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APPLICATION NOTE No. 40
June 14, 1934

APPLICATION NOTE ON HIGH POWER OUTPUT FROM TYPE 45 TUBES

Because of its use for so many years as a Class A amplifier with a power output rating of only two watts, the 45 is generally regarded as being incapable of handling the high output required of modern receivers. The facts are, however, that the type 45 can be used in push-pull amplifier combinations to provide from 12 to 19 watts output with a total harmonic content of five per cent or less. This output is obtained by the use of a plate voltage of 275 volts (the maximum value) and by supplying some driving power to the grids of the 45's.

During an investigation of the merits of 45's as power output tubes, we operated them as Class A, Class AB, and Class B amplifiers and obtained power output as high as 19 watts. Under the simplest circuit conditions, however, power output of 12 to 13 watts can be expected.

DRIVER STAGE

To drive the 45's, the triode 56 and the triode-connected 59 are suitable tubes. Both the 56 and 59 are heater-cathode types of tubes having 2.5-volt heaters which afford freedom from hum. Since both types have relatively low plate impedance, the primary inductance of the interstage transformer can be made high enough to obtain good fidelity.

Table I shows how the driver tubes were used and gives the values of plate-to-plate load, the input-transformer ratio, and input-transformer efficiency for each single and dual driver combination. Where two driver tubes were used they were connected in push-pull. The driver plate voltage was 250 volts in all cases. The grid-bias voltage was supplied from batteries and was -13.5 and -28 volts for the 56 and 59, respectively. The driver can be operated self-biased with no appreciable increase in distortion. The data for the curves showing the current and voltage relations for the 45 vs. the driver input signal were taken under optimum conditions determined with the driver at the grid-current point.

The data of Table I show that for a given grid-bias voltage, the power output obtained is approximately the same whether the driver stage uses one or two tubes. This is because one driver tube will supply enough power to operate the 45's at or under their dissipation limit of 10 watts. A driver stage consisting of a 56 or two 56's is preferable in most cases to one employing a 59 because the power sensitivity of the 56 is better than that of the 59. The

choice of a single or dual 56-driver stage depends on the method of input coupling to the driver, the overall power sensitivity (available input signal), the interstage coupling-transformer design, and the permissible higher-order harmonics.

The single 56-driver stage gives twice the power sensitivity of the dual stage and can be resistance-coupled to the preceding stage. Furthermore, the percentage of higher-order harmonics is about the same as for the dual stage.

With a dual stage, in comparison with a single stage, the interstage coupling transformer can be of better design at the same cost or can provide the same fidelity at lower cost. The fidelity is good in either case. The coupling of a dual stage to a single preceding stage requires a transformer or an inverter arrangement.

OUTPUT STAGE

A push-pull output stage of 45's was operated under conditions for Class A, Class AB, and Class B service in order to ascertain the complete possibilities of the tubes at a plate voltage of 275 volts. The results of these measurements are shown by curves and the data of Table I.

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OPERATING CONDITIONS OF AMPLIFIER

Driver Stage		Output Stage: 2 - 45's				
Tube Type	No. of Tubes	Grid-Bias Method	Grid-Bias Volts	Plate-Supply Resistance (R_p) Ohms	Grid-Supply Resistance (R_c) Ohms	See Curve	See Table I
56	2	Fixed	-56 to -76	0	0	1-a	---
56	2	Fixed	-56	0	0	---	1-b
56	2	Fixed	-64	0	0	1-c	1-c
56	2	Fixed	-76	0	0	---	1-d
56	2	Self	-56 to -64	0	775 to 1800	2-a	---
56	2	Self	-56	0	775	---	2-b
56	2	Self	-56	500	775	2-c	2-c
56	2	Self	-56	1000	775	---	2-d
56	2	F & S	-56	0-1000	0-775	2-e	---
56	1	Fixed	-56 to -68	0	0	3-a	---
56	1	Fixed	-56	0	0	3-b	3-b
56	1	Fixed	-68	0	0	---	3-c
56	1	Self	-56	0	775	---	4-a
56	1	Self	-56	500	775	4-b	4-b
56	1	Self	-56	1000	775	---	4-c
56	1	F & S	-56	0-1000	0-775	4-d	---
59	1	Self	-56	0	775	5-a	5-a
59	2	Self	-56	0	775	5-b	5-b

R_c and R_b

The total series resistance in the plate circuit of the 45's consists of: (1) r_p, the plate resistance of the tube; (2) R_p, the load resistance; (3) R_c, the equivalent series resistance of the grid supply; and (4) R_b, the equivalent series resistance of the plate power supply. It will be noted that R_c in self-biased circuits is the grid-bias resistor.

When R_c and R_b are zero, the best plate voltage regulation and the maximum power output are obtained. It is, therefore, advantageous to use fixed bias instead of self bias and to have R_b as small as possible. If a voltage source of approximately zero resistance is used in place of the regular power supply and resistance is then introduced in series with this voltage source until it has the same voltage regulation as the power supply, the resistance added to the circuit would be the equivalent internal resistance R_b. In practice, this value is determined by plotting the voltage regulation curve of the power supply and measuring the slope of the line joining the voltage outputs at the zero-signal and maximum-signal operating conditions. The slope of this line represents R_b, the equivalent d-c resistance of the power supply.

Optimum Operation with Two Driver Tubes

The first group, 1-a to 1-d, represents ideal conditions for two 45's driven by two 56's. The grid bias and plate voltage were both taken from a battery supply so that the resistance in both plate circuit and cathode circuit is minimum. This condition is expressed by $R_c = 0$ and $R_b = 0$. It is to be noted that under these operating conditions the optimum power output of 17 to 19 watts is obtained.

Normal grid-bias voltage for the 45 with a plate supply of 275 volts is -56 volts. In 1-a to 1-d, operation is shown with grid-bias voltages from -56 to -76 volts. Operation under the conditions of 1-b is as a Class A amplifier drawing grid current after power output exceeds 5.3 watts. Under the conditions of 1-c, operation is as an overbiased amplifier with grid current starting when the power output is 5.3 watts. For 1-d, the 45's are initially biased to 5 milliamperes plate current and operation is Class B with grid current beyond 5.0 watts of power output. 1-a is in the nature of a summary of curves 1-b, 1-c and 1-d.

Self-Biased Operation with Two Driver Tubes

Group 2 illustrates the more practical self-bias method of operation. Data for 2-a were taken with variation of the self-bias resistor to produce grid-bias voltages of -56 to -64 volts. The greatest power output was obtained with a bias of -56 volts (see 2-a); hence, this grid-bias value was used as the operating bias for determining the data given in 2-b, 2-c, 2-d and 2-e. Of the conditions represented by 2-b, 2-c and 2-d, that of 2-c is the most practical because R_b with a value of 500 ohms represents the approximate equivalent resistance of a power supply using a type 5Z3 rectifier. R_c, the grid-supply resistance, is 775 ohms for all three cases. The resistance affecting plate-supply regulation is equal to $R_b + R_c$. The power output obtained under these conditions is seen to be 13.2 watts with maximum signal. Semi-fixed bias operation with two driver tubes would provide power output

intermediate to that obtained with the fixed-bias method and the self-bias method of 1 and 2. Such operation can be provided by taking the bias voltage from the drop across the speaker field or a choke in the power supply. 2-e is a summary of the measurements of 2-a to 2-d.

Optimum Operation with a Single 56 Driver

Group 3 corresponds to Group 1 but applies to a single 56 driver. The data show that approximately the same power output can be realized with a single driver as with a dual driver and, furthermore, that there is some reduction in higher-order harmonics, or sizzle. In this group and in Group 4, only half the input signal to the driver tube is required as compared to that required for cases where two driver tubes are used.

