RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

RCA RADIOTRON
DIVISION

APPLICATION NOTE No.80
October 20, 1937

APPLICATION NOTE ON OPERATION OF THE 6V6-G

The 6V6-G is a beam power output tube that is capable of furnishing more than 4 watts at approximately 6 per cent distortion when 250 volts are applied to plate and screen. The principle of operation of the 6V6-G is similar to that of the 6L6: directed electron beams and aligned grids are used to obtain high plate-circuit efficiency, low screen current, and high power sensitivity. The 6V6-G is usually used single-ended or push-pull in the output stages of resistance-coupled amplifiers. In a radio receiver, a single-ended amplifier is usually fed by a single-tube voltage amplifier; a push-pull output stage is usually fed by a phase inverter. The accompanying diagrams and tables furnish design information for these arrangements.

A grid-resistor value of 0.25 megohm for the output stage is listed in the tables. This value of resistor is less than the recommended maximum value for self-bias operation (0.5 megohm) and greater than the recommended maximum value for 100 per cent fixed-bias operation (0.05 megohm). Thus, 0.25 megohm is suitable for either self-bias or partial-fixed-bias operation of the 6V6-G. When the output tubes are self-biased, an additional resistor of 0.25 megohm may be used for the grid-circuit filter. The use of a higher value of grid resistor (no grid-circuit filter) does not affect performance materially, because gain and output voltage are nearly maximum for the constants shown.

The data in Table I apply to the cascade amplifier of Fig.1A and to the phase-inverter circuit of Fig.1B. The output voltage from any of the voltage amplifiers listed in Table I is more than that required by either the single-ended or push-pull output stage. The values of R_L and R_g were selected on the basis of reasonable gain and good high-frequency response at less than 5 per cent distortion.

In the phase-inverter circuit of Fig.1B, a tube T_2 having a gain G_2 obtains its signal voltage from a portion of R_g; the output of T_2 feeds one of the push-pull output tubes. The proper point P on R_g for the grid connection of T_2 is obtained from the relation

$$R_{g1} = R_g/G_2$$

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where the values of R_g and G_2 are given in the tables. The values of R_{g1} are given in Table II for twin-triode tube types. The circuit for these types is shown in Fig.2.

Table III furnishes design data for the pentode-type voltage amplifier of Fig.3. A low value of plate load is desirable, because microphonic and hum outputs are reduced to acceptable levels. The use of a series screen resistor and self-bias for the voltage amplifier reduces the effects of varying line voltage and possible differences between tubes.

The circuit of Fig.4 is another type of phase inverter. The output of T_1 feeds T_2, which is connected in an inverse-feedback circuit. The output of T_2 is split into two phases, each of which furnishes voltage for an output tube. T_2 is usually a 6F5 or a 6C5; the values of components used in this circuit for these tube types are tabulated in Table IV.

The gain of T_2 is nearly independent of the tube type, because a large amount of inverse feedback is used; for this circuit, one-half the output of T_2 is fed back to the input of T_2. The stage gain with feedback is

$$G_f = \frac{G_o}{1 + nG_o},$$

where G_o is the gain of the stage without feedback and n is the fraction of the output voltage fed back to the input. Thus, when T_2 is a 6F5, $G_o = 63$ and $G_f = 1.94$. When T_2 is a 6C5, $G_o = 14$ and $G_f = 1.75$. For example, when the bias on the output tubes is -15 volts, the output of T_1 should be somewhat more than 15 volts peak for maximum power output. T_2 does not draw grid current until the peak value of the input signal is approximately 25 volts for the 6F5 and approximately 40 volts for the 6C5.

The phase-inverter circuit of Fig.4 has practical advantages over the circuits of Figs.1B and 2 in that the effects of possible variations between tubes are small. In the circuit of Fig.4, normal variations between tubes in position T_1 affect the input to each 6V6-G tube by the same amount; the effects of normal variations between tubes in position T_2 are negligible because of the inverse-feedback arrangement. In the circuits of Figs.1B and 2, normal variations between tubes in position T_2 and variations in the value of R_g affect the input to only one 6V6-G tube; normal variations between tubes in position T_1 affect the input to both 6V6-G tubes by the same amount.

