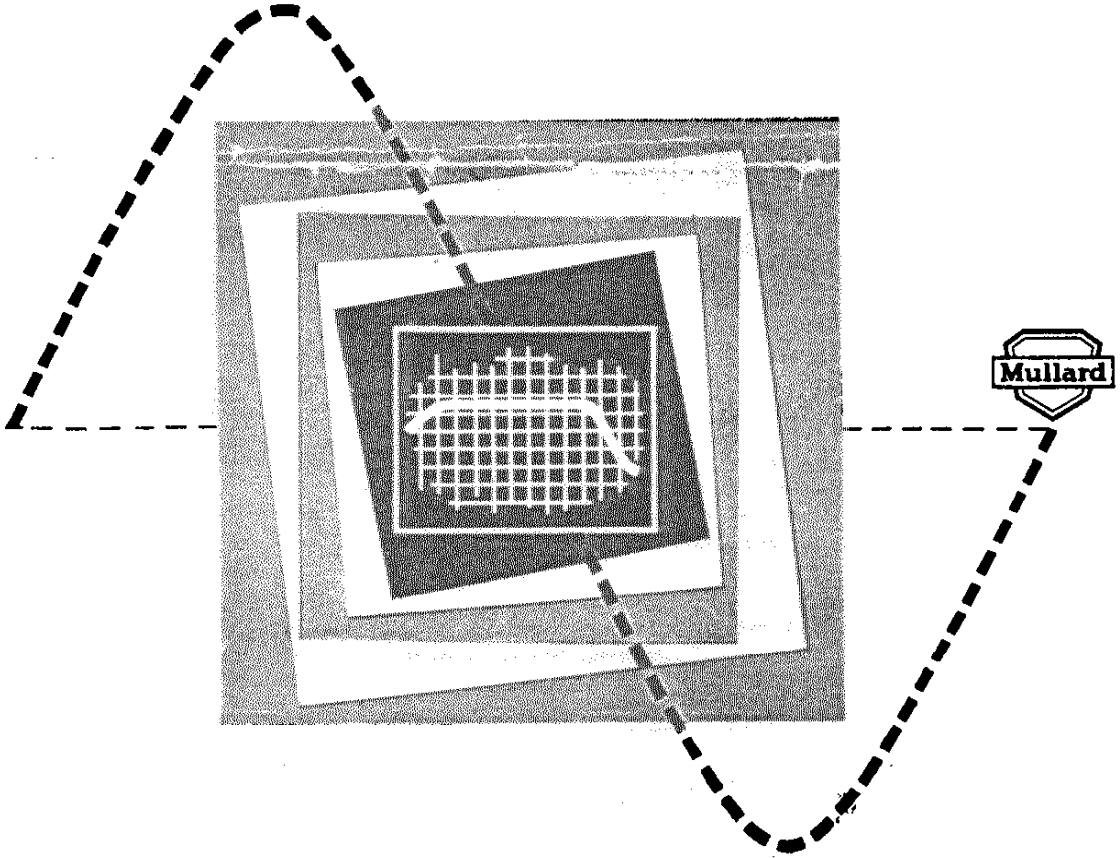
Mullard

WORLD SERIES

valves for

audio equipment



A high gain pentode of special design, the EF86 is particularly suitable for preamplifier and input stages, in which hum, noise and microphony must be kept to a minimum. The low frequency noise generated by the valve is equivalent to a voltage of 2 μV on the control grid for a bandwidth from 25 to 10,000 c/s. The electrode structure has been made particularly rigid to keep the microphony of the valve to a very low level. There are no appreciable internal resonances below 1000 c/s, the vibration at higher frequencies being effectively damped out by the chassis and the valveholder.

Hum is kept to a minimum by winding the heater as a bifilar twisted pair of wires, with the magnetic field of the one wire opposed to that of the other. Effective internal screening reduces the internal valve capacitances through which hum can be transferred to the output. The screening also shields the electrode structure from the alternating fields set up by transformers, etc., which otherwise would induce a.c. mains frequency currents in them.

