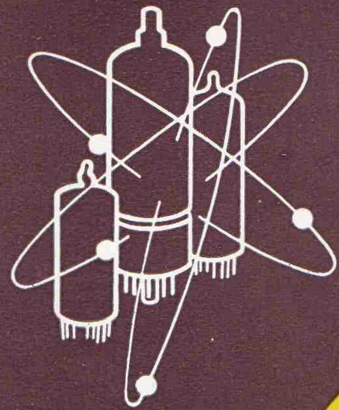

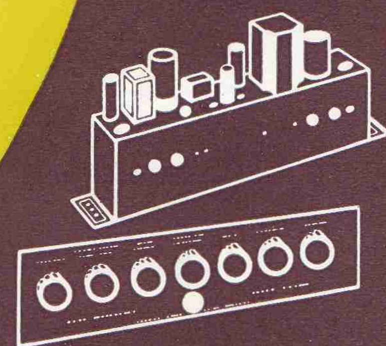

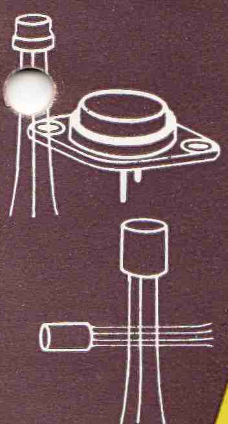

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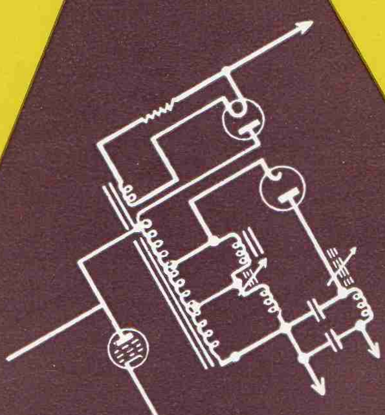

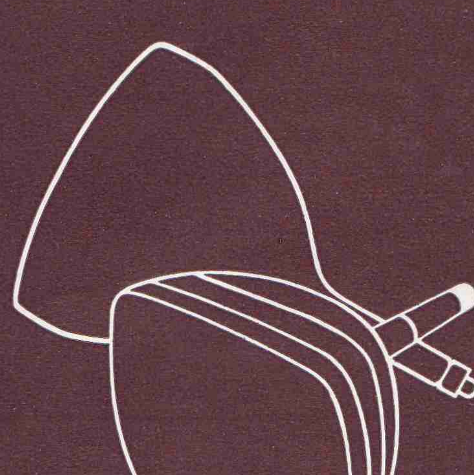

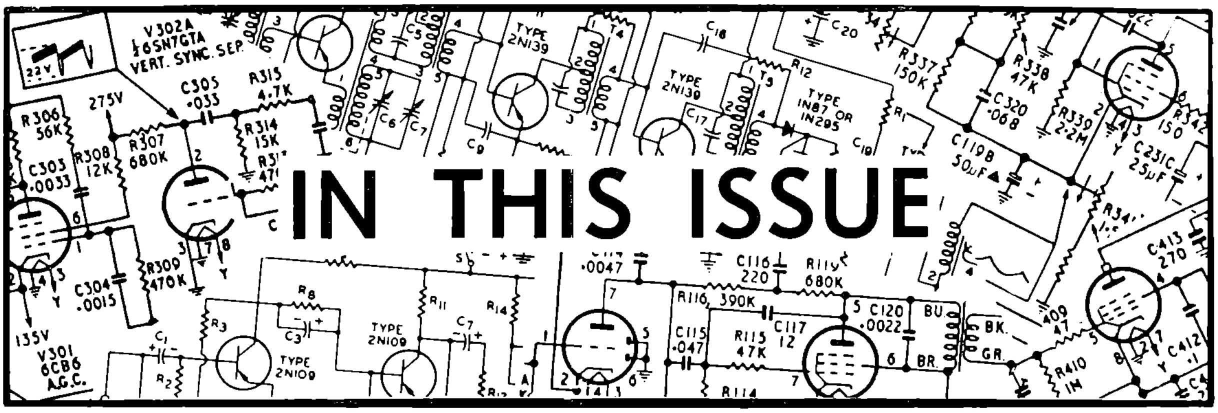

IN THIS ISSUE

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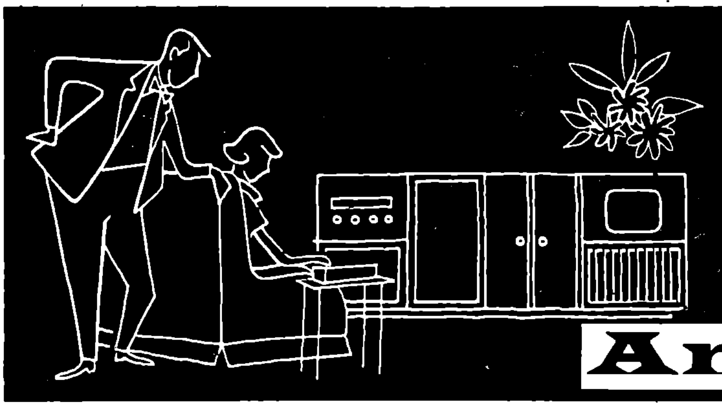


KT88 in Audio Amplifiers

PART 2

A 100W FIXED BIAS ULTRA-LINEAR AMPLIFIER

The circuit of this amplifier is given in Fig. 8 and it provides 100 watts output at 5% distortion with 560 volts high tension. The performance is shown graphically in Fig. 9 and Table III gives the operating conditions for the output stage.

With fixed bias, the large change in anode current necessitates a low impedance power supply and, with normal rectifier circuits, an inductance-input smoothing filter is essential. The smoothing capacitor should be of high value to prevent an instantaneous fall in high tension potential upon the occurrence of a transient signal. Satisfactory performance will be obtained with a single inductor and a capacitance of 50-150μf. The circuit diagram shows two 160μf 450 volt electrolytic capacitors in series as an economical method of obtaining the required capacitance.

Reducing the high tension potential to 460 volts, the load impedance to 4000 ohms and the grid bias to —65 volts results in an amplifier giving 65 watts output. The performance of this version is shown in Fig. 10 and the appropriate operating data are included in Table III.

PROTECTION AGAINST BIAS FAILURE

Should the bias supply fail, the KT88 anode currents would increase excessively and it is recommended that some device be incorporated for protecting the output valves in the event of bias failure. The arrangement illustrated in Fig. 11 inserts a suitable resistor into the output stage cathode circuit which will enable the amplifier to function temporarily at half maximum output.

A triode, which could be one half of a double triode used also in the first stage of the amplifier, is connected in series with a relay across the main high tension supply. The relay contacts are normally closed and short-circuit the emergency cathode resistor R1. The triode is held at cutoff by the connection of its grid to the bias supply at a point about 50 volts negative to earth. Should the bias fail, the grid of the triode will rise to earth potential and current will flow through the triode. This energises the relay, the contacts of which will open and bring into circuit the cathode bias resistor.

TABLE III
100W ULTRA-LINEAR AMPLIFIER
OPERATING CONDITIONS

Plate Supply Voltage	460	560	v
Plate, Screen Voltage	450	550	v
Plate, Screen Current (zero sig.)	2 x 50	2 x 50	ma
Plate, Screen Current (max. sig.)	2 x 120	2 x 150	ma
Plate, Screen Dissipation (zero sig.)	2 x 25	2 x 30	w
Plate, Screen Dissipation (max. sig.)	2 x 20	2 x 33	w
Grid Bias †	–65	–80	v
Power Output	65	100	w
Plate Load (p - p)	4	4.5	KΩ
Output Impedance	6.5	6.5	KΩ
Distortion ‡	3 - 6	3 - 6	%
Signal Input	1 - 1.5	1 - 1.5	mv

† A bias voltage range of at least ±25% is recommended.
‡ The distortion will vary according to the degree of matching by RII.

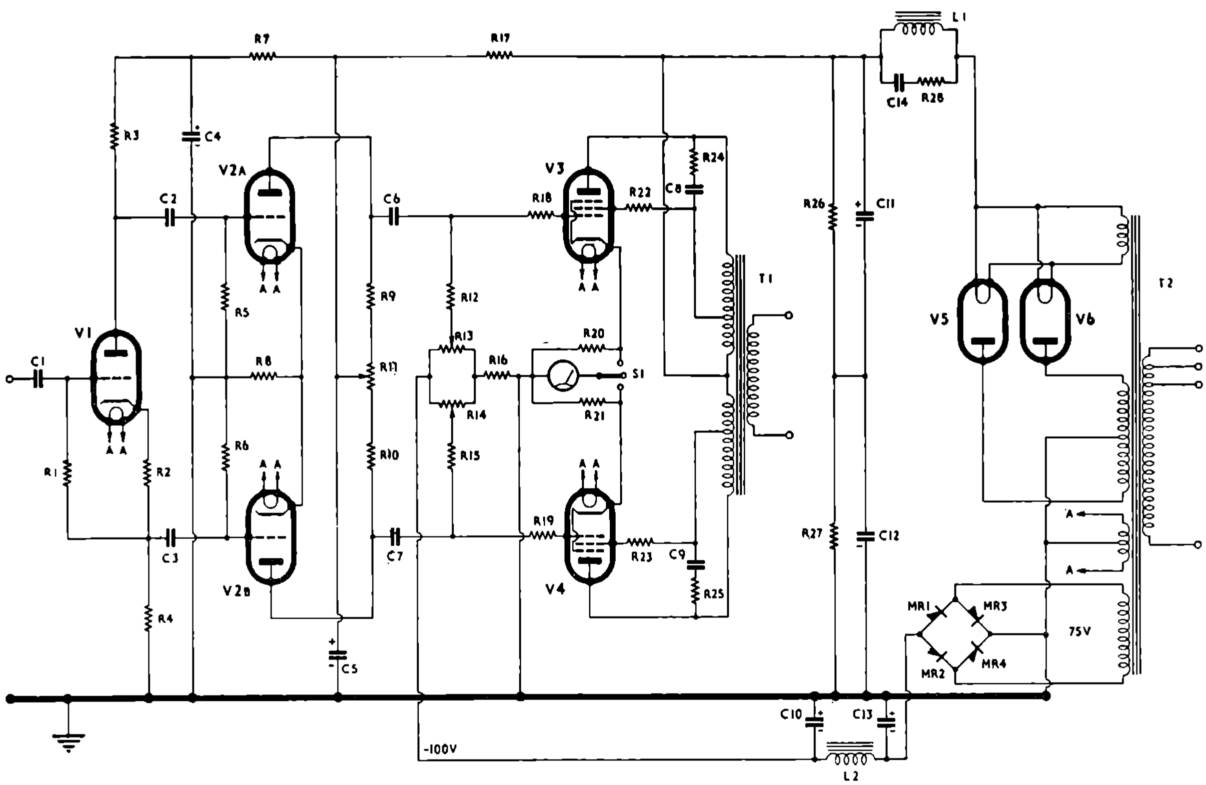


Fig. 8.—Circuit diagram of the KT88 100 watt fixed bias ultra-linear amplifier. R26 and R27 equalise the voltages across C11 and C12, the series-connected smoothing capacitors. C14 and R28 prevent the build-up of high voltage transients across L1.

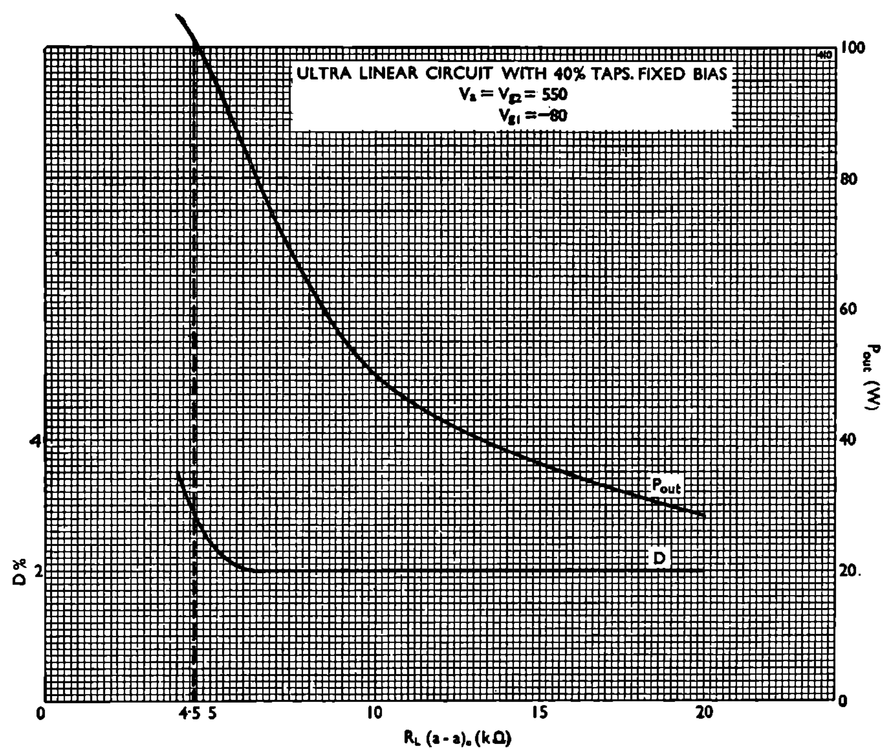


Fig. 9.—Performance of the KT88 100 watt amplifier of Fig. 8.

