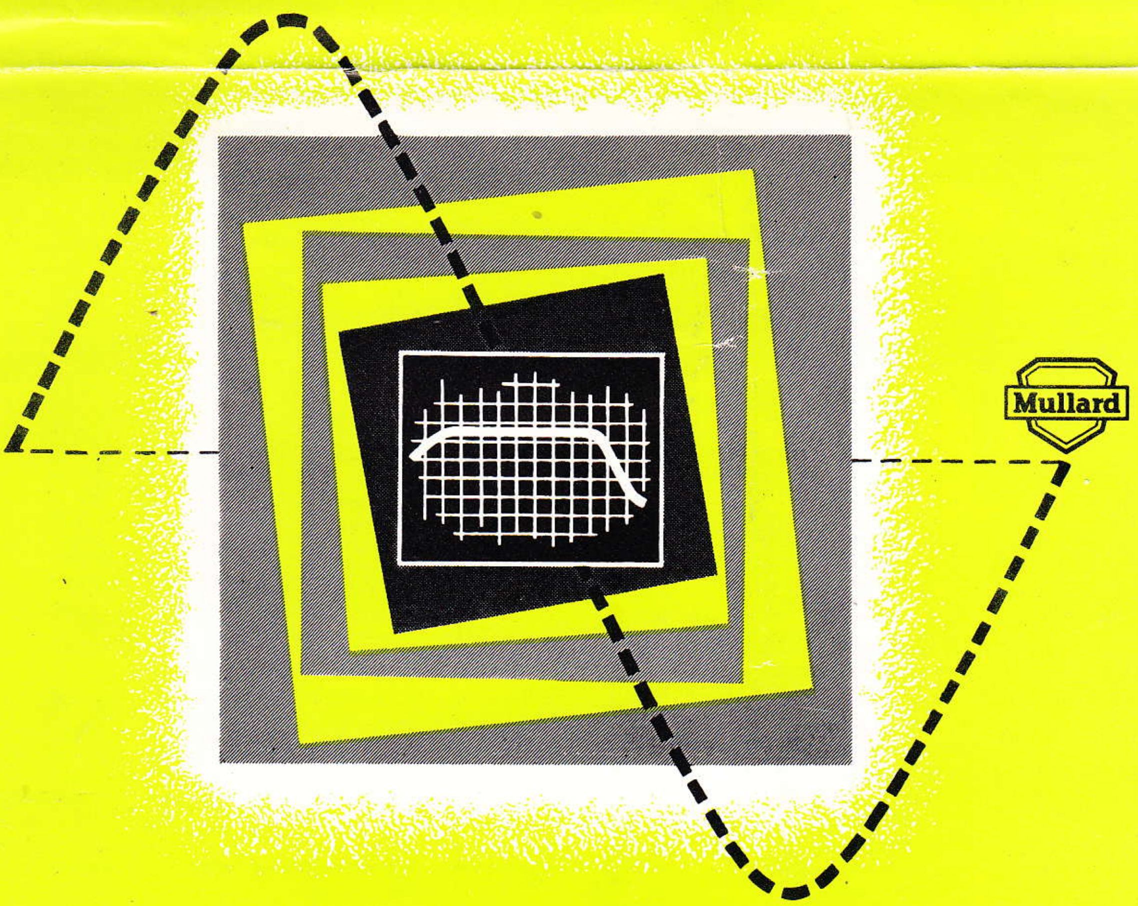
Mullard

MADE FOR MUSIC

valves for

audio equipment



INTERNATIONAL ELECTRONICS CORP., 81 SPRING STREET, NEW YORK 12, N. Y.

EF86

6267

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 2μV 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

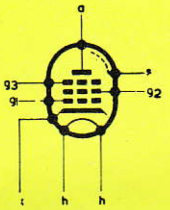
CHARACTERISTICS

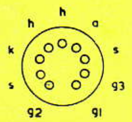
V_a	250	V
V_{g3}	0	V
V_{g2}	140	V
I_a	3	mA
I_{g2}	0.6	mA
V_{g1}	−2	V
g_m	1.8	mA/V
r_a	2.5	MΩ
μ_{g1-g2}	38	

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	MΩ
R_{g1-k} max. ($p_a < 0.2$ W)	10	MΩ
V_{h-k} max. (cathode positive)	150	V
V_{h-k} max. (cathode negative)	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 120k Ω.





