Engineering Data Sheet
Number 354-2

GAMMATRON
TYPE 354

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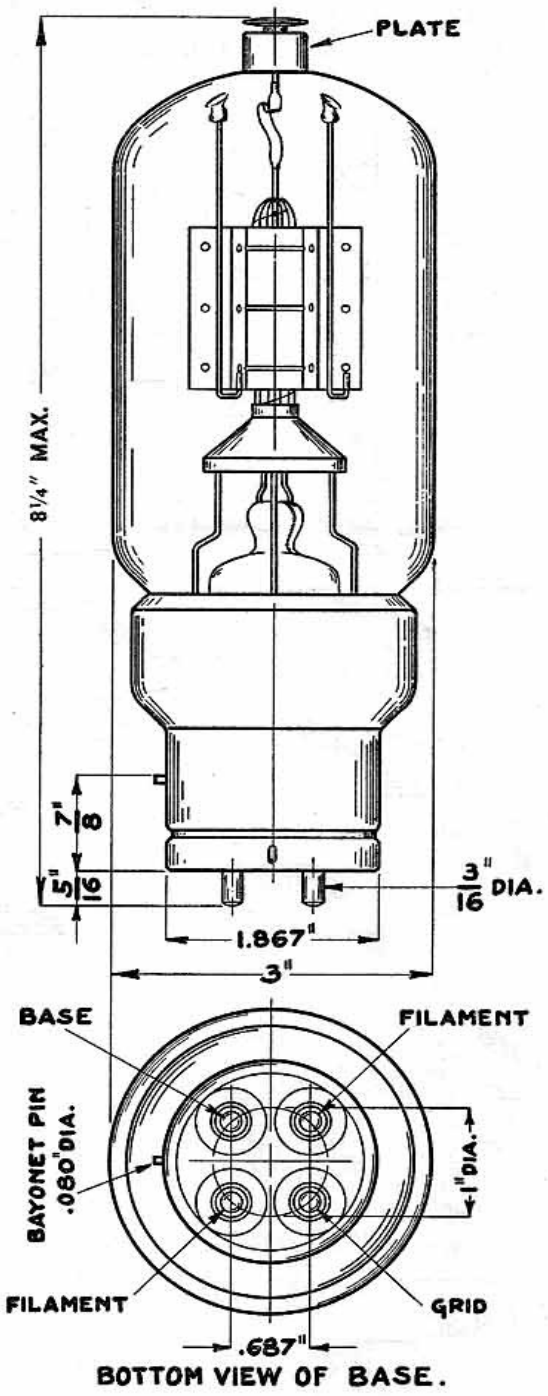

BOTTOM VIEW OF BASE.

PHYSICAL DATA

Plate	Cylindrical Tantalum
Grid	Braced Vertical Bar Tantalum
Filament	Thoriated Tungsten
Blank	Nonex Glass
Base	Standard Fifty Watt
Base Insulator	Ceramic
Net Weight	6½ Ounces
Shipping Weight	1¼ Pounds
Maximum Height	8¼ Inches
Maximum Diameter	3 Inches

ELECTRICAL DATA

Filament Voltage	5.0 Volts
Filament Current	10 Amps.
Normal Plate Dissipation	150 Watts
Maximum Average Plate Current	0.3 Amps.
Maximum Average Grid Current	0.05 Amps.
Average Plate Impedance	2800 Ohms.
Average Amplification Constant	14.

Inter-Electrode Capacities

Grid-Plate	4. mmfd.
Grid-Filament	9. mmfd.
Plate-Filament	0.2 mmfd.