Self-Biased Operation with a Single 56 Driver

Group 4 corresponds to Group 2 in that it applies to self-biased operation. However, a single driver is used. This gives only a slight reduction in power output as compared with two driver tubes. Sizzle varies over a wider range in this case than it did for the corresponding case with two drivers and is less in 4-b than in 2-c. The designer should choose between 2-c and 4-b and select the circuit best suited to his particular design requirements.

Self-Biased Operation with One or Two 59 Driver Tubes

Operating conditions for the 45's with one or two 59's in the driver stage are shown in 5-a and 5-b. The 59's are connected as triodes and used as a Class A amplifier. Although the 59's are operated well below their maximum output, a comparatively high driver-input signal is required to obtain sufficient signal to drive the 45's to their distortion limit. The higher-order harmonics are usually slightly greater than for the 56 as a driver. Two 59 driver tubes give approximately one watt greater output than two 56 driver tubes under similar self-bias conditions.

Effects of R_c and R_b with Fixed-Bias Operation

The resistance (R_c) has a greater influence on the power output than R_b. This is particularly noticeable as the power output approaches maximum and is illustrated by the curves of 2-c and 4-d. It is also shown by the data of Table I. Observe, for instance, 2-b and 2-c which show identical power outputs. In both of these cases, R_c = 775 ohms, but R_b = 0 ohms in one case and 500 ohms in the other case. Notice also 4-a and 4-b in which there is but 0.7-watt difference in the power output for a difference of 500 ohms in R_b; then notice the difference of 4 watts in power output between the fixed-bias condition and the self-bias condition of 1-b and 2-b, and the difference of 4.4 watts between the fixed-bias condition and the self-bias condition of 3-b and 4-a. Each comparison illustrates the point that a change in R_b will not materially affect the power output but that a reduction of R_c from 775 ohms to zero will allow an increase in power of approximately 30% over that obtained with self bias. Thus, if fixed-bias

operation can be had, 17 watts of audio output can be expected from two 45's. In order to obtain a fixed bias, a separate filament-type triode, preferably a 26 or 01A, can be used as a rectifier to supply a bias voltage substantially unaffected by the plate current of the 45's. The grid bias for all of the conditions mentioned is the normal value of -56 volts. Should still greater output be desired, it can be obtained by providing higher fixed-bias voltage in accordance with 1-c, 1-d and 3-c and by operating the amplifier Class AB or Class B. 1-c and 3-c illustrate Class AB operation while 1-d illustrates Class B operation.

Selection of Tubes for Output Stage

The pair of 45 tubes used in this investigation had average characteristics. The question naturally arises as to whether or not the tubes should be matched to obtain the reported results. In order to determine this, 45's were selected whose plate currents differed from the rated value by plus and minus 35 per cent. These tubes were operated in pairs under the conditions of 4-b with a single 56 driver, self-biased at -56 volts and with R_b = 500 ohms. The distortion did not exceed 7% for any combination of tubes. The zero-signal and maximum-signal grid bias and plate voltage departed less than 5% from the values obtained with the average pair. There was but a slight increase in the higher-order harmonics.

Plate-to-Plate Load

When using self bias, it is necessary to use a higher value of plate-to-plate load resistance than with fixed bias or semi-fixed bias in order to lessen plate-current swings, limit distortion, and prevent plate current cut-off at negative signal swings.

The plate-to-plate load is specified for each operating condition shown in the discussion and should be followed fairly closely. Too great a deviation from the specified load will change the operating conditions. For instance, should the plate-to-plate load be too low, the tube dissipation may exceed the maximum rated value of 10 watts; should the plate-to-plate load be too high, the full power output will not be realized. For either case the ratio of the interstage transformer would not be optimum.

Summary

As an output tube, the 45 when used in push-pull arrangements and operated beyond its grid-current point can provide power output of 12 to 13 watts for the simplest circuit conditions with comparatively low plate voltage of 275 volts, low distortion, low plate-current swings with resultant economy of transformer design, small input signal to driver, and low cost of tubes and amplifier components. If the user desires power output of the order of 17 watts or greater, it can be obtained by the use of an additional tube to provide the fixed-bias voltage.

TABLE I

INDEX	DRIVER	BIAS METHOD for 45's	DRIVER STAGE		INPUT TRANSFORMER		OUTPUT STAGE: 2 - 45's with Plate Volts = 275										POWER OUTPUT		HARMONICS	
			Input Signal RMS Volts (per tube)	Plate-to-Plate Load Ohms	Primary / 1/2 Secondary	Efficiency Per cent	Zero-Signal Grid Bias Volts	Max.-Signal Grid Bias Volts	Grid-Supply Resistance (R_c) Ohms	Plate-Supply Resistance (R_b) Ohms	Grid Input Peak Power Milliwatts	Grid Input Peak Volts (per tube)	D-C Grid Current Ma. (per tube)	Max.-Signal Plate Current Ma. (per tube)	Plate-to-Plate Load Ohms	Max.-Signal Plate Volts	At Grid-Current Point Watts	At Max.-Signal Watts	Total Per cent	Higher-Order Per cent
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1b	2-56#	Fixed	9.25	122600	3.33:1.0	81.0	-56	-56	0	0	680	95.5	1.56	65.0	4240	—	5.3	17.2	5	1.8
1c*	2-56#	Fixed	9.25	86400	2.76:1.0	85.4	-64	-64	0	0	887	107.5	1.88	71.0	3400	—	5.3	18.8	5	2.0
1d	2-56#	Fixed	9.25	71700	2.35:1.0	88.3	-76	-76	0	0	1000	119.5	2.00	68.0	3490	—	5.0	19.1	5	4.0
2b	2-56#	Self	9.25	93100	2.50:1.0	86.0	-56	-75.5	775	0	820	110.9	1.96	47.0	5420	256	4.5	13.2	5	2.3
2c*	2-56#	Self	9.25	68000	2.76:1.0	88.8	-56	-70.5	775	500	1124	105.0	2.00	43.0	6000	252	5.2	13.2	5	2.4
2d	2-56#	Self	9.25	68600	2.76:1.0	88.1	-56	-69.5	775	1000	1110	105.0	2.00	43.0	5810	246	5.2	12.7	5	2.5
3b*	1-56#	Fixed	9.35	33100	1.54:1.0	79.6	-56	-56	0	0	486	91.5	1.25	66.5	3900	—	5.5	17.0	5	1.3
3c	1-56#	Fixed	9.10	18200	1.18:1.0	87.8	-68	-68	0	0	656	97.5	1.37	69.0	3200	—	5.0	18.2	5	2.2
4a	1-56#	Self	9.25	31500	1.29:1.0	80.8	-56	-74.5	775	0	473	104.3	1.21	47.5	4710	257	5.3	12.6	5	3.3
4b*	1-56#	Self	9.25	33600	1.38:1.0	80.6	-56	-70.5	775	500	461	99.6	1.35	45.0	5060	250	4.8	11.9	5	2.0
4c	1-56#	Self	9.25	33300	1.48:1.0	79.7	-56	-68	775	1000	464	93.3	1.33	42.0	5520	250	4.7	11.2	5	1.5
5a*	1-59°	Self	19.6	—	1.33:1.0	—	-56	-75	775	0	—	—	2.20	41.0	7350	—	7.3	12.8	5	—
5b*	2-59°	Self	19.6	41200	2.42:1.0	92.0	-56	-76	775	0	1940	118.8	3.50	45.0	6020	—	7.6	14.7	5	3.9

* Also covered by curves of same figure number

\# Plate volts = 250 and Grid volts = -13.5

° Plate volts = 250 and Grid volts = -28.0

Note 1: If d.c. is used on filaments of 45's, the 775 values of R_c in Column 10 should be 760 ohms.