COMPONENT VALUES FOR THE 100W AMPLIFIER OF FIG. 8

VALVES

V1 L63 or 6J5.
V2 B65 or 6SN7GT.
V3 KT88.
V4 KT88.
V5 } U19 (4 volt filament), or GXU50 with de-
V6 } day, or 5AS4. See text.

RESISTORS

All resistors 20%, 0.25 watt unless otherwise shown.

R1 1 MΩ.
R2 1.5 KΩ.
R3 33 KΩ, 1 w } Matched 5%.
R4 33 KΩ, 1 w }
R5 470 KΩ, 10%.
R6 470 KΩ, 10%.
R7 33 KΩ, 1 w.
R8 1 KΩ.
R9 33 KΩ, 10%, 1 w.
R10 10 KΩ.
R11 33 KΩ, 10%, 1 w.
R12 100 KΩ, 10%, 0.5 w.
R13 20 KΩ, ww, preset.
R14 20 KΩ, ww, preset.
R15 100 KΩ, 10%, 0.5 w.
R16 10 KΩ, 10%, 1 w.
R17 4.7 KΩ, 1 w.
R18 5.6 KΩ.
R19 5.6 KΩ.
R20 } Meter shunts
R21 }
R22 270 Ω, 0.5 w.
R23 270 Ω, 0.5 w.
R24 470-1500 Ω, 0.5 w.
R25 470-1500 Ω, 0.5 w.
R26 100 KΩ, 10%, 1 w.
R27 100 KΩ, 10%, 1 w.
R28 10 KΩ, 0.5 w.

CAPACITORS

C1 0.01 μf.
C2 0.05 μf.
C3 0.05 μf.
C4 8 μf, 350 vw.
C5 8 μf, 450 vw.
C6 0.1 μf.
C7 0.1 μf.
C8 1000 μμf.
C9 1000 μμf.
C10 8 μf, 250 vw.
C11 160 μf, 450 vw.
C12 160 μf, 450 vw.
C13 8 μf, 250 vw.
C14 0.01 μf, 750 vw.

MISCELLANEOUS

L1 5 h, 325 ma.
L2 20 h, 10 ma.
T1 100 watt UL transformer, 4.5 KΩ plate-plate for 100 watts, 4.0 KΩ plate-plate for 65 watts, primary inductance not less than 40 h.
Leakage inductances:—
Prim-Sec:—not greater than 6 mh.
½ Prim-UL tap:—not greater than 6 mh.
T2 Mains transformer†
700-0-700 volts, 325 ma.
6.3 volts, 5 a centre tapped.
5 volts, 7 a.
75 volts, 10 ma (bias)
S1 Switch, 1 pole, 3 way.
MR1 }
MR2 } Rectifiers
MR3 } 75 volts, 10 ma.
MR4 }

† A 4-volt winding is required if U19's are used.

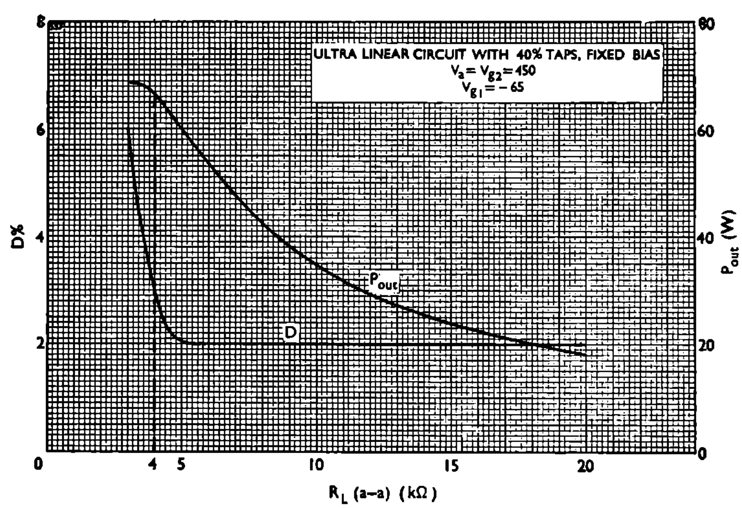


Fig. 10.—The modified characteristics of the amplifier in Fig. 8 when it is arranged for 65 watts maximum output (see Table III).

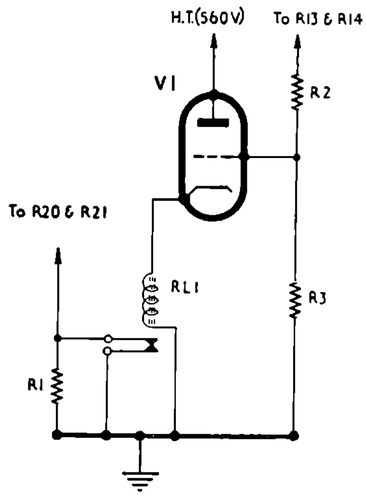


Fig. 11.—Bias failure protection for the KT88 fixed bias amplifier. R2 is connected to the positive (earthy) junction of R13 and R14 in Fig. 8. R2 and R3 take the place of R16 in the amplifier. The earth connection to the meter in Fig. 8 is broken and the meter (and R20, R21) taken to R1. Component values: V1: L63 or 6J5; R1: 330Ω 10% 5w; R2: 6.8KΩ 10% 0.5w; R3: 15KΩ 10% 0.5w; RL1: 20KΩ

A 150W CLASS B AMPLIFIER

Two KT88 valves, triode-connected in Class B, may be used when maximum output for intermittent (ICAS*) operation is required. It is permissible to use a higher anode voltage than is usual, and an output up to 150w is obtained.

This type of operation is satisfactory when a distortion higher than that obtained with the ultra-linear circuit, may be tolerated. (A typical use would be in a speech modulator for a transmitter).

* ICAS: Intermittent Commercial and Amateur Service.

CIRCUIT DESCRIPTION

The circuit is shown in Fig. 12. In this circuit, the screen and control grids are connected via resistors R18 and R19 forming, in effect, a high impedance triode. Both grids are driven into the positive region from a driver stage capable of providing 180 + 180 volts rms, the current drawn by the control grids being limited by R18 and R19.

Successful operation is almost entirely dependent upon the design of the driver stage. This should have a low impedance, so as to ensure minimum distortion in the output stage.

Satisfactory results can be obtained by using a resistance loaded pentode stage. The load resistors R16 and R17 in Fig. 12 also serve to reduce the 750 volt line to 450 volts for the pentode anodes. This method of supply prevents the line voltage from rising excessively during the quiescent periods, when the output stage passes no more than 15-20ma.

TABLE IV
150W CLASS B AMPLIFIER, ICAS RATING
OPERATING CONDITIONS

OUTPUT STAGE		
Plate Voltage (zero sig.)	850	v
Plate Voltage (max. sig.)	750	v
Screen Voltage (rms)	60	v
Plate Current (zero sig.)	2 x 10	ma
Plate Current (max. sig.)	2 x 140	ma
Current, Grid 1 + Screen	30	ma
Power Output	150	w
Plate Load (p - p)	6	KΩ
Output Impedance	25	KΩ
Distortion	6 - 8	%
Drive Power (approx.)	7	w
Signal Input (g - g) (rms)	360	v
Input Impedance	18	KΩ
DRIVER STAGE		
Plate Voltage (zero sig.)	500	v
Plate Voltage (max. sig.)	400	v
Screen Voltage (zero sig.)	375	v
Screen Voltage (max. sig.)	325	v
Plate Current (zero sig.)	2 x 50	ma
Plate Current (max. sig.)	2 x 55	ma
Screen Current (zero sig.)	2 x 2	ma
Screen Current (max. sig.)	2 x 7	ma
Signal Input (g - g) (rms)	40	v

The above conditions are suitable for normal speech applications only. For other purposes a plate load (p - p) of 7.5 KΩ should be used. At a plate voltage of 600 volts, an output of approximately 100 watts is obtained.

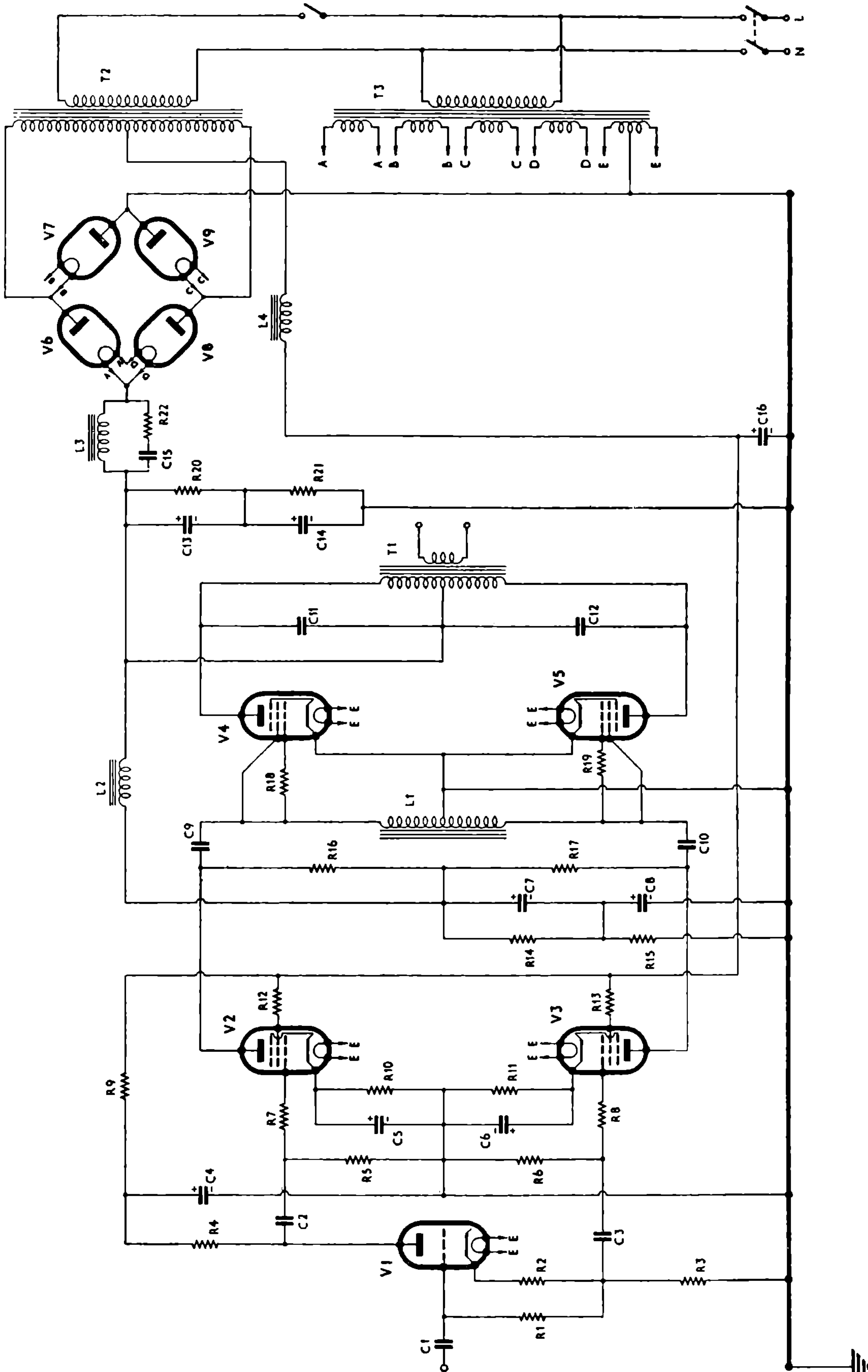


Fig. 12.—Circuit diagram of the 150 watt Class B amplifier.

An inductance L1 is used in place of grid return resistors as the output stage grids draw some 30ma at full output. The characteristics of L1 are not critical. It should have a dc resistance not exceeding 500 ohms, an inductance of about 20 henries and a centre tap. A small output transformer, with the secondary left unused, is satisfactory.

