μA is the input required by the 10W amplifier for an output of 10W. The corresponding sensitivity in the crystal pick-up position is 500mV (source capacitance 500pF), and the sensitivity in the radio position is 100mV.

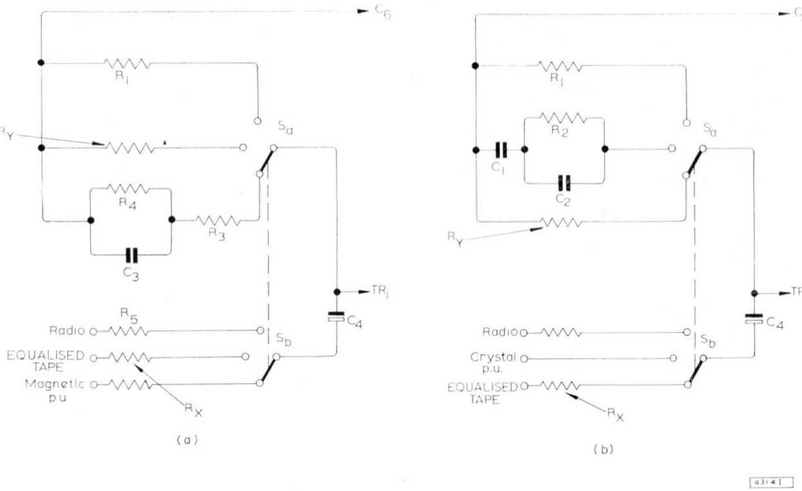


Fig. 8—CIRCUIT MODIFICATIONS FOR EQUALISED TAPE INPUT
(Values of R_X and R_Y to be chosen to suit particular tape input)

The total harmonic distortion at 1kc/s in the magnetic pick-up position is less than 0·05% for an input of 5mV. If the input is increased to 50mV and the volume control turned down so that the output is 140µA, then the total harmonic distortion increases to about 0·3%.

The tone control characteristics cover the ranges:

Bass: +12dB to −13dB at 100c/s
Treble: +8dB to −10dB at 10kc/s

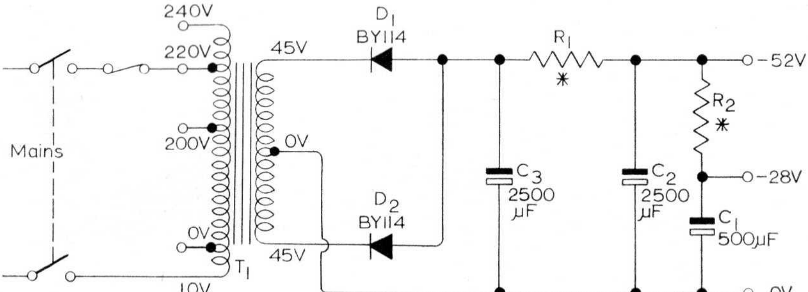
MONO AND STEREO APPLICATIONS

The circuit of Fig. 7 is suitable either for monophonic equipment or as one channel in stereophonic equipment.

In the mono application, the balance control RV_2 is not needed. In the stereo application, of course, the volume control RV_1 must be two ganged potentiometers, and the filter and tone control switches must accommodate the components of both channels.

POWER SUPPLY

The power supply circuit for two 10W amplifiers and the stereo pre-amplifier is given in Fig. 9. The smoothing of this supply should be such that the ripple level on the −52V line is not greater than 100mV peak to peak.



Voltage across C3 should be between 58 to 60V

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Fig. 9—POWER SUPPLY
*(Values of R_1 and R_2 chosen to give stated voltages)

INTRODUCING THE MULLARD TECHNICAL HANDBOOK SERVICE

The abridged technical data given in this manual, like that normally published in price lists, folders, catalogues, etc., should meet the needs of a very large number of valve users. Engineers, particularly those concerned with the design of new equipment, will, however, require information which is more comprehensive. It is primarily for these engineers that the Mullard Technical Handbook is issued.

The handbook is a loose-leaf publication containing data sheets on all available Mullard valves, tubes and semiconductor devices. The advantage of the loose-leaf system is that the handbook can be kept up-to-date by the issue of new, supplementary or revised sheets. The sheets are firmly secured in a number of hard-wearing, spring-backed binders. The information provided includes: recommended operating conditions; performance figures for various applications; limiting values; and characteristic and performance curves.

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