HEATER

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

V_h	6.3	V
I_h	0.2	A

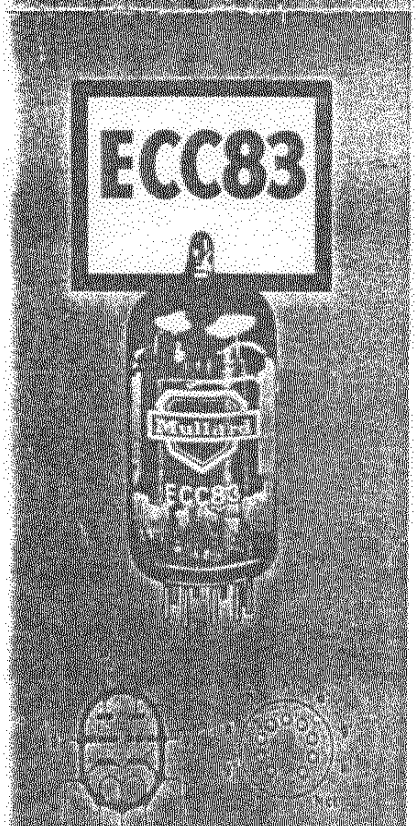
CHARACTERISTICS

V_a	250	V
V_{g3}	0	V
V_{g2}	140	V
I_a	3	mA
I_{g2}	0.6	mA
V_{g1}	−2	V
g_m	1.8	mA/V
r_a	2.5	M Ω
μ_{g1-g2}	38	

LIMITING VALUES

V_a max.	300	V
p_a max.	1.0	W
V_{g2} max.	200	V
p_{g2} max.	0.2	W
I_k max.	6.0	mA
R_{g1-k} max. ($p_a > 0.2$ W)	3.0	M Ω
R_{g1-k} max. ($p_a < 0.2$ W)	10	M Ω
V_{h-k} max. (cathode positive)	150	V
V_{h-k} max. (cathode negative)	100	V
*R_{h-k} max.	20	k Ω

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



R–C coupled amplifiers or phase splitters can conveniently be built around a high-μ double triode with separate cathodes such as the ECC83. The amplification factor of this valve is 100, so that adequate gain can be obtained in the cathode coupled type of phase splitter used for the Mullard designed 5-valve 10-watt amplifier and the 20-watt amplifier using EL34 output valves.

HEATER

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

The heater is centre-tapped and the two sections may be operated in series or in parallel with one another:—

Series V_h applied between pins 4 and 5.

Parallel V_h applied between pin 9 and pins 4 and 5 connected together.

	Series	*Parallel*	
V_h	12.6	6.3	V
I_h	0.15	0.3	A

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	k Ω

LIMITING VALUES

(each section)

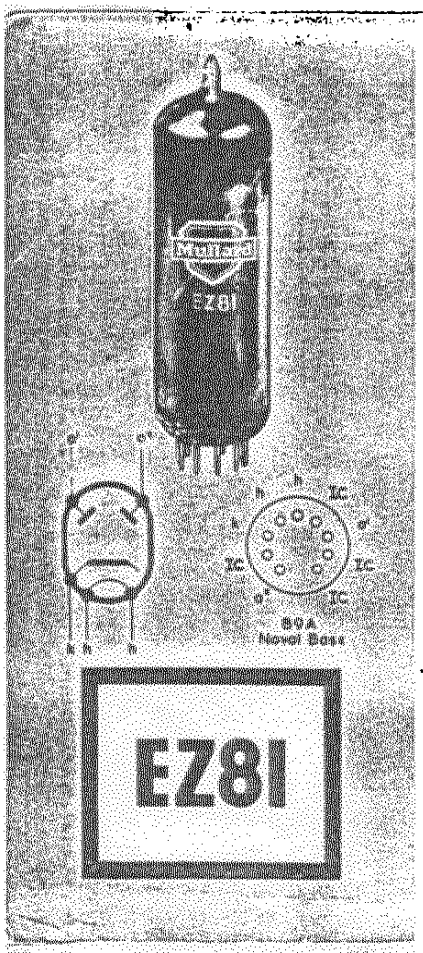
V_a max.	300	V
p_a max.	1.0	W
I_k max.	8.0	mA
*R_{g-k} max.	2.2	M Ω
V_{h-k} max.	180	V
†R_{h-k} max.	20	k Ω

