APPENDIX

FUNDAMENTAL PROPERTIES OF VACUUM TUBES

The major dynamic operating characteristics of a vacuum tube can be expressed in terms of the amplification factor (μ), the dynamic plate resistance (r_p) and the transconductance (g_m). When they are known, quantitative calculations may be made of tube performance under many conditions.

These properties are interrelated as follows:

$$\mu = r_p \, g_m$$

The **amplification factor** is defined as the ratio of a small change in plate voltage to a corresponding change in grid voltage necessary to keep the plate current constant.

$$\text{Then: } \Delta E_b = \mu \, \Delta E_g$$

The dynamic **plate resistance** (r_p) may be defined as the ratio of a small change in plate voltage to a corresponding small change in plate current produced, with grid voltage remaining constant. It represents the resistance between cathode and plate to alternating current.

The **transconductance** (g_m) is the ratio of a change in plate current with respect to a change in grid voltage when the other voltages remain constant. The unit of transconductance is the mho (ohm spelled backward), but as this is a large unit for application to vacuum tubes, the one millionth part of a mho, or μmho, is generally used.

Direct Interelectrode Capacitances are measured in vacuum tubes rather than total capacitances which are the sum of two or more direct capacitances, so that their effect on circuit operation may be estimated.

It is standard practice to connect all metal parts except input and output electrodes to the cathode unless otherwise specified. These parts include external and internal shields, base sleeves, unused pins, etc., but do not include inactive section(s) of multiplex tubes—these are connected to ground.

TABLE OF CONNECTIONS OF ELECTRODES OF TUBE SECTIONS FOR MEASURING DIRECT INTER-ELECTRODE CAPACITANCES

Capacitance	Measure Between	Ground
INDIRECTLY HEATED CATHODE TYPES		
Heater-Cathode	Heater and Cathode	All other electrodes
DIODE TYPES		
Input	Plate and (cathode + fil. + shields, etc.)	Other Sections
TRIODE, TETRODE PENTODE TYPES		
Grid-Plate	Grid and plate (Cgp)	All other electrodes
Input	Grid and (cathode + fil. + screen + shields, etc.)	Plates, diodes, inactive section
Output	Plate and (cathode + fil. + screen + shields, etc.)	Grid, diode, inactive section(s)
Input (Grounded Grid) (Receiving Tubes ONLY)	Cathode and (grid + fil. + screen + shields, etc.)	Plate, diodes inactive section(s)
Output (Grounded Grid) (Receiving Tubes ONLY)	Plate and (Grid + fil. + screen + shields, etc.)	Cathode, diode inactive section(s)

TABLE OF CONNECTIONS OF ELECTRODES OF TUBE SECTIONS FOR MEASURING DIRECT INTER-ELECTRODE CAPACITANCES

Capacitance	Measure Between	Ground
	CONVERTER TYPES	
R F Input	Signal grid and all other electrodes	
Mixer Output	Mixer plate and all other electrodes	
Osc. Input	Osc. grid and (Cathode + fil. + shields, etc.)	Osc. plate + other section(s)
Osc. Output	Osc. plate and (cathode + fil. + shields, etc.)	Osc. grid and other section(s)

Useful References

IRE 7. S1 Standards on Electron Tubes:
Definition of Terms, 1950
ASA C60.6-1952 and RETMA ET-109A Direct Interelectrode Capacitance, Measurement of
ASA C60.5-1952 and IRE 7. S2 Electron Tubes, Methods of Testing

VACUUM TUBE RATINGS

At the present time, there are two general types of ratings used in the field of receiving type vacuum tubes. These ratings are normally referred to as Design Center and Absolute Maximum ratings. Commercial receiving types normally carry a Design Center rating, while government and some special purpose types may carry an Absolute Maximum rating.

A rating is a statement giving the limiting value of a tube parameter beyond which the performance and/or life of a tube will be deleteriously affected; or it is a statement giving the value of a tube parameter under certain operating conditions.

In the **Design Center system,** the maximum rating is based on the performance of a homogeneous lot (at center supply voltage) of tubes operating so that a tube having centered characteristics will be run at the rated maximum. This, of course, means that some tubes will be operating under the rating while others will be operating above the rating. The data substantiating the rating must, of course, include all tubes from the minimum to the maximum. Providing the circuit parameters are so adjusted as to assure that the average tube does not exceed the allowable maximum under nominal line conditions, satisfactory tube life may, in general, be expected. For more detailed information, see RETMA Engineering Standard M8-210.

The **Absolute Maximum system** makes no allowance for the normal spread of tube characteristics and merely states that under no circumstances should any tube exceed the rating. This puts the burden of proof on the circuit designer to make certain that the maximum is not exceeded for any tube under any circumstance.

Vacuum tube specifications set forth the allowable characteristic spreads and inspection instructions, of which the best known are the military services' MIL-E-IB specifications for JAN tubes. The most desirable situation would be one where each tube was tested in all applications and accepted or rejected upon its operational function. As this is impossible, the tube is tested to a specification which, to the specification engineer's best knowledge, will assure satisfactory performance in the majority of applications and is still realistic from a tube production standpoint.

Useful References

RETMA Engineering Standard M8-210,
RETMA Engineering Standard ET-107:
Test Methods and Procedures for Radio Receiving Tubes
IRE 7. S2 Standards on Electron Tubes:
Methods of Testing, 1950.
MIL-E-IB Specifications—Basic Section.

VACUUM TUBE RATINGS FOR TELEVISION APPLICATIONS

Television receiver sweep circuits require classes of tube operation and ratings uncommon to other applications. These ratings and their relationship to the ratings established for Class A operation are outlined below.

I. HORIZONTAL DEFLECTION AMPLIFIERS

(a) **Maximum D C Plate Voltage.** This rating is generally expressed as the sum of the d c power supply voltage and boost voltage.

(b) **Maximum Peak Positive Pulse Plate Voltage.** This rating is based on actual voltage breakdown considerations at the frequency, duty cycle and supply impedances of the horizontal amplifier stage. This value is expressed as an absolute maximum.

(c) **Maximum Peak Negative Pulse Plate Voltage.** This rating is intended to protect the tube from failure caused by plate emission at the time the plate swings negative with respect to cathode.

(d) **Maximum Peak Negative Grid No. 1 Voltage.** The peak negative grid No. 1 voltage rating is based upon grid to cathode leakage considerations and application requirements.

(e) **Maximum Plate Dissipation.** The maximum plate dissipation rating is determined on the same basis used for establishing the plate dissipation rating for Class A service. The measurement of plate dissipation when the tube is used as a horizontal deflection amplifier is difficult. Comparison methods are considered acceptable. Comparison methods are defined as those in which the temperature of the plate or a factor which is a function of the temperature of the plate is first measured operationally. The plate dissipation is then determined by the static power input to the plate necessary to duplicate temperature, or other factors so measured holding other elements and ambient temperature at the operational value.

(f) **Maximum Average Cathode Current.** This rating is based on the same considerations as those used in establishing the maximum average cathode current for Class A service.

(g) **Maximum Peak Cathode Current.** This rating is a multiple of the average cathode current rating, based on application requirements, with due consideration given to cathode capabilities at the typical duty cycle and the repetition rate encountered in this service.

(h) **Maximum Grid No. 1 Circuit Resistance.** The value of Grid No. 1 circuit resistance is based upon the requirements of the application and limitations of the tube with respect to gas and grid emission.

II. VERTICAL DEFLECTION AMPLIFIERS

(a) **Maximum D C Plate Voltage.** The maximum d c plate voltage rating is determined on the same basis as used for establishing the maximum d c plate voltage rating for Class A service.

(b) **Maximum Peak Positive Pulse Plate Voltage.** This rating is based on actual voltage breakdown, considerations at the typical duty cycle and supply impedances of the vertical amplifier stage. This rating is expressed as an absolute maximum.

(c) **Maximum Peak Negative Pulse Grid No. 1 Voltage.** This rating is based upon grid-cathode leakage and application requirements.

(d) **Maximum Plate Dissipation.** This rating is determined on the same basis as used for establishing plate dissipation ratings for Class A service as defined under I(e).

(e) **Maximum Average Cathode Current.** This rating is based on the same considerations as those used in establishing the maximum average cathode current for Class A service.

(f) **Maximum Peak Cathode Current.** This rating is based on application requirements with due consideration being given to the limitations of the cathode at the duty cycle and repetition rate encountered in this service.

(g) **Maximum Grid No. 1 Circuit Resistance.** The maximum grid No. 1 circuit resistance rating is based on the requirements of the application and the limitations of the tube with respect to gas and grid emission.

III. HORIZONTAL AND VERTICAL DEFLECTION OSCILLATORS

(a) **Maximum D C Plate Voltage.** The maximum d c plate voltage rating is determined on the same basis as used for establishing the maximum d c plate voltage rating for Class A service.

(b) **Maximum Plate Dissipation.** This rating is determined on the same basis as used for establishing plate dissipation ratings for Class A service as defined under I(e).

(c) **Maximum Average Cathode Current.** This rating is based on the same considerations as those used in establishing the maximum average cathode current for Class A service.

(d) **Maximum Peak Cathode Current.** This rating is a multiple of the average cathode current rating based on application requirements with due consideration given to cathode capabilities at the typical duty cycle and repetition rate encountered in this service.

(e) **Maximum Grid No. 1 Circuit Resistance.** The value of Grid No. 1 circuit resistance is based upon the requirements of the application and limitations of the tube with respect to gas and grid emission.

IV. DAMPERS

(a) **Maximum Peak Inverse Plate Voltage Rating.** This rating is based on actual voltage breakdown at the typical duty cycle frequency and supply impedances encountered in the horizontal deflection circuit. This rating is shown as an absolute maximum value.

(b) **Maximum Heater Cathode Voltage.** When the heater is operated negative with respect to cathode, most damping diodes are capable of withstanding high voltages between the heater and cathode. The values shown for heater negative with respect to cathode include the d c, and total d c and peak values based on actual breakdown considerations.

For heater positive with respect to cathode the permissible heater-cathode voltage is comparative in magnitude to that of other types.

(c) **Maximum D C Plate Current.** This rating is based on capabilities of the cathode.

(d) **Maximum Peak Plate Current.** This rating is based on cathode capabilities for this service.

(e) **Maximum Plate Dissipation Rating** The maximum plate dissipation rating is based on the physical limitations of the tube and is determined in application by comparison methods as outlined in I(e).

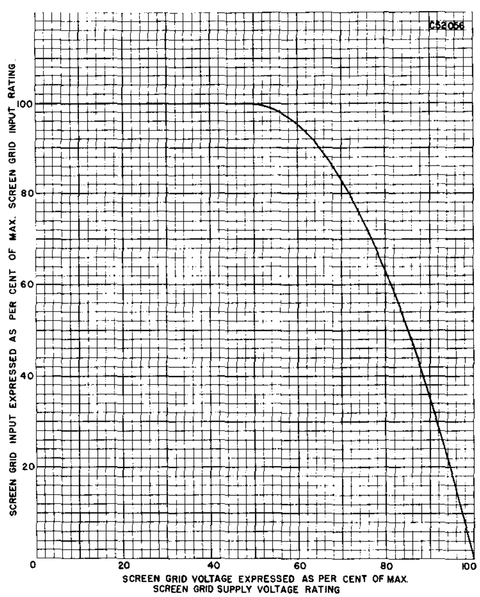
NOTE: Power rectifier ratings are not incuded for damping diodes. The high plate supply impedance required to limit steady state peak plate current and the plate dissipation to rated values makes such usage impractical.

RECEIVING TUBE SCREEN VOLTAGE RATINGS*

The voltage for the screen of a tube may be obtained from either a fixed source or through a screen dropping resistor. A voltage source is considered "fixed" if the regulation is such that no significant change in voltage takes place with variations in current.

The tube data sheets may show a maximum screen voltage, or a maximum screen supply voltage. When a maximum screen voltage is shown, the voltage measured at the screen terminal should not exceed such value under any circuit operating condition. When a maximum screen supply voltage is shown the screen voltage may be permitted to reach the rated supply voltage provided that the screen dissipation (screen current in amperes multiplied by the voltage appearing directly at the screen terminal) is held within certain specified values as indicated in Chart A.

CHART A



The chart represents the maximum permissible screen dissipation (as a percent of the maximum screen dissipation rating) at any screen voltage operating point. The chart shows that full rated screen dissipation is permissible up to 50% of the maximum rated screen supply voltage. From the 50% point to the full value of rated supply voltage the decrease in the allowable screen dissipation follows a curve of the parabolic form. The chart is of universal use for cases where either a fixed screen voltage or a series screen dropping resistor is used.

In the case where fixed screen applied voltage is desired it is necessary only to determine that the screen dissipation is within the boundary of the chart at the screen voltage to be used. In the case where a screen voltage dropping resistor is to be used it is necessary to determine the resistor value such that the dissipation in the screen grid is again within the same boundary of the chart. It is to be noted that the minimum value of the voltage dropping resistor is given by the factor.

$$\frac{E_{cc2}^2}{4\ P_{g2}}$$

where E_{cc2} is the selected screen supply voltage and P_{g2} is the maximum screen dissipation rating for the type.

