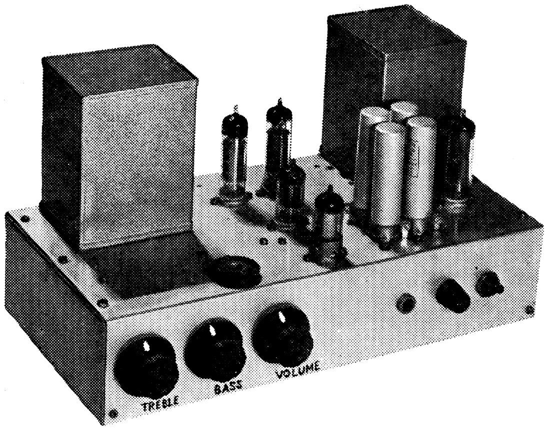
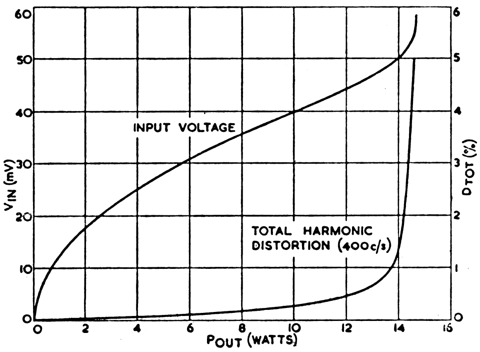
Mullard

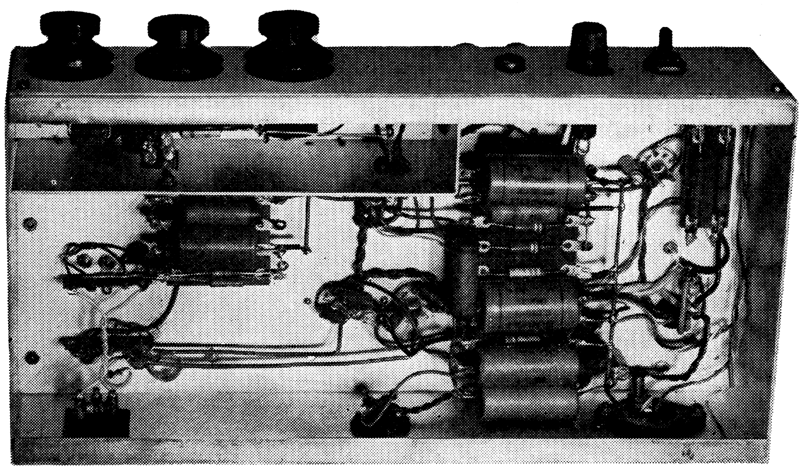
THE 5-VALVE 10-WATT HIGH QUALITY AMPLIFIER



THE PROTOTYPE CHASSIS



DISTORTION FIGURES



BENEATH THE CHASSIS

SUMMARY OF PERFORMANCE of 5-valve 10-watt amplifier

Power Output
Normal loading (sine wave input)
Rated output 10 W
Max. output 14 W approx.
Low loading (speech or music input)
Rated output 10 W*
Max. output 14 W approx.*
*Equivalent sine wave power

Distortion
Total Harmonics
Normal loading, sinusoidal test frequencies
At 400 c/s 0.3% total harmonics at 10 W
Intermodulation
40 c/s and 10 kc/s (4 : 1 ratio) 2% at 10 W
<3% at 12 W
70 c/s and 7 kc/s (4 : 1 ratio) <1.5% at 10 W
<2% at 12 W
" Beat-Note "
9 kc/s and 10 kc/s (1 : 1 ratio)
approx. 0.25% at 10 W
<0.5% at 12 W
14 kc/s and 15 kc/s (1 : 1 ratio)
0.4% at 10 W
approx. 0.6% at 12 W

Frequency Response
At 1 watt: within 1 db of 1 kc/s level from 5 c/s to 20 kc/s.
At 10 watts: within 1 db of 1 kc/s level from 30 c/s to 15 kc/s.

Phase Shift
Approx. 20° at 20 c/s and 10 kc/s.

