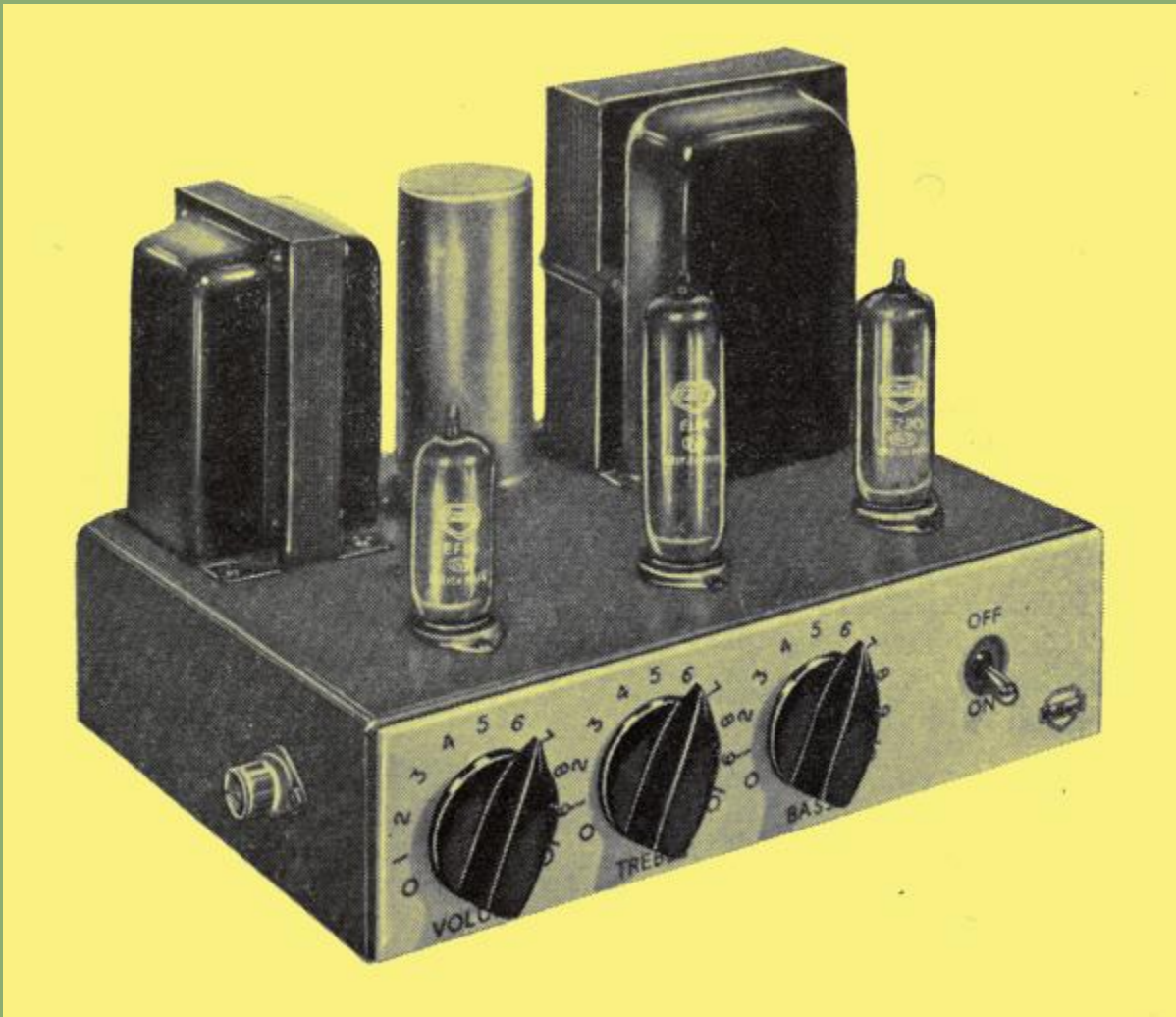
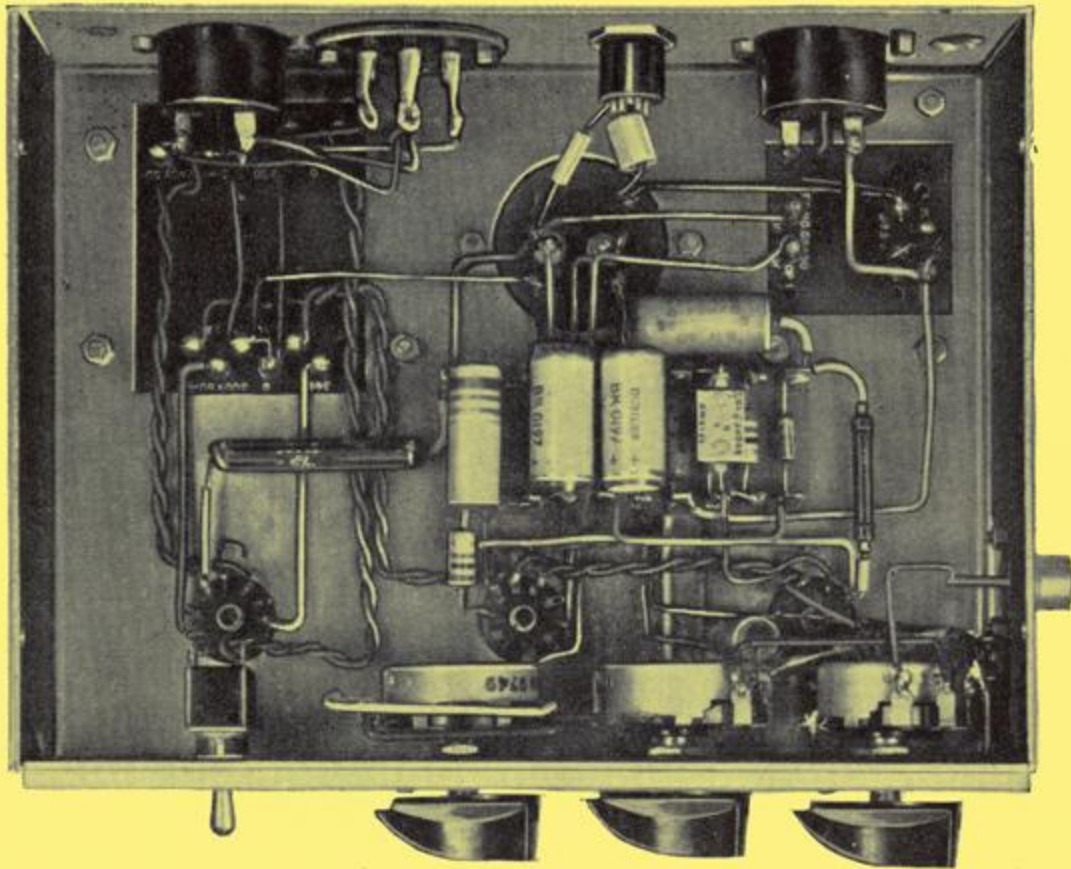