B9A
Noval Base

ECC83

12AX7

ECC81

12AT7

ECC82

12AU7

Exact plug-in replacements for the most troublesome tubes in audio and electronic equipment. Mullard special design and construction, including special mica supports and internal structure make these tubes superior particularly in critical high gain circuits where the lowest levels of hum, noise and microphonics are a necessity.

R-C coupled amplifiers or phase splitters can conveniently be built around high-mu double triodes with separate cathodes. In particular, the ECC83/12AX7, with an amplification factor of 100, has adequate gain in the cathode coupled type phase splitter used in the Mullard 510 and 520 high fidelity amplifier circuits.

HEATER

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

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

ECC83

CHARACTERISTICS (each section)

V_a	100	250	V
I_a	0.5	1.2	mA
V_g	−1	−2	V
g_m	1.25	1.6	mA/V
μ	100	100	
r_a	80	62.5	kΩ

LIMITING VALUES (each section)

$V_{a(b)}$ max.	550	V
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.	2.2	MΩ
V_{h-k} max.	180	V
†R_{h-k} max.	20	kΩ

*With grid current biasing R_{g-k} max. = 22 MΩ.

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

ECC81

CHARACTERISTICS (each section)

V_a	100	200	250	V
I_a	3.0	11.5	10	mA
V_g	−1.0	−1.0	−2.0	V
g_m	3.75	6.7	5.5	mA/V
μ	62	70	60	
r_a	16.5	10.5	11	kΩ
*r_{g-k}	21	14	25	kΩ

*Measured at 50 Mc/s

LIMITING VALUES (each section)

$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	2.5	W
I_k max.	15	mA
$-V_g$ max.	50	V
V_g ($I_g = +0.3\mu$A)	−1.3	V
R_{g-k} max. (self-bias)	1.0	MΩ
V_{h-k} max.	150	V
R_{h-k} max.	20	kΩ

ECC82

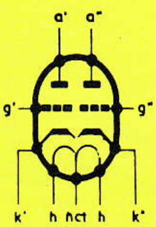
CHARACTERISTICS (each section)

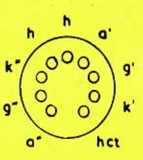
V_a	100	250	V
I_a	12	10.5	mA
V_g	0	−8.5	V
g_m	3.1	2.2	mA/V
μ	19	17	
r_a	6.2	7.7	kΩ

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
R_{g-k} max. (cathode bias)	1	MΩ
R_{g-k} max. (fixed bias)	250	kΩ
V_{h-k} max.	180	V
*R_{h-k} max.	20	kΩ

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





B9A
Noval Base

EL84

6BQ5

When operated in a single-ended output stage, the EL84 can deliver an output of up to 5.7W, and two EL84's in pentode push-pull yield an output of up to 20W. As these figures suggest, this valve makes available the higher peak powers and low distortion required for present day medium power amplifiers used in High Fidelity equipment, tape recorders, phonographs, movie projectors, AM/FM radios.

The EL84 requires unbelievably low drive voltage thereby eliminating the necessity of preceding high gain stages. The EL84 has a very high mutual conductance of 11,300 u-mhos and a plate dissipation of 12W.

HEATER

V_h	6.3	V
I_h	0.76	A

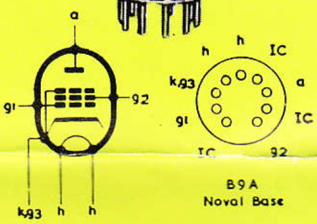
CHARACTERISTICS

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

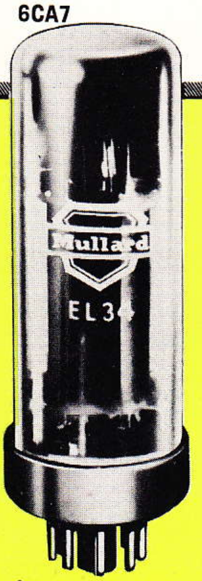
*V_a max.	300	V
*p_a max.	12	W
*V_{g2} max.	300	V
p_{g2} max. (zero signal)	2.0	W
p_{g2} max. (max. signal)	4.0	W
I_k max.	65	mA
R_{g1-k} max. (cathode bias)	1.0	MΩ
R_{g1-k} max. (fixed bias)	300	kΩ
V_{h-k} max.	100	V

*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.



EL34

6CA7



Amplifiers which provide nominal outputs of from 30 to 50 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 520 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 (ultralinear). The linear characteristics of the EL34 coupled with the extremely low driving voltage make the EL34 truly the world's finest output tube.