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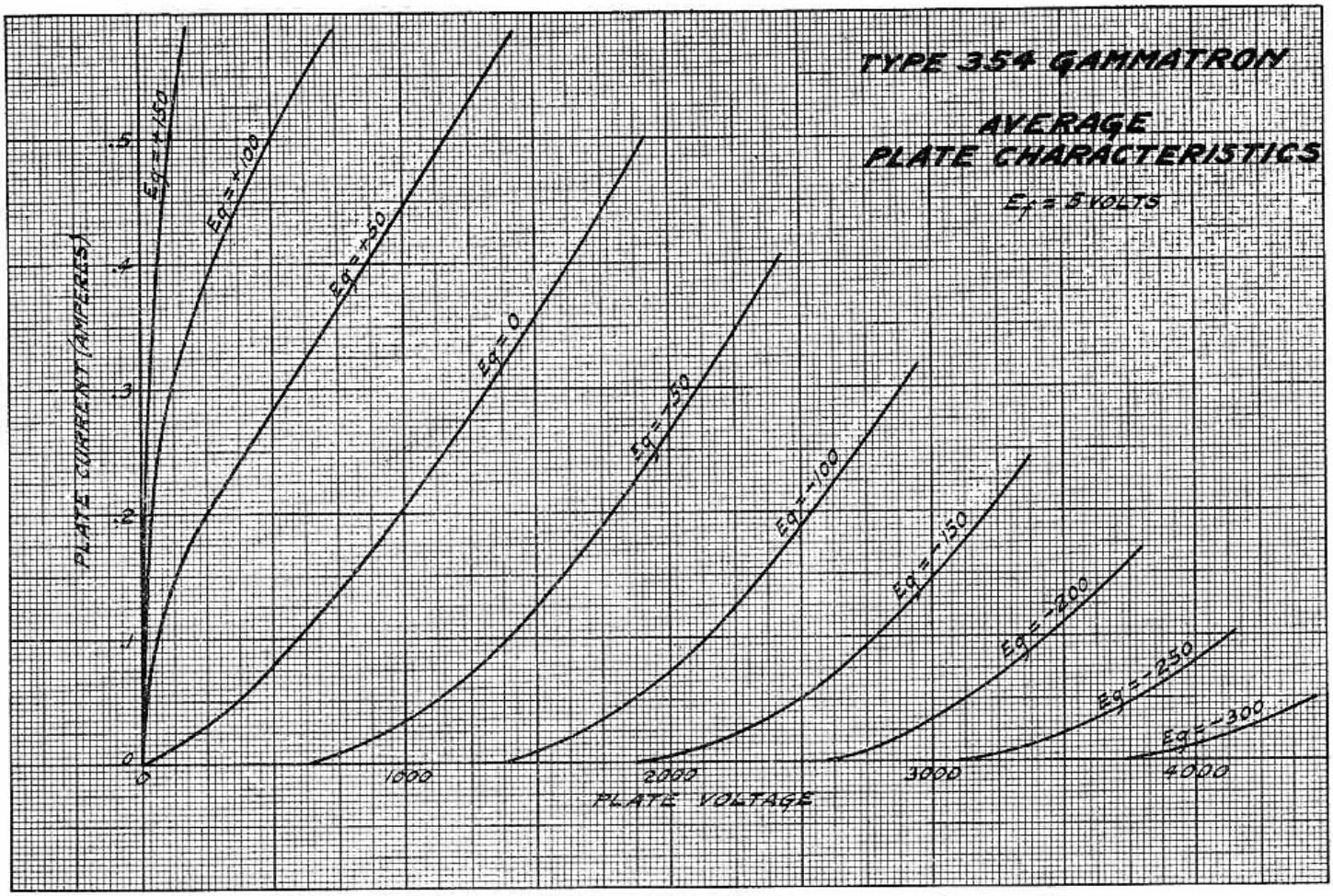
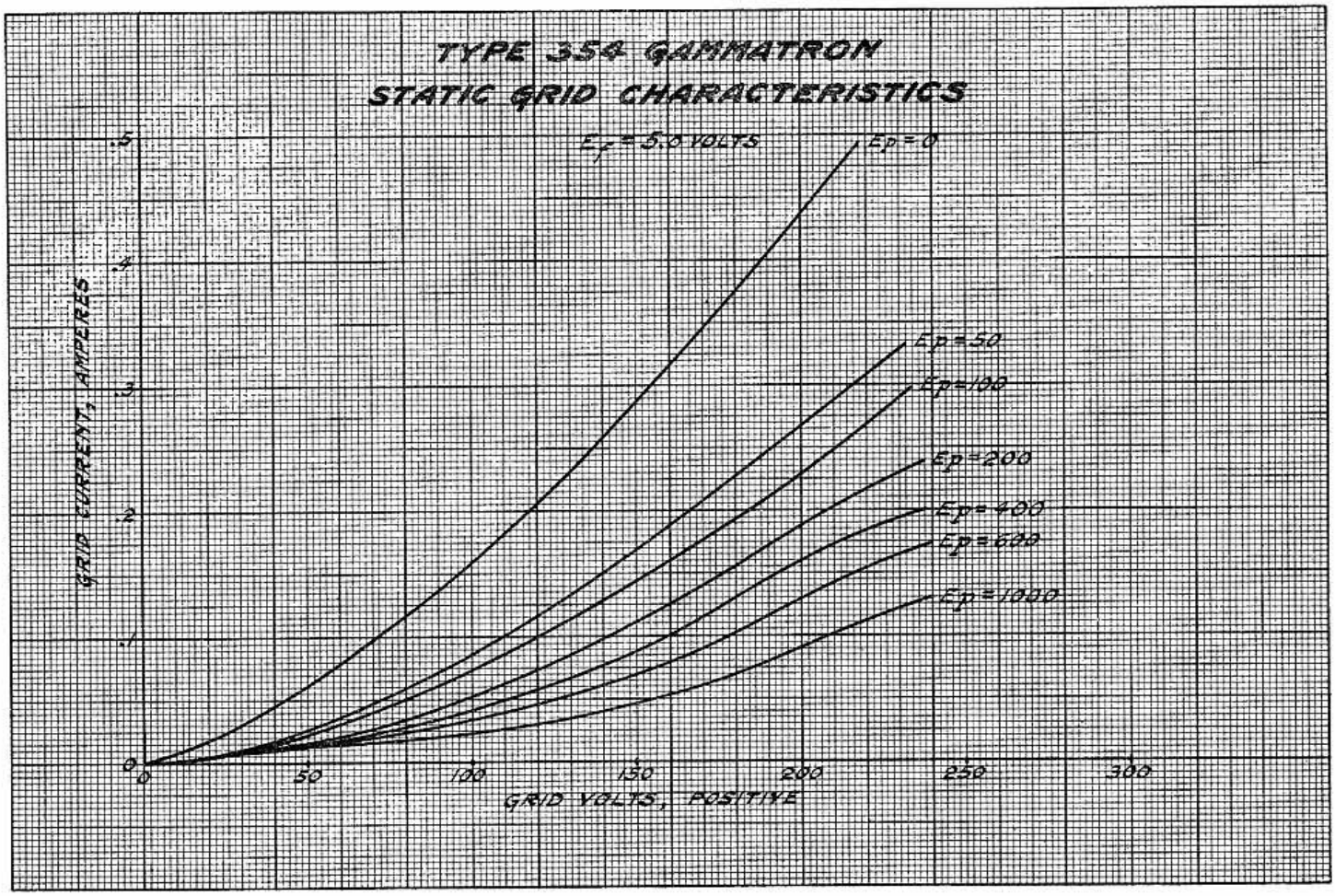