To illustrate the use of the chart, let it be assumed that the tube data for a type stipulate ratings of 300 volts maximum screen supply voltage, and 1.0 watt maximum screen dissipation. If it is desired to operate the tube at 200 volts (66⅔% of the maximum screen supply voltage rating) applied directly to the screen, the maximum allowable screen dissipation at this point (refer to Chart A) is 88% of the maximum screen dissipation, or 0.88 watt.

On the other hand, if it is desired to operate the same tube with a screen dropping resistor, the maximum screen voltage must not exceed the 300 volt rating, and the dropping resistor must be selected to hold the dissipation within the safe ratings. To assure that the tube will operate within the rating curve the dropping resistor can be determined from the formula

$$R_{c2} \geq \frac{E_{cc2}^2}{4\ P_{g2}}$$

where R_{c2} is the screen dropping resistor (ohms),
E_{cc2} is the selected screen supply voltage (volts),
P_{g2} is the maximum screen dissipation rating (watts).

For example, if a screen supply voltage of 250 volts were selected for the above cited tube type

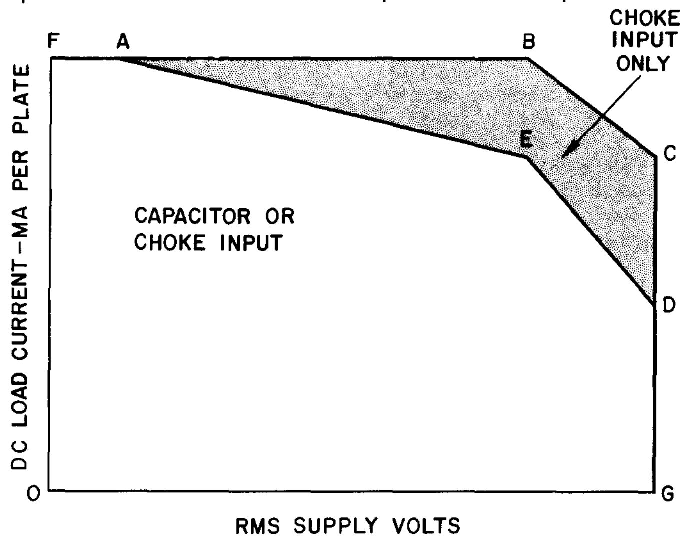
$$R_{c2} \geq \frac{250^2}{4 \times 1.0} = \frac{62500}{4} = 15625 \text{ ohms}$$

**This material was formulated by the Committee on Receiving Tubes of the Joint Election Tube Engineers Council and approved by the Council as JETEC Data.*

RECEIVING TUBE RECTIFIER RATINGS*

Ratings of rectifier tubes are based upon fundamental limitations in the operation of the tubes. In general, the limitations are peak inverse plate voltage, transient peak plate current, steady state peak plate current, D C output current, and (for types with indirectly heated cathodes) heater-cathode voltage. Maximum ratings for such parameters are included in the JETEC Tube Data. The various maximum ratings are generally not attainable simultaneously.

Certain of the limitations of operation are interrelated so that operation more lenient for one parameter will permit more severe conditions of operation in other respects. In order to define the boundaries of permissible operation, the JETEC Data for a rectifier type include a chart of the allowable D C load current per plate for values of RMS supply volts per plate up to the maximum rated value, for operation under conditions of either capacitor or choke input.



Where the tube is operated with choke input to the filter, the permissible D C Load Current vs RMS Supply Voltage operating point must fall within the area OFABCDGO. If capacitor input to the filter is used, the permissible D C Load Current vs RMS Supply Voltage operating point must fall within the area OFAEDGO.

**This material was formulated by the Committee on Receiving Tubes of the Joint Election Tube Engineers Council and approved by the Council as JETEC Data.*

SERIES STRING TELEVISION

Sylvania provides the set manufacturer with a complete line of tubes specifically designed for series string operation in television receivers.

As with radio receivers, the advantages of series heater operation include elimination of a transformer winding for the heater supply, with probable substitution of a voltage doubler rectifier circuit for the low voltage B supply winding. Thus, the power transformer can be eliminated altogether, if desired.

All the types included in the series string line incorporate 600 ma heaters, permitting series string operation without parallel networks.

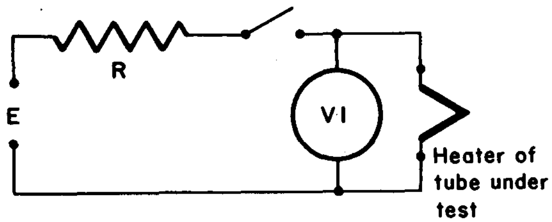
To insure proper steady-state operating voltages, heater current production tolerances have been reduced from ± 50 ma for standard receiving tubes to ± 25 ma for all series string types. Slight variations in individual heater voltages will still be present in series strings. However, the magnitude of these variations should be relatively unimportant in properly designed circuits.

At present, the generally accepted method of controlling thermal characteristics in production is by a "heater warm-up time" test. In this test, the measured time is that required for a heater, originally at room temperature, to reach 80% of its rated heater voltage after four times the rated voltage is applied to the heater in series with a fixed resistor. The fixed resistor is specified as three times the hot resistance of the tube's heater. For all types included in the new line of 600 ma tubes, the heater warm-up time in the test described is approximately 11 seconds. This figure should not be confused with the time required for the receiver to become operative.

With respect to receiver warm-up time, tests on experimental models employing new series string tubes and a fixed series resistor in place of a thermistor, have shown that a normal raster will appear 45 to 55 seconds after power is applied. This time is still somewhat longer than that required by a transformer type receiver. However, it represents approximately one-third the time required for stable operation of a receiver utilizing a thermistor.

Picture tubes for series heater strings have not been introduced as a separate line. Television picture tubes intended for transformer operation incorporate a design center heater current rating of 600 ma and have relatively high heater-cathode voltage ratings. Narrowing of heater current limits, in agreement with the newly developed receiving tubes (600 $\pm$25 ma) and control of thermal characteristics in production, provide the necessary protection against failure due to surge voltages or improper steady state voltage distribution.

Heater warm-up time is defined as the time required in the circuit shown below for the voltage across the heater terminals to increase from zero to the heater test voltage (V1). The conditions used in conjunction with the test circuit depend upon the rated heater voltage and current of the tube under test as indicated in the table which follows.



E —Applied Voltage, R M S or D C
R —Total Series Resistance
V1—Heater Test Voltage, R M S or D C (V1 = 80% of Ef)
Ef—Rated Heater Voltage of Tube Under Test
If —Rated Heater Current of Tube Under Test
T —Approximate Warm-up Time in Seconds

TABLE I

Ef Volts	If Amperes	E Volts	R Ohms	VI Volts	T
2.35	0.6	9.4	11.8	1.9	11.0
3.15	0.6	12.5	15.8	2.5	11.0
3.5	0.6	14.0	17.5	2.8	11.0
4.2	0.6	16.8	21.0	3.33	11.0
4.7	0.6	18.8	23.6	3.75	11.0
6.3	0.6	25.0	31.5	5.0	11.0
8.4	0.6	33.6	42.0	6.72	11.0
12.6	0.6	50.0	63.0	10.0	11.0
18.9	0.6	75.6	94.5	15.1	11.0
25.0	0.6	100.0	125.0	20.0	11.0
28.0	0.6	112.0	140.0	22.4	11.0

AMPLIFIER CLASSIFICATION

All radio receiving tubes except the rectifiers may be conveniently considered as amplifiers. Oscillators and detectors or frequency converters may be thought of as special cases of amplifiers in which use is made of the non-linear relations between the input voltages and output currents of the tube under consideration.

There are three major classes of amplifier service. Definitions describing these have been standardized by the Institute of Radio Engineers.

Class A Amplifier

A Class A, or Class A1, amplifier is one in which the grid bias and signal voltages are such that plate current in the tube, or in each tube of a push-pull stage flows at all times.

This is accomplished by operating at the center point of the plate current vs. grid voltage curve and using signal voltages which do not drive the grid into either the positive region or into the sharp bend near cut-off voltage.

Class A2 Amplifier

A Class A2 amplifier is the same as a Class A1 amplifier except that the signal may drive the grid into the positive region. This is accomplished by operating at a lower bias than the center point which would have been selected for class A operation.

Class B Amplifier

A Class B amplifier is an amplifier in which the grid bias is approximately equal to the cut-off value, so that the plate current is approximately zero when no signal voltage is applied and so that plate current in the tube or in each tube of a push-pull stage, flows for approximately one-half of each cycle when an alternating grid voltage is applied.

An important characteristic is that the grid circuit draws appreciable power which prevents it from being used with ordinary resistance coupled driver tubes.

Class AB1 Amplifier

A Class AB1 amplifier permits greater output to be obtained from small tubes, but requires push-pull operation to reduce distortion. It is characterized by operation at a higher bias than for Class A and uses a signal large enough to drive the grid into the cut-off region but not into the positive region.

Class AB2 Amplifier

A Class AB2 amplifier is the same as a Class AB1 above except that additional bias may be used, and the signal drives the grid into both the cut-off and grid current regions.

Class C Amplifier

A Class C amplifier is one in which the tubes operate at a bias much greater than cut-off voltage so that plate power is drawn only on the peaks of the signal voltage. It is not used in audio amplifiers because the distortion is too high but is the most efficient circuit for R. F. power amplifiers where the harmonics can be reduced by use of resonant circuits.

USE OF CURVES

The plate characteristic: The plate characteristic curves of a typical beam power tube are shown below in Fig. 1. These curves represent plate current plotted against plate voltage for specific values of grid bias and screen grid voltages. A group of such curves with various grid bias voltages is called a plate family. Plate characteristics are the most widely used since most of the other important tube characteristics may be derived from such a family of curves.

Curves shown in the tube manual represent average values and since variations occur from tube to tube during manufacturing processes, it is always advisable to leave a safety margin when using the curves for calculations.

In general, the plate characteristic is shown for only one value of screen grid voltage and various values of grid bias, although in some cases the curves are plotted using one value of grid bias for several different values of screen grid voltages. In the former case, if any other value of screen voltage is to be used then a new plate family must be plotted. Use of the tube manual curves necessitates applying the screen voltage shown on the graph.

An example will be shown here involving the use of plate characteristics for calculating approximately the power output, efficiency, and second and third harmonic distortion in a single tube Class A audio power output amplifier using a Type 6V6GT.

The first step in this example will be to locate the operating point which will indicate the value of E_b and I_b with zero applied signal. It is general practice to use the typical operating conditions as a guide and, in the case of the 6V6GT, it will be noted that there are three columns under Typical Operation for a Class A_1 Amplifier (one tube). Whichever column one intends to use will be dependent upon the supply voltage available, the power output desired, and the amount of distortion that may be tolerated. This example will use the center column.

The plate voltage (E_b) and grid voltage (E_{c1}) listed located the operating point and these are 250 V. and —12.5 V., respectively. This point is designated by 0 in Fig. 1.

For a Class A power amplifier to operate properly it is necessary to carefully proportion the load impedance and signal voltage with respect to the operating point. This is easily done with a load line which represents the locus of all corresponding instantaneous values of plate current and plate voltage assumed during the grid voltage cycle. The slope of the load line is determined solely by the load resistance (R_L).

$$(1)\ \text{Slope} = -\frac{1}{R_L}$$

Since the load line must lie on the operating point, its location is readily established knowing the value of R_L because the load line must also intersect the voltage axis at zero plate current. Therefore,

Where $E'_{max.}$ = point of load line intersection with voltage axis
I_b = plate current at operating point
E_{bb} = d c supply voltage
R_L = 5000 ohms

$$(2)\ E'_{max.} = (I_b R_L + E_{bb}) = 45 \times 10^{-3} \times 5000 + 250 = 475\ \text{V.}$$

This gives a second point through which the load line must pass. Other values of R_L, E_b and E_{c1} could be selected provided the rated maximum screen and plate dissipations are not exceeded.