# Mullard 3-3. Three Watt Amplifier

The Classic 3-3 amplifier design from [Mullard Ltd.](#) <sup>1045</sup>. This design dates to 1956.

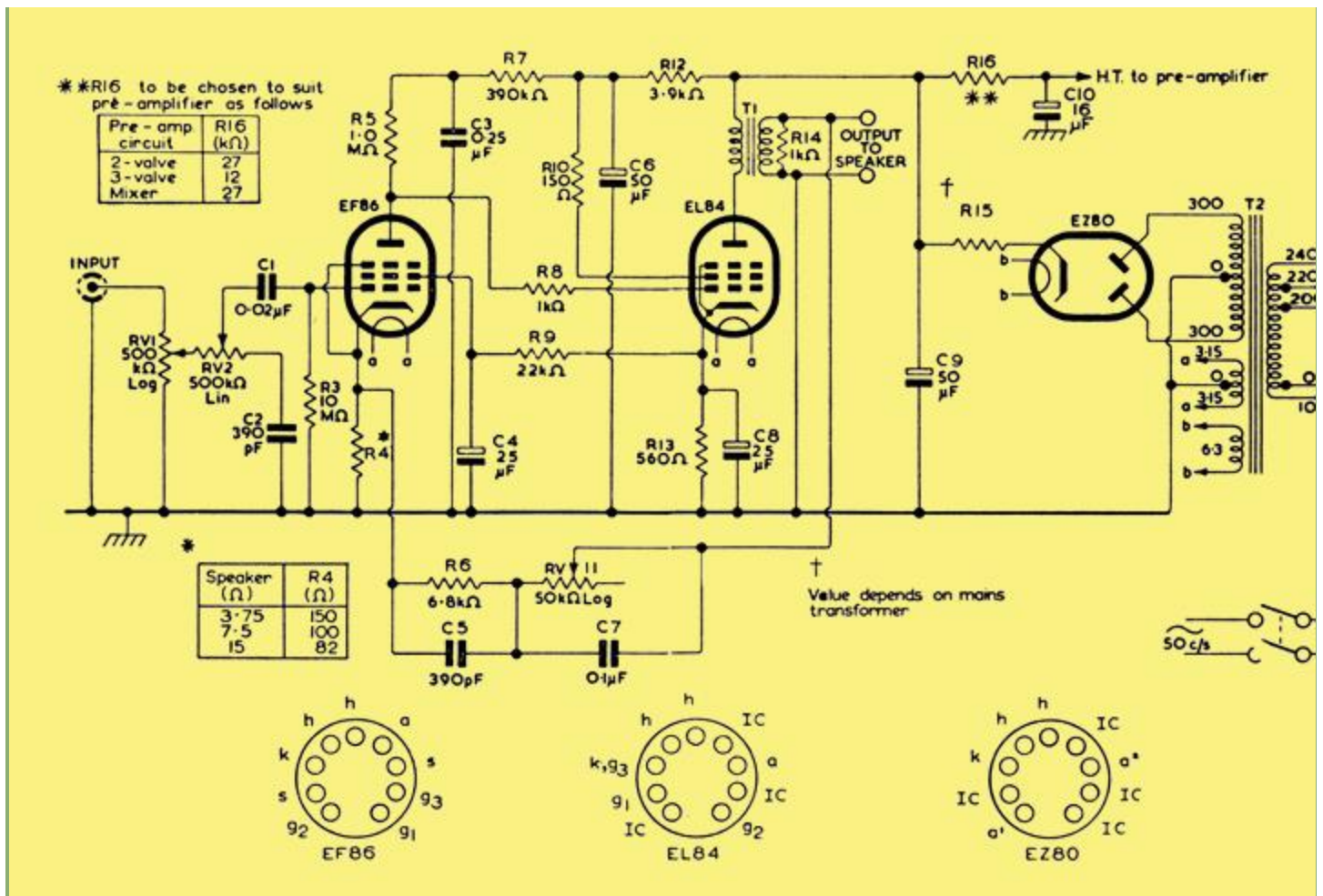


*Prototype of three Watt amplifier*



*Underside view of prototype 3-3 amplifier*

The circuit described in this chapter has been developed to meet the demand for a simple amplifier of reasonably high quality. The amplifier, which is operated from AC mains, uses three Mullard valves: an [EF86](#), an [EL84](#) and an [EZ80](#).



**Circuit diagram of the amplifier with tone controls**

The circuit given in the diagram above includes three controls: volume (RV1), treble (RV2) and bass (RV11). A modified version of this circuit, which allows the amplifier to be used with a pre-amplifier, or in stereophonic equipment, is shown below. In this version, the three controls have been omitted, and the feedback network has been simplified.





Components indicated with an asterisk are not used in the control-less version of the amplifier.

Resistors			
Circuit ref.	Value	Tolerance (±%)	Rating (W)
*RV1	500 kΩ	logarithmic potentiometer	
*RV2	500 kΩ	linear potentiometer	
R3	10 MΩ	20	
R4 for 15Ω speaker	82 Ω	5	
for 7.5Ω speaker	100 Ω	5	
for 3.75Ω speaker	150 Ω	5	
*R5	1 MΩ	10	
R6	6.8kΩ	5	
R7	390 kΩ	10	