Note 2: Higher-order harmonics of Column 21 include 10% of fifth and all higher harmonics.

OPERATION CONSIDERATIONS

PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE: CLASS A DRIVER-TWO TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5

OUTPUT STAGE: TWO TYPE 45
PLATE VOLTS = 275, FROM BATTERY OF ZERO RESISTANCE
GRID VOLTS = VARIABLE, FROM BATTERY OF ZERO RESISTANCE

NOTE: ALL VALUES ARE OPTIMUM FOR EACH BIAS VOLTAGE
PLATE DISSIPATION FOR EACH TYPE 45 IS 10 WATTS OR LESS
* HIGHER-ORDER HARMONICS INCLUDE 10% OF 5TH AND ABOVE
TOTAL HARMONIC DISTORTION IS HELD TO 5%

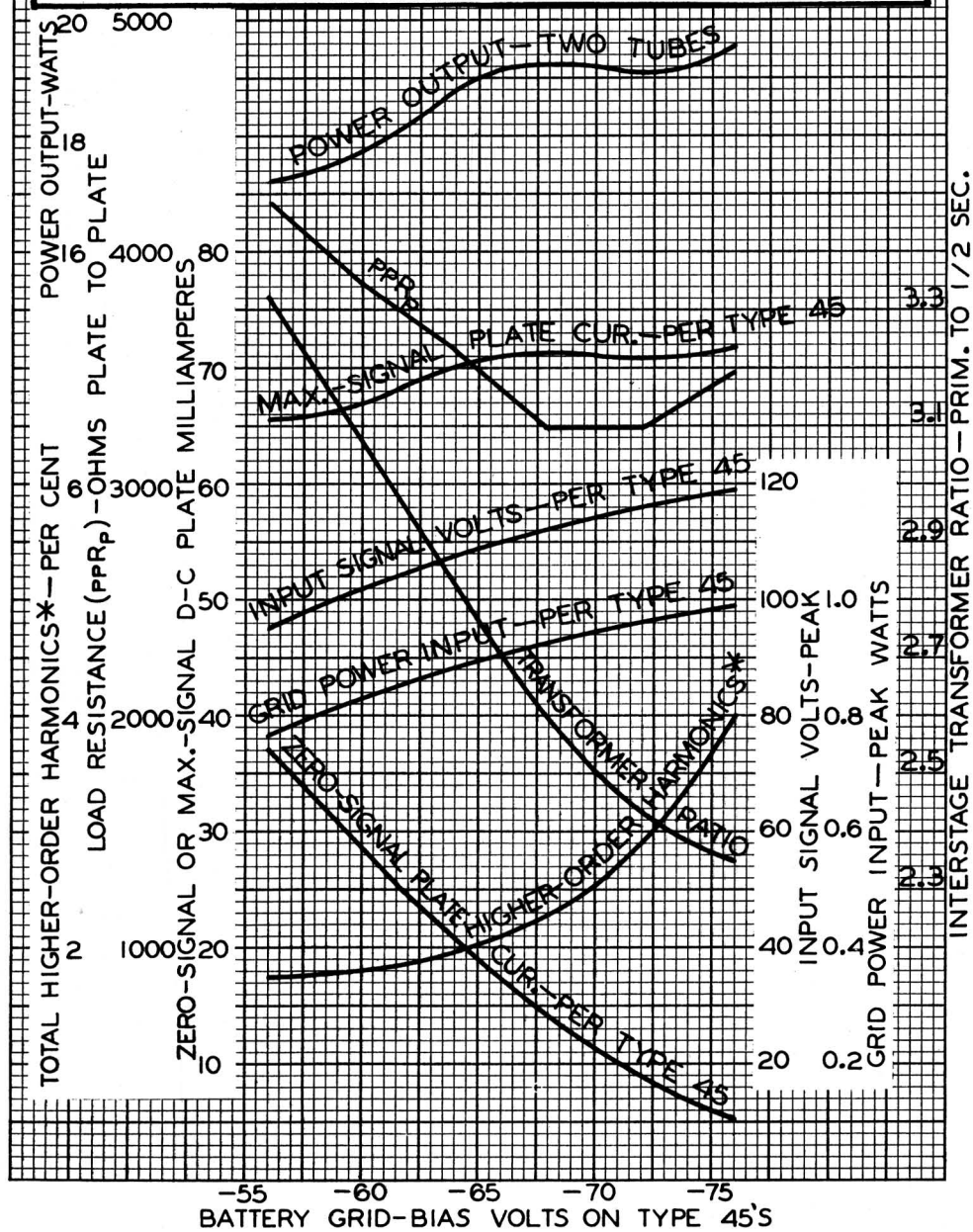

FIG. 1A

OPERATION CONSIDERATIONS

PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE: CLASS A DRIVER - TWO TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5
PLATE-TO-PLATE LOAD = 86400 OHMS

OUTPUT STAGE: TWO TYPE 45
PLATE VOLTS = 275, FROM SUPPLY OF ZERO RESISTANCE
GRID VOLTS = −64, FROM SUPPLY OF ZERO RESISTANCE
OUTPUT LOAD, PLATE TO PLATE = 3400 OHMS
PEAK INPUT-SIGNAL VOLTS PER TUBE = 107.5
PEAK GRID POWER INPUT PER TUBE = 0.887 WATTS
HIGHER-ORDER HARMONICS (10% OF 5TH AND ABOVE) DO NOT EXCEED 1.97 %

INTERSTAGE TRANSFORMER: VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 2.76