TYPE 354 GAMMATRON
AVERAGE
PLATE CHARACTERISTICS
E_f = 5 VOLTS
PLATE CURRENT (AMPERES)
.5
.4
.3
.2
.1
0
0
1000
2000
3000
4000
PLATE VOLTAGE
Eg = +150
Eg = +100
Eg = +50
Eg = 0
Eg = -50
Eg = -100
Eg = -150
Eg = -200
Eg = -250
Eg = -300


TYPE 354 GAMMATRON
STATIC GRID CHARACTERISTICS
E_f = 5.0 VOLTS
GRID CURRENT, AMPERES
.5
.4
.3
.2
.1
0
0
50
100
150
200
250
300
GRID VOLTS, POSITIVE
Ep = 0
Ep = 50
Ep = 100
Ep = 200
Ep = 400
Ep = 600
Ep = 1000

Engineering Data Sheet
Number 354-3

TYPE 354

APPLICATIONS AS AN AUDIO AMPLIFIER

AUDIO AMPLIFIER—CLASS "A"

The 354 **GAMMATRON** is an excellent power audio amplifier since it has a low plate resistance and will stand a high plate potential. At the same time it has a relatively high amplification factor thus requiring a small bias, and only a small signal voltage need be applied to the grid to develop full power output.

Under ordinary circumstances the optimum load resistance of a class "A" triode power amplifier is equal to twice the dynamic plate resistance. This is also true of larger power tubes as long as the plate dissipation does not become a limiting factor. At plate potentials over 1500 volts the 354 **GAMMATRON** class "A" operation is limited by plate dissipation. Hence, at these values it is necessary to adjust the grid bias to limit the plate dissipation to 150 watts, and use a higher load resistance. The plate dissipation is the D. C. plate voltage multiplied by the D. C. plate current with no audio signal input. Since individual tubes will vary somewhat as to amplification factor, the controlling quantity in adjusting a 354 **GAMMATRON** as a class "A" audio amplifier is the plate current. Always adjust the plate current to the value indicated in the tables below, using the bias required for that adjustment. There is little advantage in employing plate potentials of more than 2500 volts.

Below is shown the typical operating data for the 354 **GAMMATRON.** The data is divided into three tables for convenience. Table I gives the performance limiting the second harmonic distortion to five per cent. Table II gives the performance limiting the second harmonic distortion to ten per cent. Table III gives the performance for two tubes operating in push-pull. All quantities in Table III refer to two tubes. It will be noted that the output power in this connection is higher than two single tubes. Moreover, the distortion is less because of the cancellation of second order harmonics.

These power outputs are computed assuming that the grid is driven to zero. If the plate current is much greater than normal when the proper bias is applied, it is often an indication that the tube is oscillating or that it is picking up radio frequency voltage from some other circuit. An inductive grid leak often aggravates this condition.

CLASS "A" AUDIO AMPLIFIER PERFORMANCE

TABLE I

(SINGLE TUBE)

Plate Volts	Plate Amperes	Grid Volts	Plate Watts	Load Resistance Ohms	Power Output Watts	Plate Efficiency Per Cent	% Second Harmonic
1000	.080	– 30	80	8,000	5	5	3
1500	.100	– 57	150	12,000	11	7	4
2000	.100	–100	150	20,000	22	15	5
2500	.060	–140	150	30,000	32	21	5

TABLE II

(SINGLE TUBE)

1000	.060	– 36	60	8,000	7	11	10
1500	.100	– 57	150	6,000	17	11	10
2000	.075	–100	150	12,000	33	22	10
2500	.060	–140	150	20,000	42	28	10

CLASS "A" AUDIO PUSH-PULL AMPLIFIER PERFORMANCE

TABLE III

(TWO TUBES)

Plate Voltage	Plate Amperes	Grid Volts	Plate Watts	Plate-to-Plate Load Resistance	Power Output Watts	Plate Efficiency Per Cent	% Harmonic (Approx.)
1000	.100	– 40	100	12,000	17	17	3
1500	.160	– 65	240	12,000	40	17	3
2000	.150	–105	300	22,000	75	25	4
2500	.120	–140	300	22,000	95	32	5

GAMMATRON

AUDIO AMPLIFIER-MODULATOR— CLASS "B"

Where outputs in excess of the capacity of two 354 **GAMMATRONS** in class "A" are required, for modulation or high power audio work, it is desirable to use two 354's in class "B." In this connection efficiencies of more than twice those in class "A" can be obtained. Operated in this manner only one tube works at a time. One tube operates during half of the cycle while the other is idle, and during the remaining half cycle the situation is reversed.

The 354 **GAMMATRON** is particularly adapted to class "B" work since it will stand a high plate potential, has a low plate resistance and has a relatively high amplification factor. Thus, it has a large power output, and is an easy tube to drive.

To get any reasonable amount of power out of a class "B" amplifier it is necessary to drive the grids positive. This means that the driving tubes must supply power at the peak of the grid swing. The driver must have sufficient capacity to supply the peak power without appreciable drop in excitation voltage. This requires a low impedance driver circuit if distortion is to be avoided.

Since only one tube works at a time, the plate-to-plate load resistance (indicated below) is four times the single plate load resistance. Frequently, it is convenient in considering impedance relations to match the secondary impedance to one-half of the primary using the single plate load value. There is always the possibility that a high power class "B" stage will oscillate. Such a condition is indicated when the amplifier draws considerable plate current even though the correct bias is used, and no signal is applied. A cure is usually effected by the use of plate resistors (about 10 ohms), and loading each half of the input transformer secondary with about 50,000 ohms.