R8	1 kΩ	20	
R9	22 kΩ	10	
R10	150 Ω	20	
*RV11	50 kΩ	logarithmic potentiometer	
R12	3.9kΩ	10	
*R13	560 Ω	5	
R14	1 kΩ	20	
R15 value depends on mains transformer, 330Ω in prototype		20	2
R16 for 2-valve pre-amp.	27	10	
for 3-valve pre-amp.	12	10	
for input mixer	27	10 Ω	

1. High stability, cracked carbon
2. Wire wound

#### Output Transformer T1

Primary Impedance, 5kΩ

##### Commercial Components

Manufacturer	Type No.
Colne	03077
Elden	1264
Elstone	OT/3
Gardners	AS.7003
Gilson	W.O.767
Hinchley	1379
Parmeko	P2641
Partridge	P4073
Wynall	W1452

#### Valves

Mullard EF86, EL84, EZ80

#### Valveholders

B9A (noval) (two). McMurdo, BM9/U  
B9A (noval) (one), nylon-loaded with screening skirt.  
McMurdo, XM9/UC.1

Capacitors			
Circuit ref.	Value	Description	Rating (V)
C1	0.02μF	paper	150
*C2	390 pF ± 20%	silvered mica	
C3	0.25μF	paper	350
C4	25 μF	electrolytic	50
C5	390 pF ± 10%	silvered mica	
C6, C9	50 + 50 μF	double electrolytic	350
*C7	0.1 μF	paper	150
C8	25 μF	electrolytic	50
C10	16 μF	electrolytic	350

#### Mains Transformer

Primary: 10-0-200-220-240V.

Secondaries: H.T. 300-0-300V, 60mA.

L.T. 3.15-0-3.15V, 1A (for EF86, EL84).

0-6.3V, 1A (for EZ80).

If only one 6.3V secondary winding is available, it should have a 2A rating to supply all three valves.