A disadvantage of the phase-inverter circuit of Fig.4 is the possibility of obtaining high hum output when the gain following T_2 is high. Heater-cathode leakage, if present, may cause hum voltage to be developed across R_1 (the resistor connected in the cathode circuit), which is impressed on the grid of T_2 through R_p. For this reason, T_2 should feed the 6V6-G tubes directly, as shown in Fig.4.

Figs.5, 6, 7, 8, and 9 show operating characteristics of the 6V6-G. Figs.5 and 6 are plate families for 250 and 300 volts on the screen, respectively. Fig.7 is a plate family for zero bias with screen voltage as the parameter. This family is useful for determining the operation of the tube at other than listed screen voltages. The method of using this type of family has been described in Application Note No.61.

Fig.8 shows the relations between power output, distortion, plate dissipation, and screen dissipation vs load resistance. This set of data is important because it indicates the necessity for using the proper value of load resistance. Operation with an abnormally high load resistance in order to obtain high power output is not desirable from the standpoint of tube life.

The data in Fig.9 show the relation between distortion and input signal vs power output for single-ended operation of a 6V6-G. These data obtain for a 5000-ohm load and for a grid bias equal to -12.5 volts.

The bias for 250-volt, push-pull operation is -15 volts. This bias may be obtained from a self-bias resistor or from a partially fixed-bias source. The rise in d-c plate and screen currents with power output is small, approximately 16 ma. for fixed-bias operation; hence, a power supply with relatively poor regulation may be used without much loss in power output. The following conditions obtain for the output stage.

	Single-Tube Output	Push-Pull Output		
Heater Voltage	6.3	6.3	6.3	Volts
Plate Voltage	250	250	300	Volts
Screen Voltage	250	250	300	Volts
Grid Bias	-12.5	-15	-20	Volts
Peak Signal Voltage	12.5	30*	40*	Volts
Zero-Signal Plate Current	45	70	78	Milliamperes
Max.-Signal Plate Current	47	79	90	Milliamperes
Zero-Signal Screen Current	4.5	5	5	Milliamperes
Max.-Signal Screen Current	6.5	12	13.5	Milliamperes
Load	5000	10000**	8000**	Ohms
Power Output	4.25	8.5	13	Watts
Total Harmonic Distortion	6	4	4	Per cent
Second Harmonic	4.5	---	---	Per cent
Third Harmonic	3.5	3.5	3.5	Per cent