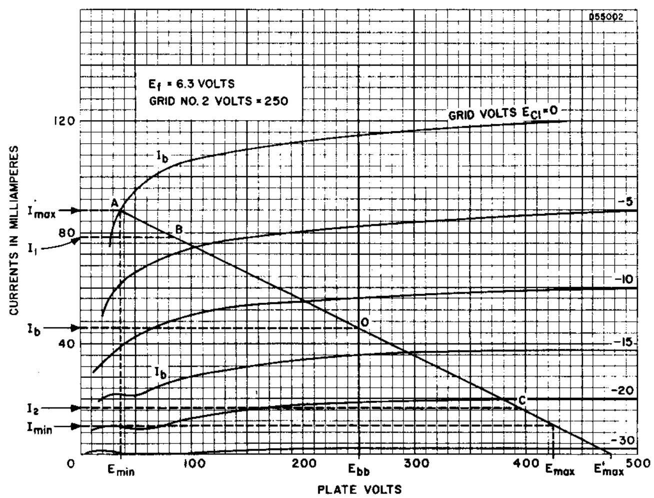


FIGURE 1

For Class A_1 Amplifier type of operation, it is not advisable to use a peak-to-peak grid driving signal greater than twice the bias at the operating point, otherwise the grid will be driven positive resulting in excessive distortion. The following calculations, therefore, will be based upon maximum signal conditions, or, in other words, the grid will be driven to zero but not beyond. The load line on the plate characteristic of Fig. 1 then is shown to extend from the $E_{c1} = O$ Volts curve (Point A) down to the curve where $E_{cl} = -25$ V. (Point D). The range over which the tube operates is indicated and the values for $E_{min.}$, $E_{max.}$, and $I_{min.}$, $I_{max.}$ are located. These are the instantaneous minimum and maximum values of plate voltage and plate current reached over the complete cycle.

A simple but approximate means for calculating power output and second and third harmonic distortion is to use the five selected ordinate method. This method uses only five points on the load line and for the example here, three have already been located (A, O and D). The other two necessary points (B and C) are determined by formula (3).

(3) E_{c1} for $I_1 = 0.293$ V.
E_{c1} for $I_2 = 1.707$ V.
Where $V = E_{cl}$ at operating point

Formulas (4) to (8) may be used for calculating power output, distortion, and plate efficiency.

(4) Power Output $= \frac{R_L}{32}\left[\sqrt{2}\,(I_1 - I_2) + I_{max.} - I_{min.}\right]^2$

(5) % 2nd Harmonic Distortion $= \frac{I_{max.} + I_{min.} - 2\,I_b}{I_{max.} - I_{min.} + \sqrt{2}\,(I_1 - I_2)} \times 100$

(6) % 3rd Harmonic Distortion $= \frac{I_{max.} - I_{min.} - \sqrt{2}\,(I_1 - I_2)}{I_{max.} - I_{min.} + \sqrt{2}\,(I_1 - I_2)} \times 100$

(7) % Total Harmonic Distortion $= \sqrt{(\%\ 2nd)^2 + (\%\ 3rd)^2}$

(8) Plate Efficiency $= \frac{P_o}{P_{in}} \times 100$ where $P_{in} = E_b I_b$

The value of power output obtained from the formula given will be less than the published value since it does not include power supplied from the 3rd harmonic content.

By using the values from Figure 1 and the above formulas the following results are obtained:

From (4) $P_o = 4.3$ watts

From (5) % 2nd Harmonic Distortion = 4.8%

From (6) % 3rd Harmonic Distortion = 5.7%

Where $E_{max.} = 425$ V. $E_{min.} = 38$ V.
$I_{max.} = 88$ Ma $I_{min.} = 10$ Ma
$I_1 = 78$ Ma. $I_2 = 16$ Ma

The illustration on use of curves presented here assumes that (1) fixed bias is used, (2) the load is resistive, (3) that good screen and plate regulation are used, (4) that rectification effects are negligible, (5) that a high efficiency output transformer is used and has been selected to present the proper load to the tube, (6) that the voltage drop in the primary of the output transformer is negligible, (7) the applied signal is sinusoidal. Despite these assumptions, reasonably good approximations may be obtained about the performance of the tube described as Class A_1 audio power output amplifier. Figure 2 shows one possible power amplifier circuit that could be used for a beam power tube applicable to the example given. The power supplied to the speaker will be less than that calculated by the amount of transformer efficiency.

R_L = effective impedance of the load R_l which is reflected back to the primary of the transformer and its value is:

$$(9) \quad R_L = R_l \left(\frac{N_1}{N_2}\right)^2$$

Where $\frac{N_1}{N_2}$ is the transformer (T) primary to secondary turns ratio, and R_l is the loudspeaker load.

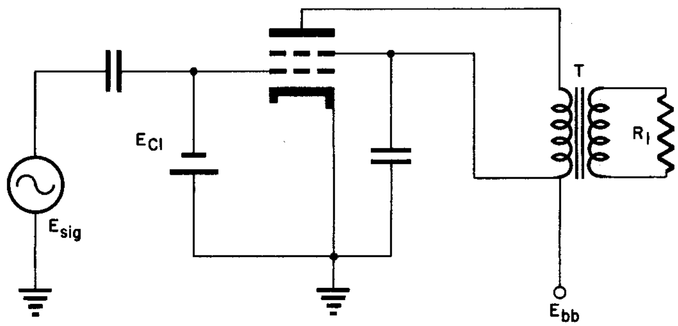


FIGURE 2

This illustration represents only one of the many possible uses for calculating tube performance with characteristic curves.

When it is desirable to use a cathode resistor for bias this may be computed from knowledge of the bias value and the sum of the plate and screen currents (given under Typical Operation).

$$(10) \quad R_k = \frac{E_{c1}}{I_{c2} + I_b}$$

For the 6V6GT the bias at the operating point is known to be —12.5 V. and the sum of plate and screen currents is 49.5 Ma (total cathode current) at the operating point.

$$\text{From (10)} \quad R_k = \frac{12.5 \text{ V.}}{49.5} = 250 \text{ ohms}$$

For more exact calculations of power output, the cathode resistance voltage drop should be subtracted from the power supply voltage to give the correct plate supply voltage.

TUBE AND BASE DIAGRAM SYMBOLS

A —Anode
Dp —Diode Plate
F —Filament
Fc —Filament Center Tap
G —Grids numbered according to their position from the cathode
H —Heater
Hc —Heater Center Tap
Ht —Heater Tap
IC —Internal Connection
IS —Internal Shield
J —Jumper
K —Cathode
NC—No Connection
P —Plate
S —Metal Shell
SA —Starter Anode
T —Target
XS —External Shield
□ —Top Cap
■ —Locating Key

INSTALLATION AND HANDLING OF TELEVISION PICTURE TUBES AND LARGE CATHODE RAY TUBES

The installation and handling of television picture tubes and other large cathode ray tubes must be undertaken with considerable care. Picture tubes are large structures made up very largely of glass and inclosing an evacuated space. They should be handled carefully and protected from severe shock. The normal precautions used when working with any high voltage circuits should be observed. The proper procedures and precautions are presented below.

Mechanical Handling

1. Protective face shield or goggles and gloves should be worn, for personal safety, whenever handling large picture tubes.

2. Picture tubes should be removed from the shipping carton face up and supported by the sides of the large portion of the tube. Handling of large picture tubes by the neck is unsafe and should be avoided at all times. It is obviously the weakest part of the tube and most easily injured. Therefore, the neck should always be kept free of strain and protected from striking other objects.

3. Picture tubes should be inserted into sockets by supporting the tube at the large end and holding the neck only for guiding the base pins into the socket.

4. The tubes should be removed from their sockets in the same manner as they are inserted, supported at the large end.

5. When not installed in a television receiver or other equipment, picture tubes should be stored in shipping cartons with the covers closed.

6. Avoid placing picture tubes on a table or bench where there is any possibility of the tube rolling off. This is very important.

7. Scratching the surface of a picture tube weakens the glass and may be the cause of the tube imploding. If it is necessary to place a tube elsewhere than in its shipping carton, a piece of felt or other soft material should be placed under it.

8. Picture tubes should be used for display purposes only after the vacuum seal has been broken. Economy dictates that only wornout, or otherwise worthless, tubes be used for this purpose. The vacuum seal may be broken in the following manner.

   A. Place the tube in a shipping carton, face down, with enough soft packing material underneath so that the base will extend above the closed cover.

   B. Drill a ¼-inch hole in the end of the locating lug or break off the lug entirely with a sharp blow or with pliers.

   C. Using a small file or cutting pliers, make a small hole at the tip of the exhaust tube. Care should be used to make a small hole in the tip so that air will enter the tube slowly and not disturb the screen coating. In tubes using a metal exhaust tube a small three-cornered file may be used to make a small hole. The bright getter deposit on the neck should change color almost immediately. As a precaution, some time after the small hole has been made, it is well to break off the tip completely. The tube cannot implode after the vacuum seal has been broken, but it should still be handled as carefully as any other glassware of equal weight.

9. Discretion should be exercised in the disposal of tubes which are no longer useful to avoid possible legal liability. A safe method of breaking up a tube for disposal is to place it in a carton, seal the carton, and drive a metal rod through the carton into the face of the side of the tube. The broken parts may then be disposed of in the usual manner.

10. If a tube does break causing small cuts in the skin, such cuts should be washed carefully to be certain that all dirt and other small particles are removed. While the materials used for coating Sylvania picture tubes are not considered to be toxic, there is the possibility of an unusual personal sensitivity or allergy in some persons.

Handling High Voltage Circuits

1. Stand on dry wood, a rubber mat, linoleum or other dry insulating material when working on any electrical circuit.

2. One hand should be kept in a pocket to reduce the effects of accidental shock.

3. Respect all safety interlock switches and be certain that they are in good working condition.

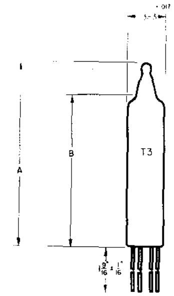
4. Be certain that high voltage condensers are discharged before working on the circuit. Bleeder resistors may be open.

5. Some picture tubes have a conductive coating on both the inside and outside surfaces to form a condenser. This condenser should be discharged before the tube is handled. Even a slight unexpected shock might cause a tube to be dropped.

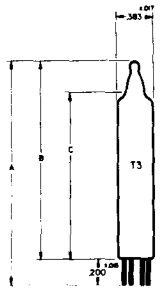
6. In some circuits where the picture tube operates with a voltage on its second anode higher than its specified maximum rating, or higher than 16,000 volts whichever is less, it is possible that low intensity X-rays may be emitted. Therefore, X-ray radiation shielding may be necessary to protect against possible danger of personal injury from prolonged exposure at close range if the tube is operated at such high voltages.

7. Take the time to be safe.

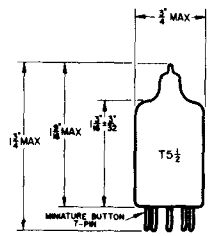
TUBE OUTLINES



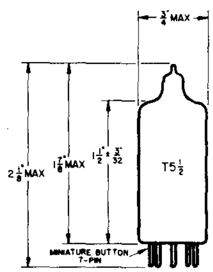
RETMA OUTLINE NUMBER	DIMENSIONS	
	A MAX	B ±.060"
3-1	1.375	1.075
3-2	1.500	1.200
3-3	1.750	1.450
3-4	2.000	1.700
3-8	1.625	1.325
3-11	1.250	.950



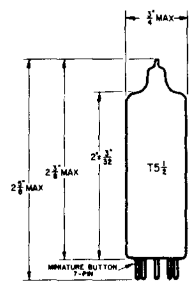
RETMA OUTLINE NUMBER	DIMENSIONS		
	A MAX	B MAX	C ±.060"
3-5	1.750	1.500	1.200
3-9	1.620	1.375	1.075
3-10	2.000	1.750	1.450
3-12	1.500	1.250	.950
3-13	1.875	1.625	1.325
3-14	2.125	1.875	1.575
3-15	2.250	2.000	1.700



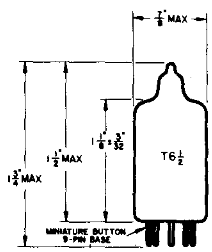
5-1



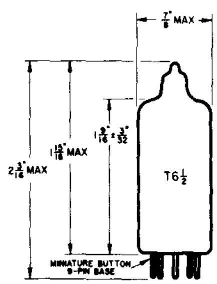
5-2



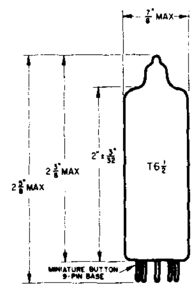
5-3



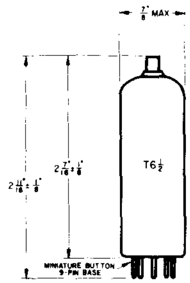
6-1



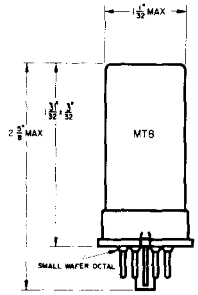
6-2



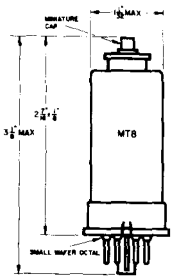
6-3



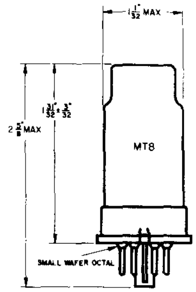
6A-2



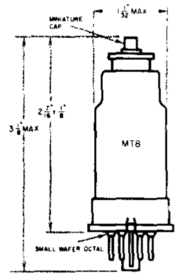
8-1



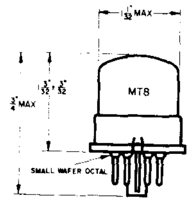
8-2



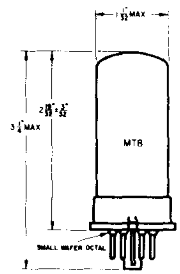
8-3



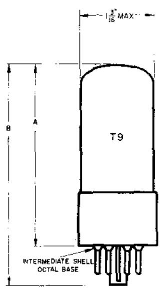
8-4



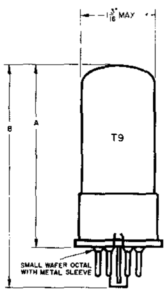
8-5



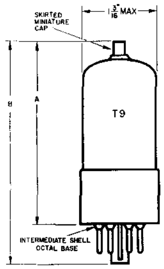
8-6



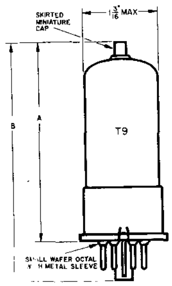
RETMA OUTLINE NUMBER	DIMENSIONS A MAX	DIMENSIONS B MAX
9-1	1 3/4"	2 5/16"
9-3	2 5/16"	2 7/8"
9-5	2 7/16"	3"
9-7	2 1/2"	3 1/16"
9-9	2 11/16"	3 1/4"
9-11	2 3/4"	3 5/16"
9-13	2 13/16"	3 3/8"
9-15	2 7/8"	3 7/16"
9-33	3 1/4"	3 13/16"