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 plate dissipation is 25W with a high mutual conductance of 11,000 u-mhos

HEATER

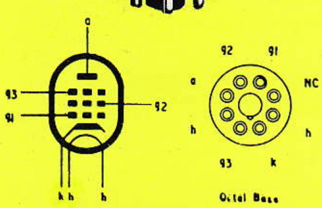
V_h	6.3	V
I_h	1.5	A

CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
V_{g3}	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	

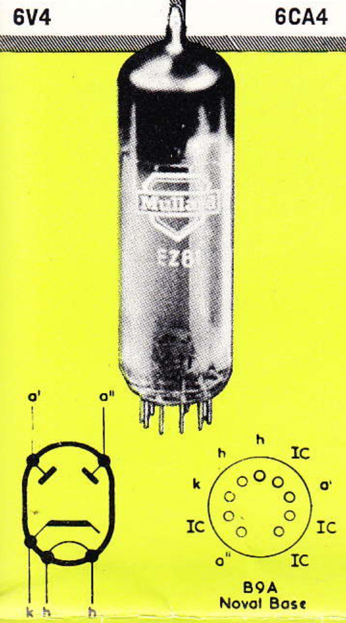
LIMITING VALUES

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



EZ80 EZ81

6V4 6CA4



GZ34

PRELIMINARY DATA

HEATER

V_h	6.3	V
I_h	0.6	A

EZ80

LIMITING VALUES

$V_{a(r.m.s.)}$ max.	2×350	V
I_{out} max.	90	mA
C max.	50	μF
$i_{a(pk)}$ max. (per anode)	270	mA
$V_{h-k(pk)}$ max.	500	V

TYPICAL OPERATION

V_a (r.m.s.)	2×250	2×300	2×350	V
C	50	50	50	μF
†R_{lim} min.	125	215	300	Ω
I_{out}	90	90	90	mA
V_{out}	265	310	360	V

† Per anode.

EZ81

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.

These three valves are low-impedance, indirectly heated, full-wave rectifiers that offer many benefits in electronic circuitry:

1. Better voltage regulation due to lowered power supply impedance;
2. Higher output voltage and cooler operation due to lower voltage drop;
3. Protection of costly filter condensers and power output valves due to delayed warm-up and reduced ripple.

The GZ34, due to its compactness and unique characteristics is an excellent replacement for most high power rectifiers such as the 5U4G, 5U4GA, 5V4G, etc., at the same time offering the advantages as outlined above.

The EZ81 is a miniature tube able to deliver 150 MA and able to power most medium power amplifiers and pre-amplifiers.

The EZ80 and EZ81 are mounted on noval bases; the GZ34 on octal base.

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.

TYPICAL OPERATING CONDITIONS

EF 86 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_{g1}* (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_3 to k)

V_b (V)	R_a (k Ω)	I_a (mA)	R_b (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.

ECC 83 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.

†Va 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.

EL 34 OPERATING CONDITIONS FOR TWO VALVES IN PUSH-PULL

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

$V_a + V_{Rk}$	430	430	V
R_{g2} (per valve)	1	1	k Ω
$V_{g2} + V_{Rk}$	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	k Ω
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} = 90W. The optimum anode-to-anode load under these conditions is 11k Ω.

$V_{b(a)}$	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	k Ω
$V_{in(g1-g1)}$ r.m.s.	47	V
P_{out}	100	W
D_{tot}	5.0	%

*Screen-grid resistor common to both valves.

EL 84 OPERATING CONDITIONS AS SINGLE VALVE CLASS "A" AMPLIFIER

V_a	250	250	V
V_{g2}	250	250	V
R_a	5.2	4.5	k Ω
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
$V_{in(r.m.s.)}$ (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	k Ω
$I_{a(o)}$	2 × 31	2 × 36	mA
I_a (max. sig.)	2 × 37.5	2 × 46	mA
$I_{g2(o)}$	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	%

Strict quality control and uniformity in the manufacture of the EL37 makes this tube an excellent replacement for the 6L6, 5881, 1614, and KT66 where clean, undistorted reproduction and longer life is required. The specialized manufacture of Mullard high fidelity tubes, particularly the EL37, assures balanced audio power output heretofore unavailable in ordinary power output tubes. The EL37 is highly recommended where true balanced sound reproduction is required.