It is well to use a battery bias. If a bias rectifier is used care should be taken to see that the bleeder resistance is not too high, and that it is shunted by at least an 8 mf. condenser.

Table IV shown below gives the normal operating data for two 354 **GAMMATRONS** in class "B" push-pull. No allowance is made in this table for the transformer transfer loss. The driving equipment indicated is in the nature of a suggestion. Tubes of equivalent power output may be used as desired.

Further information on class "B" amplifiers may be found in texts and current literature. For instance, see Barton, "High Audio Power from Relatively Small Tubes," I. R. E., July, 1931, and Collins, "Getting Quality Performance with Class B Modulation," QST, May, 1933.

CLASS "B" AUDIO AMPLIFIER PERFORMANCE

TABLE IV

(TWO TUBES)

Plate Volts	Plate Current M. A.	Plate M. A. No Signal	Load* Resistance Plate-to-Plate	Bias Voltage	Grid Swing	Peak Driving Power	Power Output	Plate Loss	Plate Eff.	% Distortion
1000	160	.020	15,000 Ohms	– 60	140 Volts	5.6 Watts	100 Watts	60 Watts	62%	3
1500	240	.020	15,000 Ohms	–100	200 Volts	11 Watts	220 Watts	134 Watts	61%	4
2000	320	.020	15,000 Ohms	–150	280 Volts	21 Watts	400 Watts	232 Watts	62%	5
2500	345	.020	18,000 Ohms	–180	320 Volts	26 Watts	560 Watts	300 Watts	65%	5
3000	330	.020	25,000 Ohms	–225	375 Volts	30 Watts	650 Watts	300 Watts	66%	6

SUGGESTED DRIVERS

Gammatron Plate Volts	Tube	Plate Volts	Class "B" Input Trans Ratio
1000	2-45's Push-Pull	300	2.5:1
1500	2-2A3's Push-Pull	350	2:1 (Fixed Bias)
2000	2-2A3's Push-Pull	400	1:1 (Fixed Bias)
2500	4-2A3's Push-Pull, Parallel	350	1:1 (Fixed Bias)
3000	4-2A3's Push-Pull, Parallel	400	1:1 (Fixed Bias)

*** Single plate load equals one-fourth plate-to-plate load.**

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GAMMATRON

Engineering Data Sheet
Number 354-4

TYPE 354

APPLICATIONS AS A RADIO FREQUENCY AMPLIFIER

MODULATED RADIO FREQUENCY AMPLIFIER—CLASS "C" (TELEPHONY)

The 354 **GAMMATRON** may be used as a class "C" radio frequency amplifier with exceptionally good results. High mutual conductance, low internal capacitance, and the ability to stand high plate voltages make it possible to operate the 354 **GAMMATRON** at high efficiencies with low power excitation.

A class "C" amplifier operates at a bias greater than cut off. The plate current flows in pulses less than one-half cycle during the period of positive grid swing when the plate impedance is low. The shorter the duration of the plate current pulse the higher the efficiency becomes, but the power output becomes less. High efficiency requires a large bias with a resultant increase in excitation power. Normal operation results in a compromise between the factors of power output, efficiency and excitation power. Table V gives the operating data at the point of best compromise for various plate voltages.

The amount of excitation power required is governed by the output power desired and the operating efficiency. The 354 **GAMMATRON** is unusually easy to drive as may be seen by examination of the operating data. Using less driving power will merely reduce the output power and lower the efficiency slightly.

Grid leak bias may be used, but it is wise to provide enough fixed bias in addition to prevent the tube from becoming injured in the event of an excitation failure. The amount of protective fixed bias required is small, and it is well worth the insurance that it provides against tube injury. Its importance cannot be over-emphasized when plate potentials in excess of 1000 volts are used. The resultant bias is the fixed bias plus the grid leak resistance multiplied by the rectifier D. C. current. The correct value of the grid leak resistor (usually between 5,000 and 20,000 ohms) is readily determined by experiment. It should never be necessary to run the grid current above 50 milliamperes in order to properly excite a 354 **GAMMATRON.**

In order to obtain relatively high efficiencies it is essential to use a tank circuit of low loss and a high L/C ratio. For high quality phone transmission the importance of adequate shielding and complete neutralization cannot be over-stressed. Link coupling between the buffer and amplifier is highly recommended.