Hum and Noise
At least 75 db below 10 W.

Sensitivity
40 mV for 10 W output.

Output Resistance
Approx. 0.9 Ω on 15 Ω termination.

Loop Gain
26 db at 1 kc/s.

GENERAL

The popularity of this amplifier has made it necessary for us to provide constructional details in leaflet form. The circuit diagram together with the parts list and point to point wiring diagram will provide sufficient information for the average home constructor to successfully build this unit.

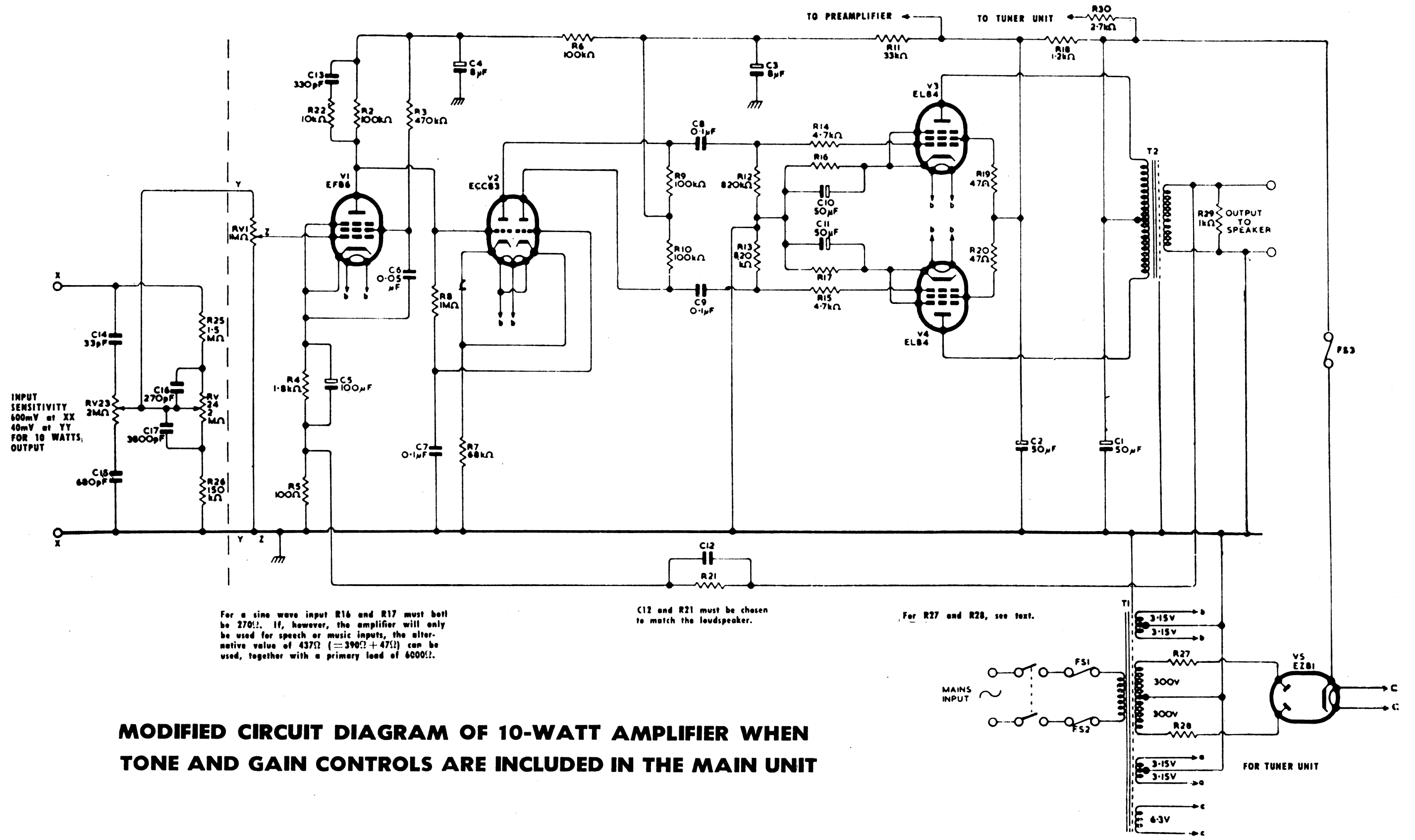
INSTRUCTION PRECAUTIONS

The performance obtained with the original Mullard 5-10 High Quality Amplifier is easily duplicated providing the following precautions are taken.