*Grid-to-grid
**Plate-to-plate

CASCADE AMPLIFIER CIRCUIT USING 6V6-G IN ONE STAGE AND A TRIODE IN THE OTHER

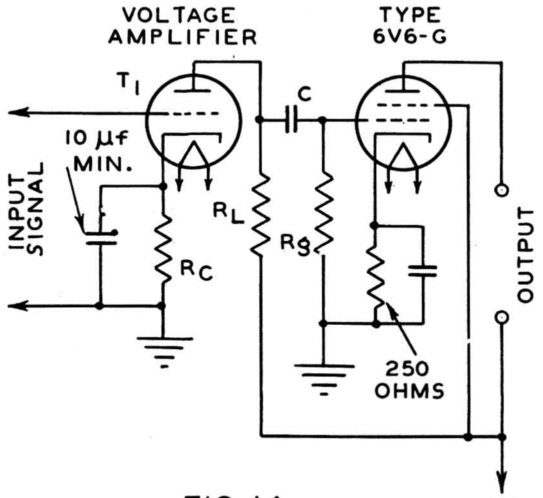

FIG. 1A

PHASE-INVERTER CIRCUIT USING TWO 6V6-G'S IN THE PUSH-PULL OUTPUT STAGE AND TRIODE PREAMPLIFIERS

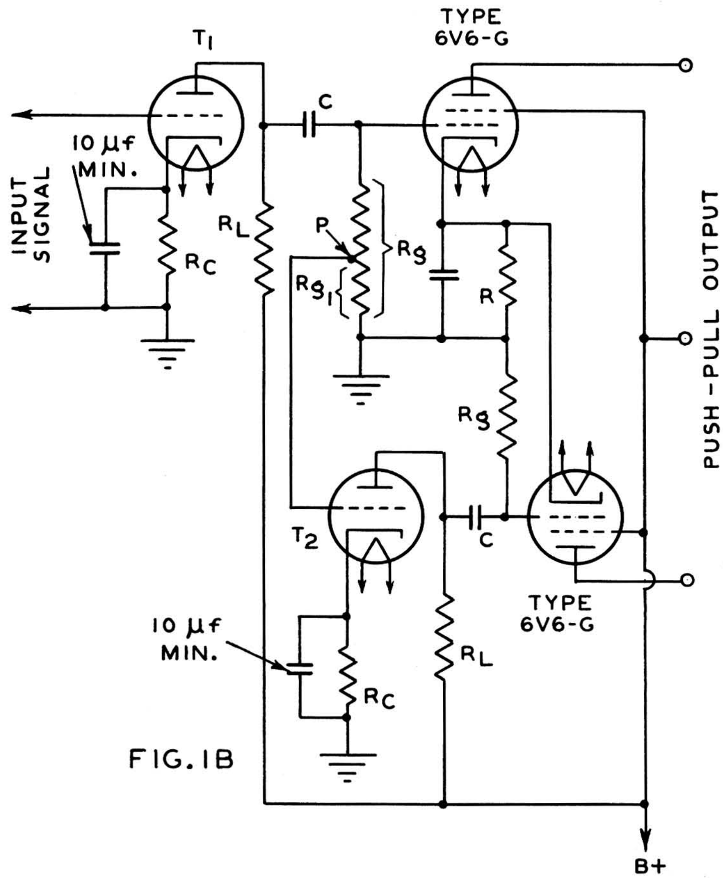

FIG. 1B

R = GRID-BIAS RESISTOR FOR PUSH-PULL 6V6-G'S
= { 165 OHMS WHEN B+ IS 250 VOLTS
195 OHMS WHEN B+ IS 300 VOLTS

TABLE I

TRIODE VOLTAGE AMPLIFIER (T_1 or T_2)	R_L Megohms	R_g Megohms	R_c Ohms	C µf	GAIN *
2A6, 75	0.1	0.25	2200	0.015	39
6C5: also 6C6, 6J7, 57 as triodes	0.1	0.25	5300	0.015	13
6F5	0.1	0.25	1600	0.010	49
6Q7	0.1	0.25	1500	0.015	39
6R7	0.1	0.25	3800	0.015	10
55, 85	0.1	0.25	8300	0.015	5.7
56, 76	0.1	0.25	6400	0.020	10

* Voltage amplifier only.

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PHASE-INVERTER CIRCUIT USING TWO 6V6-G'S IN THE PUSH-PULL OUTPUT STAGE AND A TWIN TRIODE AS THE PREAMPLIFIER

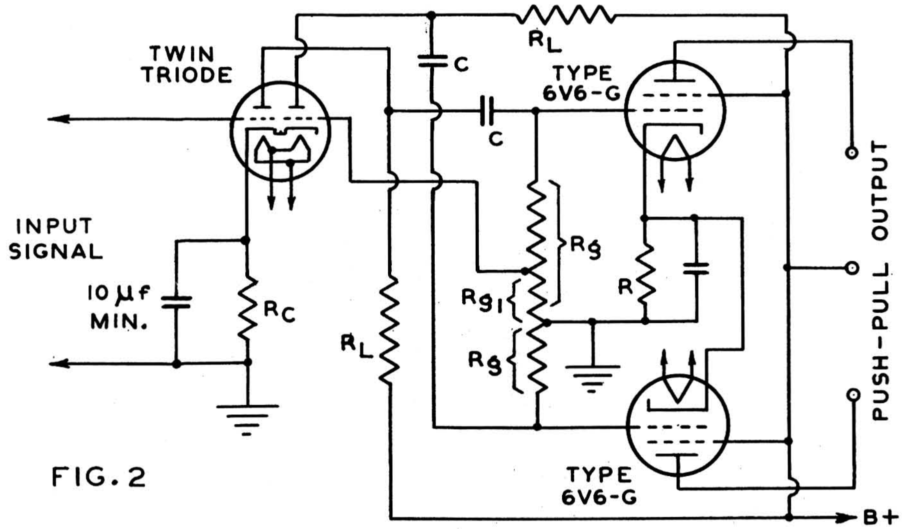

FIG. 2

R = GRID-BIAS RESISTOR FOR PUSH-PULL 6V6-G'S
= { 165 OHMS WHEN B+ IS 250 VOLTS
  { 195 OHMS WHEN B+ IS 300 VOLTS

TABLE II

TWIN TRIODE VOLTAGE AMPLIFIER	R_L Megohms	R_g Megohms	R_{g_1} Ohms	R_c Ohms	C µf	GAIN *
6A6, 6N7, 53	0.1	0.25	11350	1500	0.015	22
79	0.1	0.25	7350	1000	0.010	34

* One unit only of twin triode.