A bridge-connected rectifier system fed by a transformer giving 900 volts rms provides the anode supply to both the output and driver stages. A centre tap on this transformer enables half the dc anode voltage to be obtained for the driver screens and the previous stage(s). The electrolytic capacitors C13, C14 and C16 are of high value in order to absorb the large fluctuations of anode current (from about 120 to 400ma). The series connection of C13 and C14 permits a voltage up to 900. Suitable rectifiers are: GU50, GXU50, U52 or U54*.

Table IV gives the operating conditions for the amplifier and Fig. 13 illustrates its performance.

* Alternatively the AWV Radiotron 5AS4.

COMPONENT VALUES FOR THE 150W AMPLIFIER OF FIG. 12

VALVES

V1 L63 or 6J5.
V2 KT66 or 6L6G.
V3 KT66 or 6L6G.
V4 KT88.
V5 KT88.
V6, V7, V8, V9 } U52, U54, 5AS4, GU50 or GXU50. See text.

RESISTORS

All resistors 20%, 0.25 watt unless otherwise shown.

R1 470 KΩ.
R2 1 KΩ.
R3 33 KΩ, 1 w } Matched 5%.
R4 33 KΩ, 1 w } Matched 5%.
R5 220 KΩ.
R6 220 KΩ.
R7 10 KΩ.
R8 10 KΩ.
R9 22 KΩ, 1 w.
R10 600 KΩ, 5%, 3 w ww.
R11 600 KΩ, 5%, 3 w ww.
R12 220 KΩ.
R13 220 KΩ.
R14 100 KΩ, 10%, 1 w ww.
R15 100 KΩ, 10%, 1 w ww.
R16 5 KΩ, 5%, 20 w ww.
R17 5 KΩ, 5%, 20 w ww.
R18 22-100 KΩ, 1 w.
R19 22-100 KΩ, 1 w.
R20 100 KΩ, 10%, 1 w.
R21 100 KΩ, 10%, 1 w.
R22 10 KΩ.

CAPACITORS

C1 0.01 μf.
C2 0.05 μf.
C3 0.05 μf.
C4 8 μf.
C5 25 μf.
C6 25 μf.
C7 32 μf.
C8 32 μf.
C9 0.5 μf.
C10 0.5 μf.
C11 0.01 μf.
C12 0.01 μf.
C13 160 μf.
C14 160 μf.
C15 0.01 μf.
C16 160 μf.

MISCELLANEOUS

L1 20 h, 30 ma, dc resistance not greater than 500 ohms.
L2, L3 } HT filter chokes.
T1 150 watt output transformer, 6 KΩ plate-plate.
T2, T3 } Mains ht and heater transformers to suit selected arrangement.

MULTIPLE-PAIR PUSH-PULL AMPLIFIERS

The circuit diagram of Fig. 14 illustrates the use of ten valves in a fixed bias ultra-linear output stage and this arrangement gives 400 watts output. More or less than five pairs of valves can be used, depending upon the output power required.

A single control is used for grid bias adjustment and this simplifies the amplifier at the expense of somewhat higher distortion and lower output.

It is not essential to use accurately matched valves but the total current in each half of the push-pull stage should be equalised as closely as possible. This becomes easier with an increasing number of pairs and is facilitated by the cathode current meter built into the amplifier. The individual cathode currents will vary from about 35ma to about 60ma and each valve should be measured in turn and the valves sorted into two groups of approximately similar total current.

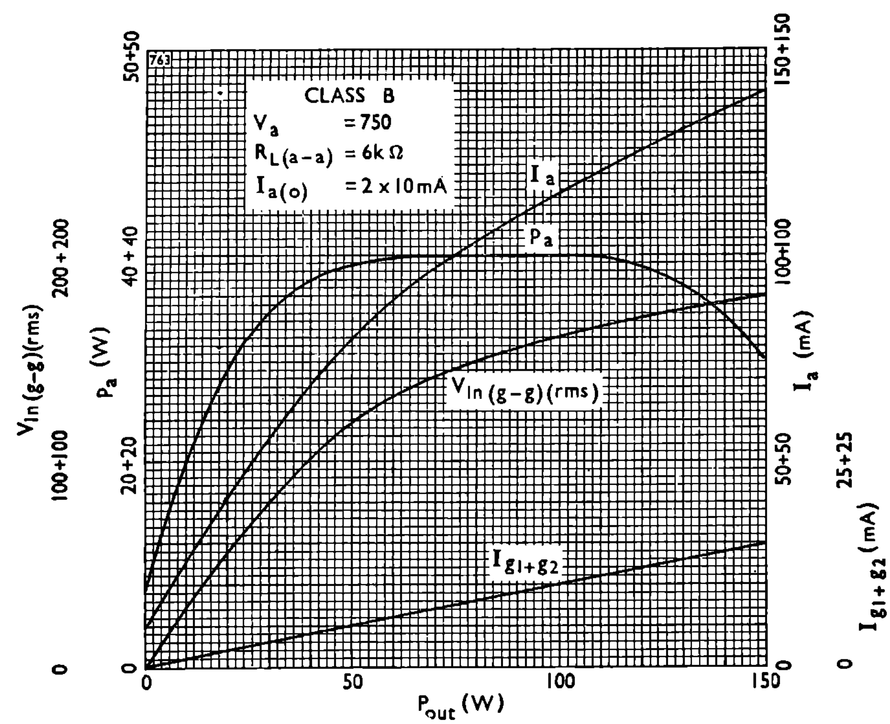


Fig. 13.—Performance of the 150 watt Class B amplifier of Fig. 12.

When the valves have been sorted and the two groups plugged into their respective halves of the amplifier, the optimum operating condition is obtained by adjusting the grid bias with R5 (Fig. 15) so that the current drawn by any single valve does not exceed 60ma. In this way an output of 400 watts will be obtained at a distortion of about 5%.

When using six or more valves in this type of amplifier, the value of the grid return resistors R14 and R15 is of importance and a low value is desirable. In order to facilitate the production of the necessary distortion-free input signal of 55 + 55 volts rms, the output stage is driven by a pair of cathode followers V2B and V3B. With four output valves the grid resistors could be increased to 100K ohms and the cathode followers dispensed with. However, as they form parts of double triodes, the saving in cost is insignificant and, on the whole, it is preferable to retain them.

The method of measuring the cathode current of each KT88 valve is shown in Fig. 14. A resistor of 10 ohms is inserted in the cathode lead of each valve (i.e. R38, R39, etc.) and a meter M1 is connected across this resistor through switch S1 and a series resistor (R48, R49, etc.).

It was found convenient to use a meter with a full-scale deflection of 200μa, the value of the series resistor being such that the meter indicated 0-200ma. At full output each cathode current is about 100ma to 125ma. It may be preferred to substitute the individual cathode series resistors with a single resistor inserted between the meter and switch but the possibility of instability should be borne in mind as the individual resistors act as cathode circuit isolators.

The ultra-linear output transformer must have low leakage inductance between: primary and secondary; half-primary and half-primary; and each half-primary and its tap. The absolute values of leakage inductance will depend upon the number of valves used but a 400 watt transformer used in the prototype had the following characteristics:

Primary Inductance	4h
Leakage Inductances:	
Primary to secondary	0.75mh
Half-primary to half-primary	0.75mh
Each half-primary to tap	1.5mh

To prevent ultrasonic oscillation, resistor/capacitor combinations are connected between each tap and the anode terminal of each half-primary. In the prototype, C10 and R60 were also found to be desirable, the values being 3500$\mu\mu$f and 1000 ohms respectively.

Negative feedback may be added to this amplifier in the normal way, from the secondary of the output transformer to the cathode circuit of the input valve. The values of the resistors R2 and R3 in Fig. 14 are determined by the amount of feedback and the ratio of the transformer.

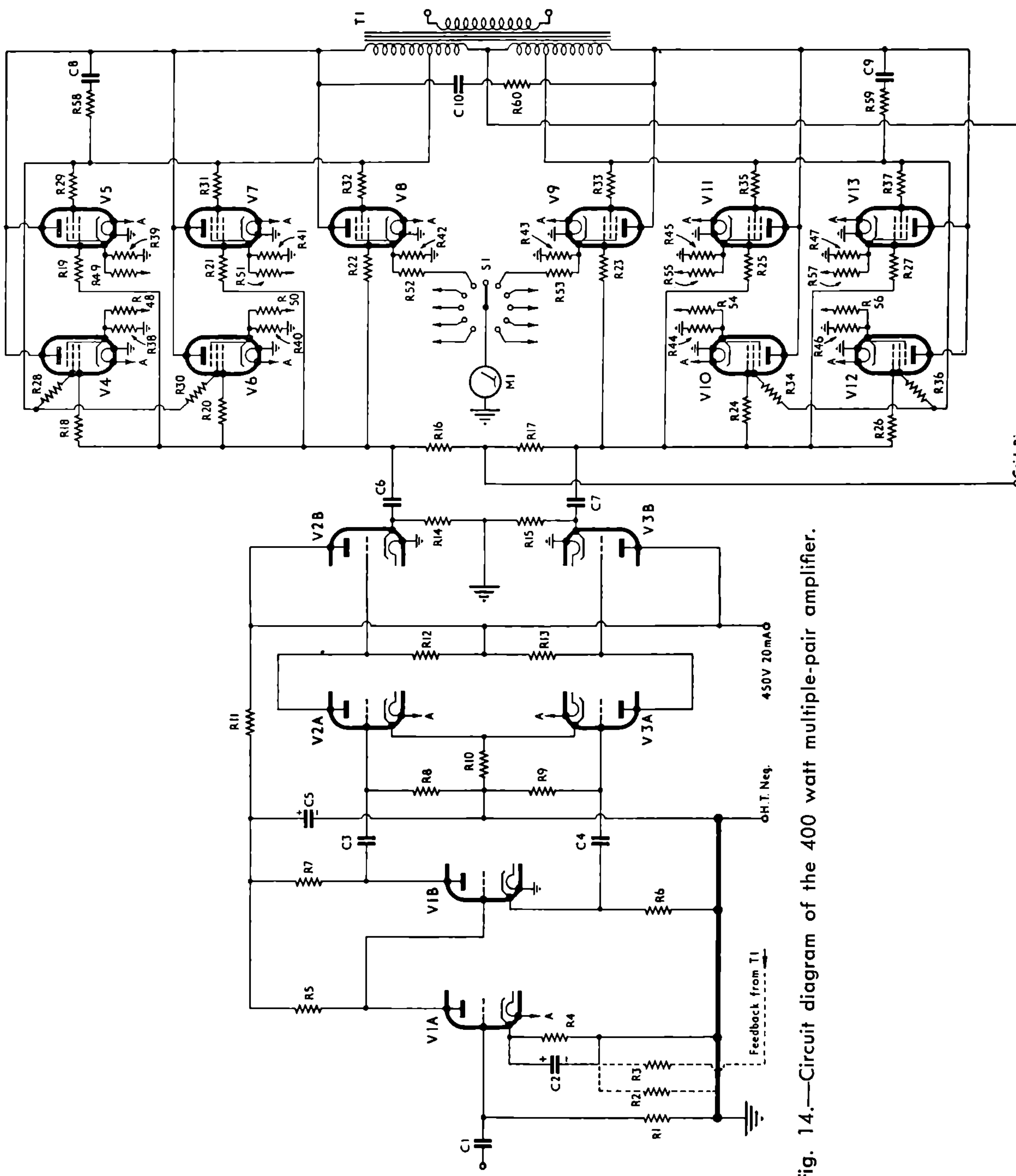


Fig. 14.—Circuit diagram of the 400 watt multiple-pair amplifier.

Fig. 16 illustrates a recommended layout for the output valves and is self-explanatory. Adequate ventilation should be provided; if in doubt, temperature sensitive paint should be used, as mentioned in Part I.

POWER SUPPLY

The design of the power supply is an important factor in the satisfactory operation of an amplifier of this type. The regulation should be good; better than 10% with a current variation of 400-1200ma was obtained in the prototype. This order of regulation was achieved by using the xenon filled rectifier GXU1 which, in this application, is considerably under-run at a peak inverse voltage of 1000 volts as against the rated peak inverse voltage of 10,000 volts. For up to six output valves, the smaller xenon rectifier GXU50 is suitable*.

The circuit of a complete power supply is given in Fig. 15 and this provides the lower high tension voltage required by the earlier stages as well as the grid bias supply.

A single inductance-input filter is shown and, with a smoothing capacitance of 150-200μf (obtained by series-connecting two larger capacitors),

* The AWV Radiotron 3B28 may be used in lieu of the GXU1.

COMPONENT VALUES FOR 400W AMPLIFIER OF FIG. 14

VALVES

V1-V3 B65 or 6SN7GT.
V4-V13 KT88.