* With grid current biasing R_{g-k} max. 22M Ω.

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

The abridged data in this leaflet have been chosen to illustrate the performance of the valves.

Equipment designers should refer to the Mullard Technical Handbook for complete up-to-date information.



EZ81

PRELIMINARY DATA

HEATER

V_h	6.3	V
I_h	1.0	A

LIMITING VALUES

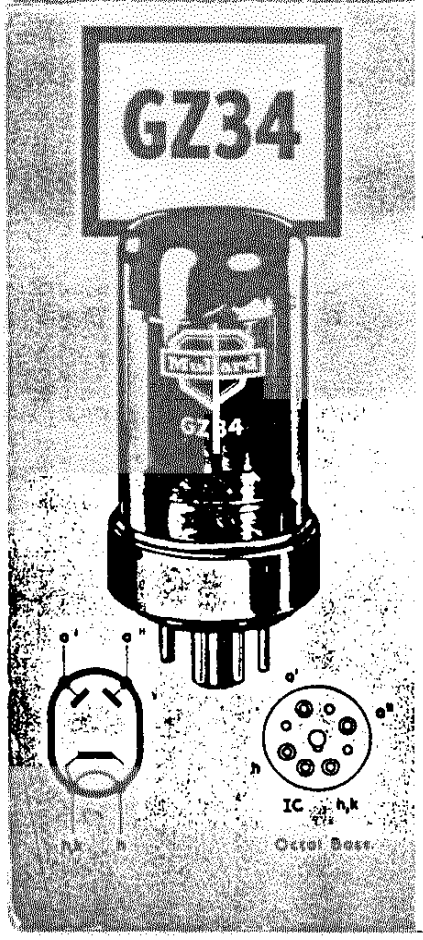
$V_{a\,(r.m.s.)}$ max.	350	V
P.I.V. max.	1.0	kV
$i_{a(pk)}$ max.	450	mA
I_{out} max.	150	mA
C max.	50	μF
*$V_{h-k(pk)}$ max.	500	V

* Heater negative.

TYPICAL OPERATION

V_a (r.m.s.)	2 x 250	2 x 300	2 x 350	V
I_{out}	150	150	150	mA
C	50	50	50	μF
+R_{lim} min.	150	200	240	Ω
V_{out}	245	293	347	V

+ Per anode.



GZ34

PRELIMINARY DATA

HEATER

V_h	5.0	V
I_h	1.9	A

LIMITING VALUES

$V_{a\,(r.m.s.)}$ max.	550	V
P.I.V. max.	1.5	kV
$i_{a(pk)}$ max.	750	mA
I_{out} max.	250	mA
C max.	60	μF