(1) In a high gain amplifier of this type all connections must be well soldered in order to avoid dry joints which give rise to instability and intermittent operation.

(2) Strict adherence to specified component values and tolerances is strongly recommended together with careful layout in accordance with the accompanying illustrations.

(3) Parasitic suppressors R14, R15 and R19, R20 should be soldered to the valve socket pin with a minimum of lead length (approx. $\frac{1}{8}''$) to ensure stability and freedom from parasitic oscillation.



MODIFIED CIRCUIT DIAGRAM OF 10-WATT AMPLIFIER WHEN TONE AND GAIN CONTROLS ARE INCLUDED IN THE MAIN UNIT

COMPONENTS LIST

Resistors

RV1	1MΩ	log. pot. (10% law)	
R2[1]	100kΩ	10%	¼W
R3[1]	470kΩ	10%	¼W
R4	1·8kΩ	10%	¼W
R5	100Ω	5%	¼W
R6	100kΩ	10%	¼W
R7	68kΩ	10%	1W
R8	1MΩ	10%	¼W
R9[2]	100kΩ	10%	½W
R10[2]	100kΩ	10%	½W
R11	33kΩ	10%	¼W
R12	820kΩ	10%	¼W
R13	820kΩ	10%	¼W
R14	4·7kΩ	20%	¼W
R15	4·7kΩ	20%	¼W
R16, R17	270Ω (normal loading) or 390+47Ω (low loading)	5%	2W
R18	1·2kΩ	10%	1W
R19	47Ω	20%	¼W
R20	47Ω	20%	¼W
R21	15kΩ (3·75Ω load) / 33kΩ (15Ω load)	5%	¼W
R22	10kΩ	10%	¼W
RV23	2MΩ	log. pot. (10% law)	
RV24	2MΩ	log. pot. (10% law)	
R25	1·5MΩ	10%	¼W
R26	150kΩ	10%	¼W
R27	see p. 3	20%	1W
R28	see p. 3	20%	1W
R29	1kΩ	20%	½W
R30	2·7kΩ	5%	4W

[1] High Stability

[2] The 100kΩ resistors for R9 and R10 should be matched to within 5% and the larger used for R10.

Capacitors

C1, C2	50+50μF	Double electrolytic	350V d.c. wkg.
C3	8μF	Electrolytic	350V d.c. wkg.
C4	8μF	Electrolytic	350V d.c. wkg.
C5	100μF	Electrolytic	12V d.c. wkg.
C6	0·05μF	Paper	350V d.c. wkg.
C7	0·1μF	Paper	350V d.c. wkg.
C8	0·1μF	Paper	350V d.c. wkg.
C9	0·1μF	Paper	350V d.c. wkg.
C10	50μF	Electrolytic	25V d.c. wkg.
C11	50μF	Electrolytic	25V d.c. wkg.
C12	270pF (3·75Ω load) / 120pF (15Ω load)	5% Ceramic or Mica	
C13	330pF	10% Ceramic	
C14	33pF	10% Ceramic	
C15	680pF	10% Ceramic or Mica	
C16	270pF	10% Ceramic or Mica	
C17	3300pF	10% Ceramic or Mica	

(4) The following table shows values for R21 to cover a wide range of output transformer secondary impedances, however, in the case of C12 it is recommended that individual adjustment be made in order to obtain the optimum value. This will ensure (a) freedom from ringing on transients and (b) loss of transient response.

FEEDBACK RESISTOR R21

Loudspeaker Impedance	R21
2.0 Ω	11kΩ
2.7 Ω	13kΩ
3.75Ω	15kΩ
8 Ω	24kΩ
12 Ω	30kΩ
15 Ω	33kΩ

(5) In order to reduce the possibility of hum loops, all earth returns should be made to a common earth busbar, which is itself insulated from the chassis except at one point, preferably the earth side of the signal input socket.