RESISTORS

All resistors 20%, 0.25 watt unless otherwise shown.

R1 1 MΩ.
R2, R3 See text.
R4 1 KΩ.
R5 100 KΩ, 0.5 w.
R6 15 KΩ, 0.5 w; R7 15 KΩ, 0.5 w — Matched 5%.
R8 1 MΩ.
R9 1 MΩ.
R10 4.7 KΩ, 10%, 0.5 w.
R11 33 KΩ, 0.5 w.
R12 220 KΩ, 1 w; R13 220 KΩ, 1 w — Matched 5%.
R14 47 KΩ, 1 w; R15 47 KΩ, 1 w — Matched 5%.
R16 47 KΩ, 10%, 0.5 w.
R17 47 KΩ, 10%, 0.5 w.
R18-R27 15 KΩ.
R28-R37 220 Ω.
R38-R47 Meter shunts, see text.
R48-R57 Meter series resistors, see text.
R58 1 KΩ, 2 w.
R59 1 KΩ, 2 w.
R60 See text.

CAPACITORS

C1 0.01 μf.
C2 50 μf, 12 vw.
C3 0.01 μf.
C4 0.01 μf.
C5 8 μf, 450 vw.
C6 0.25 μf.
C7 0.25 μf.
C8 1000 μμf.
C9 1000 μμf.
C10 See text.

MISCELLANEOUS

M1 Meter, 200 μa, see text.
S1 Switch, 1 pole, 11 way, bbm.
T1 400 watt UL transformer, see text.

TABLE V
400W MULTIPLE PAIR AMPLIFIER
OPERATING CONDITIONS

Plate Supply Voltage (zero sig.)	570	v
Plate Supply Voltage (max. sig.)	530	v
Plate, Screen Voltage (zero sig.)	565	v
Plate, Screen Voltage (max. sig.)	525	v
Plate, Screen Current (zero sig.) (per valve)	35 - 60	ma
Plate, Screen Current (max. sig.) (per valve)	100 - 125	ma
Plate, Screen Current (zero sig.) (total)	450	ma
Plate, Screen Current (max. sig.) (total)	1200	ma
Plate, Screen Dissipation (zero sig.) (per valve)	35	w
Plate, Screen Dissipation (max. sig.) (per valve)	25	w
Grid Bias (approx.)	–75	v
Power Output	400	w
Plate Load (p - p)	1	KΩ
Output Impedance	1.2	KΩ
Distortion	5 - 7	%
Signal Input	250	mv

If 10 db of negative feedback is applied, the last three values become 400Ω, 2% and 750 mv respectively.

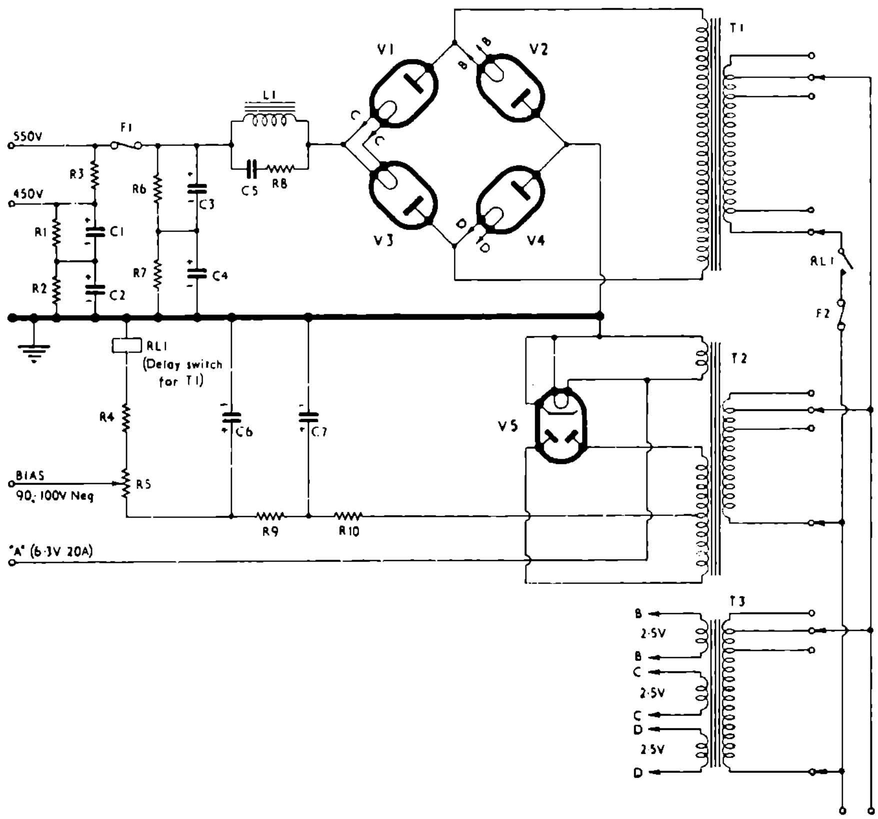


Fig. 15.—Power supply circuit for the 400 watt multiple-pair amplifier. The winding of T3 is simplified if four identical secondaries are used. To prevent mains-borne interference with nearby receivers, generated by the xenon rectifiers, a pair of capacitors (0.05 μf, 700 v ac) should be connected in series across the 700 volt winding and their junction connected to the negative (earth) line.

this should be satisfactory for most purposes. A further filter section may be inserted if desired. The smoothing inductor(s) should have a value of 2-3 henries and a dc resistance of about 25 ohms.

APPENDIX

Intermodulation in Ultra-Linear Amplifiers

The curves of Fig. 17 illustrate the various degrees of intermodulation with varying positions of the screen taps on the output transformer from 0% (pentode operation) to 100% (triode operation). The measurements were made under SMPE* conditions using frequencies of 50 and 6000 cps at a ratio of 4 : 1. It will be noticed that the lowest level of intermodulation is obtained with taps of about 40%. A slight increase in intermodulation is produced at 33% or 57% and a significant increase at 25% or 75%.

The triode performance (100%) is inferior to the ultra-linear at all outputs except below 10 watts with 25% taps. The high intermodulation of the pentode arrangement (0%) is to be expected.

* Society of Motion Picture Engineers.

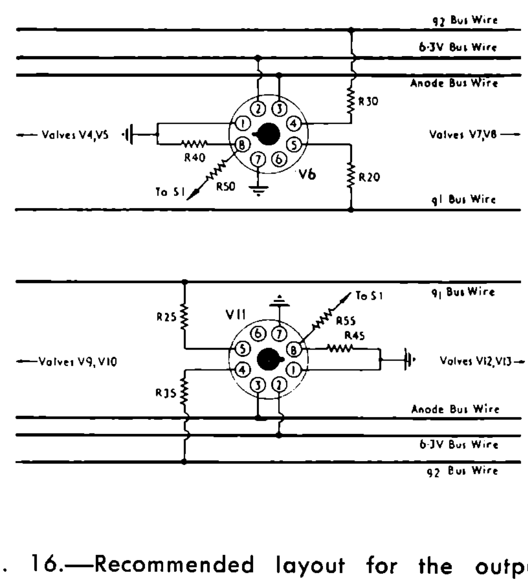


Fig. 16.—Recommended layout for the output valves of the 400 watt amplifier. If the distance between pairs of valves is reduced to the minimum of 4 in centre to centre, they should be oriented as shown in Figs. 2 and 3, Part I.

The application of negative feedback will reduce intermodulation roughly in proportion to the reduction in gain. For example, a 3 : 1 reduction in intermodulation is obtained with 10db and a 5 : 1 reduction with 14db feedback. It can be seen from Fig. 17 that it is not difficult to reduce intermodulation to below 1% at 50 watts output.

(With acknowledgements to G.E.C.)

COMPONENT VALUES FOR 400W AMPLIFIER POWER SUPPLY OF FIG. 15

VALVES

V1-V4 GXU1 or 3B28.
V5 U709, U78 or 6X4.

RESISTORS

R1 100 KΩ, 10%, 0.5 w.
R2 100 KΩ, 10%, 0.5 w.
R3 4.7 KΩ, 20%, 2 w.
R4 22 KΩ, 20%, 1 w.
R5 10 KΩ, ww.
R6 47 KΩ, 10%, 1 w.
R7 47 KΩ, 10%, 1 w.
R8 10 KΩ, 20%, 1 w.
R9 22 KΩ, 20%, 1 w.
R10 1.5 KΩ, 20%, 0.25 w.

CAPACITORS

C1 32 μf, 350 vw.
C2 32 μf, 350 vw.
C3 300 μf, 350 vw.
C4 300 μf, 350 vw.
C5 0.01 μf, 500 vw.
C6 2 μf, 250 vw.
C7 2 μf, 250 vw.

MISCELLANEOUS

L1 2 h, 1200 ma, 25 Ω.
T1 700 volts, 1200 ma, with 10 volt taps on primary.
T2 Bias transformer.
150-0-150 volts, 10 ma.
6.3 volts, 20 a.
T3 2.5 volts, 5 a.
2.5 volts, 5 a.
2.5 volts, 10 a (or 2 x 2.5 volts, 5 a).
F1 Fuse, 2 a.
F2 Fuse, 5 a.

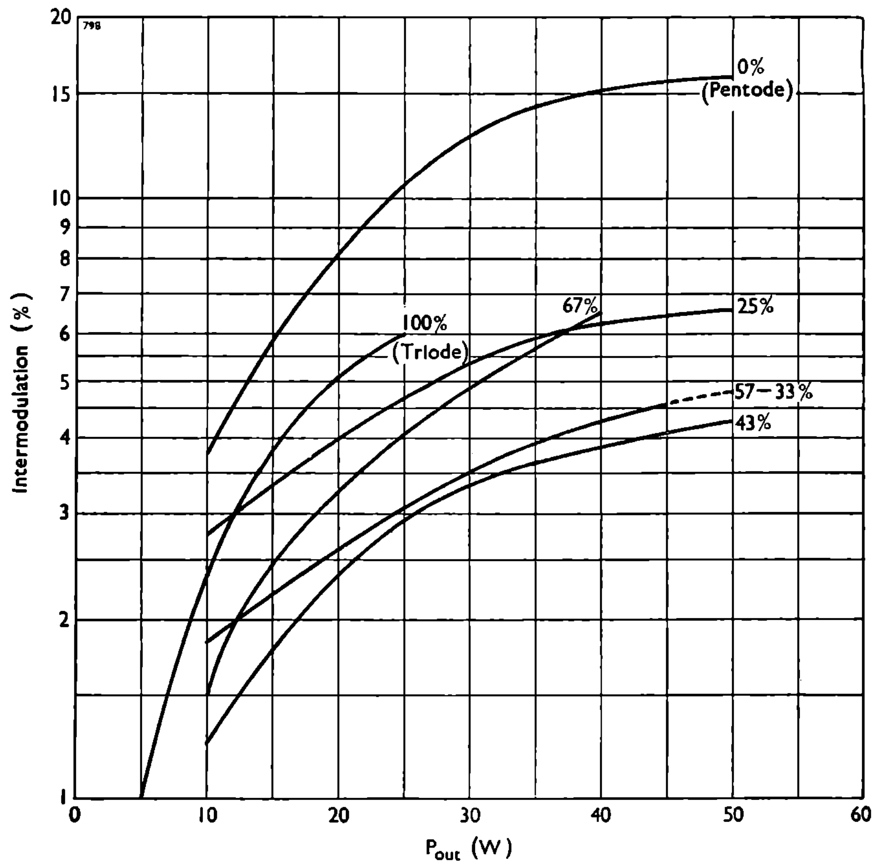


Fig. 17.

REVIEW QUESTIONS

TRANSISTOR FUNDAMENTALS AND APPLICATIONS

The following multi-choice questions are based on the material which has been presented in "Transistor Fundamentals" and "Transistor Applications". To use the questions, circle the letter corresponding to the completion which you think is correct. The correct answers are given at the end of the list of questions.