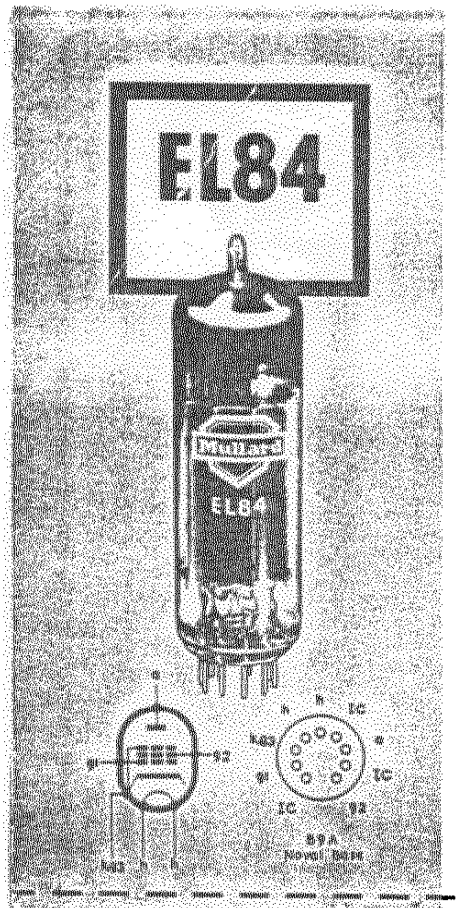
TYPICAL OPERATION

V_a (r.m.s.)	2 x 300	2 x 450	2 x 550	V
I_{out}	250	250	160	mA
C	60	60	60	μF
+R_{lim} min.	50	125	175	Ω
V_{out}	300	450	610	V

+ Per anode.

These two valves are full-wave rectifiers. The EZ81 has a noval base and a 6.3 volt, 1 amp heater. It can supply output currents of up to 150 milliamps, and is therefore suitable for the Mullard 5-valve 10-watt amplifier circuit when the circuit is arranged for normal or low loading (anode-to-anode load 8000 Ω or 6000 Ω), with or without a radio feeder unit.

The GZ34 is mounted on an octal base and has a 5 volt, 1.9 amp heater. It can supply output currents of up to 250 milliamps.



When operated in a single-ended output stage, the EL84 can deliver an output of up to 5.7W at 10% total harmonic distortion. And two EL84's in pentode push-pull yield an output of up to 17W at 4% distortion. As these figures suggest, this valve makes available the higher peak powers and low distortion required for present day receivers and medium power amplifiers for home listening, and is of particular importance now that better quality reception is provided by the f.m. service in Band II.

The maximum anode dissipation of the EL84 is 12W, as compared with the 9W of earlier valves such as the EL41. It has the high mutual conductance of 11.3mA/V.

HEATER

V_h	6.3	V
I_h	0.76	A

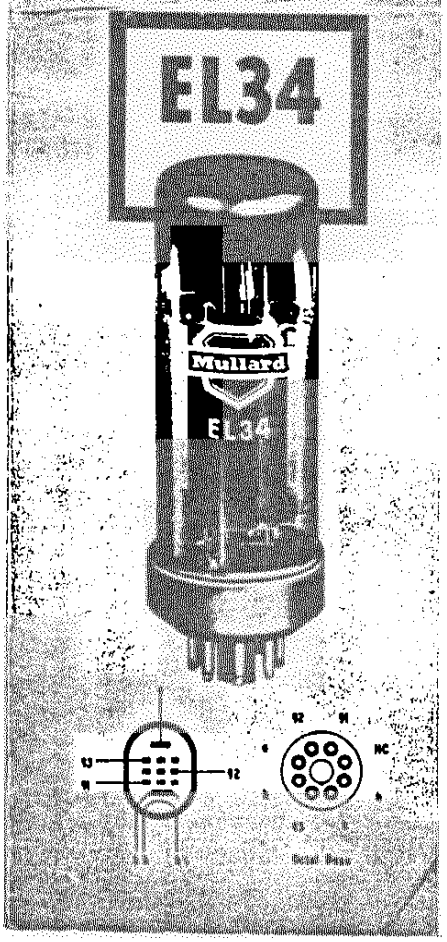
CHARACTERISTICS

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	

LIMITING VALUES

*V_a max.	300	V
*p_a max.	12	W
*V_{g2} max.	300	V
p_{g2} max. (zero signal)	2.0	W
p_{g2} max. (max. signal)	4.0	W
I_k max.	65	mA
R_{g1-k} max. (cathode bias)	1.0	MΩ
R_{g1-k} max. (fixed bias)	300	kΩ
V_{h-k} max.	100	V

*If the heater, anode, and screen-grid voltages are obtained from an accumulator by means of a vibrator, V_a max. = 250 V, V_{g2} max. = 250 V, p_a max. = 9 W.