#### Commercial Components

Manufacturer	Type No.
Colne	03097
Elden	890A
Elstone	MT3M
Gardners	RS.3103
Gilson	W.O.839
Hinchley	1442
Parmeko	P2631
Partridge	11300/60
Wynall	W1547

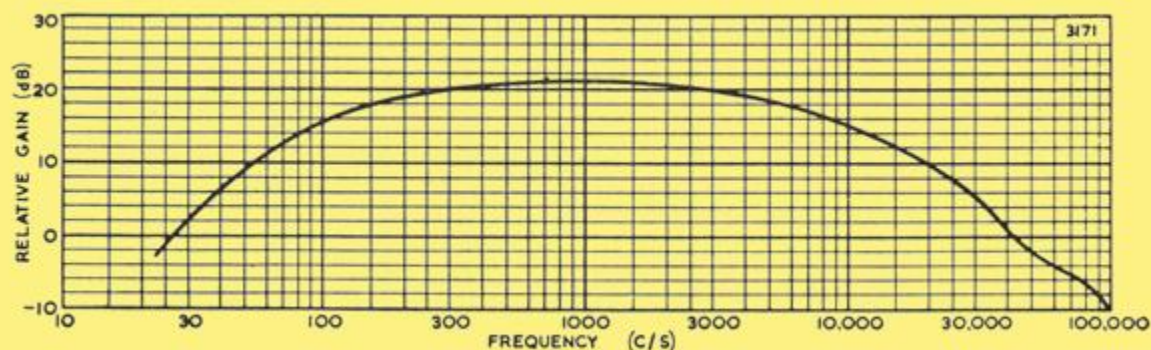
#### Miscellaneous

Mains input plug and socket. Bulgin, P.340  
Mains switch. N.S.F., 8370/B3  
Mains voltage selector. Clix, CTSP/2 + P.62/2  
H.T. supply plug and socket (pre-amplifier), 6-pin miniature.  
Bulgin P.194  
Fuse, Belling Lee Minifuse, L.575  
Lampholder (optional). Bulgin, D.180/red  
Indicator lamp (optional). 6.3V, 0.04A, M.E.S  
Input socket, coaxial, Belling Lee, L.604/S  
Output plug and socket. 2-pin. Bulgin, P.350  
Tagboard (10-way). Bulgin, C.125; Denco  
Pointer knob (three). Bulgin, K.370

List of components. An \* indicates for tone control version only

## CIRCUIT DESCRIPTION

Because of the inherently high level of distortion with single-ended output stages, appreciable negative feedback around the output stage is necessary to produce an output of acceptable quality. At the same time, an overall sensitivity of 100 mV is required if the amplifier is to be suitable for use with any type of crystal pick-up head. (The attenuation resulting from pick-up equalisation with passive RC networks must also be borne in mind.)



Open loop-gain characteristics

The basic sensitivity of the circuit without feedback should be about 1 μV in order that the desirable level of feedback (about 20dB) can be provided. From considerations of stability, this feedback should be taken around

the minimum number of stages.

The EF86 in the voltage-amplifying stage is used under conditions approaching those of starvation operation. With a high value of anode load resistance ( $R5$  is  $1\text{ M}\Omega$ ) and reduced values of anode and screen-grid voltage, the gain of the stage is raised two or three times above that obtained under normal operating conditions. This increase is attributable mainly to the fact that, because the voltage at the anode of the EF86 is very low, direct coupling can be used between this anode and the control grid of the EL84 in the output stage. Thus the shunt loading on the anode circuit of the EF86 is least at low and medium frequencies.

The use of direct coupling between the stages necessitates a higher cathode voltage in the output stage than is required with RC coupling. The value of  $R13$  is thus greater than is usual for the cathode resistance. The screen-grid voltage for the EF86 is, taken from the cathode of the EL84. In this way, negative DC feedback (which is essential in a directly coupled circuit to stabilise the operating conditions of both stages) is applied to the voltage amplifier.