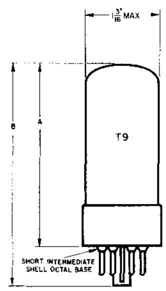
RETMA OUTLINE NUMBER	DIMENSIONS A MAX	DIMENSIONS B MAX
9-2	1 3/4"	2 5/16"
9-4	2 5/16"	2 7/8"
9-6	2 7/16"	3"
9-8	2 1/2"	3 1/16"
9-10	2 11/16"	3 1/4"
9-12	2 3/4"	3 5/16"
9-14	2 13/16"	3 3/8"
9-16	2 7/8"	3 7/16"



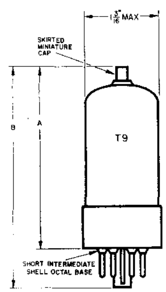
RETMA OUTLINE NUMBER	DIMENSIONS		
	A		B
	MIN	MAX	MAX
9-17	2 5/16"	2 3/4"	3 5/16"
9-19	2 5/16"	2 7/8"	3 7/16"
9-21	2 5/16"	2 15/16"	3 1/2"
9-23	2 5/16"	3"	3 9/16"
9-50	2 7/8"	3 5/16"	3 7/8"



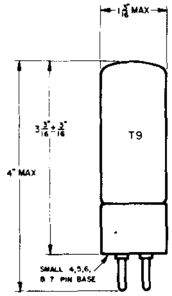
RETMA OUTLINE NUMBER	DIMENSIONS		
	A		B
	MIN	MAX	MAX
9-18	2 5/16"	2 3/4"	3 5/16"
9-20	2 5/16"	2 7/8"	3 7/16"
9-22	2 5/16"	2 15/16"	3 1/2"
9-24	2 5/16"	3"	3 9/16"



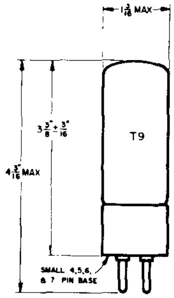
RETMA OUTLINE NUMBER	DIMENSIONS	
	A MAX	B MAX
9-36	1 3/4"	2 5/16"
9-37	2 5/16"	2 7/8"
9-38	2 7/16"	3"
9-39	2 1/2"	3 1/16"
9-40	2 11/16"	3 1/4"
9-41	2 3/4"	3 5/16"
9-42	2 13/16"	3 3/8"
9-43	2 7/8"	3 7/16"
9-44	3 1/4"	3 13/16"



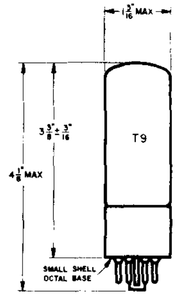
RETMA OUTLINE NUMBER	DIMENSIONS		
	A		B
	MIN	MAX	MAX
9-45	2 5/16"	2 3/4"	3 5/16"
9-46	2 5/16"	2 7/8"	3 7/16"
9-47	2 5/16"	2 15/16"	3 1/2"
9-48	2 5/16"	3"	3 9/16"
9-49	2 7/8"	3 5/16"	3 7/8"



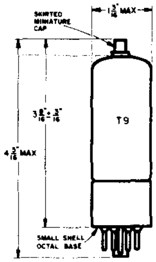
9-25



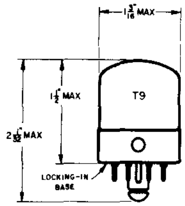
9-26



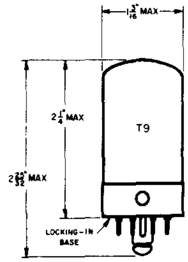
9-27



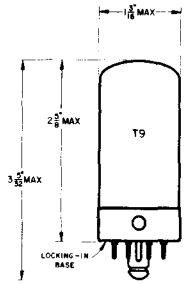
9-28



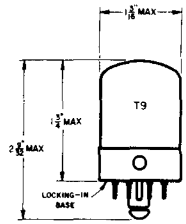
9-29



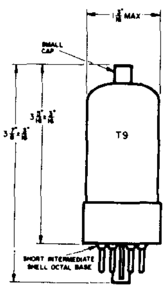
9-30



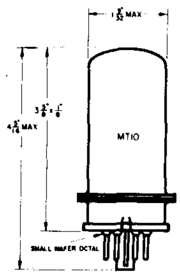
9-31



9-32

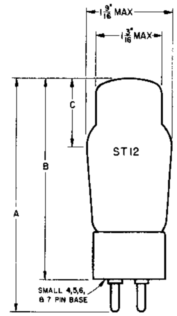


9-51

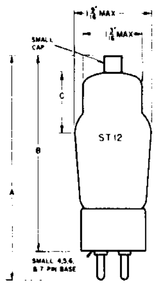


10-1

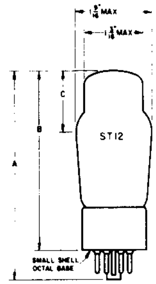
RETMA OUTLINE NUMBER	DIMENSIONS		
	A	B	C
12-1	4 19/32" MAX	3 25/32" ± 3/16"	1 5/16"
12-5	4 3/16" MAX	3 3/8" ± 3/16"	1 1/4"
12-2	4 15/16" MAX	4 3/16" ± 1/8"	1 5/16"
12-6	4 17/32" MAX	3 25/32" ± 1/8"	1 1/4"
12-3	4 17/32" MAX	3 25/32" ± 3/16"	1 5/16"
12-7	4 1/8" MAX	3 3/8" ± 3/16"	1 1/4"
12-4	4 7/8" MAX	4 5/32" ± 5/32"	1 5/16"
12-8	4 15/32" MAX	3 3/4" ± 5/32"	1 1/4"



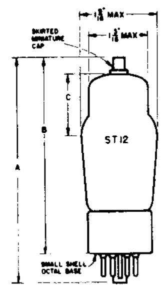
12-1
12-5



12-2
12-6

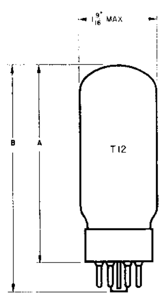


12-3
12-7

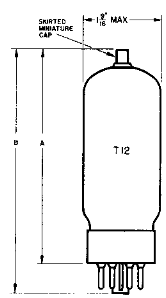


12-4
12-8

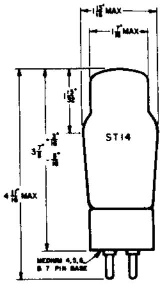
RETMA OUTLINE NUMBER	DIMENSIONS		
	A ± 3/16"	A MAX	B MAX
12-101		3 5/16"	3 7/8"
12-102		3 13/16"	4 3/8"
12-103		4 1/16"	4 5/8"
12-104		4 3/16"	4 3/4"
12-105	3 9/16"		4 1/4"
12-106	4 1/4"		5



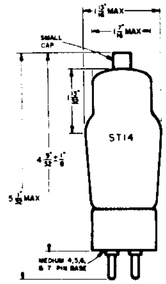
12-101
12-102
12-103
12-104



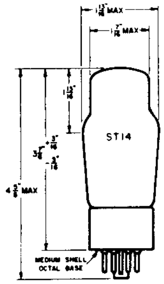
12-105
12-106



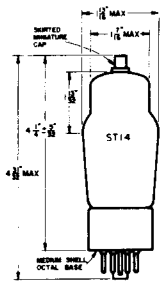
14-1



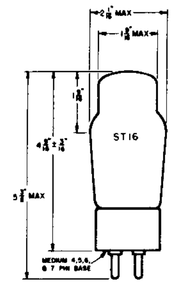
14-2



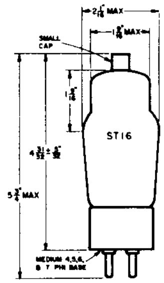
14-3



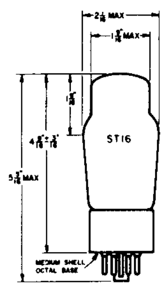
14-4



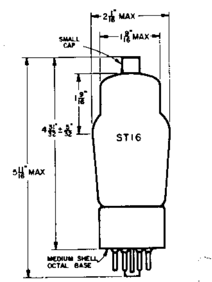
16-1



16-2



16-3



16-5

INDEX FOR RESISTANCE COUPLED AMPLIFIER SECTION

Sylvania Type	Chart Number	Sylvania Type	Chart Number
1L4	I	6ST7	XIII
1S5	II	6SU7GT	XIV
1SA6GT	III	6SZ7	VII
1U4	III	6T8	VII
1U5	II	6U8	XXII
2A6	XI	6W7GT	XII
6AD5GT	X	7A4	IX
6AN8	XX	7AJ7	XII
6AQ6	VII	7B4	X
6AQ7GT	XIV	7B6	XI
6AT6	VII	7C7	XII
6AU6	XXI	7E6	XIII
6AV6	X	7F7	XIV
6B6G	XI	7K7	XIV
6BF6	XIII	7N7	IX
6BH6	XIX	12AT6	VII
6BK6	XV	12AT7	XVII
6C4	IV	12AU7	IV
6C5GT	V	12AU7A	IV
6C6	XII	12AV6	X
6F5GT	X	12AV7	XVIII
6F8G	IX	12AX7	XV
6J5GT	IX	12AY7	XVI
6J7GT	XII	12BF6	XIII
6K5G	VII	12BK6	XV
6N7GT	VI	12SJ7GT	VIII
6Q7GT	VII	12SW7	XIII
6R7GT	XIII	12SX7GT	IX
6S8GT	XI	14C7	XII
6SC7	XIV	19T8	VII
6SF5GT	X	26BK6	XV
6SJ7GT	VIII	26C6	XIII
6SL7GT	XIV	57	XII
6SN7GTA	IX	75	XI
6SQ7GT	XI	954	XII
6SR7GT	XIII	1273	XII
		1280	XII

RESISTANCE COUPLED AMPLIFIER DATA

On the following pages are given the necessary data for the construction of resistance coupled amplifiers using the types of tubes commonly employed for this purpose. The data are necessarily quite condensed but with the aid of the five reference diagrams and the equations given on the following page for determining the size by-pass and coupling condensers, any serviceman should be able to build a good amplifier or check the design of one under repair.

Notice that data are given for use under all the B supply voltages commonly used with a given type. Values of gain are given for two different values of applied signal; the first a typical small signal likely to be found for the type and the second is the maximum which can be used without exceeding the 5% distortion limit.