Amplifiers which provide a nominal output of some 20 watts to handle the loudest music, or even higher powers for public address equipment, include an output stage equipped with two EL34's in push-pull.

An interesting method of connecting the push-pull output stage (Fig. 1) has been used in a recently published Mullard-designed amplifier. The screen grids of the EL34's are connected to taps on the primary of the output transformer, so that the operating conditions lie somewhere between those of a triode (" tap " connected to anode) and those of a pentode (screen grid connected to primary centre-tap). Thus the low distortion of a triode is combined with the high sensitivity of a pentode. The valves are said to be operated with distributed load. Two EL34's in the output stage illustrated can yield an output of 20W at 0.8% total harmonic distortion, or 37W at 1.3% distortion, with 430V between each anode and earth.

For public address equipment, line voltages of up to 800V can be used, and two EL34's in pentode push-pull with fixed bias give an output of up to 100W.

The maximum anode dissipation of the EL34 is 25W, and it has the high mutual conductance of 11mA/V.

HEATER

V_h	6.3	V
I_h	1.5	A

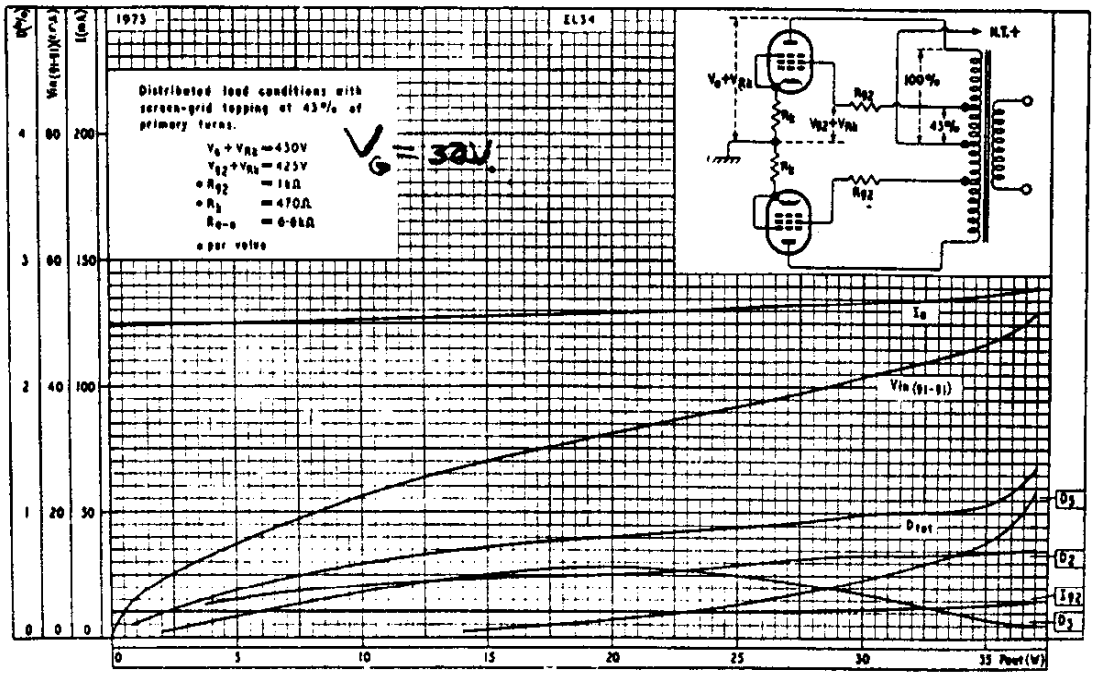
CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
V_{g1}	0	V
I_a	100	mA
I_{g2}	14.9	mA
V_{g1}	−13.5	V
g_m	11	mA/V
r_a	15	kΩ
μ_{g1-g2}	11	