CASCADE AMPLIFIER CIRCUIT USING 6V6-G IN ONE STAGE AND A PENTODE IN THE OTHER

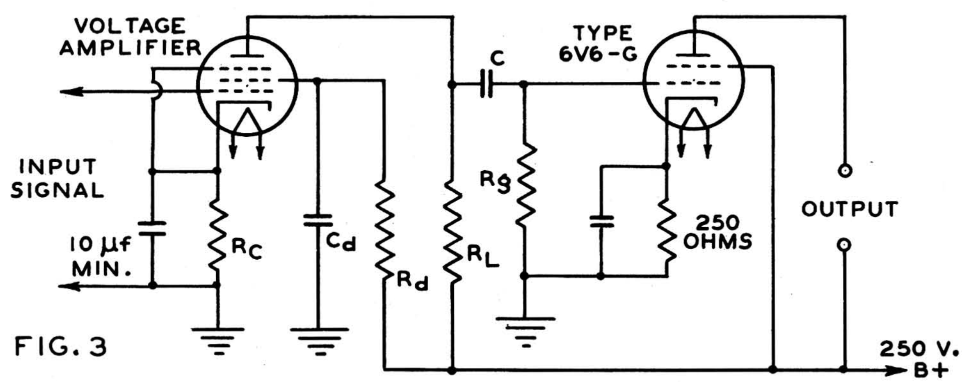

FIG. 3

TABLE III

PENTODE VOLTAGE AMPLIFIER	R_L Megohms	R_g Megohms	R_d Megohms	R_c Ohms	C_d µf	C µf	GAIN *
2B7, 6B7, 6B8	0.1	0.25	0.55	1100	0.09	0.015	47
6C6, 6J7, 57	0.1	0.25	0.50	450	0.07	0.010	82

* Voltage amplifier only.

PHASE-INVERTER CIRCUIT USING TWO 6V6-G'S IN THE PUSH-PULL OUTPUT STAGE AND INVERSE-FEEDBACK IN THE PRECEDING VOLTAGE AMPLIFIER STAGE

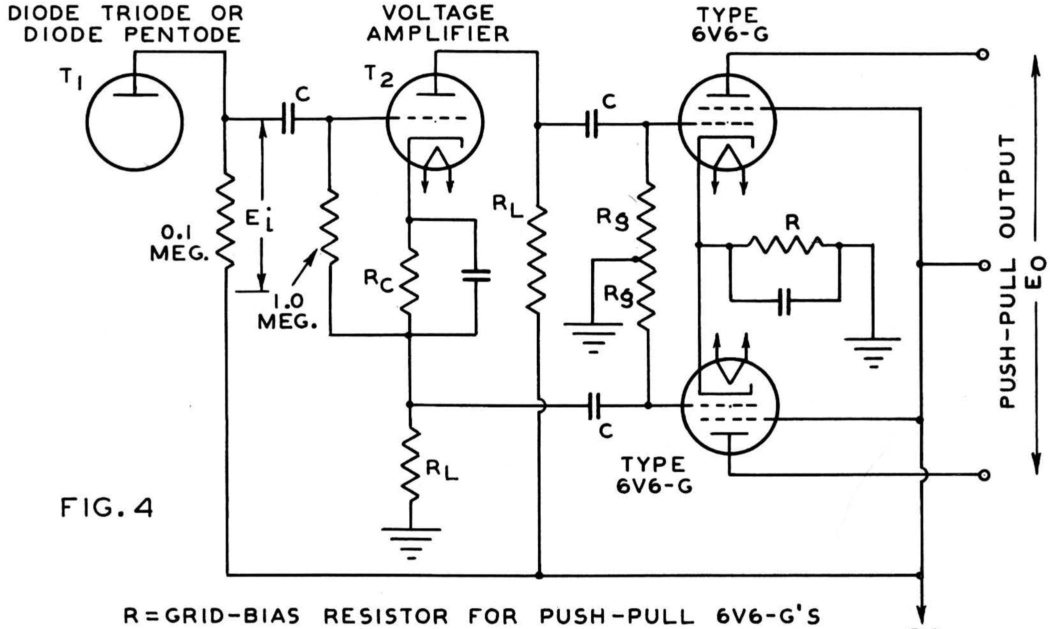

FIG. 4

R = GRID-BIAS RESISTOR FOR PUSH-PULL 6V6-G'S
= {165 OHMS WHEN B+ IS 250 VOLTS
{195 OHMS WHEN B+ IS 300 VOLTS

TABLE IV

TRIODE VOLTAGE AMPLI-FIER (T_2)	R_L Megohms	R_g Megohms	R_c Ohms	C µf	GAIN * E_o/E_i
6C5	0. 125	0.25	12300	0.016	25
6F5	0. 125	0.25	3200	0.015	28

* Approximate.