1.	Collector current in a junction transistor of the p-n-p type will: (a) be less than unity as compared to the emitter current; (b) be more than unity as compared to the emitter current; (c) be greater than the total current; (d) always be constant.	a	b	c	d
2.	In point contact transistors there is: (a) a constant current at all times; (b) a current gain less than unity; (c) a current gain greater than unity; (d) equal current in all regions.	a	b	c	d
3.	The potential which exists at the junction of n and p-type semiconductors is called the: (a) potential high voltage region; (b) reverse bias potential; (c) forward bias potential; (d) potential gradient or potential energy barrier.	a	b	c	d
4.	The nucleus of an atom exhibits: (a) a charge equal to zero; (b) a negative charge; (c) a positive charge; (d) a positive and negative charge.	a	b	c	d
5.	The action of binding the valence rings together is known as the formation of: (a) covalent bonds; (b) trivalent bonds; (c) pentavalent bonds; (d) "Series E" Bonds.	a	b	c	d
6.	Forward bias applied to a p-n junction: (a) changes the semiconductor to a higher resistivity; (b) increases the resistance to current flow; (c) has a net charge of +5; (d) decreases the resistance to current flow.	a	b	c	d
7.	For best performance, the maximum operating frequency of a transistor should be what percentage of the frequency cutoff of the transistor: (a) 50%; (b) 100%; (c) 20%; (d) 80%.	a	b	c	d
8.	When an impurity atom having a valence of +5 is added to germanium: (a) it changes to a liquid; (b) p-type semiconductor is formed; (c) there is no change; (d) n-type semiconductor is formed.	a	b	c	d
9.	What is the most important factor of a power transistor: (a) impedance matching; (b) mounting; (c) output resistance; (d) heat dissipation.	a	b	c	d
10.	In a point contact transistor the presence of holes in the vicinity of the collector causes: (a) a marked increase in the resistance of the collector region; (b) a marked increase in the collector current; (c) the collector current to decrease rapidly; (d) transistor action to cease.	a	b	c	d
11.	The collector of a transistor is similar to: (a) the plate of a thermionic valve; (b) the grid of a valve; (c) the cathode of a valve; (d) the outer shell of a metal valve.	a	b	c	d
12.	Germanium in its pure form is (a) a conductor; (b) an insulator; (c) a transistor; (d) a liquid.	a	b	c	d
13.	A p-n junction is capable of: (a) rectification; (b) amplification; (c) replacing a pentode; (d) large power output.	a	b	c	d

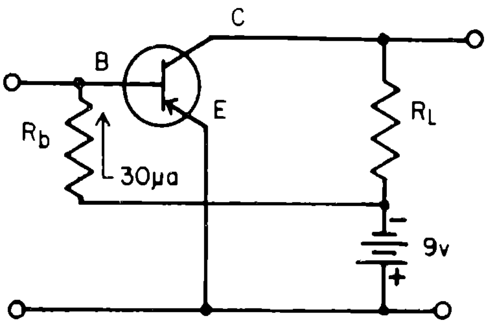


Figure 1

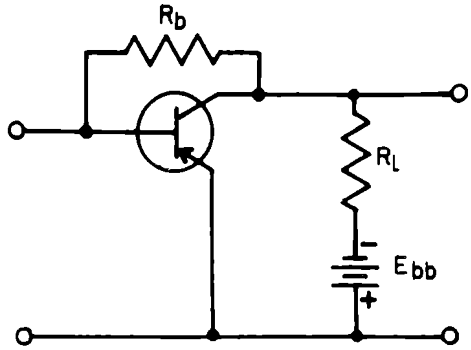


Figure 2

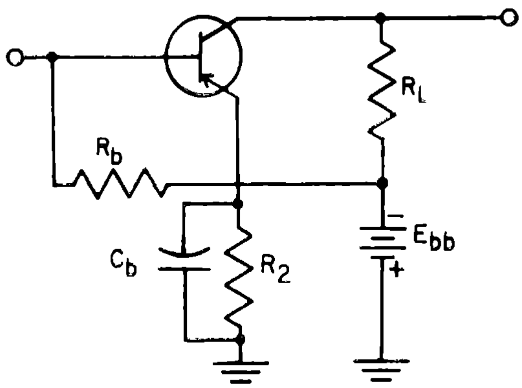


Figure 3

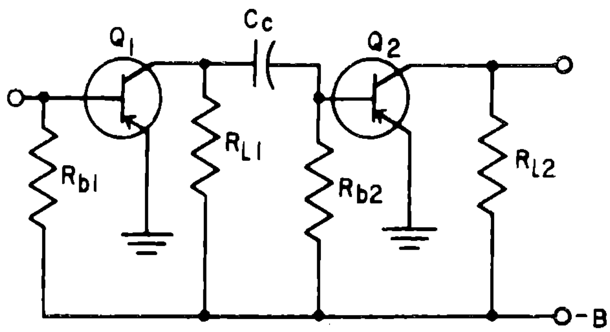


Figure 4

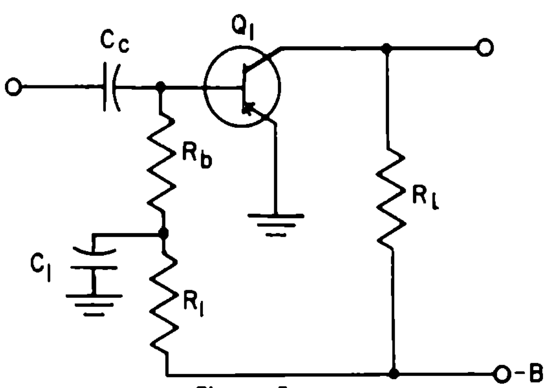


Figure 5

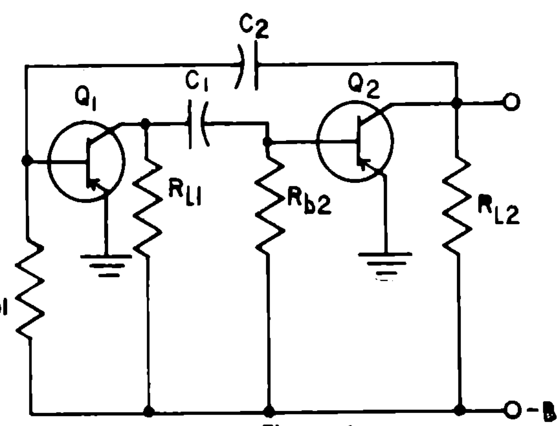


Figure 6

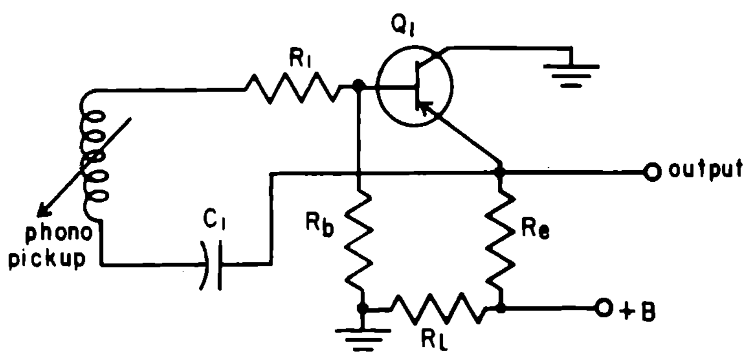


Figure 7

CIRCUIT DIAGRAMS FOR QUESTIONS

14.	Valence electrons are located in the: (a) outer electron ring of the atom; (b) inner ring of electrons of the atom; (c) nucleus; (d) protons.	a	b	c	d
15.	The base of a transistor is similar to the: (a) suppressor grid of a thermionic valve; (b) plate of a valve; (c) cathode of a valve; (d) grid of a valve.	a	b	c	d
16.	The "drift" transistor has a high frequency cutoff: (a) due to the high resistance of the base area; (b) since high collector voltages can be used; (c) due to the large base area (d) due to its inherent low internal capacitance and low electron transit time through the base.	a	b	c	d
17.	When transistor applications call for a temperature operating condition which exceeds 185°F, which element is most suitable: (a) antimony; (b) germanium; (c) silicon; (d) not possible to operate transistors above 185°F.	a	b	c	d
18.	The output resistance of a p-n-p junction transistor is: (a) the same as the input (b) less than the input resistance; (c) much greater than the input; (d) zero.	a	b	c	d
19.	A short electron transit time through the base region: (a) usually provides a higher frequency cutoff; (b) creates higher potential barriers; (c) provides a higher break down voltage; (d) reduces the amplification capabilities of the transistor.	a	b	c	d
20.	Conduction within n-type semiconductor material is carried on primarily by: (a) protons; (b) electrons; (c) holes; (d) neutrons.	a	b	c	d
21.	An arrowhead drawn on the emitter lead on a transistor symbol indicates: (a) the direction of current flow; (b) the direction of electron flow; (c) it is a point contact; (d) the ground end of the lead.	a	b	c	d
22.	The hole is the means of conduction within a: (a) p-type semiconductor: (b) pentavalent semiconductor; (c) molecule; (d) n-type semiconductor.	a	b	c	d
23.	An element which falls somewhere between being an insulator and conductor is called a: (a) n-type conductor; (b) intrinsic conductor; (c) semiconductor; (d) p-type conductor.	a	b	c	d
24.	The method of operating a transistor similar to that of a normal valve circuit is called a: (a) common or grounded base; (b) common or grounded emitter; (c) common or grounded collector; (d) normal base load connection.	a	b	c	d
25.	A grounded emitter transistor amplifier circuit is similar to the thermionic valve: (a) grounded plate circuit; (b) grounded grid circuit; (c) grounded cathode circuit; (d) bootstrap circuit.	a	b	c	d
26.	The current gain in a grounded emitter circuit is: (a) less than unity; (b) greater than unity; (c) equal to unity; (d) zero.	a	b	c	d
27.	The input resistance as compared to the output resistance of a grounded emitter amplifier is: (a) smaller; (b) greater; (c) the same; (d) the same as valve amplifiers.	a	b	c	d
28.	In Figure 1, the base current is 30 μa. What is the value of R_b?: (a) 100K; (b) 300K; (c) 200K; (d) 1K.	a	b	c	d
29.	If the stabilizing resistor in the emitter is unbypassed the effective gain of an amplifier is: (a) increased; (b) reduced; (c) unaffected; (d) normal at low frequencies and increased at high frequencies.	a	b	c	d
30.	The secondary impedance as compared to the primary impedance of an interstage coupling transformer in transistor circuits is usually: (a) higher; (b) lower; (c) the same; (d) not critical.	a	b	c	d
31.	Large value coupling and bypass capacitors are required in transistor circuits due to the inherent: (a) low impedances; (b) miniaturization; (c) instability; (d) high impedances.	a	b	c	d
32.	Class B amplifiers are usually preferred to Class A because there is: (a) less harmonic content; (b) better stability; (c) lower power requirement; (d) less critical to design.	a	b	c	d
33.	To sustain oscillation in a transistor circuit what type of feedback is generally employed: (a) voltage; (b) sawtooth; (c) resistance; (d) current.	a	b	c	d
34.	What is the main advantage of using a transistor as a phonograph preamplifier: (a) better stability; (b) increased sensitivity; (c) no microphonics; (d) no equalization required.	a	b	c	d

35. What type of transistor is used in video amplifiers: (a) drift; (b) hook; (c) diffused junction; (d) point contact. a b c d

36. What is the main limitation of video amplifiers using transistors: (a) low peak currents; (b) low peak voltage output; (c) poor frequency response; (d) will not pass sync pulses. a b c d

37. What metal is most widely used in miniaturised capacitors: (a) aluminium; (b) tantalum; (c) zinc; (d) cobalt. a b c d

38. Iron core transformers used in transistor circuits are readily miniaturized due to the: (a) low frequency response required; (b) few windings required; (c) lack of mounting space; (d) low dc current requirements. a b c d

39. What type of energy can cause destruction to transistors: (a) light; (b) sound; (c) heat; (d) ac voltages. a b c d

40. If resistor R_b in Figure 2 should increase in value which of the following would occur: (a) collector current increase; (b) collector current decrease; (c) base current increase; (d) no change in circuit operation. a b c d

41. If resistor R_L in Figure 2 should increase in value the input resistance would: (a) increase; (b) remain unchanged; (c) look capacitive; (d) decrease. a b c d

42. If capacitor C_b in Figure 3 should open the signal gain of the circuit would: (a) decrease; (b) increase; (c) cause distortion; (d) remain unchanged. a b c d

43. If capacitor C_e in Figure 4 should short, which of the folowing would occur: (a) R_{b2} would burn open; (b) Q_1 would be destroyed due to heat; (c) Q_2 would be in a non-conducting state; (d) signal distortion due to heavy conduction of Q_2. a b c d

44. If capacitor C_1 in Figure 5 should short, which of the following would occur: (a) decreased gain; (b) increased gain; (c) Q_1 would destroy itself; (d) R_L would burn open. a b c d

45. If resistor R_{b2} in Figure 6 should open, which of the following would occur: (a) sine wave would be produced instead of a square wave; (b) Q_2 would conduct heavily; (c) little or no output of generated signal; (d) Q_1 would stop conduction. a b c d

46. If capacitor C_2 in Figure 6 should open, which of the following would occur: (a) frequency would decrease; (b) stage would have no output; (c) greater output but would be distorted; (d) frequency would increase slightly. a b c d

47. If capacitor C_1 in Figure 7 should short, which of the following would occur: (a) coil in phono pickup would burn open; (b) collector current would increase; (c) R_1 would open; (d) output would be distorted. a b c d

48. Excessive leakage current in a transistor can cause: (a) other components in the circuit to open; (b) decreased gain; (c) increased gain; (d) little or no effect. a b c d

ANSWERS TO REVIEW QUESTIONS

1. a	13. a	25. c	37. b
2. c	14. a	26. b	38. d
3. d	15. d	27. a	39. c
4. c	16. d	28. b	40. b
5. a	17. c	29. b	41 d
6. d	18. c	30. b	42. a
7. c	19. a	31. a	43. d
8. d	20. b	32. c	44. a
9. d	21. a	33. d	45. c
10. b	22. a	34. c	46. b
11. a	23. c	35. a	47. d
12. b	24. b	36. b	48. b

ABC TRANSISTOR GLOSSARY XYZ

A

Acceptor. Impurity used to produce p-type semiconductor, and induce "hole" conduction.