LIMITING VALUES

V_a max.	800	V
p_a max.	25	W
p_a max. (max. signal speech and music)	27.5	W
V_{g2} max.	425	V
p_{g2} max.	8.0	W
I_k max.	150	mA
R_{g1-k} max. (cathode bias)	700	kΩ
R_{g1-k} max. (fixed bias)	500	kΩ
V_{h-k} max.	100	V

Fig. 1 PERFORMANCE OF TWO EL34 IN PUSH-PULL WITH DISTRIBUTED LOAD CONDITIONS. SCREEN-GRID TAPPING AT 43% OF PRIMARY TURNS



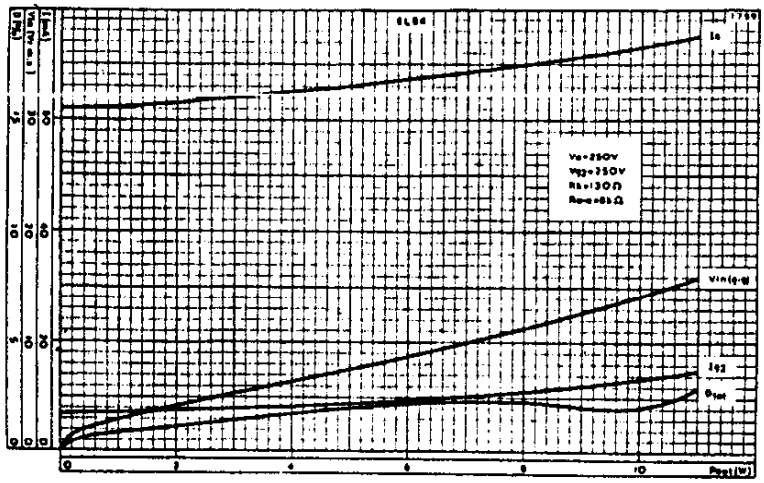


Fig. 2

PERFORMANCE OF TWO EL84 IN CLASS "AB" PUSH-PULL

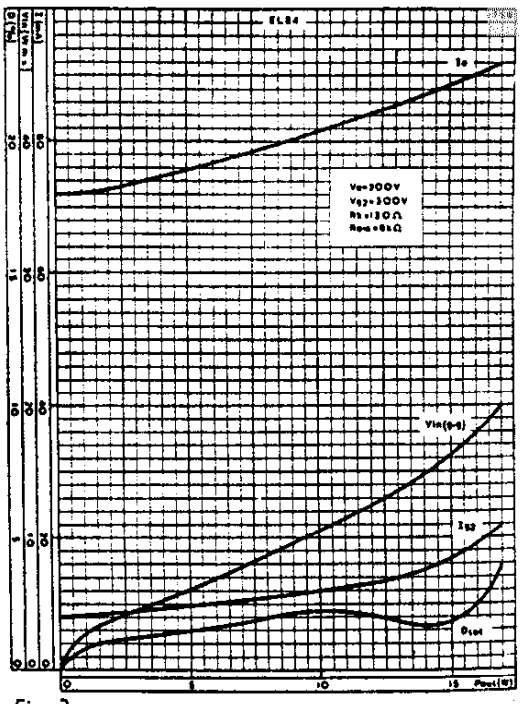
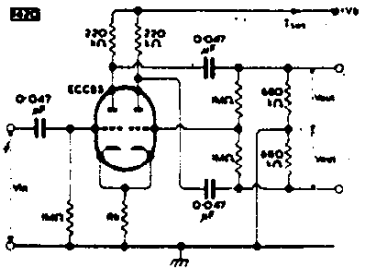
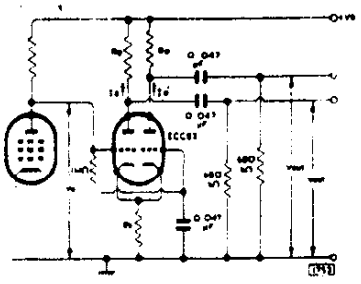