PEAK PLATE EFFICIENCY = 85.4%

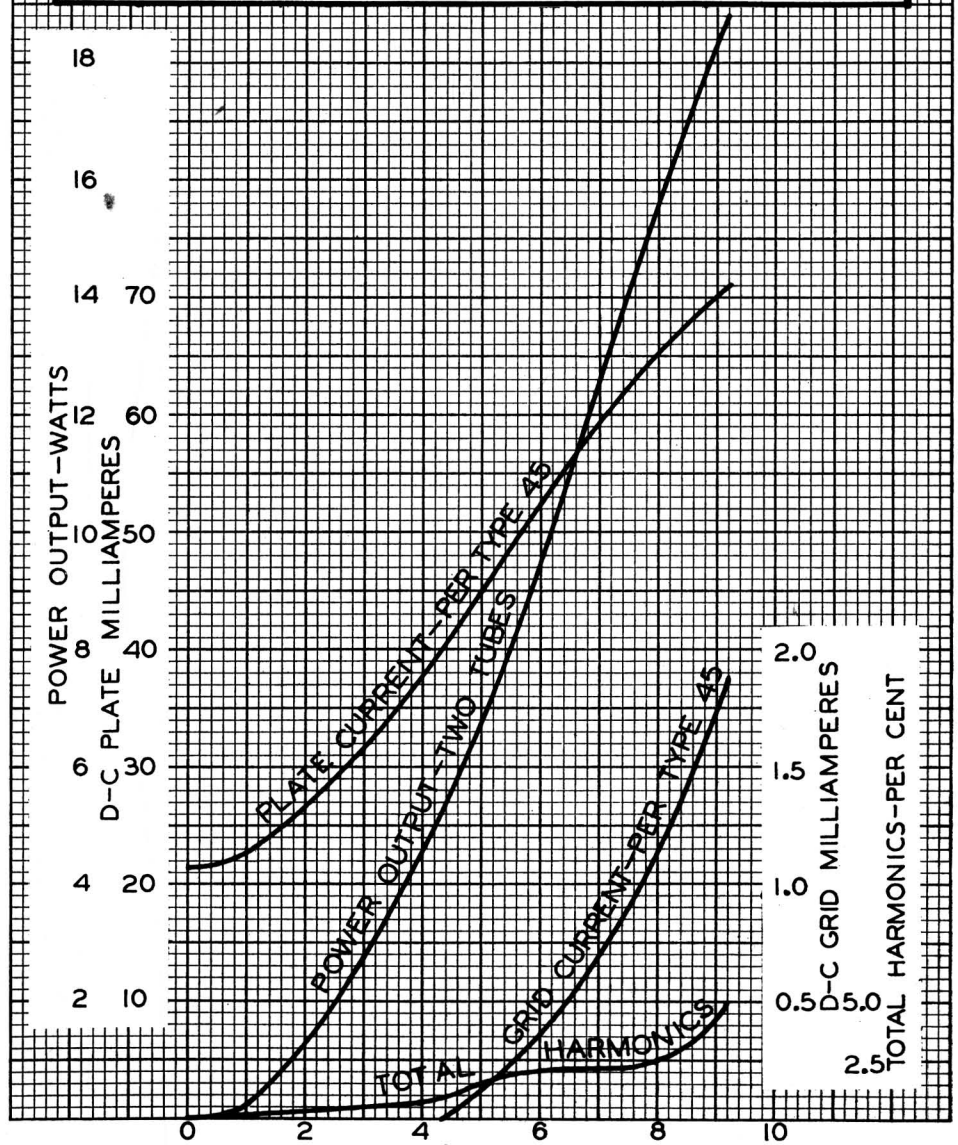

FIG. 1C

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE: CLASS A DRIVER—TWO TYPE 56
PLATE VOLTS=250 GRID VOLTS=—13.5

OUTPUT STAGE: TWO TYPE 45
PLATE SUPPLY=275 VOLTS+ZERO-SIGNAL BIAS VOLTS AND HAS ZERO RESISTANCE
MAX.-SIGNAL PLATE VOLTS=PLATE SUPPLY—MAX.-SIGNAL GRID BIAS VOLTS
ZERO-SIGNAL BIAS VOLTS, FROM GRID BIAS RESISTANCE (R_C)

NOTE: ALL VALUES ARE OPTIMUM FOR EACH ZERO-SIGNAL GRID BIAS VOLTAGE
PLATE DISSIPATION FOR EACH TYPE 45 IS 10 WATTS OR LESS
TOTAL HARMONIC DISTORTION IS HELD TO 5%
*TOTAL HIGHER-ORDER HARMONICS INCLUDE 10% OF 5TH AND ABOVE
CURVES MARKED (S) GIVE VALUES PER TYPE 45

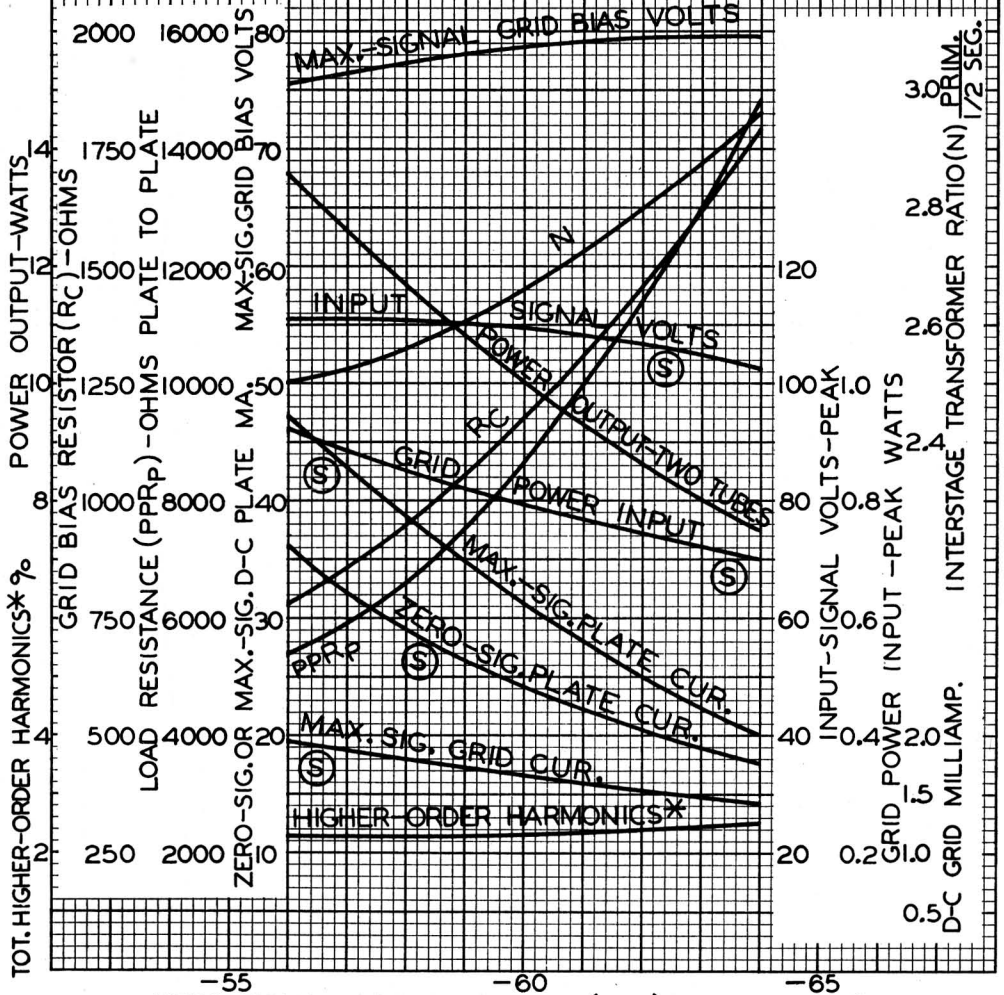

FIG. 2A

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE: CLASS A DRIVER – TWO TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5
PLATE-TO-PLATE LOAD = 68000 OHMS

OUTPUT STAGE: TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY HAVING 500 OHMS RESISTANCE
MAX.-SIGNAL PLATE VOLTS = 251.6
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS RESISTOR (R_C) OF 775 OHMS
MAX.-SIGNAL BIAS VOLTS = −70.5
OUTPUT LOAD, PLATE TO PLATE = 6000 OHMS
PEAK INPUT-SIGNAL VOLTS PER TUBE = 105
PEAK GRID POWER INPUT PER TUBE = 1.124 WATTS
HIGHER-ORDER HARMONICS (10% OF 5TH AND ABOVE) DO NOT EXCEED 2.43%