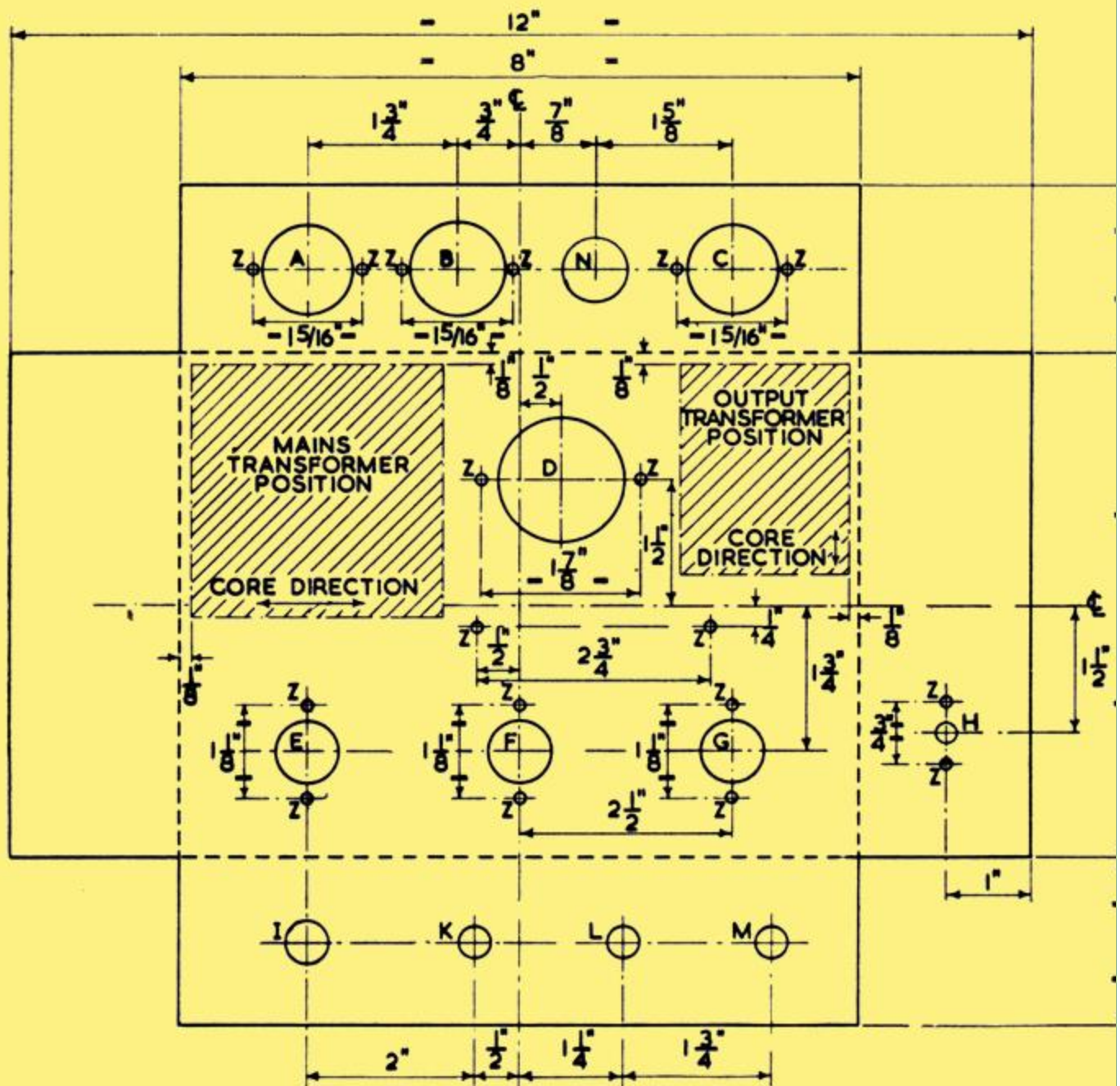
Negative AC feedback is applied from the secondary winding of the output transformer to the cathode of the EF86. In the circuit with tone controls, this feedback loop incorporates the bass-boost control, the amount of feedback being changed continuously at low frequencies as the resistance of the control potentiometer  $RV11$  is varied. In the simplified version of the circuit, the control  $RV11$  is omitted, and the feedback loop consists of  $R6$  and  $C5$  only.

Provision for volume and treble control is made at the input of the amplifier. The potentiometers  $RV1$  and  $RV2$  constitute these controls respectively. In the control-less version of the amplifier, the output is taken directly to the capacitor  $C1$  in the control-grid, circuit of the EF86.

The power supply uses the EZ80 in combination with a mains transformer meeting the specification given below. The resistor  $R15$  between the cathode of the EZ80 and the reservoir capacitor  $C9$  is for voltage control. The anode of the EL84 is supplied from  $C9$ , and the screen-grid is supplied through another filter network  $R12$ ,  $C6$ . The HT supply for a pre-amplifier is taken from  $C9$ . Extra smoothing is provided by  $R16$  and  $C10$ .