Fig. 3



CIRCUIT A



CIRCUIT B

Mullard **MULLARD LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2**

MV 821

TYPICAL OPERATING CONDITIONS

EF86 OPERATING CONDITIONS AS R.C. COUPLED A.F. AMPLIFIER

PENTODE CONNECTION

V_b (V)	R_a (k Ω)	I_k (mA)	R_{g2} (M Ω)	R_k (k Ω)	$\frac{V_{out}}{V_{in}}$	V_{out} $V_{r.m.s.}$	D_{tot} (%)	R_g* (k Ω)
400	100	3.3	0.39	1.0	124	87	5.0	330
350	100	2.85	0.39	1.0	120	75	5.0	330
300	100	2.45	0.39	1.0	116	64	5.0	330
250	100	2.05	0.39	1.0	112	50	5.0	330
200	100	1.65	0.39	1.0	106	40	5.0	330
150	100	1.0	0.47	1.5	95	22	5.0	330
400	220	1.55	1.0	2.2	200	73	5.0	680
350	220	1.4	1.0	2.2	196	63	5.0	680
300	220	1.1	1.0	2.2	188	54	5.0	680
250	220	0.9	1.0	2.2	180	46	5.0	680
200	220	0.75	1.0	2.2	170	36	5.0	680
150	220	0.55	1.0	2.7	150	24.5	5.0	680

* Grid resistor of following valve.

TRIODE CONNECTION (g_2 to a: g_1 to k)

V_b (V)	R_a (k Ω)	I_a (mA)	R_k (k Ω)	$\frac{V_{out}}{V_{in}}$	V_{out}* $V_{r.m.s.}$	D_{tot}* (%)	R_{g1}† (k Ω)
400	220	1.05	3.9	32	74	3.8	680
350	220	0.9	3.9	31.5	62	3.7	680
300	220	0.8	3.9	31	51	3.7	680
250	220	0.65	3.9	30.5	39	3.5	680
200	220	0.5	3.9	30.5	28	3.1	680

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

†Grid resistor of following valve.

ECC83 OPERATING CONDITIONS AS R.C. COUPLED A.F. AMPLIFIER

(with cathode bias)

V_b (V)	R_a (k Ω)	I_k (mA)	R_k (Ω)	$\frac{V_{out}}{V_{in}}$	V_{out}* ($V_{r.m.s.}$)	D_{tot}* (%)	R_{g1}† (k Ω)
400	47	2.45	680	44	37	3.6	150
350	47	1.98	820	42.5	33	4.4	150
300	47	1.55	1000	40	26	5.0	150
250	47	1.18	1200	37.5	23	7.0	150
200	47	0.86	1500	34	18	8.5	150
400	100	1.72	820	63	38	1.7	330
350	100	1.4	1000	61	36	2.2	330
300	100	1.11	1200	57	30	2.7	330
250	100	0.86	1500	54.5	26	3.9	330
200	100	0.65	1800	50	20	4.8	330
400	220	1.02	1200	76.5	38	1.1	680
350	220	0.85	1500	75.5	37	1.6	680
300	220	0.63	2200	72	36	2.6	680
250	220	0.48	2700	66.5	28	3.4	680
200	220	0.36	3300	56	24	4.6	680

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

†Grid resistor of following valve.