Alloy-diffused Transistor. Transistor in which the base is diffused in, and the emitter alloyed.

Alloy Process. Process for making junctions by fusing an acceptor or donor on the surface of the semiconductor and letting it resolidify.

Alloy Transistor. Transistor made by the alloy process.

Alpha. Emitter-to-collector current gain. For a junction transistor alpha is less than one.

Alpha-cutoff Frequency. The high frequency at which the forward current transfer ratio drops to 0.707 times the value at 1 Kc.

Avalanche. The fast progressive build-up of charge carriers in a semiconductor, for example, through the collision of fast-moving carriers with valence electrons in the crystal lattice, thereby giving them enough energy to escape the valence bond and, in turn, liberate further valence electrons.

Avalanche Breakdown. One of the forms of sudden current increase in a reverse-biased p-n junction, caused by an avalanche build-up of carriers as the reverse voltage is increased.

Avalanche Transistor. A switching transistor relying for its conducting state on the condition of avalanche.

B

Back Bias. See Reverse Bias.

Barrier. See Junction.

Barrier Capacitance. See Depletion-layer Capacitance.

Barrier Layer, Barrier Region. See Depletion Layer.

Barrier-layer Capacitance. See Depletion-layer Capacitance.

Base. Transistor electrode consisting of an ohmic or majority carrier contact to the base region.

Base Region. The interelectrode region of a transistor into which minority carriers are injected.

Base Resistance. Resistance in series with the base lead in the common T equivalent circuit of a transistor.

Base Ring. Ohmic contact to the base region of power transistors, made in the shape of a ring.

Beta. Base-to-collector current gain of a transistor.

Bias. The quiescent direct emitter current or collector voltage.

Bottoming. The condition in a transistor where the collector current has become so large that the voltage drop across the load has reduced the collector voltage to a value where it can collect no further increase in current.

Boundary, p-n. See p-n Junction.

Breakdown Voltage. The reverse voltage at which a junction draws a large current.

C

Carrier. A mobile conduction electron or hole.

Class A Amplifier. An amplifier in which the bias of the input electrode and the alternating input signal are such that output current flows at all times.

Collector. Transistor electrode, through which a flow of minority carriers leaves the interelectrode region.

Collector Capacitance. Depletion-layer capacitance associated with the collector junction.

Collector Efficiency. Ratio of useful power output to final stage power supply power input, usually expressed in percentage.

Collector Family. Set of characteristic curves for a transistor in which collector current is plotted against collector voltage for a set of fixed input conditions, e.g., for a number of fixed emitter currents.

Collector Junction. On junction transistors, the junction between the collector and the base.

Collector Resistance. Resistance in series with the collector lead in the common-T equivalent circuit of a transistor.

Collector Transition Capacitance. See Collector Capacitance.

Common Base. Amplifier configuration, in which the base is common to both input and output circuits.

Common Collector. Amplifier configuration, in which the collector is common to both input and output circuits.

Common Emitter. Amplifier configuration, in which the emitter is common to both input and output circuits.

Complementary Symmetry. Any of several types circuits using both p-n-p and n-p-n transistors in a symmetrical arrangement.

Conduction Band. A range of states in the energy spectrum of a solid in which electrons can move freely.

Conductivity. The characteristic of a material expressing how easily current may flow through it under the action of a voltage gradient. In a semiconductor it is a function of the number of free carriers and their mobility.

Conductivity Modulation (of a Semiconductor). The variation of the conductivity of a semiconductor by variation of the charge carrier density.

Configuration. Type of amplifier circuit, depending on which electrode is common to input and output; for example, common-emitter configuration.

Coupling. Method of passing the signal from one stage to another; for example, capacitor coupling, transformer coupling.

Crossover Distortion. Distortion caused in Class-B amplifiers through the increase in input resistance at low emitter currents. Can be reduced by increasing quiescent emitter current, i.e. idling current.

Crystal. Regular array of atoms in a solid; for example, single-crystal germanium.

Current Amplification, Current Gain. Ratio of output to input currents, current flowing into the transistor being considered positive and current flowing out of the transistor being considered negative.

Current Transfer Ratio. See large-signal and small signal current transfer ratio.

Cutoff Current. Collector (emitter) current with emitter (collector) reverse biased or open circuited, at a specified collector-to-base (emitter-to-base) reverse voltage.

Czochralski Technique. Method of growing large single crystals by pulling them from a molten state. Also known as "crystal pulling."

D

Depletion Layer. Region straddling a p-n junction where the mobile carrier charge density is insufficient to neutralize the net fixed donor and acceptor charge densities. The depletion layer is a region of high voltage fields and increases in width with increasing reverse voltage.

Depletion-Layer Capacitance. Capacitance of the depletion layer, decreasing as the layer spreads with increased reverse voltage.

Depletion-Layer Transistor. Any of several types of transistors which rely directly on motion of carriers through depletion layers for their operation; for example, spacistor.

Derating. Reducing ratings on a transistor, especially the maximum power dissipation rating at higher temperatures.

Diamond Lattice. The crystal structure of both germanium and silicon as well as diamond.

Diffused-base Transistor. Any of several types of drift transistor in which the grading of impurity concentration in the base region is obtained by diffusing an impurity at high temperature.

Diffused Emitter-collector Transistor. Transistor in which both the emitter and collector are made by the diffusion process.

Diffusion. Particle movement due to spatial variation in concentration of the particles, i.e., due to concentration gradients.

Diffusion Process. Method for making junctions by diffusing acceptors or donors into a semiconductor at a high temperature.

Diffusion Transistor. Transistor relying on diffusion for carrying current; for example, ordinary junction transistor.

Diode. Two-terminal semiconductor device with a rectification current characteristic.

Dissipation. Loss of electrical energy into heat.

Donor. Impurity used to produce n-type semiconductor, and induce electronic conduction.

Doping. Adding impurities to change the resistivity of semiconductors and to make n-type or p-type.

Double-base Diode. See Unijunction Transistor.

Drain. Electrode of a field-effect transistor.

Drift. Movement of charged particles due to spatial variation in voltage, i.e. due to voltage gradients.

Drift Mobility (in a Homogeneous Semiconductor). The average drift velocity of carriers per unit electric field.

Drift Transistor. Transistor utilising grading of impurity concentrations in the base region to provide space charge voltage gradients to impart accelerating drift movement to current carriers.

E

Early Effect. The decrease in collector resistance due to the widening of the collector depletion layer with increasing voltage.

Electroforming. Process of creating p-n junctions by passing current through point contacts.

Electrons. Negatively charged current carriers.

Emitter. Transistor electrode, from which a flow of minority or majority carriers enters the interelectrode region.

Emitter Efficiency. The ratio of minority carriers to total carriers in the emitter current injected into the base region.

Emitter Junction. On junction transistors, the junction between the emitter and the base.

Emitter Resistance. Resistance in series with the emitter lead in the common-T equivalent circuit of a transistor.

Energy Gap. The energy range between the bottom of the conduction band and the top of the valence band. This gap governs the temperature at which thermally-produced charge carriers will swamp the charge carriers introduced by means of donor or acceptor impurities, and thus decides the maximum temperature at which a p-n junction can be used.

Equivalent Circuit. A circuit which approximates the actual transistor under some conditions.

Extrinsic Base Resistance. Resistance between the active base region and the external base connection to the transistor. Generally represented by the symbol r_{bb1}.

Extrinsic Semiconductor. One in which the electrical properties depend on impurities.

F

Field-effect Transistor. Transistor relying on movement of a depletion layer to vary the cross-sectional area of the conduction path between two electrodes, source and drain.

Fieldistor. Type of field-effect transistor.

Figure of Merit. The frequency at which the power gain of the transistor in the common-emitter configuration has dropped to unity.

Floating Junction. Junction through which no net current flows.

Forward Bias. Voltage applied in the direction of easy current flow of a diode; opposite to reverse bias.

Fused-junction Transistor. See Alloy Transistor.

Fused Transistor. See Alloy Transistor.

G

Gate. Electrode of a field-effect transistor.

Germanium. Common semiconductor material, usually used for making transistors.

Grounded Base. See Common Base.

Grounded Collector. See Common Collector.

Grounded Emitter. See Common Emitter.

Grown-diffused Transistor. Junction transistor with junctions formed by diffusion of impurities near a grown junction.

Grown-junction Transistor. Junction Transistor with junctions formed by adding impurities to the melt while the crystal was being grown.

H

Hall Effect. Transverse voltage produced by current travelling at right angles to a magnetic field; especially prominent in semiconductors.

Header. Part of the transistor casing through which the leads pass (in other than large power types).

Heat Sink. Provision for conduction of heat away from power transistors, usually a metal mounting plate.

Hole. A mobile vacancy in the electronic valence structure of a semiconductor that acts like a positive electronic charge.

Hook Transistor. Four layer transistor with a p-n-p (or n-p-n) structure for collector which acts as a current amplifier.

h-parameters. See Hybrid Parameters.

Hybrid π Parameters. A set of 7 frequency-independent parameters which, in a hybrid-π equivalent circuit specify the small signal behaviour of a transistor over its whole useful frequency range.

I

Impurity. Small addition to a semiconductor, especially a donor or an acceptor.

Injector. Electrode of a spacistor.

Interbase Current. In a junction tetrode transistor the current that flows from one base connection to the other through the base region.

Input Resistance. See Small-signal Input Resistance and Large-signal DC Input Resistance.

Intrinsic-region Transistor. Four-layer transistor with an intrinsic region between the base and the collector.

Intrinsic Semiconductor. Neither n-type nor p-type, containing roughly equal numbers of electrons and holes.

i-type. Intrinsic semiconductor. A semiconductor in which the electrical properties are essentially not modified by impurities or imperfections in the crystal.

J

Junction. Region separating two different types of semiconductor, especially p-n junction.

Junction Diode. A diode which uses a junction to achieve a rectifying characteristic.

Junction Transistor. Most common type of transistor, using two junctions with the base region between them.

L

Large-signal Analysis. Consideration of large excursions from the no-signal bias, so that the nonlinear, switching properties of the transistor are important.

Large-signal DC Current Transfer Ratio. The quotient of the dc output current at constant output voltage divided by the dc input current producing the dc output current.

Large-Signal DC Input Resistance. The dc input voltage divided by the dc input current.

Leakage Current. That portion of cutoff current due to surface effects.

M

Majority Carriers. Whichever type is more plentiful, i.e. electrons in n-type and holes in p-type.

Meltback Process. Method of making junctions by melting a correctly doped semiconductor and allowing it to refreeze.

Meltback Transistor. Junction transistor made by the meltback process.

Melt-quench Transistor. Junction transistor made by quickly cooling a melted-back region.

Microalloy Transistor. Transistor using very thin alloyed collector and emitter, usually made in the same shape as a surface-barrier transistor.

Minority Carriers. Whichever type is less plentiful, i.e. electrons in p-type and holes in n-type.

Mobility. The average drift velocity of carriers per unit electric field.

Modulator. Electrode of a spacistor.

N

Neutralisation. The process of balancing out an undesirable effect, such as regeneration.

Noise Figure. The ratio of actual equivalent noise input to thermal noise input, usually expressed in decibels.

n-p-i-n Transistor. Intrinsic-region transistor with p-type base and n-type emitter and collector.

n-p-n-p Transistor. Hook transistor with p-type base, n-type emitter, and hook collector.

n-p-n Transistor. Junction transistor with p-type base and n-type collector and emitter.

n-type. Semiconductor doped with a donor so that electrons are more plentiful than holes.

O

Ohmic Contact. A contact possessing the property that the potential difference across it is proportional to the current through it.

P

Parameters. Set of numbers which characterize a device.

Peak Inverse Voltage. Maximum reverse voltage rating for a diode or a transistor.

Photodiode. A semiconductor diode which utilises the fact that the reverse current across a p-n junction increases upon illumination.

Photoresistor. Semiconductor resistor whose resistance drops when illuminated.