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AVERAGE PLATE CHARACTERISTICS
WITH E_{C1} AS VARIABLE

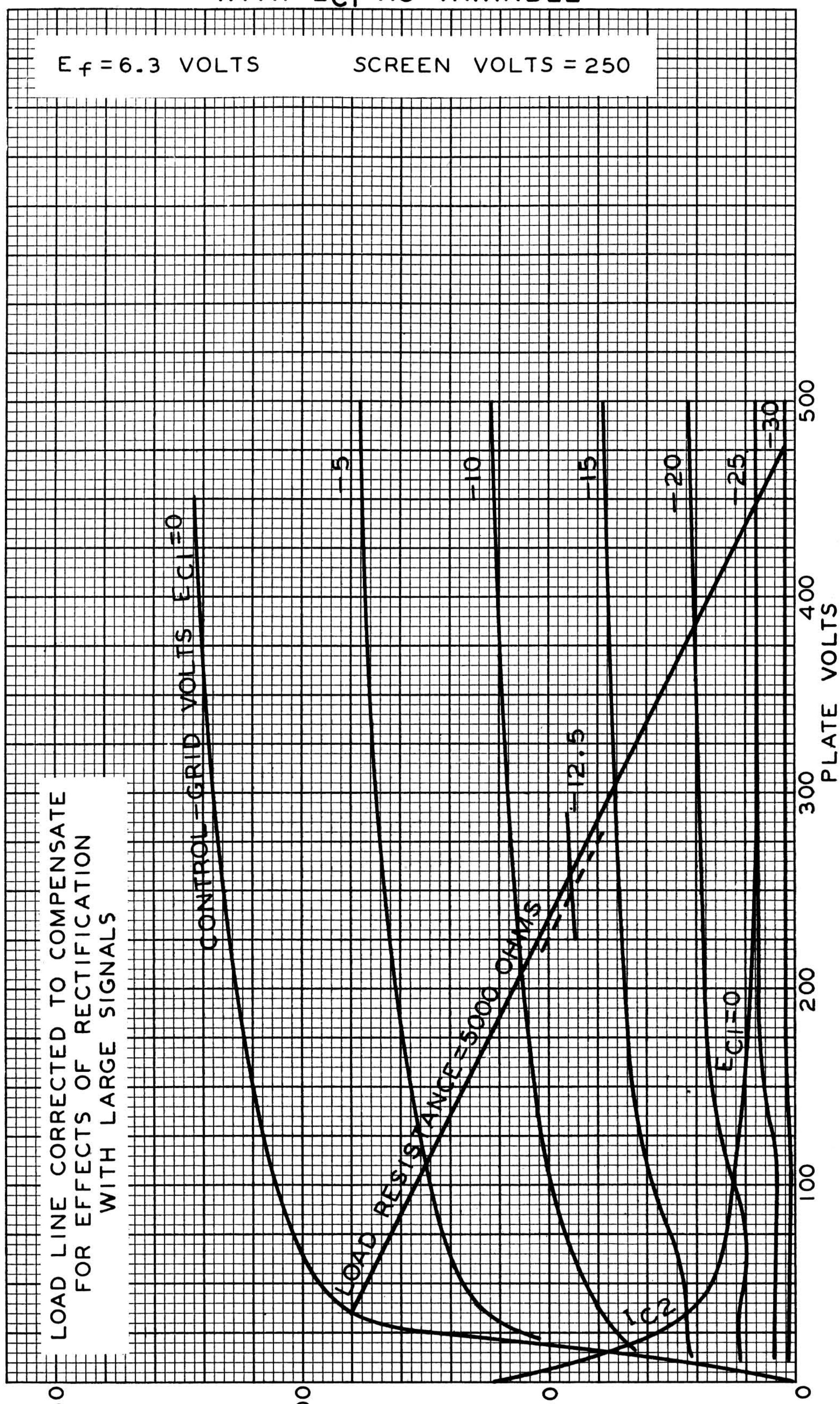

FIG.5

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