For those constructors wishing to use a separate preamplifier, the passive tone control network in the input circuit may be omitted, the grid being connected directly to the input socket and a 2.2 Megohm resistor connected directly from grid to earth busbar.

POWER SUPPLY

The recommended rectifier for all power requirements is the 6CA4/EZ81 which is not a preferred type in Australia, however, providing a power transformer having a 5V winding is chosen the 5V4G may be used in its place. It can supply currents of up to 150mA which is more than sufficient for the amplifier under normal or low loading conditions, with adequate reserve for a radio tuner and preamplifier. Where it is not intended to use a tuner, the 6V4/EZ80 may be used with complete safety. Care

CIRCUIT VOLTAGES

Testing Point	D.C. Voltage (V)	Meter Range
*C_1	320	1000 V d.c.
C_2	305	1000 V
Cathodes V_3, V_4	12	100 V
Anodes V_3, V_4	310	1000 V
Screen grids V_3, V_4	305	1000 V
C_3	235	1000 V
Anodes V_2	185	1000 V
Cathodes V_2	71.5	1000 V
C_4	145	1000 V
Anode V_1	70	1000 V
Screen grid, V_1	85	1000 V
Cathode V_1	1.5	25 V

*A.C. voltage at C_1 is 4 V for normal loading and 2.5 V for low loading.

These voltages were measured with Model 8 Avometer (20,000 Ω/V) with zero input signal.

must be taken to include limiting resistors R27 and R28 in the anode circuits of the rectifier where applicable. Their value is chosen so that after adding the series transformer resistance at each anode, the total limiting resistance for the rectifier is 100 ohms per anode for the 5V4G and 215 ohms per anode in the case of the 6V4. The calculation of R27 and R28 for any mains transformer is as follows:—