INTERSTAGE TRANSFORMER: VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 2.76
PEAK PLATE EFFICIENCY = 88.8%

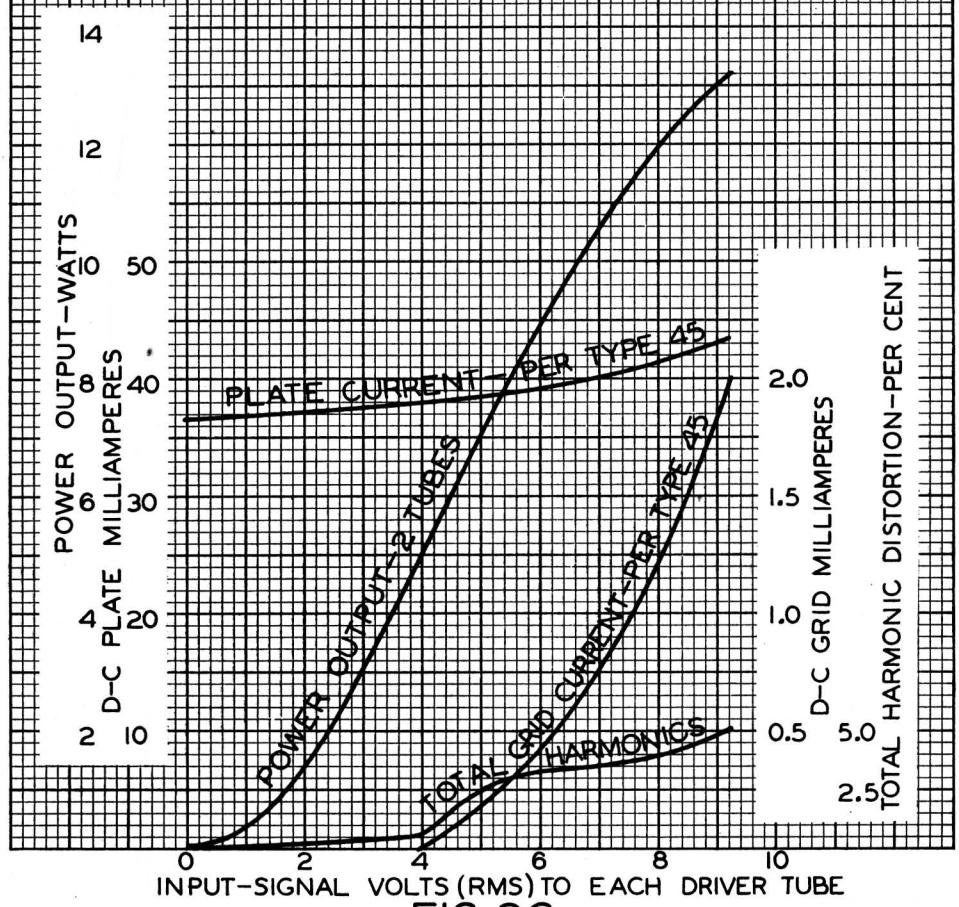

FIG. 2C

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE : CLASS A DRIVER - TWO TYPE 56
PLATE VOLTS = 250, GRID VOLTS = −13.5
OUTPUT STAGE : TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY HAVING RESISTANCE (R_b) SHOWN IN TABLE
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS SUPPLY HAVING RESISTANCE (R_C) SHOWN IN TABLE