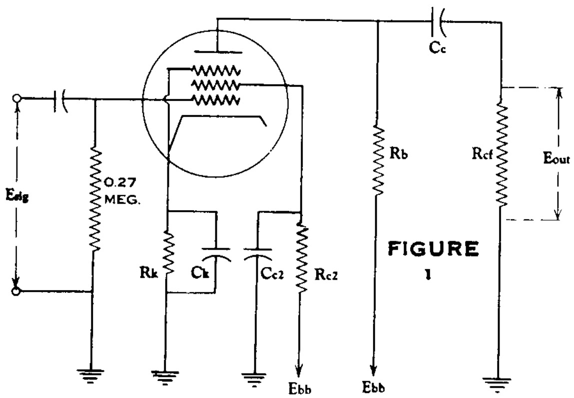


FIGURE 1

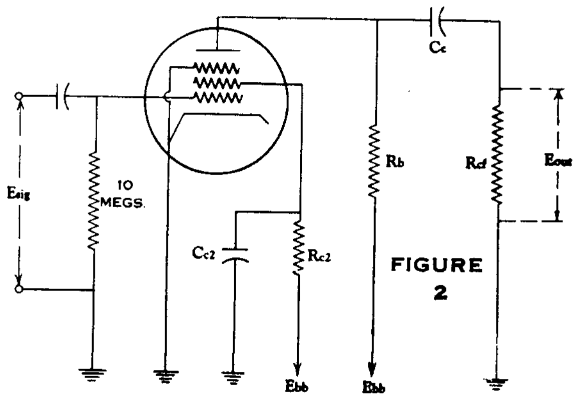


FIGURE 2

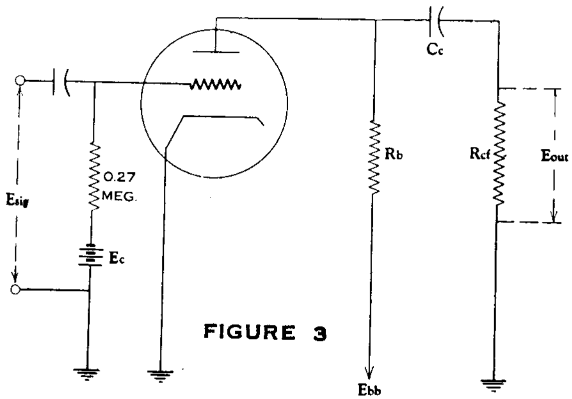


FIGURE 3

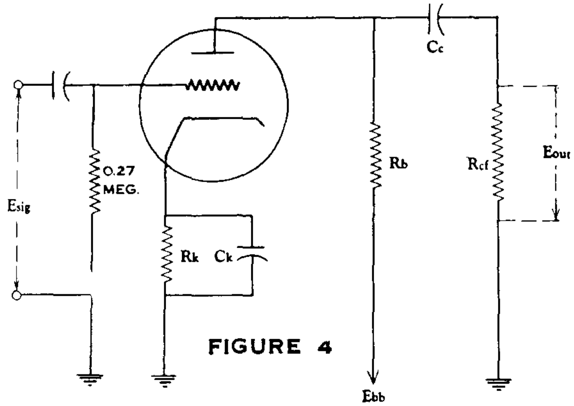


FIGURE 4

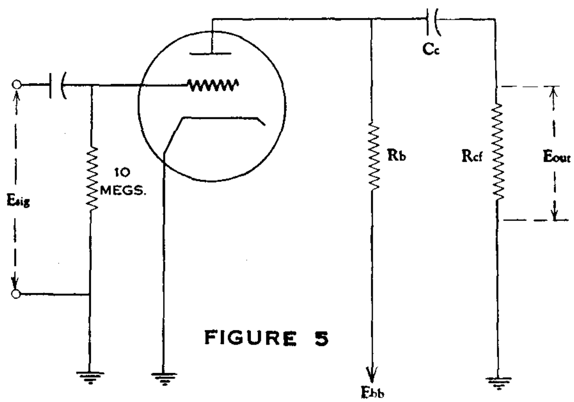


FIGURE 5

SYMBOLS USED

Symbol	Function	Unit
Rb	Plate Load Resistor	Megohms
Rc2	Screen Dropping Resistor	Megohms
Rcf	Grid Resistor of following Tube	Megohms
Ebb	Plate Supply Voltage	Volts
Eb	Plate Voltage at Plate	Volts
Ec or Ecl	Grid to Neg. Fil. Voltage	Volts
Ec2	Screen Grid Voltage	Volts
Esig	Input Signal	RMS Volts
Eout	Output to following Grid	RMS Volts
Ib	Plate Current	Ma.
Ic2	Screen Grid Current	Ma.
Cc	Coupling Condenser	mfd.
Cc2	Screen By-pass Condenser	mfd.

Values of capacity are not specified since these are dependent mostly on the frequency characteristic required in each individual case.

For low frequency limit $= f_1$

$$Cc = \frac{1.6 \times 10^6}{f_1 \, Rcf} \text{ mfd.}$$

$$Ck = \frac{1.6 \times 10^6}{f_1 \, Rk} \text{ mfd.} \qquad Cc2 = \frac{1.6 \times 10^6}{f_1 \, Rc2} \text{ mfd.}$$

Some text books show a more complicated method for calculating these by-pass condensers, but this method is quite rapid and gives conservative values. The loss due to incomplete by-passing will be less than 1% except for the cathode by-pass where it will be about 3%. The size condenser may be halved where economy is essential unless stages are cascaded and highest quality is required.

CHART I
RESISTANCE COUPLED AMPLIFIER DATA
Zero Bias Operation

	Ebb = 45 VOLTS									Ebb = 67.5 VOLTS									Ebb = 90 VOLTS								
Rb	0.27			0.47			1.0			0.27			0.47			1.0			0.27			0.47			1.0		
R_{c2}	0.68			1.2			2.2			0.68			1.2			2.2			0.68			1.2			2.2		
Rcf	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10
Ib	.072	.072	.072	.043	.043	.043	.023	.023	.023	.134	.134	.134	.078	.078	.078	.041	.041	.041	.20	.20	.20	.116	.116	.116	.06	.06	.06
Eb	25.6	25.6	25.6	24.8	24.8	24.8	22.0	22.0	22.0	31.3	31.3	31.3	30.8	30.8	30.8	26.5	26.5	26.5	35.9	35.9	35.9	35.5	35.5	35.5	30.0	30.0	30.0
I_{c2}	.042	.042	.042	.025	.025	.025	.0146	.0146	.0146	.07	.07	.07	.0421	.0421	.0421	.024	.024	.024	.101	.101	.101	.06	.06	.06	.034	.034	.034
E_{c2}	16.5	16.5	16.5	15.0	15.0	15.0	12.9	12.9	12.9	20.0	20.0	20.0	17.0	17.0	17.0	14.6	14.6	14.6	21.3	21.3	21.3	18.0	18.0	18.0	15.0	15.0	15.0
Esig	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	1.64	1.94	2.30	2.05	2.67	2.80	2.77	3.27	3.58	4.58	5.5	6.45	6.08	7.8	8.1	7.85	9.25	9.8	5.5	6.67	8.0	7.5	10.0	10.4	10.0	11.4	12.2
Gain	32.8	38.8	46.0	41.0	53.4	56.0	55.5	65.5	71.7	45.8	55.0	64.5	60.8	78.0	81.0	78.5	92.5	98.0	55.0	66.7	80.0	75.0	100	104	100	114	122
% Distortion	2.70	2.40	3.30	3.00	2.80	2.80	3.10	2.80	2.50	2.60	2.10	1.70	4.20	3.60	3.00	3.80	3.00	2.80	1.60	1.20	1.20	2.40	1.70	1.70	2.40	2.50	2.90
Esig [1]	0.09	0.10	0.11	0.08	0.09	0.09	0.07	0.09	0.09	0.16	0.18	0.20	0.12	0.15	0.15	0.12	0.13	0.14	0.24	0.26	0.27	0.17	0.19	0.20	0.16	0.16	0.16
Eout	2.85	3.75	4.97	0.13	4.76	4.90	3.83	5.65	6.05	7.0	9.6	11.9	7.2	11.1	11.5	9.3	11.3	12.8	12.5	1.59	19.4	12.3	17.7	19.0	14.9	17.2	18.4
Gain	31.7	37.5	45.2	39.1	52.8	54.5	54.8	62.7	67.2	43.7	53.2	59.5	60.0	74.0	76.6	77.5	87.0	91.5	52.0	61.2	71.9	72.3	93.1	95.0	93.1	107	115
% Distortion	4.60	4.70	4.50	5.00	4.70	4.50	4.20	4.90	4.60	4.70	4.70	4.80	5.00	4.90	4.80	4.80	4.50	4.70	4.90	4.90	4.90	5.0	4.30	4.70	4.50	4.70	4.90

Note [1] Maximum signal for 5.0% Distortion.

FOR CIRCUIT SEE FIGURE 2

CHART II
RESISTANCE COUPLED AMPLIFIER DATA

Zero Bias Operation

	Ebb = 45 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.0			1.8			3.9		
Rcf	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10
Ib	.080	.080	.080	.050	.050	.050	.025	.025	.025
Eb	23.4	23.4	23.4	21.5	21.5	21.5	20.0	20.0	20.0
Ic_2	.0232	.0232	.0232	.0146	.0146	.0146	.0077	.0077	.0077
Ec_2	21.8	21.8	21.8	18.7	18.7	18.7	15.0	15.0	15.0
Esig	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Eout	1.55	1.94	2.25	2.15	2.75	2.85	2.80	3.25	3.50
Gain	31.0	38.8	45.0	43.0	55.0	57.0	56.0	65.0	70.0
% Distortion	2.10	1.90	1.20	2.00	1.70	1.60	2.90	2.40	2.0
Esig (1)	0.13	0.17	0.19	0.12	0.15	0.15	0.1	0.11	0.11
Eout	3.95	6.0	7.55	5.0	7.40	7.6	5.60	6.50	6.90
Gain	30.4	35.3	39.7	41.6	49.3	50.6	56.0	59.0	62.7
% Distortion	4.90	4.60	4.70	4.60	4.90	4.60	4.70	4.80	4.70

	Ebb = 67.5 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.0			1.8			3.9		
Rcf	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10
Ib	.145	.145	.145	.087	.087	.087	.045	.045	.045
Eb	28.3	28.3	28.3	26.6	26.6	26.6	22.5	22.5	22.5
Ic_2	.041	.041	.041	.025	.025	.025	.013	.013	.013
Ec_2	26.5	26.5	26.5	22.5	22.5	22.5	16.8	16.8	16.8
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	4.10	5.0	5.7	5.5	6.8	7.0	7.1	8.2	8.65
Gain	41.0	50.0	57.0	55.0	68.0	70.0	71.0	82.0	86.5
% Distortion	1.80	1.30	1.60	1.70	2.0	2.1	2.30	2.50	2.70
Esig (1)	0.26	0.28	0.30	0.21	0.23	0.24	0.15	0.17	0.17
Eout	9.85	12.6	15.2	10.4	13.9	14.8	10.0	12.8	13.4
Gain	37.9	45.0	50.6	49.6	60.3	61.8	66.8	75.3	78.8
% Distortion	4.80	4.60	4.80	4.50	4.50	4.90	4.40	4.90	4.60

	Ebb = 90 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.0			1.8			3.9		
Rcf	0.47	1.0	4.7	1.0	4.7	10	2.2	4.7	10
Ib	.22	.22	.22	.13	.13	.13	.065	.065	.065
Eb	30.5	30.5	30.5	29.0	29.0	29.0	25.0	25.0	25.0
Ic_2	.061	.061	.061	.036	.036	.036	.0187	.0187	.0187
Ec_2	29.0	29.0	29.0	25.0	25.0	25.0	17.0	17.0	17.0
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	4.9	6.0	6.9	6.65	8.35	8.7	9.0	10.4	11.0
Gain	49.0	60.0	69.0	66.5	83.5	87.0	90.0	104	110
% Distortion	.80	1.40	2.0	1.70	3.10	3.50	3.0	3.30	3.60
Esig (1)	0.34	0.34	0.34	0.28	0.28	0.28	0.18	0.18	0.17
Eout	14.4	17.5	20.0	16.5	20.3	21.0	15.1	17.4	17.6
Gain	42.4	51.5	58.9	59.0	72.5	75.0	84.0	96.8	103.5
% Distortion	4.40	4.50	5.0	4.60	4.50	4.80	4.70	4.90	4.80

Note (1) Maximum signal for 5.0% distortion.