TYPICAL OPERATING CONDITIONS AS A PHASE INVERTER

CIRCUIT A

V_b (V)	I_{tot} (mA)	R_k (Ω)	V_{out}* ($V_{r.m.s.}$)	$\frac{V_{out}}{V_{in}}$	D_{tot}* (%)
250	1.08	1200	35	58	5.5
250	1.08	1200	7	58	1.1
350	1.7	820	45	62	3.5
350	1.7	820	9	62	0.7

CIRCUIT B

V_b (V)	†V_a (approx.) (V)	I_a+I_a' (mA)	R_k (k Ω)	R_a (k Ω)	V_{out}* ($V_{r.m.s.}$)	$\frac{V_{out}}{V_{in}}$	D_{tot}* (%)
250	65	1.0	68	100	20	25	1.8
250	65	1.0	68	100	7	25	0.6
350	90	1.2	82	150	35	27	1.8
350	90	1.2	82	150	10	27	0.5

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

†V_a should be adjusted so that $I_a+I_a'=1$mA at $V_b=250$ V and 1.2 mA at $V_b=350$ V.

EL34 OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

Distributed load conditions with screen-grid tapping at 43% of primary turns (See Fig. 1)

$V_a=V_{g2}$	430	430	V
R_{g2} (per valve)	1	1	kΩ
$V_{g2}=V_{gk}$	425	425	V
I_a (o)	2 × 62.5	2 × 62.5	mA
I_a (max. sig.)	2 × 65	2 × 70	mA
I_{g2} (o)	2 × 5.0	2 × 5.0	mA
I_{g2} (max. sig.)	2 × 5.1	2 × 7.5	mA
R_k (per valve)	470	470	Ω
$V_{in(g1-g1)}$ r.m.s.	32	52	V
R_{a-a}	6.6	6.6	kΩ
P_{out}	20	37	W
D_{tot}	0.8	1.3	%

With separate screen-grid supply and fixed bias.

These operating conditions apply with stabilised line voltages and allow for a 25V drop in the primary winding of the output transformer at maximum signal. If there is an additional drop of 25V in the line voltages at maximum signal $P_{out}=90$W. The optimum anode-to-anode load under these conditions is 11kΩ.

$V_{b(a)}$	800	V
$V_{b(g2)}$	400	V
*R_{g2}	750	Ω
V_{g3}	0	V
$I_{a(o)}$	2 × 25	mA
I_a (max. sig.)	2 × 91	mA
$I_{g2(o)}$	2 × 3.0	mA
I_{g2} (max. sig.)	2 × 19	mA
V_{g1}	−39	V
R_{a-a}	11	kΩ
$V_{in(g1-g1)}$ r.m.s.	47	V
P_{out}	100	W
D_{tot}	5.0	%

*Screen-grid resistor common to both valves.

EL84 OPERATING CONDITIONS AS SINGLE VALVE CLASS "A" AMPLIFIER

V_a	250	250	V
V_{g2}	250	250	V
R_a	5.2	4.5	kΩ
R_k	135	135	Ω
V_{g1}	−7.3	−7.3	V
I_a	48	48	mA
I_{g2}	5.5	5.5	mA
$V_{in(r.m.s.)}$ ($P_{out}=50$ mW)	0.3	0.3	V
†P_{out} ($D_{tot}=10\%$)	5.7	5.7	W
V_i (r.m.s.) ($D_{tot}=10\%$)	4.3	4.4	V
D_3	9.5	8.0	%
D_2	2.0	5.0	%

†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 approximately 10% reduction in power output.

OPERATING CONDITIONS FOR TWO VALVES IN CLASS "AB" PUSH PULL

(See Figs. 2 and 3.)

V_a	250	300	V
V_{g2}	250	300	V
$R_{k(common)}$	130	130	Ω
R_{a-a}	8.0	8.0	kΩ
$I_{a(o)}$	2 × 31	2 × 36	mA
I_a (max. sig.)	2 × 37.5	2 × 46	mA
$I_{g(o)}$	2 × 3.5	2 × 4.0	mA
I_{g2} (max. sig.)	2 × 7.5	2 × 11	mA
$V_{in(g1-g1)}$ (r.m.s.)	16	20	V
P_{out}	11	17	W
D_{tot}	3.0	4.0	%