$$R_t = R_s + n^2 R_p$$

Where R_s = resistance of half the secondary

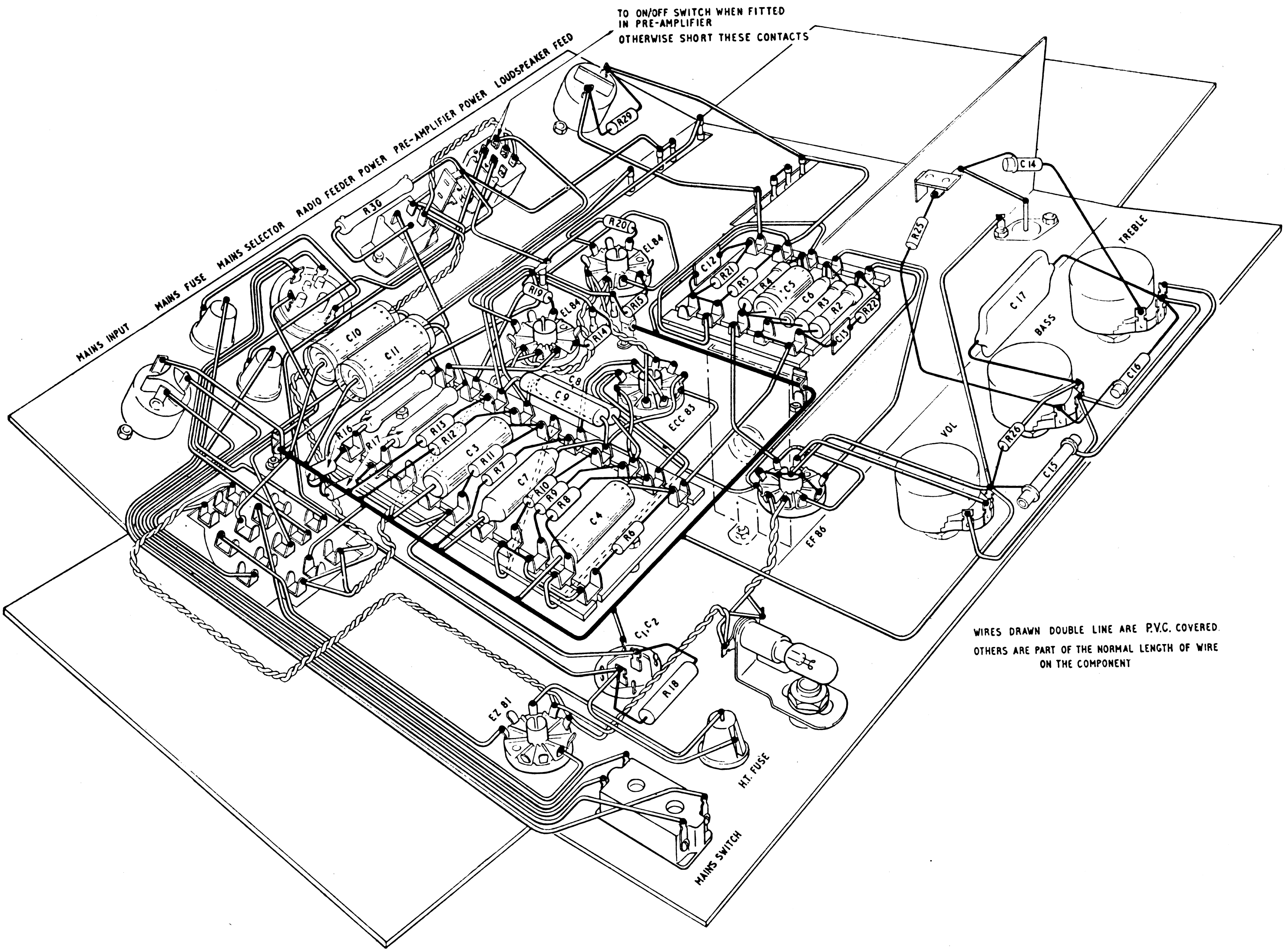
,, R_p = resistance of primary

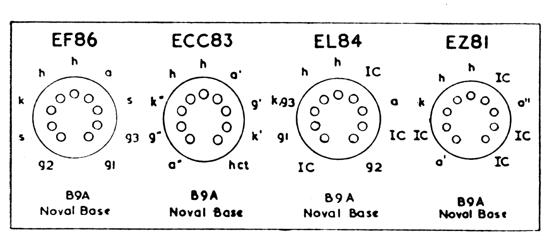
,, n = ratio of number of turns on half the secondary to the number of turns on the primary.

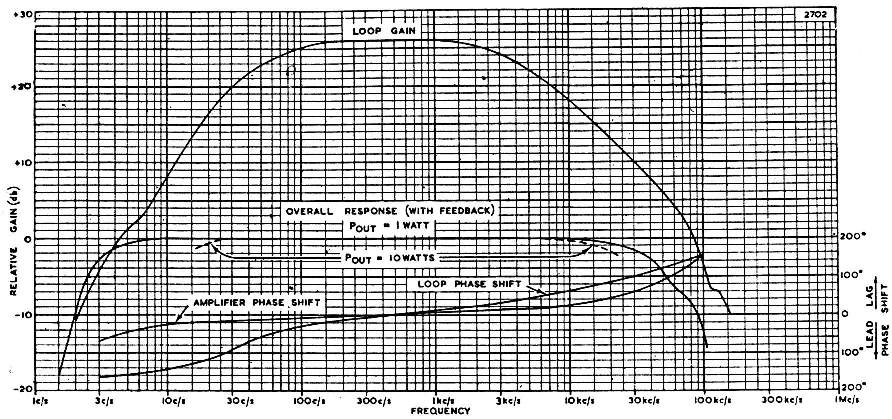
Where R_t is less than the value prescribed above, additional resistance should be added to bring the total up to the quoted figure.

For most 300-0-300 V mains transformers the effective transformer resistance is about 130 ohms per anode. With the power supply delivering 80mA h.t. current, the voltage across C_1 should be close to the specified 320V. The voltage across C_1 should not exceed 320 V at 80mA normal loading, ($R_{a\text{-}a}$ 8,000 ohms) or 60mA low loading ($R_{a\text{-}a}$ 6,000 ohms).