Table V, shown below, has been computed for an average tube, and individual tubes may vary somewhat from these values. This data applies only to operation at frequencies below 15 megacycles. When operating at ultra high frequencies it will be necessary to reduce these ratings. Limiting factors become plate, grid and glass bulb temperatures, and R. F. grid and plate current.

For details of design and adjustment of a class "C" amplifier refer to any of the several current radio magazines. See, for instance, Perrine, Jr., "Improved Amplifier Design for High Power," Radio, November, 1934; Grammar, "Improving the Performance of the Neutralized Power Amplifier," QST, January, 1934, and Anderson and Hawkins, "Mis-Matching Impedances for Efficiency — and Why Low "C" Plate Tank Is Desirable," Radio, April, 1934.

RADIO FREQUENCY POWER AMPLIFIER—CLASS "C" (TELEGRAPHY)

For class "C" amplifier continuous wave operation it is possible to work the 354 **GAMMATRON** somewhat harder, because it is not necessary to provide for the peak output as required in modulated amplifiers and the tube operates only during the key-down period. Also, less excitation power is required.

The conditions for bias, maximum rating, and adjustment are about the same as in the case of a modulated amplifier. They may be determined by inspection of Table V.

R. F. POWER AMPLIFIER—CLASS "C"

TABLE V

(SINGLE TUBE)

Plate Voltage	Plate Current	Load Resistance	Input Watts	Output Watts	Plate Eff., %	Excitation Volts-Eff.	Grid Bias	Grid Current	Driving Power
1500	.285	2340 Ohms	430	320	74	459	– 428	.050	30 Watts
2000	.285	3060 Ohms	572	450	78	575	– 602	.045	35 Watts
2500	.285	3840 Ohms	715	580	81	735	– 814	.040	40 Watts
3000	.283	4690 Ohms	850	700	82	855	– 960	.037	45 Watts
3500	.285	5630 Ohms	1000	850	85	1030	–1180	.036	53 Watts
4000	.277	6750 Ohms	1100	950	86	1120	–1300	.040	65 Watts

RADIO FREQUENCY AMPLIFIER—CLASS "B"

The efficiency of a class "B" amplifier is about one-half of a class "C" amplifier and consequently its power output is much less. However, a class "B" amplifier is attractive because it is a linear amplifier —the output signal is directly proportional to the input signal. It is possible then to modulate at low power requiring a small inexpensive modulation system, and amplify the modulated carrier. Another convenient method is to use grid modulation requiring only a few watts of audio power. The load impedance in a radio frequency amplifier is a resonant circuit, hence either a single tube or two tubes in push-pull may be employed. The 354 **GAMMATRON** performs excellently in class "B" circuits.

Since the power required at peak modulation (100% modulation) is four times the carrier power, the tube must be operated at about one-fourth full power output and about one-half normal efficiency.

To obtain satisfactory operation of a class "B" circuit, consistent with good output and small distortion, careful adjustment is required. First, the neutralization must be complete. With a high load impedance (loose coupling to the load) and bias adjusted to cut off, increase the excitation, fully modulated, until a grid meter indicates current is being taken by the grid (about 10 milliamperes). Then with the carrier unmodulated decrease the load impedance (increase the load coupling) until a maximum power output is obtained or until the plate loss becomes the rated value.

The grid modulated amplifier closely resembles a class "B" amplifier, and its power outputs are similar. The adjustment is somewhat critical, however, but with proper adjustment good performance can be expected.

A good description of the operation may be found in the article by Grammar, "Grid-Bias Modulator for the General Purpose Transmitter," QST, March, 1935. See also Wirkler and Collins, "Grid-Bias Modulator of the 100-Watt Type Power Amplifier," in the same issue.

RADIO FREQUENCY AMPLIFIER PERFORMANCE—CLASS "B"

TABLE VI

(SINGLE TUBE)

Plate Volts	Bias Voltage	Plate Current M. A.	Driving Power, Approx.	Carrier Power* Output	Plate Loss	Per Cent Eff.
1500	−105	65	6 Watts	27.5	70	30
2000	−155	84	11 Watts	50	116	30
2500	−188	88	13 Watts	70	150	32
3000	−233	82	15 Watts	81	150	33

*Less than three per cent distortion.

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