## **CONSTRUCTION AND ASSEMBLY**





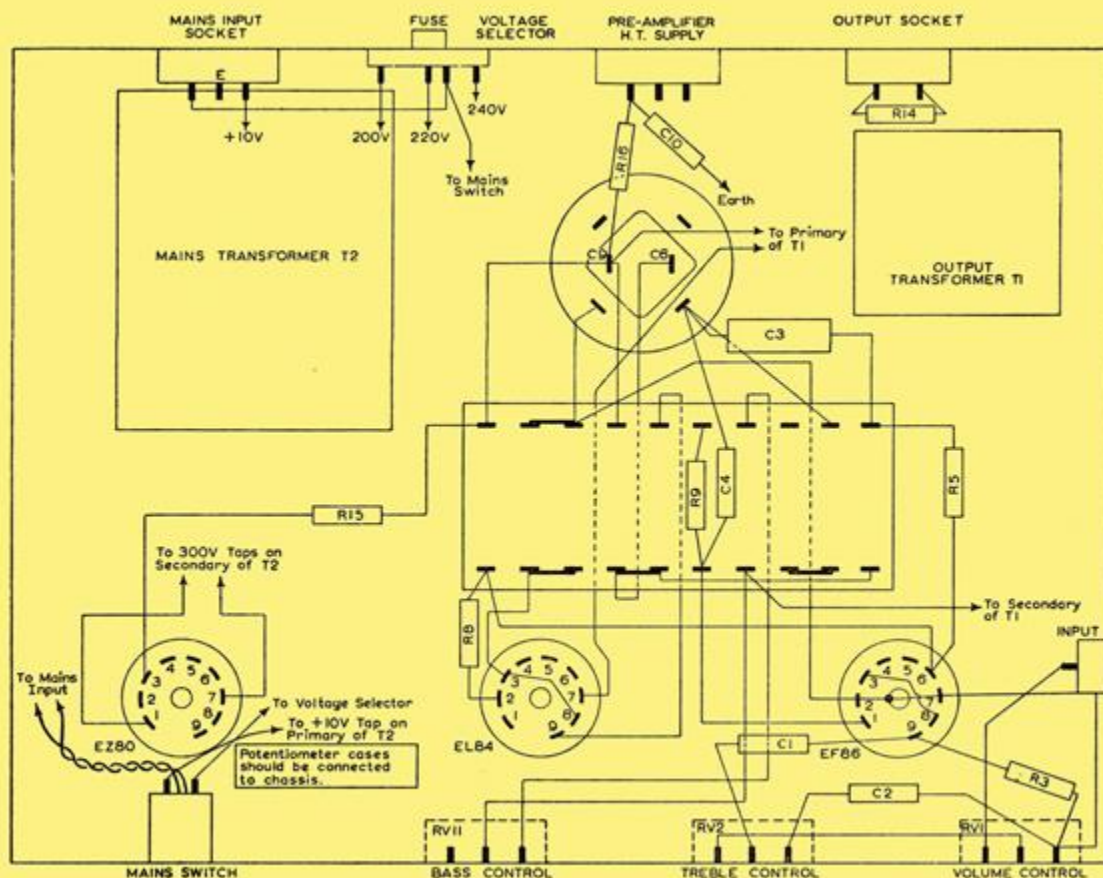
Chassis details. Bend up through 90° along dotted lines

## KEY TO HOLES IN CHASSIS

Hole	Dimension	Use	Type No.
A	$\frac{1}{8}$ in. dia.	Mains input plug, 3-pin. Bulgin .. ..	P340
B	$1\frac{1}{8}$ in. dia.	Voltage selector. Clix .. ..	CTSP/2
C	$1\frac{1}{8}$ in. dia.	Output plug, 2-pin. Bulgin .. ..	P350
D	$1\frac{1}{8}$ in. dia.	Electrolytic capacitor .. ..	—
E	$\frac{1}{4}$ in. dia.	B9A valveholder. McMurdo .. ..	BM9/U
F	$\frac{1}{4}$ in. dia.	B9A valveholder. McMurdo .. ..	BM9/U
G	$\frac{1}{4}$ in. dia.	B9A nylon-loaded valveholder .. .. with screening skirt. McMurdo .. ..	XM9/UC1
H	$\frac{1}{4}$ in. dia.	Input socket, coaxial. Belling Lee .. ..	L.604/S
I	$\frac{1}{4}$ in. dia.	Mains switch. N.S.F. .. ..	837-/33
K	$\frac{1}{4}$ in. dia.	50k $\Omega$ logarithmic potentiometer .. ..	—
L	$\frac{1}{4}$ in. dia.	500k $\Omega$ linear potentiometer .. ..	—
M	$\frac{1}{4}$ in. dia.	500k $\Omega$ logarithmic potentiometer .. ..	—
N	$\frac{1}{4}$ in. dia.	H.T. supply plug, 6-pin miniature. Bulgin .. ..	P194
Z	Drill No. 34	6 B.A. clearance hole .. ..	—