AVERAGE PLATE CHARACTERISTICS
WITH E_{C1} AS VARIABLE

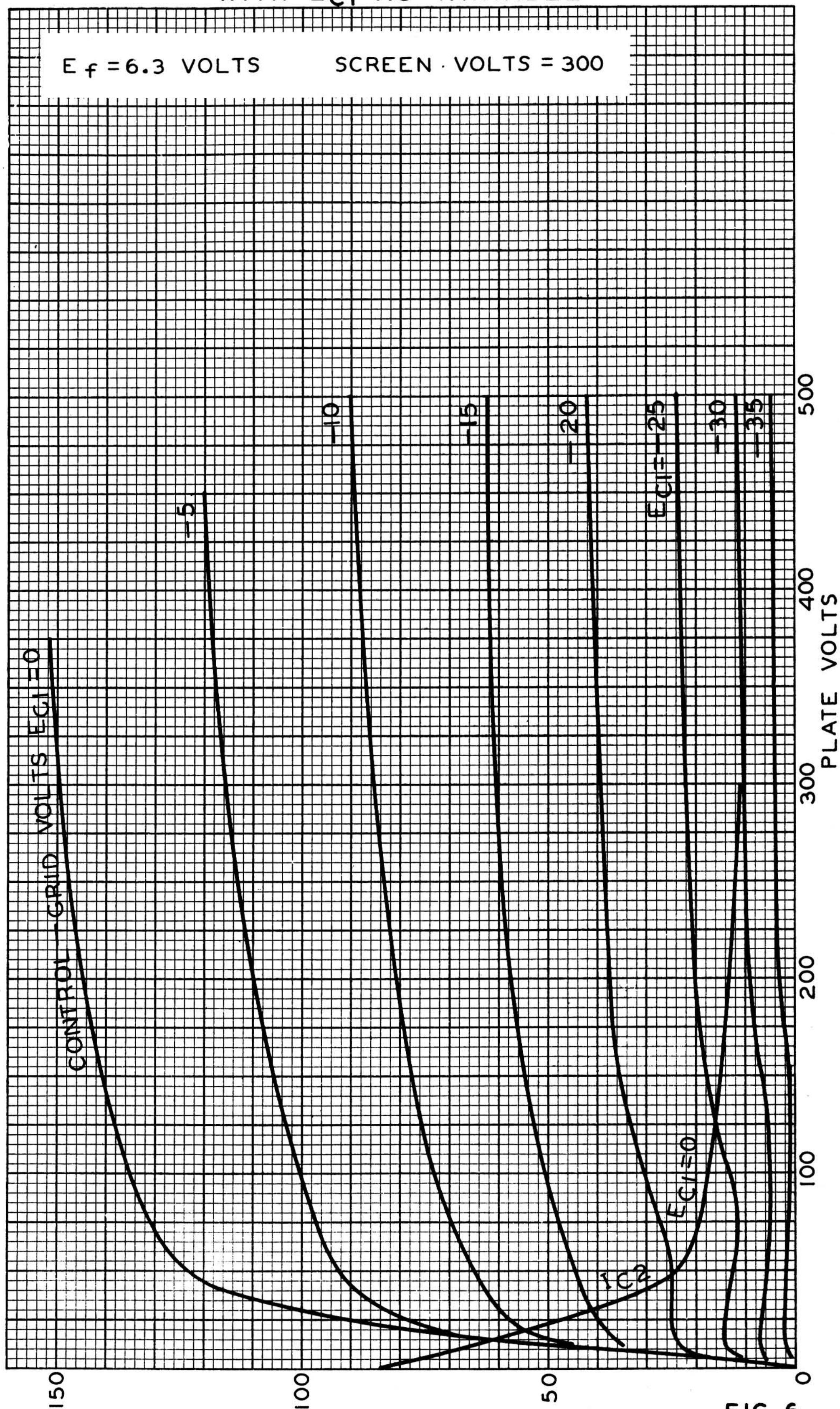

FIG.6

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AVERAGE PLATE CHARACTERISTICS