FOR CIRCUIT SEE FIGURE 2

CHART III

RESISTANCE COUPLED AMPLIFIER DATA

Zero Bias Operation

Sylvania Type 1U4

	Ebb = 45 VOLTS (See Note 2)								
Rb	0.27			0.47			1.0		
Rc2	1.0			1.5			3.3		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib	.048	.048	.048	.034	.034	.034	.0175	.0175	.0175
Eb	32.14	32.14	32.14	29.12	29.12	29.12	28.5	28.5	28.5
Ic2	.0165	.0165	.0165	.012	.012	.012	.006	.006	.006
Ec2	28.5	28.5	28.5	27.0	27.0	27.0	25.2	25.2	25.2
Esig	.05	.05	.05	.05	.05	.05	.04	.04	.05
Eout	1.46	1.75	2.10	2.00	2.55	2.68	2.25	2.52	3.45
Gain	28.3	35	42	40	51	53.6	56.3	63.1	69.0
% Distortion	3.4	3.4	3.9	4.2	4.3	4.0	4.1	4.4	4.9
Esig (1)	.06	.06	.06	.05	.05	.06	.04	.04	.05
Eout	1.70	2.08	2.50	2.00	2.55	3.20	2.25	2.52	3.45
Gain	28.3	34.8	41.7	40	51	53.4	56.3	63.1	69.0
% Distortion	4.4	4.3	4.5	4.2	4.3	4.9	4.1	4.4	4.9

	Ebb = 67.5 VOLTS								
Rb	0.27			0.47			1.0		
Rc2	1.0			1.5			3.3		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib	.101	.101	.101	.070	.070	.070	.035	.035	.035
Eb	40.2	40.2	40.2	34.6	34.6	34.6	32.5	32.5	32.5
Ic2	.033	.033	.033	.0235	.0235	.0235	.0115	.0115	.0115
Ec2	34.5	34.5	34.5	32.25	32.25	32.25	29.6	29.6	29.6
Esig	.05	.05	.05	.05	.05	.05	.05	.05	.05
Eout	2.3	2.75	3.3	3.3	4.25	4.45	4.35	5.2	5.55
Gain	46	55	66	66	85.0	89	87	104	111
% Distortion	2.0	2.0	2.0	2.3	2.3	1.9	3.8	3.6	3.3
Esig (1)	.10	.11	.11	.09	.10	.10	.06	.07	.07
Eout	4.45	5.9	7.0	5.8	8.35	8.60	5.20	7.15	7.6
Gain	44.5	53.5	63.5	64.5	83.5	86.0	86.8	102	108
% Distortion	4.6	5.0	4.8	4.8	4.9	4.1	4.6	5.0	4.6

	Ebb = 90 VOLTS								
Rb	0.27			0.47			1.0		
Rc2	1.0			1.5			3.3		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib	.156	.156	.156	.11	.11	.11	.054	.054	.054
Eb	47.9	47.9	47.9	38.3	38.3	38.3	36.0	36.0	36.0
Ic2	.049	.049	.049	.036	.036	.036	.017	.017	.017
Ec2	41.0	41.0	41.0	36.0	36.0	36.0	33.5	33.5	33.5
Esig	.05	.05	.05	.05	.05	.05	.05	.05	.05
Eout	2.92	3.60	4.25	4.20	5.40	5.60	5.70	6.80	7.40
Gain	58.4	72.0	85.0	84.0	108	112	113	136	148
% Distortion	1.4	1.2	1.3	1.3	1.1	0.9	2.5	2.2	1.8
Esig (1)	0.13	0.15	0.15	0.13	0.15	0.16	0.09	0.09	0.11
Eout	7.35	10.3	12.0	10.4	15	16.5	10	11.8	15.1
Gain	56.5	68.8	80	80	100	103	111	131	138
% Distortion	4.4	5.0	4.8	4.8	4.9	5.0	4.9	4.4	4.6

Note (1) Maximum signal for 5.0% distortion. Note (2) Operation at Ebb = 45 volts is not recommended. Above 45 volts data is shown only to assist in determining end of life performance with 67.5 volt supply.

FOR CIRCUIT SEE FIGURE 2

CHART IV

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 VOLTS						Ebb = 250 VOLTS					
Rb	0.047		0.1		0.27		0.047		0.1		0.27	
Rcf	0.1	0.27	0.1	0.47	0.27	0.47	0.1	0.27	0.1	0.47	0.27	0.47
Rk	1200	1200	2200	2700	6800	8200	1000	1000	1500	1800	4700	6800
Ib	1.22	1.22	.66	.628	.259	.246	3.2	3.2	1.78	1.72	.684	.63
Ec	1.465	1.465	1.45	1.695	1.76	2.02	3.2	3.2	2.67	3.10	3.21	4.28
Eb	42.7	42.7	34	37.2	30	33.6	150.5	150.5	72	78	65	80
Esig	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Eout	6.25	6.6	6.35	6.75	6.3	6.3	13.5	14.1	13.8	14.3	13.4	13.2
Gain	12.5	13.2	12.7	13.5	12.6	12.6	13.5	14.1	13.8	14.3	13.4	13.2
% Distortion	4.0	3.6	4.3	2.9	3.0	2.5	3.3	3.1	3.8	2.8	2.5	2.0
Esig (1)	0.65	0.65	0.57	0.77	0.71	0.98	1.70	1.70	1.34	1.70	1.80	2.52
Eout	8.1	8.6	7.2	10.4	8.9	12.4	23.0	24.0	18.5	24.5	24.1	33.1
Gain	12.5	13.2	12.6	13.5	12.5	12.6	13.5	14.1	13.8	14.3	13.4	13.1
% Distortion	4.8	4.4	4.8	4.6	4.6	5.0	4.9	4.6	5.0	5.0	4.9	5.0

(1) At grid current point, less than ⅛ microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART V

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 VOLTS						Ebb = 250 VOLTS					
Rb	0.047		0.1		0.27		0.047		0.1		0.27	
Rcf	0.1	0.27	0.1	0.47	0.27	0.47	0.1	0.27	0.1	0.47	0.27	0.47
Rk	1800	2200	2700	3900	6800	8200	1800	1800	2700	3900	6800	8200
Ib	0.98	0.90	0.58	0.51	0.24	0.227	2.50	2.50	1.45	1.28	0.60	0.57
Ec1	-1.765	-1.98	-1.565	-1.99	-1.63	-1.86	-4.50	-4.50	-3.92	-4.99	-4.08	-4.67
Eb	54	57.7	42	49	35.2	38.7	132.5	132.5	105	122	88	96
Esig	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Eout	5.75	6.0	6.15	6.65	6.5	6.7	12.6	13.45	13.2	14.25	13.6	14.1
Gain	11.5	12.0	12.3	13.3	13.0	13.4	12.6	13.45	13.2	14.25	13.6	14.1
% Distortion	2.0	1.7	2.4	1.7	2.3	1.9	1.5	1.2	1.9	1.3	1.9	1.6
Esig (1)	0.92	1.1	0.8	1.1	0.86	1.0	3.07	3.07	2.5	3.3	2.58	3.0
Eout	10.55	13.2	9.8	14.6	11.1	13.3	38.4	41.2	32.6	46.8	35.0	42.0
Gain	11.5	12.0	12.25	13.3	12.9	13.3	12.5	13.4	13.05	14.2	13.55	14.0
% Distortion	4.0	4.0	4.1	4.1	4.5	4.1	5.0	4.0	5.0	4.8	5.0	5.0

Note (1) At grid current point, less than 1/8 microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART VI

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation
Single Section of Type 6N7GT

	Ebb = 100 VOLTS						Ebb = 250 VOLTS					
Rb	0.047		0.1		0.27		0.047		0.1		0.27	
Rof	0.10	.27	.10	.47	.27	.47	.10	.27	.10	.47	.27	.47
Rk	1800	1800	2700	3300	6800	6800	1000	1200	1500	1800	3300	3900
Ib	.81	.81	.51	.469	.225	.225	2.36	2.21	1.45	1.36	.64	.61
Ec	1.46	1.46	1.38	1.55	1.53	1.53	2.36	2.65	2.18	2.45	2.11	2.38
Eb	61.9	61.9	49	53.1	39.2	39.2	139	146	105	114	77	85.5
Esig	.10	.10	.10	.10	.10	.10	.50	.50	.50	.50	.50	.50
Eout	1.74	1.93	1.93	2.2	2.23	2.38	10.0	10.9	10.9	12.5	12.8	13.0
Gain	17.4	19.3	19.3	22.0	22.3	23.8	20.0	21.8	21.8	25.0	25.6	26.0
% Distortion	1.2	1.0	1.3	1.0	1.3	1.1	1.8	1.8	2.6	2.2	2.7	2.4
Esig (1)	.40	.40	.30	.50	.42	.42	1.20	1.40	1.00	1.22	.90	1.1
Eout	6.85	7.65	5.76	10.9	9.34	10.0	23.8	30.4	21.8	30.5	23.0	28.8
Gain	17.1	19.1	19.2	21.8	22.0	23.8	19.8	21.7	21.8	25.0	25.6	26.2
% Distortion	4.7	3.7	3.7	4.8	5.0	4.2	4.5	4.9	4.8	4.7	4.7	5.0

Note (1) At grid current point, less than 1/8 microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART VII

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	3300	3300	5600	5600	6800	8200	10,000	1800	2200	3300	3900	4700	5600	6800
Ib	.288	.288	.161	.161	.146	.108	.099	.95	.88	.476	.46	.425	.31	.29
Ec	.95	.95	.9	.9	.99	.89	.99	1.71	1.94	1.57	1.79	2.0	1.73	1.97
Eb	71.2	71.2	56.5	56.5	60.6	49.2	53.5	155.	162.	121.5	125.8	135.2	104.4	113.7
Esig.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.53	3.82	4.1	4.53	4.73	4.63	4.9	4.23	4.4	4.9	5.2	5.4	5.3	5.7
Gain	35.3	38.2	41.	45.3	47.3	46.3	49.	42.3	44.	49.	52.	54.	53.	57.
% Dist.	.55	0.9	1.6	1.2	1.1	1.5	1.2	.3	.3	.25	.3	.3	.2	.25
Esig. (1)	.23	.24	.19	.2	.25	.19	.25	.79	.89	.63	.77	.91	.71	.86
Eout	8.	8.9	7.75	8.93	11.8	8.7	12.2	33.3	38.5	30.8	39.6	49.	37.5	48.6
Gain	34.8	37.1	40.8	44.6	47.2	45.8	48.8	42.2	43.3	48.9	51.4	53.9	52.8	56.6
% Dist.	3.6	3.4	3.95	3.4	4.15	3.9	4.6	3.67	4.28	3.4	4.3	4.75	4.8	4.95

Note (1) For self bias operation this is taken at the grid current point with less than 1/8 Microampere grid current.

FOR CIRCUIT SEE FIGURE 4

Zero Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ib	0.325	0.325	0.17	0.17	0.17	0.1125	0.1125	1.35	1.35	0.65	0.65	0.65	0.385	0.385
Ec	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eb	67.5	67.5	54.1	54.1	54.1	47.1	47.1	115	115	74.5	74.5	74.5	69	69
Esig.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.7	3.8	4.35	4.6	4.83	4.6	5.2	4.5	4.75	5.2	5.8	5.8	5.7	6.2
Gain	37.0	38.0	43.5	46.0	48.3	46.0	52.0	45.0	47.5	52.0	58.0	58.0	57.0	62.0
% Dist.	0.806	0.72	1.58	1.17	0.88	1.56	0.985	0.583	0.61	0.53	0.65	0.65	0.5	0.64
Esig. (1)	0.26	0.28	0.21	0.24	0.28	0.21	0.26	0.9	0.96	0.76	0.87	0.97	0.74	0.88
Eout	8.8	9.8	8.25	10.5	12.5	9.2	12.5	37.0	41.7	36.5	44.2	53.0	39.3	50.0
Gain	33.8	35.0	39.3	43.7	44.6	43.8	48.1	41.2	43.4	48.0	50.8	54.6	53.1	56.8
% Dist.	4.71	4.9	4.96	4.79	4.96	4.8	4.78	4.8	4.88	4.86	4.96	4.88	4.89	4.89

Note (1) Maximum signal for 5.0% Distortion.

FOR CIRCUIT SEE FIGURE 5

CHART VIII
RESISTANCE COUPLED AMPLIFIER DATA
Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
R_{c2}	0.39		1.2			1.8		0.39		1.2			2.2	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	1200	1200	2700	2700	2700	4700	4700	560	560	1200	1200	1200	1800	1800
Ib	0.645	0.645	0.259	0.259	0.259	0.165	0.165	1.77	1.77	0.675	0.675	0.675	0.402	0.402
I_{c2}	0.18	0.18	0.068	0.068	0.068	0.045	0.045	0.50	0.50	0.183	0.183	0.183	0.102	0.102
E_{c1}	0.99	-0.99	0.882	-0.882	-0.882	-0.99	-0.99	-1.27	-1.27	-1.03	-1.03	-1.03	-0.908	-0.908
E_{c2}	29.8	29.8	18.5	18.5	18.5	19.0	19.0	55	55	30.5	30.5	30.5	25.5	25.5
Eb	35.5	35.5	30.2	30.2	30.2	22.5	22.5	73	73	67.8	67.8	67.8	61.2	61.2
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	6.85	7.8	8.2	10.2	12.5	10.2	13.1	10.2	11.5	13.6	17.9	21.6	19.5	25.6
Gain	68.5	78.0	82	102	125	102	131	102	115	136	179	216	195	256
% Distortion	0.6	0.7	3.4	2.6	2.3	2.8	3.2	0.7	0.8	2.2	1.8	1.5	3.1	2.4
Esig(1)	0.2	0.2	0.14	0.14	0.14	0.13	0.13	0.5	0.5	0.25	0.25	0.25	0.15	0.15
Eout	13.15	14.9	11.1	13.9	17.2	12.8	16.6	47	54	33	41.8	50	28	37
Gain	65.8	74.5	79.4	99.5	123	98.5	128	94	108	132	167.5	200	187	247
% Distortion	3.0	2.9	5.1	4.3	3.7	4.6	5.0	4.2	5.0	5.2	4.4	4.7	4.5	3.7

Note (1) At grid current point, less than 1/8 microampere grid current.