### Key to holes in chassis

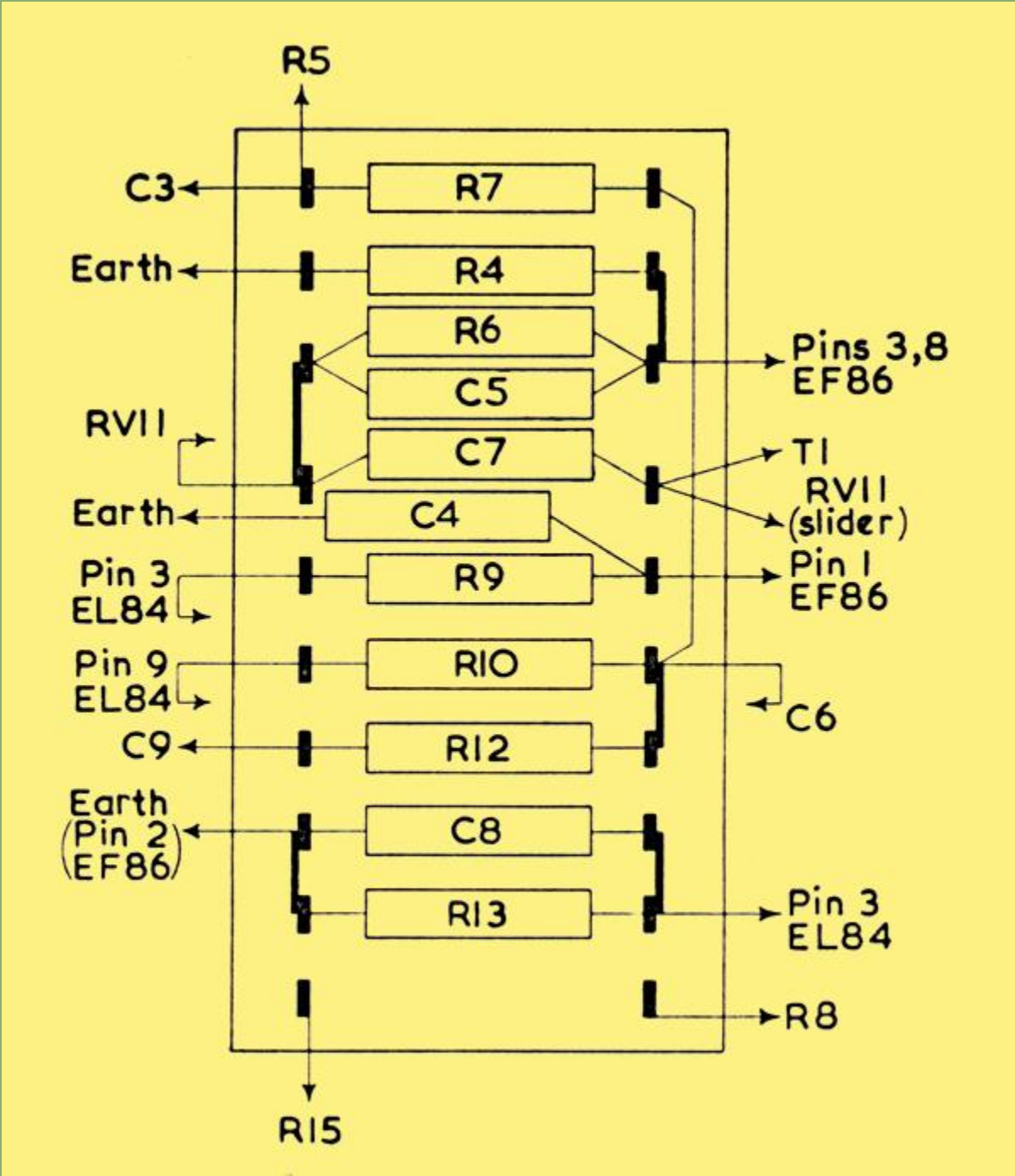
Chassis details of the amplifier are given above. For the control-less version, holes for the potentiometers will not be required. The chassis can be cut from one piece of 16 SWG aluminium sheet, 12 in. long and 10 in. wide. A bottom cover plate to the amplifier is not necessary.



### Suggested layout of components



A suitable arrangement of the components in the amplifier with controls is shown above. The position of the components on the tagboard is given below.



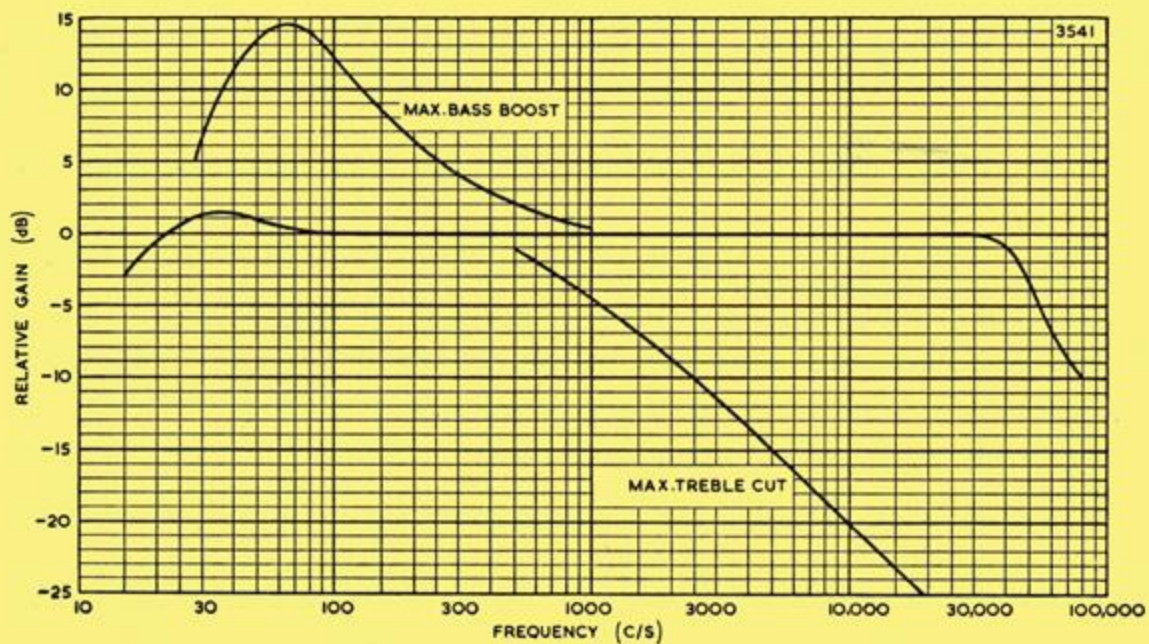
*Layout of components on the tagboard. For the control-less version, the potentiometers RV1, RV2 and RV11 and the capacitors C2 and C7 are omitted. The capacitor C1 will be connected directly to the input socket, and the feedback path will be completed by connecting the appropriate junction of R6 and C5 to the speaker terminal.*