WITH E_{C2} AS VARIABLE

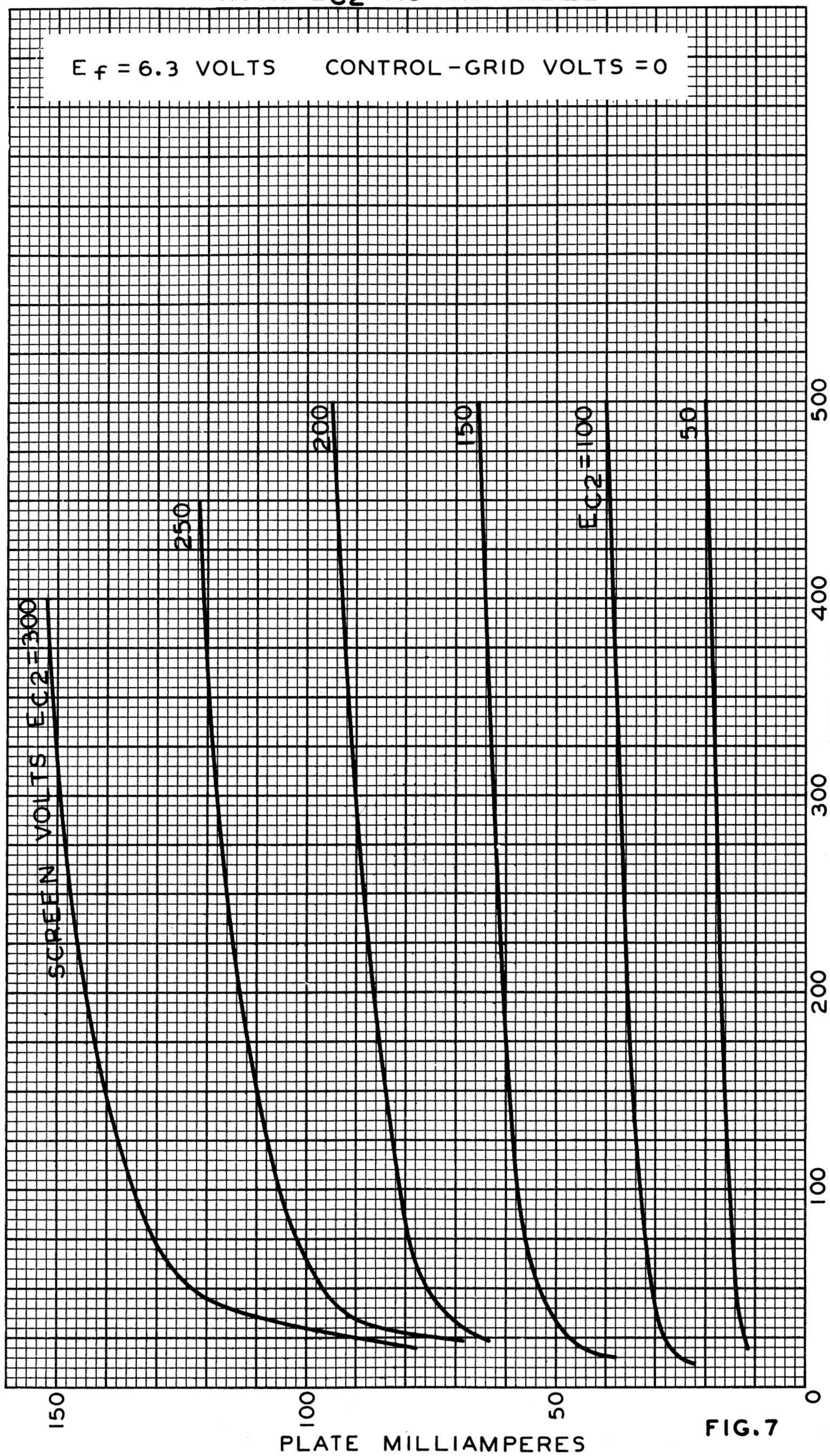

FIG. 7

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AVERAGE OUTPUT CHARACTERISTICS