FOR CIRCUIT SEE FIGURE 1

CHART IX

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation
Type 7A4 or Single Section of Type 7N7

	Ebb = 100 VOLTS						Ebb = 250 VOLTS					
Rb	0.047		0.10		0.27		0.047		0.10		0.27	
Rcf	0.1	0.27	0.1	0.47	0.27	0.47	0.1	0.27	0.1	0.47	0.27	0.47
Rk	1800	2200	3300	4700	8200	10,000	1500	2200	2700	3900	6800	8200
Ib	1.05	0.97	0.57	0.50	0.24	0.22	2.79	2.4	1.49	1.31	0.61	0.58
Ec	-1.89	-2.13	-1.90	-2.35	-1.93	-2.19	-4.18	-5.28	-4.03	-5.11	-4.15	-4.74
Eb	50.6	54.4	43.0	50.0	36.5	40.9	119	137	101	119	85	94
Esig	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Eout	6.6	7.1	6.8	7.4	7.3	7.4	14.8	15.0	15.2	16.2	15.9	16.2
Gain	13.2	14.2	13.6	14.8	14.6	14.8	14.8	15.0	15.2	16.2	15.9	16.2
% Distortion	1.9	1.8	2.4	2.0	2.0	1.7	1.4	1.4	1.8	1.3	1.6	1.3
Esig (1)	0.95	1.13	0.95	1.3	0.95	1.20	2.70	3.50	2.55	3.30	2.64	3.05
Eout	12.5	15.5	12.9	19.2	13.7	17.7	39.9	52.5	38.4	53.0	42.0	49.4
Gain	13.1	13.9	13.6	14.7	14.4	14.7	14.7	15.0	15.0	16.1	15.9	16.2
% Distortion	3.9	4.2	4.9	4.7	4.4	4.5	4.1	4.9	4.9	4.6	4.7	4.5

Note (1) For self bias operation this is taken at the grid current point with less than ½ microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART X

RESISTANCE COUPLED AMPLIFIER DATA

Zero Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ib	0.223	0.223	0.126	0.126	0.126	0.89	0.89	1.1	1.1	0.54	0.54	0.54	0.34	0.34
Ec	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eb	77.7	77.7	66.0	66.0	66.0	58.2	58.2	140	140	104	104	104	90	90
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.85	4.15	4.32	4.9	5.45	5.0	5.8	6.0	6.3	7.0	7.5	8.2	7.7	8.5
Gain	38.5	41.5	43.2	49.0	54.5	50.0	58.0	60.0	63.0	70.0	75.0	82.0	77.0	85.0
% Dist.	4.6	4.3	5.0	4.2	3.3	4.5	3.4	0.8	0.8	1.1	1.0	0.9	1.3	1.1
Esig (1)	0.1	0.11	0.1	0.11	0.14	0.1	0.14	0.46	0.46	0.35	0.40	0.48	0.36	0.45
Eout	3.85	4.55	4.32	5.35	7.4	5.0	7.84	25.3	26.0	22.5	28.0	35.3	25.1	34.2
Gain	38.5	41.4	43.2	48.6	53.0	50.0	56.0	55.0	56.5	64.4	70.0	74.0	70.0	76.0
% Dist.	4.6	4.9	5.0	4.7	5.0	4.5	5.0	4.8	4.7	4.9	4.8	4.8	5.0	4.8

Note (1) Maximum signal for 5% Distortion.

FOR CIRCUIT SEE FIGURE 5

Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	3900	3900	5600	5600	6800	8200	10,000	1500	800	2700	2700	2700	3900	4700
Ib	0.22	0.22	0.144	0.144	0.13	0.10	0.091	0.84	0.76	0.443	0.443	0.443	0.295	0.271
Ec	-0.86	-0.86	-0.81	-0.81	-0.88	-0.82	-0.91	-1.26	-1.37	-1.19	-1.19	-1.19	-1.15	-1.27
Eb	78	78	61.1	61.1	64.9	53	57.2	166	174	131	131	131	111.5	123
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	4.25	4.3	4.8	5.35	5.62	5.4	6.4	5.65	5.8	6.5	7.15	7.65	7.3	7.65
Gain	42.5	43.0	48.0	53.5	56.2	54.0	64.0	56.5	58.0	65.0	71.5	76.5	73.0	76.5
% Dist.	4.1	4.1	4.3	3.7	3.2	4.1	3.6	0.9	0.9	1.0	1.0	1.0	1.3	1.2
Esig (1)	0.12	0.12	0.1	0.1	0.13	0.1	0.15	0.47	0.54	0.39	0.39	0.39	0.33	0.45
Eout	5.1	5.15	4.8	5.35	7.25	5.4	9.0	26.5	30.5	24.5	27.5	29.2	23.5	34.0
Gain	42.5	43.0	48	53.5	55.8	54.0	60.0	56.4	56.5	63.0	70.5	75.0	71.3	75.5
% Dist.	5.1	5.0	4.3	3.7	4.6	4.1	5.0	4.5	5.3	5.1	4.2	3.9	5.2	5.3

Note (1) For self bias operation this is taken at the grid current point with less than 1/8 microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART XI

RESISTANCE COUPLED AMPLIFIER DATA

Zero Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ib	0.228	0.228	0.132	0.132	0.132	0.09	0.09	1.0	1.0	0.52	0.52	0.52	0.34	0.34
Ec	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eb	77.2	77.2	64.4	64.4	64.4	57.7	57.7	150	150	110	110	110	90	90
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.3	3.55	3.95	4.48	5.05	4.63	5.4	4.63	5.0	5.6	6.1	6.7	6.43	7.15
Gain	33.0	35.5	39.5	44.8	50.5	46.3	54.0	46.3	50.0	56.0	61.0	67.0	64.3	71.5
% Dist.	3.0	2.9	3.8	3.2	2.6	3 6	2.6	0.8	0.7	0.9	0.8	0.7	0.8	0.7
Esig (1)	0.15	0.16	0.12	0.14	0.17	0.13	0.17	0.55	0.6	0.5	0.57	0.65	0.5	0.6
Eout	4.73	5.4	4.65	6.12	8.3	5.9	8.8	23.4	26.6	25.5	31.8	39.0	29.5	39.5
Gain	31.5	33.8	38.7	43.8	49.0	45.4	51.7	42.5	44.5	51.0	56.0	60.0	59.0	66.0
% Dist.	4.9	5.0	4.9	4.8	5.0	5.0	5.0	4.7	4.9	5.0	4.9	4.9	5.0	5.0

Note (1) Maximum Signal for 5.0% Distortion

FOR CIRCUIT SEE FIGURE 5

Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	3900	3900	5600	6800	6800	8200	10,000	1800	1800	2700	3300	3900	3900	4700
Ib	0.214	0.214	0.138	0.126	0.126	0.095	0.086	0.725	0.725	0.43	0.395	0.365	0.288	0.261
Ec	-0.835	-0.835	-0.774	-0.857	-0.857	-0.78	-0.86	-1.31	-1.31	-1.16	-1.30	-1.42	-1.12	-1.25
Eb	78.6	78.6	62.8	66.0	66.0	55.3	59.6	177.5	177.5	134	143.5	151.5	114.5	124.5
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.3	3.5	4.1	4.5	5.0	4.9	5.2	4.37	4.78	5.50	5.92	6.13	6.24	6.75
Gain	33.0	35.0	41.0	45.0	50.0	49.0	52.0	43.7	47.8	55.0	59.2	61.3	62.4	67.5
% Dist.	2.7	2.6	3.2	3.0	2.5	3.1	2.6	0.8	0.7	0.8	0.8	0.7	0.8	0.7
Esig (1)	0.16	0.16	0.10	0.17	0.17	0.12	0.19	0.55	0.55	0.40	0.53	0.61	0.40	0.53
Eout	5.15	5.5	4.1	7.3	8.2	5.75	9.7	23.9	26.0	21.8	31.2	37.0	25.0	36.0
Gain	32.2	34.4	41.0	43.0	48.1	48.0	51.0	43.5	47.4	54.5	59.0	60.6	62.4	67.5
% Dist.	4.5	4.0	3.2	5.0	4.5	4.0	5.0	4.5	4.0	3.3	4.0	4.5	3.3	3.8

Note (1) For self bias operation this is taken at the grid current point with less than ⅛ Microampere grid current.

FOR CIRCUIT SEE FIGURE 4

CHART XII

Resistance Coupled Amplifier Data

Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rc2	0.47		1.2			1.8		0.47		1.2			2.2	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	1000	1000	2200	2200	2200	3900	3900	470	470	1000	1000	1000	1500	1500
Ib	0.62	0.62	0.27	0.27	0.27	0.168	0.168	1.76	1.76	0.75	0.75	0.75	0.44	0.44
Ic2	0.145	0.145	0.064	0.064	0.064	0.465	0.465	0.41	0.41	0.177	0.177	0.177	0.10	0.10
Ec1	-0.765	-0.765	-0.735	-0.735	-0.735	-0.622	-0.622	-1.02	-1.02	-0.927	-0.927	-0.927	-0.81	-0.81
Ec2	31.9	31.9	23.3	23.3	23.3	16.3	16.3	57.2	57.2	37.5	37.5	37.5	30	30
Eb	38	38	27.2	27.2	27.2	21	21	74	74	47.5	47.5	47.5	43.5	43.5
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	7.0	8.05	8.0	10.0	12.0	9.8	12.5	10.6	12.0	13.0	17.0	20.4	18.8	24.5
Gain	70.0	80.5	80	100	120	98	125	106	120	130	170	204	188	245
% Distortion	2.7	2.4	3.7	2.7	2.3	3.2	1.9	1.6	1.4	1.5	1.6	2.4	2.0	2.8
Esig (1)	0.18	0.18	0.14	0.14	0.14	0.14	0.14	0.4	0.4	0.27	0.27	0.27	0.18	0.18
Eout	12.3	13.9	10.8	13.8	16.7	13.2	17.0	40.3	45.2	33.0	41.6	49.5	32	41.5
Gain	68.5	77.2	77.2	98.7	119	94.5	121.5	101	113	122	154	183.5	178	230
% Distortion	4.7	4.1	5.5	4.6	3.8	4.9	5.0	4.3	4.4	5.0	5.0	5.9	4.3	4.9

Note (1) For self bias operation this is taken at the grid current point with less than 1/8 microampere grid current.

FOR CIRCUIT SEE FIGURE 1

CHART XIII
RESISTANCE COUPLED AMPLIFIER DATA
Self Bias Operation

	Ebb = 100 VOLTS						Ebb = 250 VOLTS					
Rb	0.047		0.1		0.27		0.047		0.1		0.27	
Rcf	0.1	0.27	0.1	0.47	0.27	0.47	0.1	0.27	0.1	0.47	0.27	0.47
Rk	1800	2200	2700	3900	6800	8200	1500	1800	2200	3300	5600	8200
Ib	1.07	1.0	0.62	0.56	0.256	0.240	2.85	2.69	1.63	1.46	0.661	0.60
Ec	-1.93	-2.2	-1.67	-2.18	-1.74	-1.97	-4.27	-4.84	-3.59	-4.82	-3.70	-4.92
Eb	49.6	53.0	38	44	31	35.2	116	123.8	87	104	71.8	88
Esig	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Eout	5.3	5.4	5.6	5.8	5.7	5.8	11.2	11.8	11.8	12.4	12.1	12.2
Gain	10.6	10.8	11.2	11.6	11.4	11.6	11.2	11.8	11.8	12.4	12.1	12.2
% Distortion	2.1	1.9	2.0	1.8	2.2	1.8	1.3	1.2	1.8	1.3	1.8	1.3
Esig (1)	1.02	1.24	0.87	1.23	0.97	1.10	2.80	3.25	2.23	3.27	2.40	3.32
Eout	10.6	13.2	9.5	14.2	11.0	12.8	31.2	38.0	26.0	40.4	28.5	40.6
Gain	10.4	10.6	10.9	11.5	11.3	11.6	11.1	11.7	11.7	12.3	12.1	12.2
% Distortion	4.5	4.9	4.7	4.8	4.9	4.3	4.5	4.6	4.4	4.5	4.5	4.9

Note (1) For self bias operation this is taken at the grid current point with less than 1/8 microampere grid current

FOR CIRCUIT SEE FIGURE 4

CHART XIV
RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation—All Values Per Single Section

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.10		0.27			0.47		0.10		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	4.7	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	3300	3300	5600	5600	6800	6800	8200	1800	2200	3300	3900	3900	4700	5600
Ib	0.30	0.30	0.169	0.169	0.152	0.1240	0.112	0.917	0.83	0.475	0.44	0.44	0.312	0.29
Ec	-0.99	-0.99	-0.948	-0.948	-1.03	-0.844	-0.92	-1.65	-1.83	-1.57	-1.72	-1.72	-1.47	-1.62
Eb	70	70	54.3	54.3	59.9	41.7	47.3	158.3	167	122	131	131	103	113.5
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.2	3.23	3.7	4.15	4.5	4.28	4.65	4.0	4.1	4.5	5.0	5.25	5.25	5.55
Gain	32.0	32.3	37.0	41.5	45.0	42.8	46.5	40.0	41.0	45.0	50.0	52.5	52.5	55.5
% Dist.	1.3	1.3	1.8	1.5	1.4	1.8	1.4	0.6	0.5	0.6	0.5	0.4	0.5	0.4
Esig (1)	0.33	0.33	0.21	0.21	0.34	0.2	0.3	0.87	1.03	0.83	0.97	0.97	0.77	0.90
Eout	10.3	10.4	7.7	8.6	14.8	8.5	13.5	33.6	41.5	36.3	46.6	48.8	38.8	48.5
Gain	31.2	31.5	36.6	41.0	43.5	42.5	45.0	38.6	40.2	43.7	48.0	50.4	50.4	54.0
% Dist.	4.9	4.8	4.0	3.1	5.0	3.4	4.4	4.0	4.8	4.5	4.8	3.8	3.9	3.7

Note (1) For self bias operation this is taken at the grid current point with less than ¼ Microampere grid current.