If the can of the double electrolytic capacitor is used as the negative side, then it should be isolated from the chassis. The earth connection to the chassis should be made at the input socket only.

The mains transformer should have an HT rating of 300-0-300 V, 60 mA, and it is preferable, though not essential, that a separate LT winding (6.3 V) be used for the EZ80 rectifier. This is indicated in the circuit diagram, and also in the list of components.

# PERFORMANCE

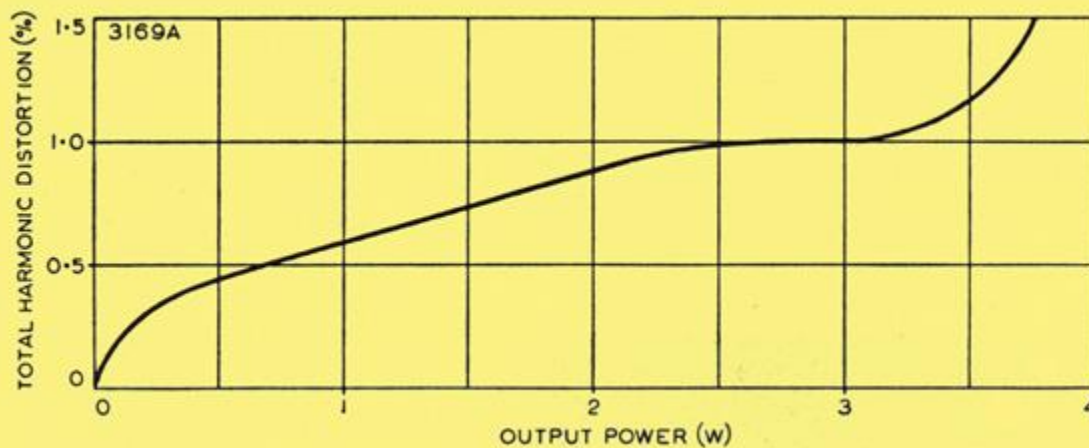
Frequency Response



*Frequency response of amplifier showing relative gain without application of tone controls, and also showing relative gain with maximum application of tone controls*

With the treble and bass controls in their minimum effective positions, or with the control-less circuit, the frequency response is essentially flat from 35 Hz to 30 kHz. With maximum application of the respective controls, a treble cut of 20 dB is available at 10 kHz, and a bass boost of 10dB is available at 70 Hz. The bass boost is obtained by reducing the main feedback at low frequencies by means of RV11 and C7.

#### Distortion



*Variation of total harmonic distortion with output power*

The relationship between the total harmonic distortion and the output power is shown. It will be seen that, for a typical amplifier, for outputs above about 3.5 W, the distortion increases rapidly. This indicates the point beyond which over loading of the amplifier occurs.

#### Output Impedance

The output impedance of the amplifier for a loudspeaker load of 15  $\Omega$  is less than 1.5  $\Omega$ . This gives an adequate damping factor of more than 10 (that is,  $GT 15/1.5$ ).

## DC CONDITIONS

The DC voltages at points in the equipment should be tested with reference to the table. The results shown in this table were obtained using an Avometer No. 8.

Point of Measurement		Voltages (V)	D.C. Range of Avometer* (V)
	C9	310	1000
	C6	290	1000
	C3	210	1000
EL84	Anode	290	1000
	Screen grid	290	1000
	Cathode	28	100
EF86	Anode	20	100
	Screen grid	28	100

\*Resistance of Avometer

1000V-range, resistance =  $20\text{M}\Omega$

100V-range, resistance =  $2\text{M}\Omega$

*DC conditions as measured with an AVO 8 (20,000  $\Omega$ /Volt)*

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