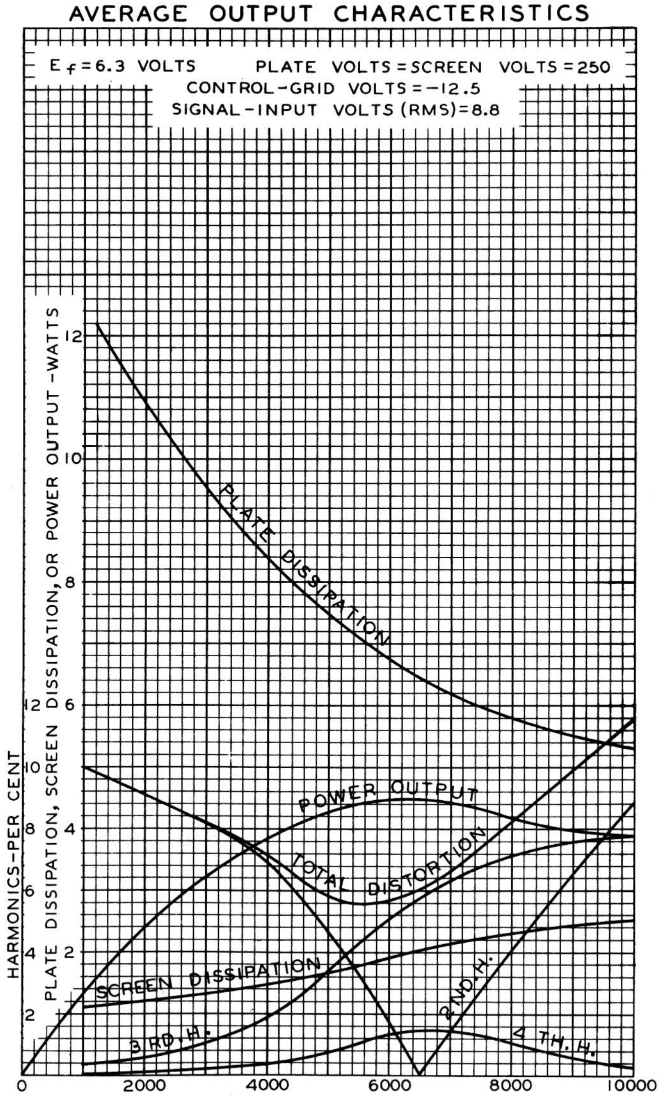

FIG. 8

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OPERATION CHARACTERISTICS

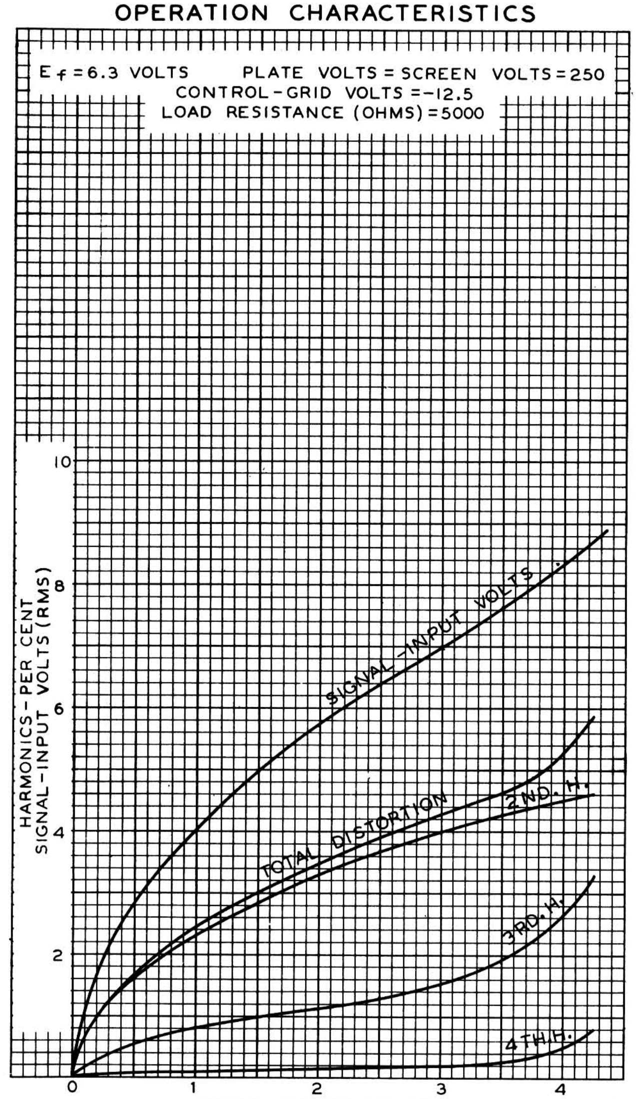

FIG. 9

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