Phototransistor. Photodiode with a built-in amplifier; physical construction is the same as a junction transistor.

Photovaristor. A varistor in which the current-voltage relation may be modified by illumination, e.g. cadmium sulphide or lead telluride.

Pinch-off Voltage. The voltage at which pinch-off occurs.

Pinch-off. In a field-effect transistor the effect of having broadened the depletion layer to a point where the source-to-drain current path cross-section has been reduced to zero.

p-n-i-p Transistor. Intrinsic-region transistor with n-type base and p-type emitter and collector.

p-n Junction. Junction between p-type and n-type areas of a semiconductor, at which the donor and acceptor concentration are equal.

p-n-p-n Transistor. Hook transistor with n-type base, p-type emitter, and hook collector.

p-n-p Transistor. Junction transistor with n-type base, and p-type collector and emitter.

Point Contact. A sharp point placed on a semiconductor for making point-contact devices.

Point-contact Diode. A diode which uses a point contact to achieve a rectifying characteristic.

Point-contact Transistor. Early-style transistor made by forming junctions by the unpredictable process of electro-forming.

Power Gain. Ratio of output power to signal input power, not to be confused with collector efficiency.

Power Transistor. A transistor, usually an alloy-junction type, designed to handle high currents and high power.

p-type. Semiconductor doped with an acceptor so holes are more plentiful than electrons.

Punch-through. At a high collector voltage in a junction transistor with a narrow base region, the space-charge layer may extend completely across the base region, causing an emitter/collector breakdown.

R

Rate-grown Transistor. Junction transistors with junctions formed by varying the rate of the crystal's growth.

Recombination. Simultaneous elimination of both an electron and a hole by their combination at the surface of a semiconductor.

Rectifier. Any device which has a non-symmetrical volt-ampere curve and which therefore can be used to rectify ac; for example, junction diodes.

Resistivity. The reciprocal of conductivity.

Reverse Bias. Voltage applied in the direction of difficult current flow of a diode; opposite to forward bias.

Reverse Current. The small current that flows in a diode under reverse bias.

S

Saturation. The low-resistance condition in a transistor when the collector has bottomed.

Saturation Current. That portion of reverse current of a semiconductor diode not due to surface leakage or diode breakdown. Has nothing to do with the saturation of a transistor. Can be taken as the current at a reverse voltage of 0.5 volt.

Saturation Resistance. The ratio of voltage to current in saturation.

Seed. Special single crystal used to start the growth of large single crystals.

Selenium. Semiconductor used mainly in rectifiers.

Semiconductor. An electronic conductor, with resistivity in the range between metals and insulators, in which the electrical charge carrier concentration increases with increasing temperature over some temperature range. Certain semiconductors possess two types of carriers, namely, negative electrons and positive holes.

Silicon. Common semiconductor, used in transistors and diodes.

Small-signal Analysis. Consideration of only small excursions from the no-signal bias, so that the transistor can be represented by a linear equivalent circuit.

Small-signal Current Transfer Ratio. The quotient of the change of output current with ac output shorted divided by the change in input current producing the change in output current. The current components are understood to be small enough for linear relations to hold between them.

Small-signal Input Resistance. The change in input voltage with the ac output circuit shorted, divided by the change in input current.

Source. Electrode of a field-effect transistor.

Space-charge Layer. See Depletion Layer.

Spacistor. Type of transistor relying on modulation of carriers injected into a depletion layer.

Stability. Lack of tendency toward thermal runaway.

Stability Factor. A number which expresses the temperature-dependence of collector current (or emitter current) in any given transistor stage. It is the ratio of collector current (or emitter current) variation to collector cutoff current variation for the same collector temperature change. A low figure improves the stability of the stage.

Surface Barrier. A barrier formed automatically at a surface due to trapped electrons held at the surface.

Surface-barrier Transistor. Transistor using surface barriers instead of p-n junctions.

Symmetrical Transistor. Transistor in which collector and emitter are made identical, so either can be used for either purpose.

T

Tandem Transistor. Two transistors in one package, internally connected together.

Tetrode Transistor. Any of several types of transistors with four electrodes.

Thermal Resistance. The resistance to heat flow between a heat-generating device and its environment. Stated as the temperature rise of the device per unit power dissipation.

Thermal Runaway. Condition in which the heat-generation in a device increases with device-temperature faster than does the heat-removal; consequently the device-temperature keeps on rising.

Thermistor. Temperature-sensitive resistor, usually made from a semiconductor.

Transducer Gain. Ratio of power output to signal power available from driving stage or generator.

Transistor. Semiconductor device with three or more electrodes used for amplification.

Transistor Action. The physical mechanism of amplification in a junction transistor.

Transit Time. Average time it takes a minority carrier to move from emitter to collector in a junction transistor.

Transition Layer. See Transition Region.

Transition-layer Capacitance. Capacitance due to the charge distribution in the transition region.

Transition Region. A region between two homogeneous semiconductor regions, in which the impurity concentration changes.

Trapping. Holding of electrons or holes by any of several mechanisms in a crystal, preventing the carriers from moving.

Traps. Any of several imperfections in a crystal which can trap carriers.

Thyristor. Bi-stable, solid state switching element which can also operate as a conventional hf transistor or in amplifying circuits. The bi-stable performance characteristic enables the switching functions which formerly used two transistors.

U

Unijunction Transistor. Transistor made for switching circuits, having only one junction.

Unilateralization. A special case of neutralization in which the feedback parameters are completely balanced out. These feedback parameters include a resistive component in addition to a capacitive component. Unilateralization changes a bilateral network into a unilateral network.

Unipolar Transistor. A transistor in which the main current flow is by means of majority carriers only, e.g. field-effect transistor.

V

Valence Band. The range of energy states in the spectrum of a solid crystal in which lie the energies of the valence electrons that bind the crystal together.

Varistor. A semiconductor device with a symmetrical but nonlinear voltampere characteristic.

Voltage Amplification, Voltage Gain. Ratio of output voltage to input voltage.

W

Whisker. A point contact.

Z

Zener Breakdown. One of the forms of sudden current increase in a reverse-biased p-n junction, due to the liberation of valence electrons through dielectric breakdown of the crystal under high electric field.

Zener Diode. A diode which breaks down at the Zener voltage, used for voltage regulators.

Zener Voltage. The voltage at which Zener breakdown occurs.

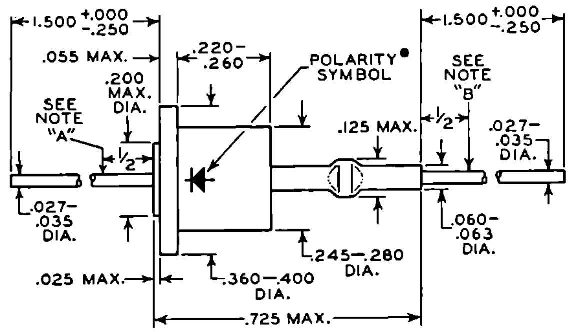
Zone Levelling (Pertaining to Semiconductor Processing). The passage of one or more molten zones along a semiconductor body for the purpose of uniformly distributing impurities throughout the material.

Zone Refining. A technique for purifying crystals by passing a melted zone through the crystals, which drags the impurities with it.

1N1763, 1N1764

SILICON RECTIFIERS

Diffused-Junction Types



ALL DIMENSIONS ARE IN INCHES

NOTE: DO NOT DIP SOLDER BEYOND POINTS "A" AND "B".

The 1N1763 and 1N1764 are hermetically sealed silicon rectifiers of the diffused-junction type designed for use in the power supplies of television receivers, radio receivers, phonographs, and other electronic equipment.

Having conservative ratings and capable of operating at ambient temperatures up to 100°C., the 1N1763 and 1N1764 employ a compact structure in which special attention has been given to the following design features: (1) sturdy mount structure having axial leads for flexibility of circuit connections, (2) welded hermetic seal to provide complete protection against moisture and contamination, and (3) superior junction design made possible by a diffusion process with very precise controls. These features in addition to extensive quality-control procedures contribute to the dependable performance of these devices in power supplies of electronic equipment.

GENERAL DATA

Mechanical:

Operating Position	Any
Case	Metal
Envelope Seals	Hermetic

RECTIFIER SERVICE

Maximum Ratings, Absolute Values:

For supply frequency of 50 cps and with capacitor input to filter

	1N1763		1N1764		
PEAK INVERSE VOLTAGE	400 max.		500 max.		volts
RMS SUPPLY VOLTAGE	140 max.		175 max.		volts
FORWARD CURRENT:					
At an ambient temperature	Up to 75°C	Above 75°C	Up to 75°C	Above 75°C	
DC	0.5 max.	See Rating Chart	0.5 max.	See Rating Chart	amp
Peak, Recurrent	5 max.		5 max.		amp
Surge, for a "turn-on" transient of 2 milliseconds duration	35 max.		35 max.		amp
AMBIENT TEMPERATURE:					
Operating	100 max.		100 max.		°C
Storage	−65 to +150		−65 to +150		°C

Characteristics, at Ambient Temperature of 25°C:

	1N1763	1N1764	
Maximum instantaneous forward voltage at instantaneous forward current of 15 amperes	3	3	volts
Maximum Reverse Current:			
At peak inverse voltage of 400 volts	100	—	μa
At peak inverse voltage of 500 volts	—	100	μa

Characteristics, at Ambient Temperature of 100°C:

Maximum Reverse Current:	1N1763	1N1764	
At peak inverse voltage of 400 volts	1	—	ma
At peak inverse voltage of 500 volts	—	1	ma

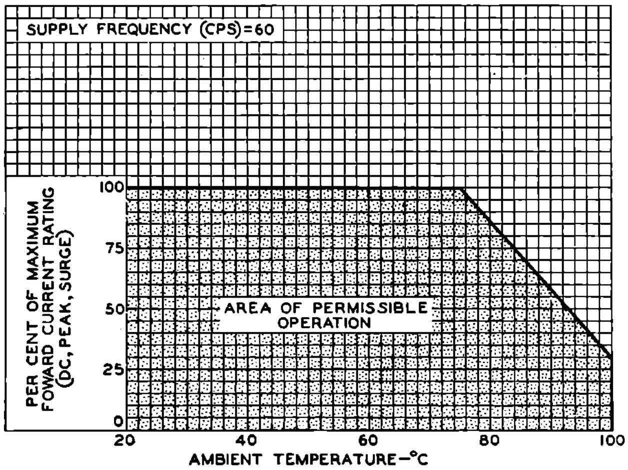


Fig. 1 — Rating Chart for 1N1763, 1N1764

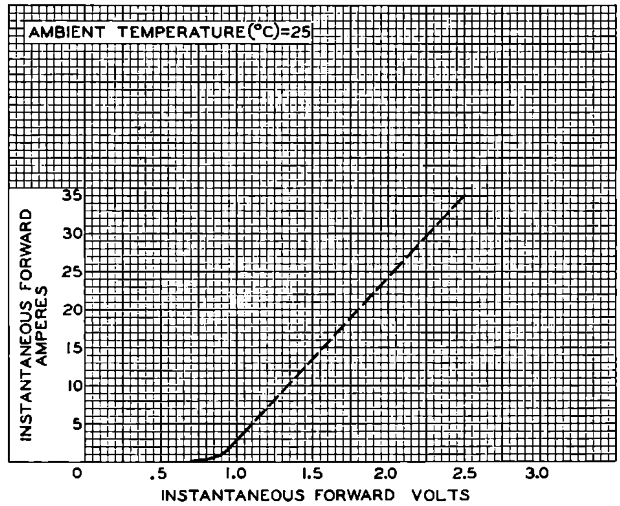


Fig. 2 — Typical Forward Voltage and Current Characteristic for 1N1763, 1N1764.

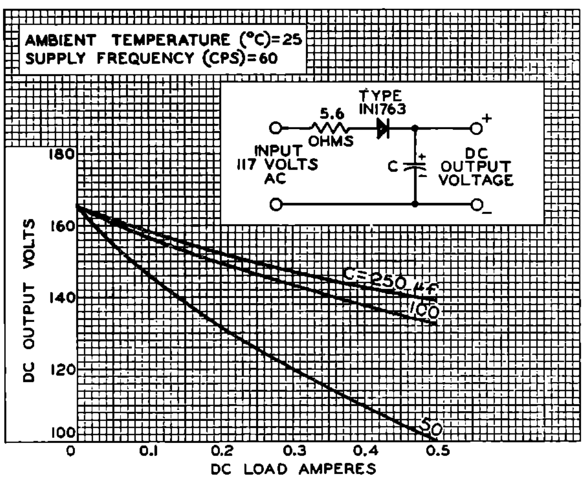


Fig. 3 — Typical Operation Characteristics of 1N1763 in Half-Wave Rectifier Service.