CURVE	TYPE OF BIAS	R_C	R_b
1 ———	FIXED	0	0
2 — —	SELF	775	0
3 — — —	SELF	775	500
4 -------	SELF	775	1000

R_b & R_C EACH BY-PASSED WITH 8μf CONDENSER

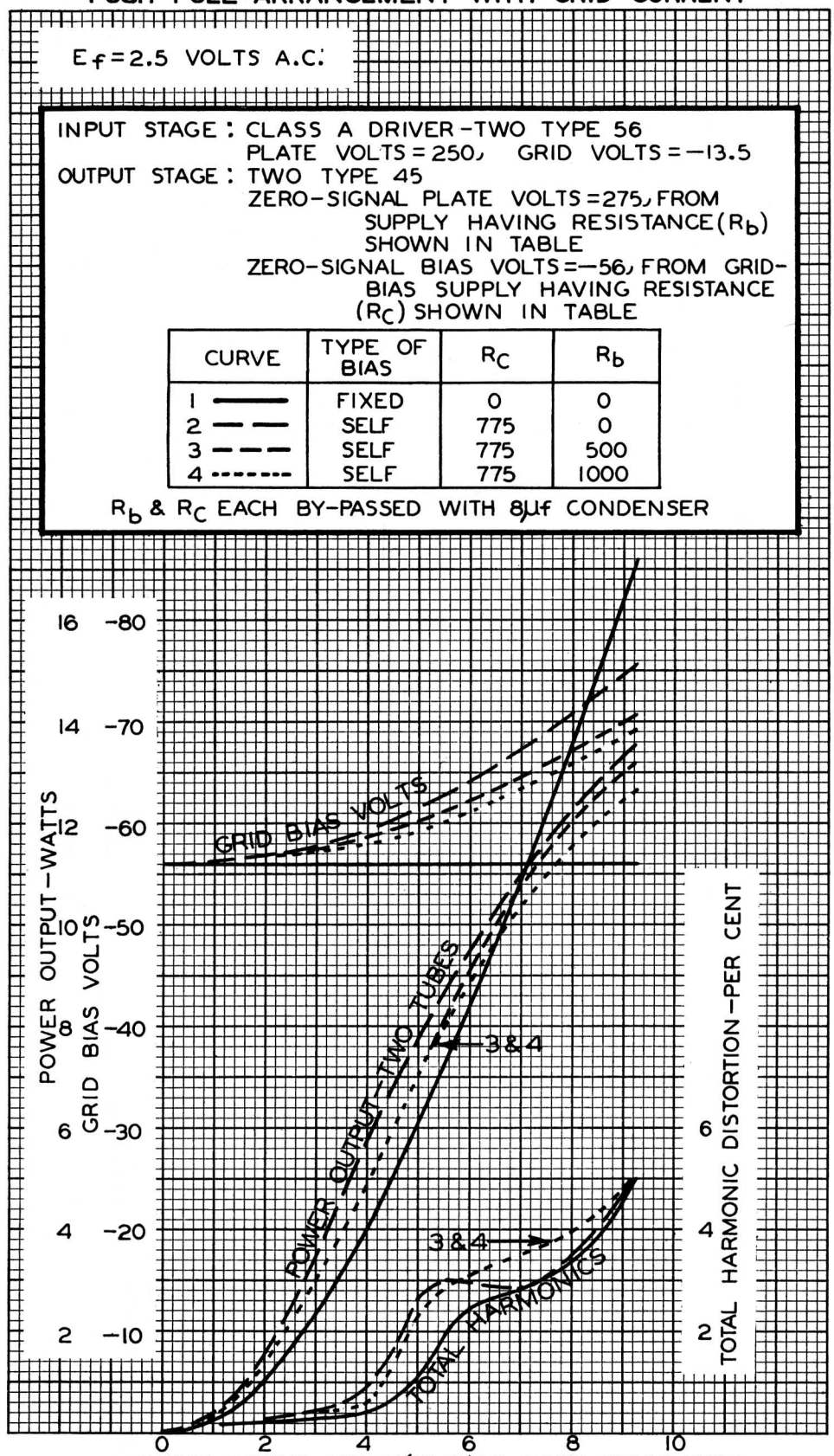

FIG. 2E

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OPERATION CHARACTERISTICS

PUSH-PULL ARRANGEMENT WITH GRID CURRENT

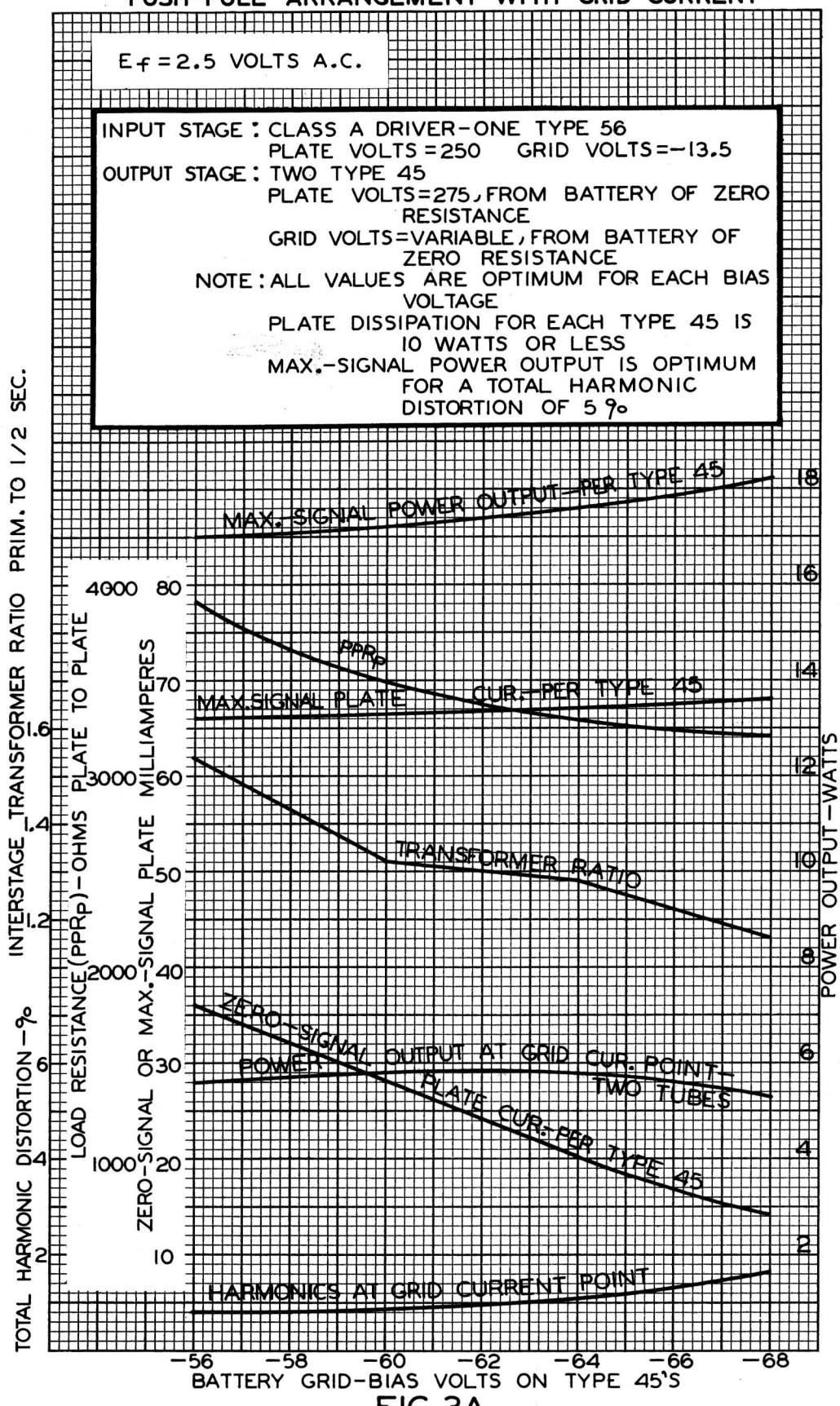

FIG. 3A

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE: CLASS A DRIVER-ONE TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5
PLATE LOAD = 33100 OHMS

OUTPUT STAGE: TWO TYPE 45
PLATE VOLTS = 275, FROM BATTERY OF ZERO RESISTANCE
GRID VOLTS = −56, FROM BATTERY OF ZERO RESISTANCE
OUTPUT LOAD, PLATE TO PLATE = 3900 OHMS
PEAK INPUT-SIGNAL VOLTS PER TUBE = 91.5
PEAK GRID POWER INPUT PER TUBE = 0.486 WATTS
HIGHER-ORDER HARMONICS (10% OF 5TH AND ABOVE) DO NOT EXCEED 1.32 %

INTERSTAGE TRANSFORMER: VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 1.54

PEAK PLATE EFFICIENCY = 79.6 %

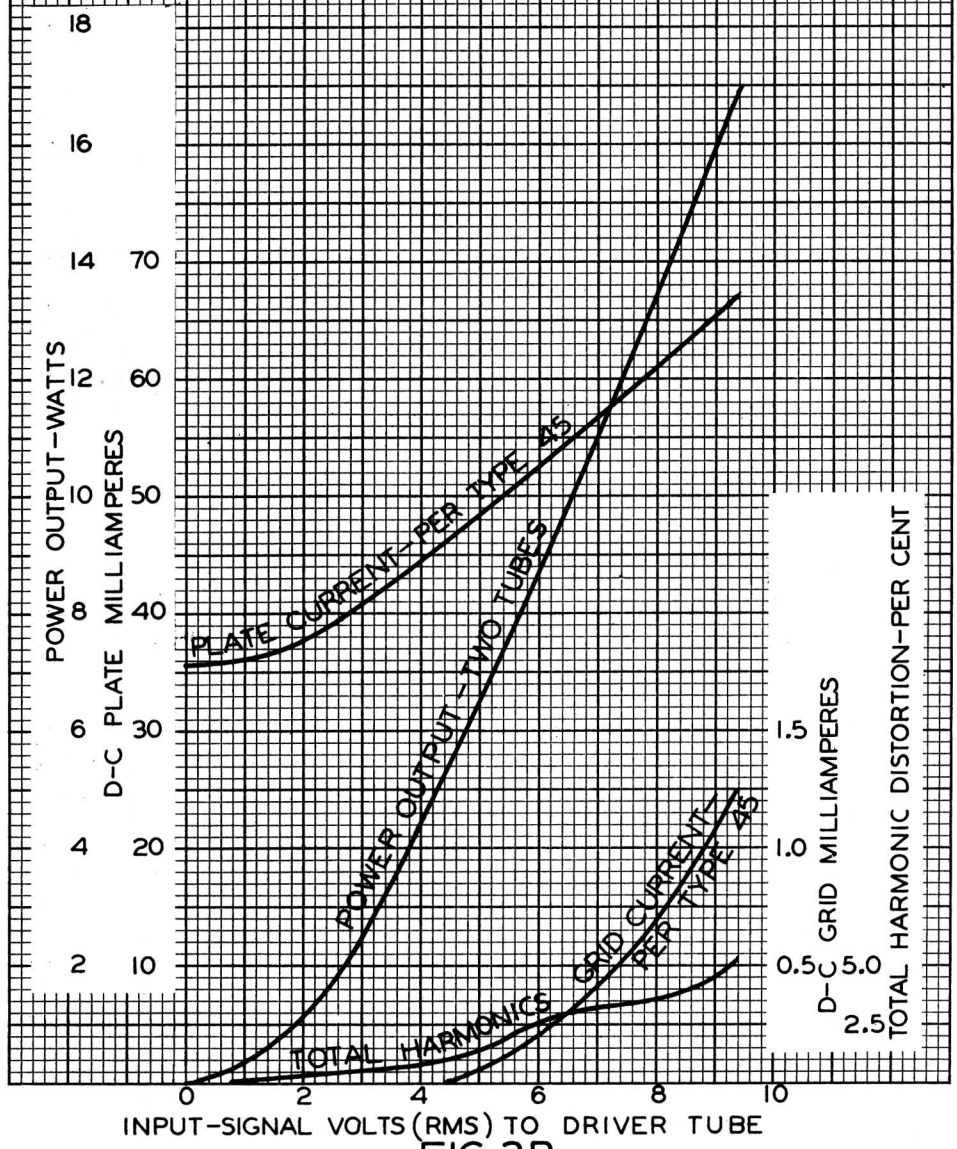

FIG. 3B

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE : CLASS A DRIVER-ONE TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5
PLATE LOAD = 33565 OHMS