When a radio tuner is used, the additional h.t. current drawn will not







normally exceed 20-30mA and the line voltage across C_1 will then drop to approximately 300 volts. This additional drain should be taken from C_1 via a suitable dropping resistor and decoupling capacitor, (8 μF) which should be incorporated in the tuner itself. Under these circumstances the overload capacity of the amplifier is reduced from 13-14 watts to approximately 12 watts.

Both h.t. and l.t. windings of the mains transformer must be adequate for the intended requirements. When a radio tuner is to be catered for, the h.t. rating will not normally exceed 120 to 125mA. The corresponding heater current rating is 6.3V at 4A, which includes 2A for the tuner. This unit is preferably supplied from a separate l.t. winding, in which case two windings at 6.3V 2A each are required. Both of these windings must be centre-tapped.

H.T. SUPPLY FOR PREAMPLIFIERS

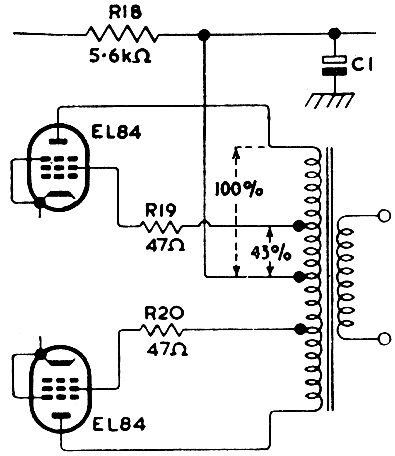
The h.t. supply for preamplifiers whose current drain does not exceed 2 to 3mA should be taken from C_2 via suitable filtering (R_{46}, C_{26} in the recommended preamplifier circuits).

DISTRIBUTED LOAD OPERATION

COMPARISON OF PERFORMANCE

A. Conventional pentode push-pull output stage.
B. Distributed load output stage.

	A	B
Rated power output	10W	10W
Overload point	≃14W	≃11W
Sensitivity across volume control ...	40mV	40mV
Harmonic distortion (10W, 400c/s)	0·3%	≃0·1%
Intermodulation distortion (at 10W, for 40c/s and 10kc/s in 4 : 1 amplitude ratio)	2·0%	≃1·0%
'Beat-note' distortion at 10W for:		
(i) 9kc/s and 10kc/s with equal amplitudes	≃0·25%	0·25%
(ii) 14kc/s and 15kc/s with equal amplitudes	0·4%	0·33%
Loop gain at 1000c/s...	26dB	20·5dB



A distributed load (ultralinear) output stage was described in the articles on the 20-watt amplifier using Mullard EL34's. A similar type of output stage has now been designed for the 5-valve 10-watt amplifier using an output transformer having the appropriate anode to anode loading and screen grid taps.

The illustration on this page shows the output stage of the circuit adapted for distributed loading. The screen grids are disconnected from the capacitor C2 and taken to the taps of the primary of the output transformer via the existing stopper resistors R19 and R20 of 47 ohms. The centre-tap of the primary is fed from the reservoir capacitor C1. The dropping resistor R18 in the h.t. line must be increased from 1.2 Kohms to 5.6 Kohms to maintain the same d.c. conditions in the first two stages, as it no longer carries the screen grid current.

The anode-to-anode loading should be 8 Kohms, corresponding to the normal loading published for the original circuit. Best results are obtained with each half of the output transformer primary tapped at about 43% of its number of turns, counting from the centre-tap. The low loading condition may also be used and indeed is often preferred.

The table on page 4 gives a comparison between the performance of the circuit with pentode push-pull and distributed load operation. Distortion is reduced in the distributed load circuit whilst retaining the original design rating of 10 watts. The maximum power output of 11 watts at the overload point (onset of clipping with sine wave input) is somewhat less than for the original circuit. However, the rate at which distortion increases beyond the 11-watt point (that is, the slope of the P_{out}/D_{tot} curve) is very much less than for the basic circuit driven beyond 14 watts. There is virtually no change in the frequency response. Overall stability is considerably better partly because the lower distortion is obtained with reduced loop gain.

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