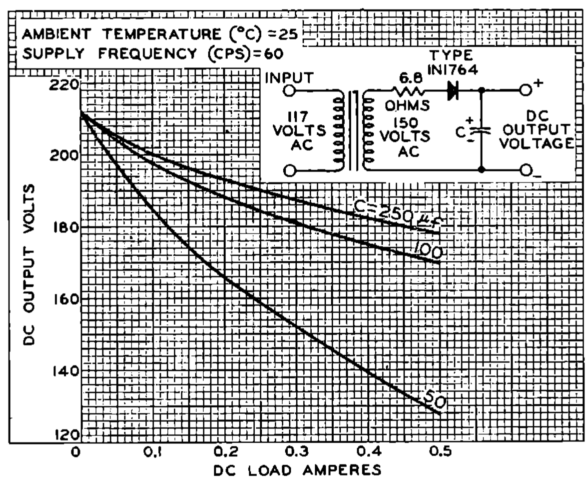


Fig. 4 — Typical Operation Characteristics of 1N1764 in Half-Wave Rectifier Service.

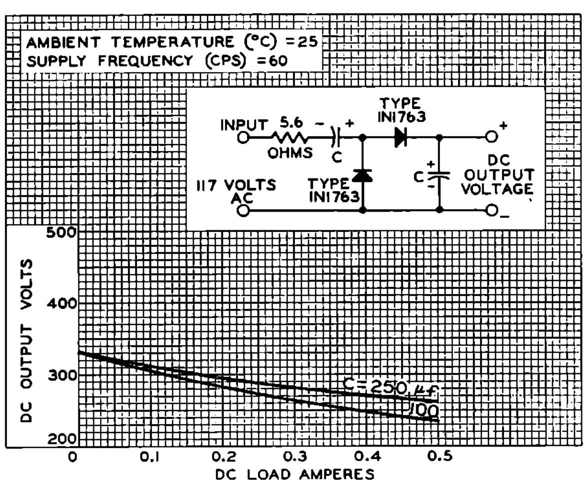


Fig. 5 — Typical Operation Characteristics of 1N1763 in Half-Wave Voltage-Doubler Service.

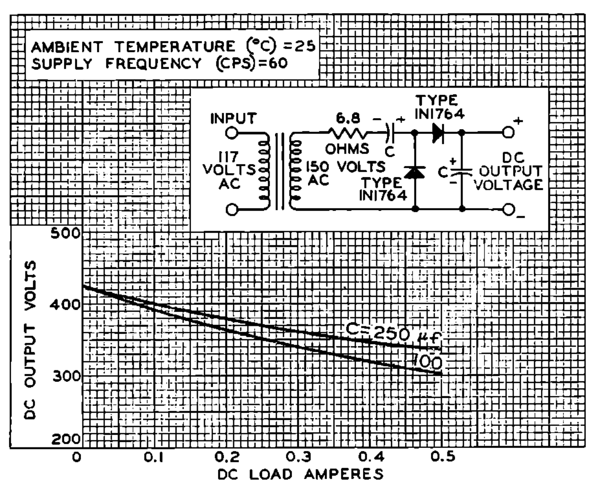


Fig. 6 — Typical Operation Characteristics of 1N1764 in Half-Wave Voltage-Doubler Service.

TYPICAL OPERATION OF 1N1763 IN HALF-WAVE RECTIFIER SERVICE

RMS Supply Voltage	117	117	117	volts
Filter - Input Capacitor (C)	50	100	250	μf
Surge-Limiting Resistance *	5.6	5.6	5.6	ohms
DC Output Voltage at Input to Filter (Approx.):				
At half-load current of 250 ma.	126	146	150	volts
At full-load current of 500 ma.	100	132	139	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	26	14	11	volts

TYPICAL OPERATION OF 1N1764 IN HALF-WAVE RECTIFIER SERVICE

RMS Supply Voltage	150	150	150	volts
Filter - Input Capacitor (C)	50	100	250	μf
Surge-Limiting Resistance *	6.8	6.8	6.8	ohms
DC Output Voltage at Input to Filter (Approx.):				
At half-load current of 250 ma.	158	184	190	volts
At full-load current of 500 ma.	128	170	178	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	30	14	12	volts

TYPICAL OPERATION OF 1N1763 IN HALF-WAVE VOLTAGE-DOUBLER SERVICE

RMS Supply Voltage	117	117	volts
Filter - Input Capacitor (C)	100	250	μf
Surge-Limiting Resistance *	5.6	5.6	ohms
DC Output Voltage at Input to Filter (Approx.):			
At half-load current of 250 ma.	273	288	volts
At full-load current of 500 ma.	235	262	volts
Voltage Regulation (Approx.):			
Half-load to full-load current	36	26	volts

TYPICAL OPERATION OF 1N1764 IN HALF-WAVE VOLTAGE-DOUBLER SERVICE

RMS Supply Voltage	150	150	volts
Filter - Input Capacitor (C)	100	250	μf
Surge-Limiting Resistance *	6.8	6.8	ohms
DC Output Voltage at Input to Filter (Approx.):			
At half-load current of 250 ma.	345	367	volts
At full-load current of 500 ma.	301	336	volts
Voltage Regulation (Approx.):			
Half-load to full-load current	44	31	volts

TYPICAL OPERATION OF 1N1763 IN FULL-WAVE VOLTAGE-DOUBLER SERVICE

RMS Supply Voltage	117	117	117	volts
Filter - Input Capacitor (C)	50	100	250	μf
Surge-Limiting Resistance *	5.6	5.6	5.6	ohms
DC Output Voltage at Input to Filter (Approx.):				
At half-load current of 250 ma.	260	280	290	volts
At full-load current of 500 ma.	220	260	275	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	40	20	15	volts

TYPICAL OPERATION OF 1N1764 IN FULL-WAVE VOLTAGE-DOUBLER SERVICE

RMS Supply Voltage	150	150	150	volts
Filter - Input Capacitor (C)	50	100	250	μf
Surge-Limiting Resistance *	6.8	6.8	6.8	ohms
DC Output Voltage at Input to Filter (Approx.):				
At half-load current of 250 ma.	340	370	380	volts
At full-load current of 500 ma.	290	340	360	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	50	30	20	volts

* The transformer series resistance or other resistance in the line may be deducted from the value shown

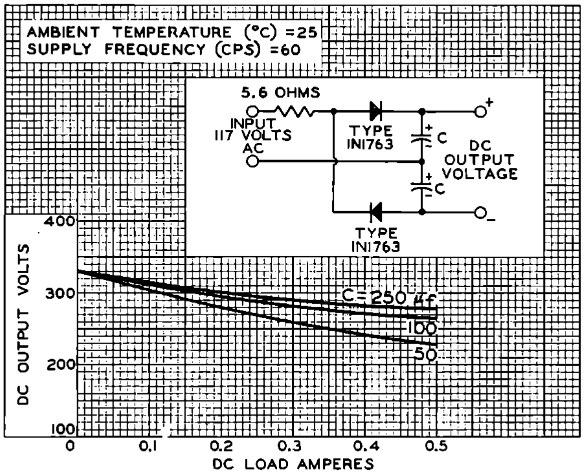


Fig. 7 — Typical Operation Characteristics of 1N1763 in Full-Wave Voltage-Doubler Service.

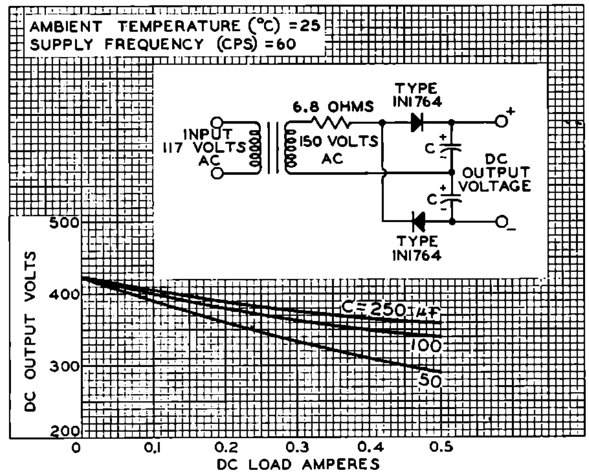


Fig. 8 — Typical Operation Characteristics of 1N1764 in Full-Wave Voltage-Doubler Service.

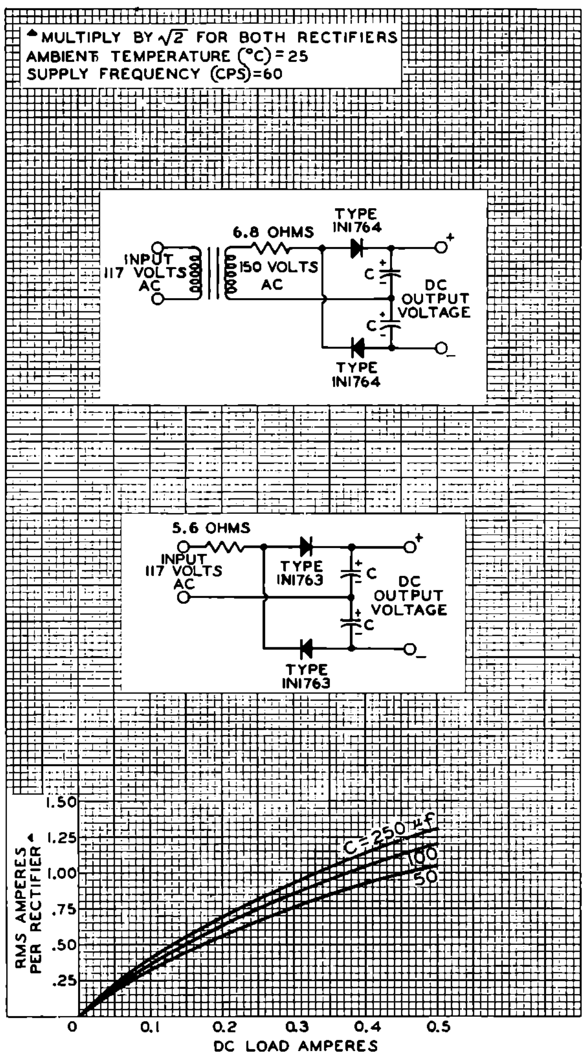


Fig. 9 — Typical Operation Characteristics for 1N1763 and 1N1764 in Full-Wave Voltage-Doubler Service.

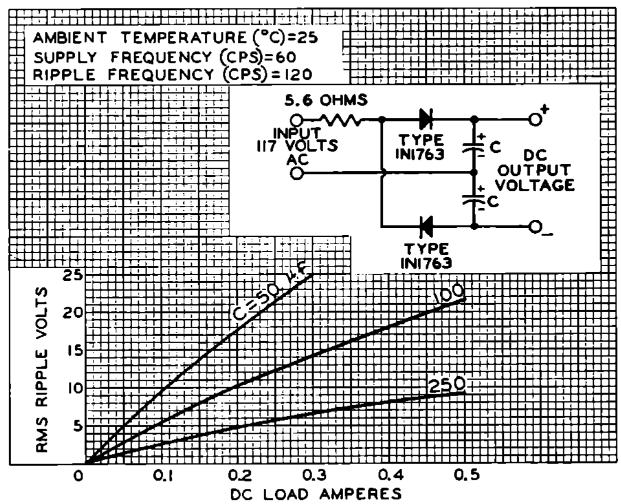


Fig. 10 — Typical Operation Characteristics of 1N1763 in Full-Wave Voltage-Doubler Service.

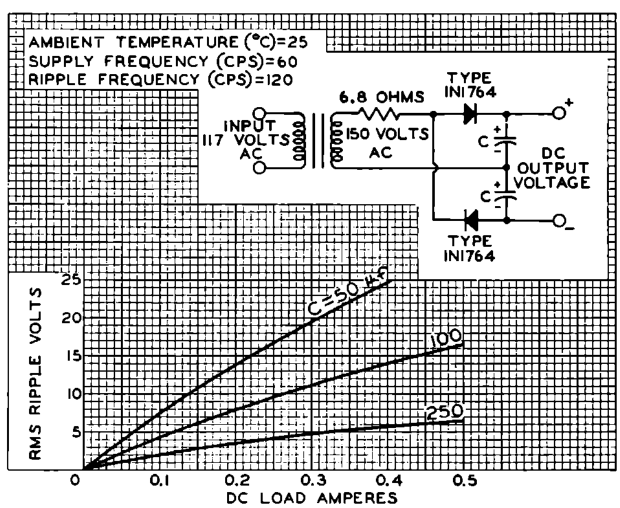


Fig. 11 — Typical Operation Characteristics of 1N1764 in Full-Wave Voltage-Doubler Service.

AWV