OUTPUT STAGE : TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY HAVING 500 OHMS RESISTANCE
MAX.-SIGNAL PLATE VOLTS = 250
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS RESISTANCE (R_C) OF 775 OHMS
MAX.-SIGNAL BIAS VOLTS = −70.5
OUTPUT LOAD, PLATE TO PLATE = 5060 OHMS
PEAK INPUT-SIGNAL VOLTS PER TUBE = 99.6
PEAK GRID POWER INPUT PER TUBE = 0.461 WATTS
HIGHER-ORDER HARMONICS (10% OF 5TH AND ABOVE) DO NOT EXCEED 2%

INTERSTAGE TRANSFORMER : VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 1.38

PEAK PLATE EFFICIENCY = 80.6%

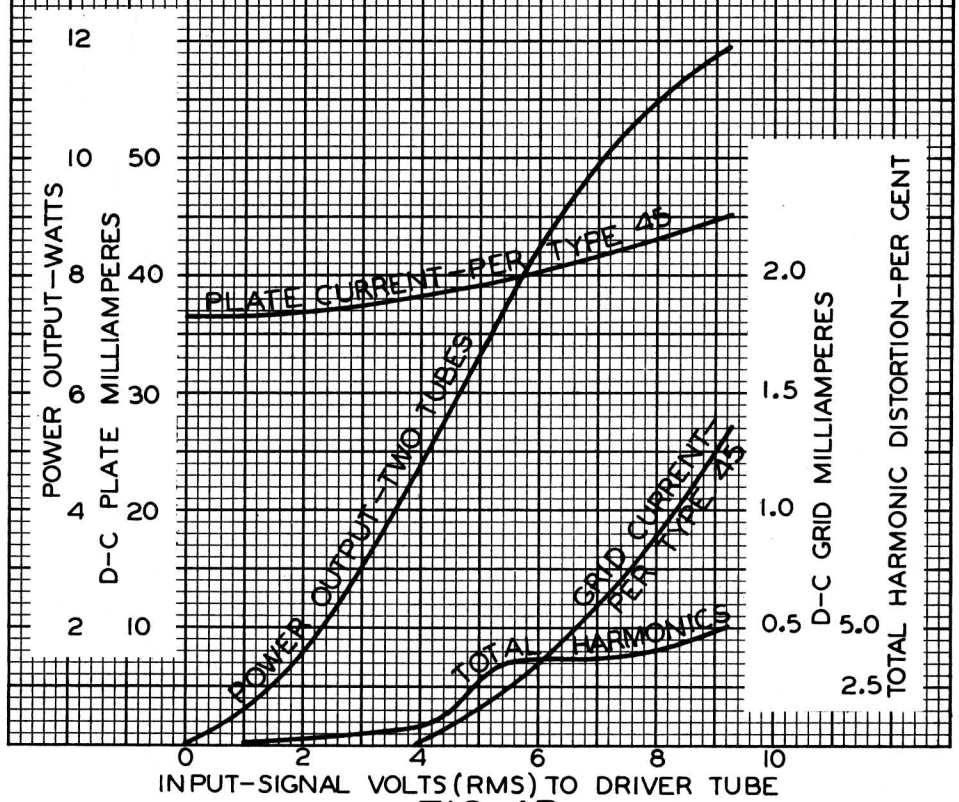

FIG. 4B

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OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE : CLASS A DRIVER - ONE TYPE 56
PLATE VOLTS = 250 GRID VOLTS = −13.5
OUTPUT STAGE : TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY RESISTANCE (R_b) SHOWN IN TABLE
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS SUPPLY HAVING RESISTANCE (R_C) SHOWN IN TABLE

CURVE	TYPE OF BIAS	R_C	R_b
1 ———	FIXED	0	0
2 — —	SELF	775	0
3 — — —	SELF	775	500
4 ·····	SELF	775	1000

R_b & R_C EACH BY-PASSED WITH 8 μf CONDENSER

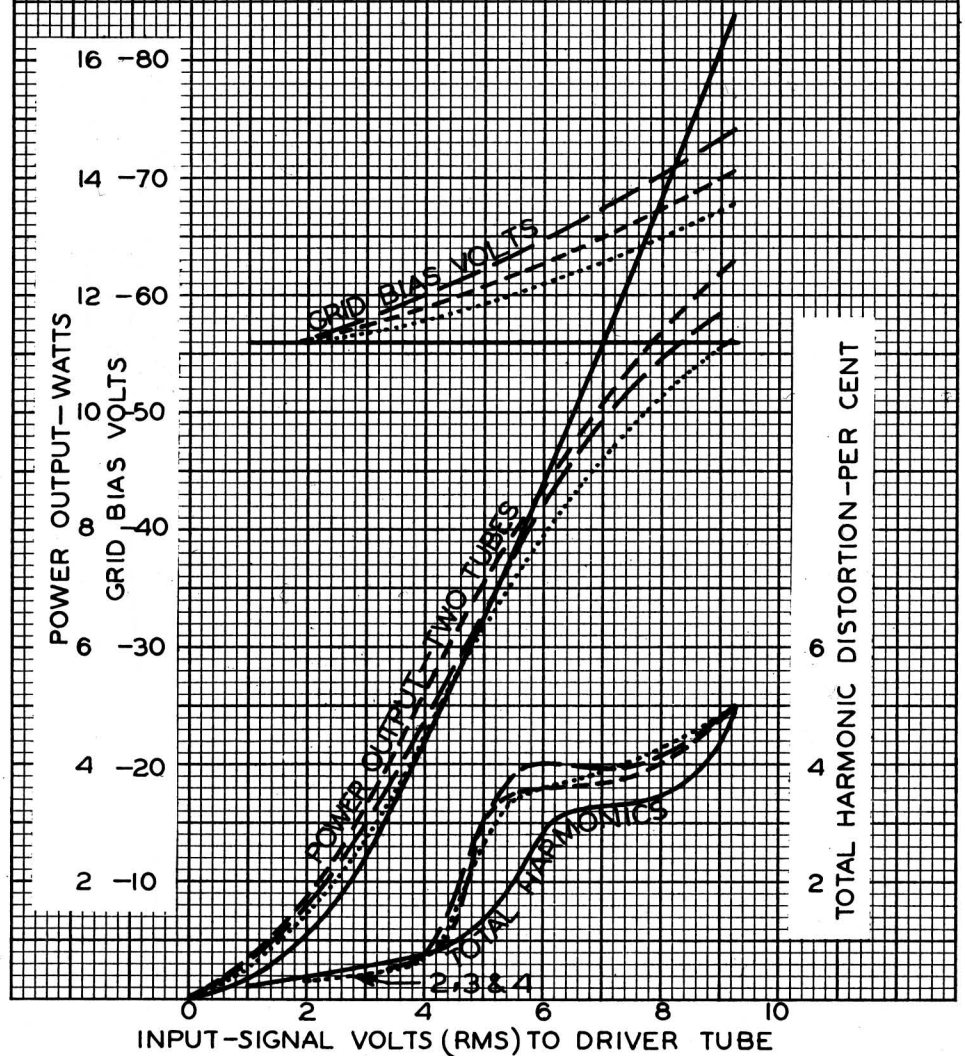

FIG. 4D

OPERATION CHARACTERISTICS
PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE : CLASS A DRIVER-ONE TYPE 59 AS TRIODE
PLATE VOLTS = 250 GRID VOLTS = −28