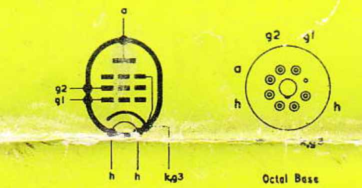
HEATER			
	V_h	6.3	V
	I_h	1.4	A

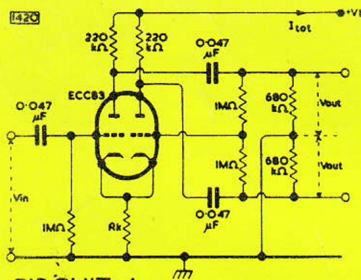
CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
V_{g1}	–13.5	V
I_a	100	mA
I_{g2}	13.5	mA
R_k	120	Ω
g_m	11	mA/V
r_a	13.5	kΩ
μ_{g1-g2}	10	

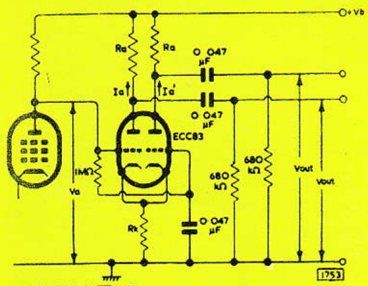
LIMITING VALUES -

$V_{a(b)}$ max.	800	V
V_a max.	400	V
$V_{g2(b)}$ max.	800	V
V_{g2} max.	400	V
V_{h-k} max.	75	V
R_{g1-k} max. (cathode bias)	500	kΩ
R_{g1-k} max. (fixed bias)	100	kΩ
p_a max.	25	W
p_{g2} max.	6.0	W





CIRCUIT A



CIRCUIT B

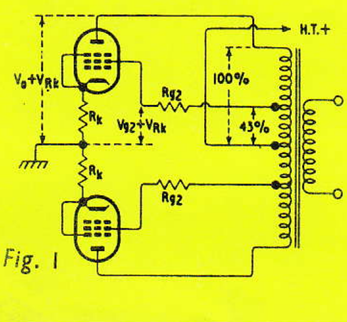


Fig. I

Mullard QUALITY HIGH FIDELITY TUBES

MULLARD TYPE	RETMA EQUIVALENT	DESCRIPTION	PRICE
EL34	6CA7	Output Pentode	$4.35
		Matched Pair, 2-EL34	9.75
EL37	6L6 5881 KT66-1614	Output Pentode	3.50
		Matched Pair, 2-EL37	7.95
EL84	6BQ5	Output Pentode, Miniature	2.40
		Matched Pair, 2-EL84	5.80
†*EF86	6267-Z729	Low Noise, AF Pentode	2.75
†*ECC81	12AT7	RF Double Triode	2.60
†*ECC82	12AU7	Low-µ AF Double Triode	2.20
†*ECC83	12AX7	High-µ AF Double Triode	2.50
ECC85		RF Double Triode	2.90
EZ80	6V4	Indirectly Heated, Full Wave Rectifier, 90 MA	1.80
EZ81	6CA4	Indirectly Heated, Full Wave Rectifier, 150 MA	2.20
GZ32	5V4G	Indirectly Heated, Full Wave Rectifier, 300 MA	2.95
*GZ34	5U4GA/B (ref. spec.)	Bantam Indirectly Heated Full Wave Rectifier 250 MA	3.50
ECC91	6J6	RF Double Triode with Common Cathode	2.70
EB91	6AL5	Miniature Double Diode with Separate Cathodes	1.80
EC90	6C4	Miniature RF Power Triode	3.50
EZ90	6X4	Indirectly Heated Full Wave Rectifier, 70 MA	1.70
EF94	6AU6	Sharp cut-off RF or AF Pentode	2.15
EM81		Electron Beam Tuning Indicator	3.90

OTHER MULLARD PREFERRED REPLACEMENT TYPES

Mullard Type	Retma Equivalent	Price	Mullard Type	Retma Equivalent	Price
EBC90	6AT6	1.75	HBC90	12AT6	1.75
EBC91	6AV6	1.75	HBC91	12AV6	1.70
EF93	6BA6	2.10	HF93	12BA6	2.10
EF95	6AK5	4.90	HK90	12BE6	2.20
EK90	6BE6	2.20	HL92	50C5	2.25
EL90	6AQ5	2.25	HY90	35W4	1.45

† Especially designed and constructed for lowest hum, noise and microphonics

* Maximum levels specified and guaranteed