OUTPUT STAGE : TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY HAVING ZERO RESISTANCE
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS RESISTOR (R_C) OF 775 OHMS
MAX.-SIGNAL BIAS VOLTS = −75
OUTPUT LOAD, PLATE TO PLATE = 7350 OHMS

INTERSTAGE TRANSFORMER : VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 1.33

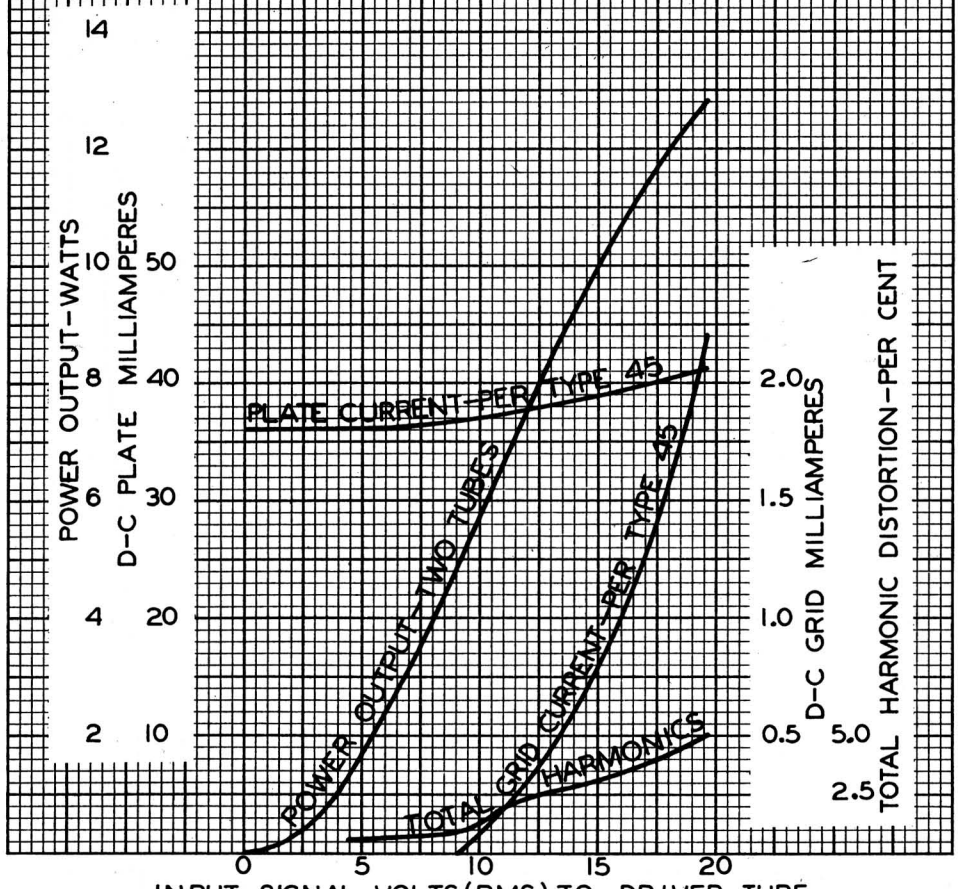

FIG. 5A

45

OPERATION CHARACTERISTICS

PUSH-PULL ARRANGEMENT WITH GRID CURRENT

E_f = 2.5 VOLTS A.C.

INPUT STAGE : CLASS A DRIVER-TWO TYPE 59 AS TRIODES
PLATE VOLTS = 250 GRID VOLTS = −28
PLATE-TO-PLATE LOAD = 41200 OHMS

OUTPUT STAGE : TWO TYPE 45
ZERO-SIGNAL PLATE VOLTS = 275, FROM SUPPLY HAVING ZERO RESISTANCE
ZERO-SIGNAL BIAS VOLTS = −56, FROM GRID-BIAS RESISTOR (R_C) OF 775 OHMS
MAX.-SIGNAL BIAS VOLTS = −76
OUTPUT LOAD, PLATE TO PLATE = 6020 OHMS
PEAK INPUT-SIGNAL VOLTS PER TUBE = 118.8
PEAK GRID POWER INPUT PER TUBE = 1.94 WATTS
HIGHER-ORDER HARMONICS (10% OF 5TH AND ABOVE) DO NOT EXCEED 3.93%

INTERSTAGE TRANSFORMER : VOLTAGE RATIO $\frac{\text{PRIM.}}{1/2\ \text{SEC.}}$ = 2.42
PEAK PLATE EFFICIENCY = 92%

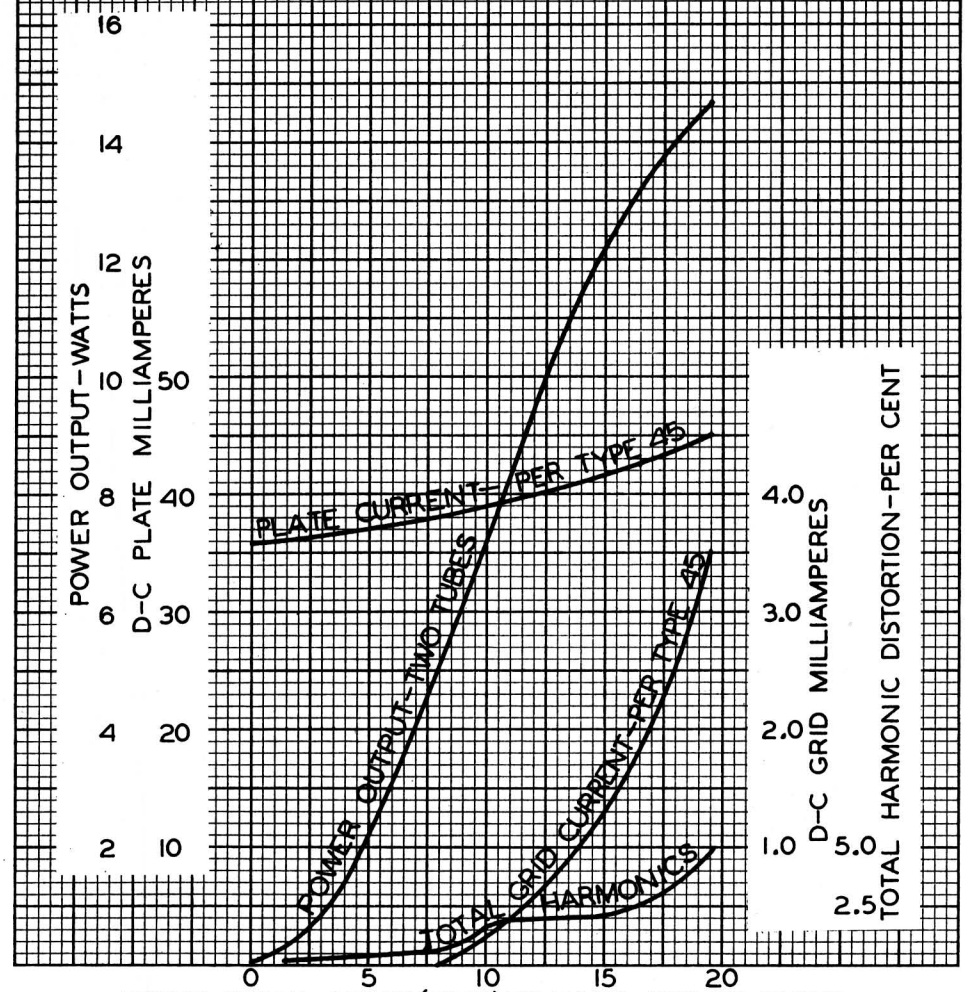

FIG. 5B

MAY 28, 1934 RCA RADIOTRON COMPANY, INC. 925—5522