FOR CIRCUIT SEE FIGURE 4

Zero Bias Operation—All Values Per Single Section

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ib	0.40	0.40	0.202	0.202	0.202	0.13	0.13	1.36	1.36	0.64	0.64	0.64	0.40	0.40
Ec	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eb	60.0	60.0	45.5	45.5	45.5	38.6	38.6	114	114	77.0	77.0	77.0	62.0	62.0
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.4	3.6	3.95	4.35	4.7	5.1	4.95	4.1	4.32	4.7	5.1	5.5	5.25	5.75
Gain	34.0	36.0	39.5	43.5	47.0	51.0	49.5	41.0	43.2	47.0	51.0	56.0	52.5	57.5
% Dist.	1.1	1.0	1.1	1.0	1.0	1.0	0.9	0.4	0.4	0.5	0.4	0.4	0.4	0.4
Esig (1)	0.33	0.34	0.25	0.3	0.34	0.25	0.32	1.0	1.07	.86	.97	1.09	.83	1.03
Eout	10.3	11.2	9.25	11.8	14.7	10.4	14.7	37.0	41.5	37.3	45.4	53.6	40.0	53.0
Gain	31.2	33.0	37.0	39.4	43.4	41.6	46.0	37.0	38.8	43.4	46.8	49.3	48.3	51.5
% Dist.	5.0	4.8	4.9	5.0	5.0	5.0	5.0	4.9	5.0	5.0	5.0	4.8	5.0	5.0

Note (1) Maximum gnal for 5.0% Distortion.

FOR CIRCUIT SEE FIGURE 5

CHART XV

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	4700	5600	8200	10,000	10,000	12,000	15,000	1800	1800	3300	3300	3900	4700	5600
Ib	.23	.204	.132	.117	.117	.092	.08	.84	.84	.45	.45	.41	.30	.28
Ec	-1.08	-1.143	-1.03	-1.17	-1.17	-1.10	-1.2	-1.51	-1.51	-1.49	-1.49	-1.59	-1.41	-1.57
Eb	77.0	79.6	64.4	68.4	68.4	56.8	62.4	166.	166.	128.	128.	139.	109.	118.5
Esig.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.6	3.8	4.2	4.35	5.0	4.7	5.2	5.4	5.7	6.1	6.6	6.9	6.6	7.1
Gain	36.0	38.0	42.0	43.5	50.0	47.0	52.0	54.0	57.0	61.0	66.0	69.0	66.0	71.0
% Dist.	3.4	3.4	3.6	3.2	2.6	3.2	2.6	0.3	....	0.5	0,2	0.2	0.4	0.2
Esig. (1)	.14	.14	.11	.14	.17	.13	.17	.5	.5	.41	.45	.54	.38	.48
Eout	5.0	5.2	4.6	6.0	8.3	6.1	8.5	26.5	28.5	24.5	29.0	37.0	25.0	33.5
Gain	35.7	37.2	41.8	42.9	48.8	46.9	50.0	53.0	52.0	59.8	64.4	68.5	65.8	69.8
% Dist.	5.0	5.1	4.1	4.9	5.1	4.4	5.0	5.0	4.4	4.95	4.4	4.8	4.1	4.2

(1) At grid current point, less than ⅛ Microampere grid current through 0.27 megohm grid resistor.

FOR CIRCUIT SEE FIGURE 4

Zero Bias Operation

	Ebb = 100 VOLTS							Ebb = 250 VOLTS						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ib	.255	.255	.146	.146	.146	.100	.100	1.16	1.16	.57	.57	.57	.355	.355
Ec	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eb	74.5	74.5	60.6	60.6	60.6	53	53	134.	134.	123.	123.	123.	83.	83.
Esig.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.9	4.2	4.35	5.0	5.5	4.85	5.7	6.0	6.3	6.6	7.2	7.7	7.3	8.0
Gain	39	42	43.5	50	55	48.5	57	60	63	66	72	77	73	80
% Dist.	3.0	2.7	3.4	2.6	2.0	2.9	2.0	....	....	....	....	....	0.3	....
Esig. (1)	.14	.15	.13	.15	.18	.14	.18	.52	.56	.43	.5	.57	.42	.53
Eout	5.3	6.1	5.6	7.2	9.3	6.7	8.5	28.5	32.0	26.5	33.0	40.5	29.0	39.0
Gain	37.9	40.7	43	48	51.7	47.8	47.2	54.8	57.1	61.6	66	71.1	69.	73.6
% Dist.	4.8	4.8	4.8	4.7	4.9	4.7	4.8	4.8	5.0	4.9	5.0	4.9	4.8	4.8

(1) Maximum signal for 5.0% distortion.

FOR CIRCUIT SEE FIGURE 5

CHART XVI

RESISTANCE COUPLED AMPLIFIER DATA

Zero Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ib	0.55	0.55	0.25	0.25	0.25	0.16	0.16	1.75	1.75	0.74	0.74	0.74	0.45	0.45
Ec	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eb	45.0	45.0	32.5	32.5	32.5	25.0	25.0	75	75	50	50	50	38	38
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	2.55	2.62	2.55	2.75	2.87	2.65	2.85	3.15	3.25	3.20	3.35	3.45	3.25	3.36
Gain	25.5	26.2	25.5	27.5	28.7	26.5	28.5	31.5	32.5	32.0	33.5	34.5	32.5	33.6
% Dist.	1.1	1.1	1.4	1.2	1.0	1.4	1.1	0.6	0.6	0.7	0.7	0.6	0.7	0.7
Esig(1)	0.42	0.46	0.35	0.40	0.47	0.38	0.47	1.15	1.20	0.86	1.00	1.16	0.87	1.16
Eout	9.7	11.0	8.3	9.8	12.1	9.2	12.0	31.5	33.5	24.5	29.0	35.0	25.0	31.7
Gain	23.1	23.9	23.7	24.5	26.8	24.2	25.5	27.3	27.9	28.5	29.0	30.1	28.7	28.8
% Dist.	5.0	4.9	4.9	4.8	4.8	4.9	4.9	5.0	4.8	4.8	4.8	4.9	4.9	4.9

(1) Maximum Signal For 5.0% Distortion

FOR CIRCUIT SEE FIGURE 5

Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	1800	2200	3900	3900	4700	6800	8200	1200	1200	2200	2700	3300	3900	4700
Ib	0.48	0.45	0.23	0.23	0.22	0.14	0.14	1.39	1.39	0.64	0.61	0.58	0.39	0.38
Ec_1	-.9	-1.0	-.9	-.9	-1.0	-1.0	1.2	-1.7	-1.7	-1.4	-1.7	-1.9	-1.5	-1.8
Eb	51	54	37	37	40	33	33	109	109	76	83	91	60	65
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	2.43	2.48	2.46	2.68	2.75	2.45	2.60	2.80	2.90	2.81	3.00	2.98	2.90	2.95
Gain	24.3	24.8	24.6	26.8	27.5	24.5	26.0	28.0	29.0	28.1	30.0	29.8	29.0	29.5
% Dist.	1.3	1.3	1.5	1.3	1.2	1.5	1.2	0.5	0.6	0.7	0.7	0.6	0.8	0.5
Esig(1)	0.35	0.45	0.32	0.32	0.43	0.36	0.46	1.02	1.02	0.79	0.95	1.16	0.83	0.99
Eout	8.4	11.0	7.9	8.4	11.6	8.7	11.7	28.1	29.2	22.2	28.0	33.8	24.1	29.5
Gain	24.0	24.4	24.6	26.2	27.0	24.1	25.4	27.5	28.6	28.1	29.4	29.1	29.0	29.8
% Dist.	3.9	4.8	4.4	3.7	4.4	4.7	4.9	4.5	4.0	4.3	4.6	4.9	4.6	4.5

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than 1/8 Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 4

CHART XVII

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	1500	1800	3900	3900	4700	5600	6800	680	680	1800	1800	2200	3300	3900
Ib	0.54	0.51	0.23	0.23	0.22	0.150	0.141	1.62	1.62	0.69	0.69	0.65	0.41	0.40
Ec_1	-0.81	-0.92	-0.90	-0.90	-1.04	-0.840	-0.960	-1.10	-1.10	-1.24	-1.24	-1.43	-1.35	-1.56
Eb	45.2	48.1	37.1	37.1	39.6	28.7	32.7	86.9	86.9	62.3	62.3	75.6	55.7	59.9
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.0	3.0	2.8	3.0	3.1	2.95	3.0	3.90	4.10	3.55	3.70	3.65	3.50	3.60
Gain	30.0	30.0	28.0	30.0	31.0	29.5	30.0	39.0	41.0	35.5	37.0	36.5	35.0	36.0
% Dist.	1.9	1.7	1.9	1.7	1.4	1.8	1.4	.54	1.0	1.0	.92	.79	.89	.75
Esig (1)	0.54	0.29	0.30	0.29	0.38	0.22	0.34	0.61	0.49	0.54	0.56	0.71	0.64	0.77
Eout	6.6	8.7	8.4	8.4	11.5	6.5	10.0	23.0	19.7	19.0	20.6	25.5	22.1	27.0
Gain	30.0	30.0	28.0	28.9	30.3	29.5	29.4	37.0	40.2	35.2	36.8	35.9	34.5	35.1
% Dist.	3.9	4.7	5.0	4.5	4.9	3.6	4.1	4.4	4.2	4.7	4.2	4.6	4.8	4.6

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than ⅛ Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 4

Zero Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ib	0.590	0.590	0.262	0.262	0.262	0.160	0.160	1.82	1.82	0.75	0.75	0.75	0.44	0.44
Ec_1	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eb	41.0	41.0	29 3	29.3	29.3	24.8	24.8	68.0	68.0	48.0	48.0	48.0	43.0	43.0
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	3.0	3.3	3.1	3.3	3.5	3.1	3.3	4.3	4.4	4.0	4.1	4.2	3.85	4.1
Gain	30	33.0	31.0	33.0	35.0	31.0	33.0	43.0	44.0	40.0	41.0	42.0	38.5	41.0
% Dist.	2.0	1.7	2.06	1.8	1.6	1.9	1.6	1.3	1.25	1.30	1.22	1.19	1.25	1.20
Esig (1)	0.28	0.31	0.27	0.33	0.38	0.30	0.40	0.58	0.63	0.57	0.70	0.80	0.63	0.79
Eout	8.3	9.3	7.9	10.0	12.0	8.8	12.0	22.0	24.0	20.5	25.0	29.0	21.0	28.0
Gain	29.6	30.0	29.2	30.3	31.5	29.3	30.0	38.0	38.1	35.9	35.7	36.3	33.3	35.5
% Dist.	5.0	5.0	4.9	5.0	4.8	4.9	5.0	5.0	5.0	4.9	5.0	4.9	5.0	5.0

Note (1) Maximum Signal For 5.0% Distortion.

FOR CIRCUIT SEE FIGURE 5

CHART XVIII

Resistance Coupled Amplifier Data

Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	**0.1**		**0.27**			**0.47**		**0.1**		**0.27**			**0.47**	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	2200	2700	5600	5600	6800	10000	12000	1000	1200	2700	3300	3900	5600	6800
Ib	0.61	0.56	0.250	0.250	0.235	0.150	0.140	1.79	1.72	0.70	0.68	0.65	0.41	0.39
Ec_1	-1.3	-1.5	-1.4	-1.4	-1.6	-1.5	-1.7	-1.8	-2.1	-1.9	-2.2	-2.5	-2.3	-2.7
Eb	38	43	31	31	35	28	33	69	76	59	64	72	55	63
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	2.05	1.96	1.83	2.00	1.95	1.90	1.93	2.42	2.40	2.20	2.24	2.22	2.12	2.12
Gain	20.5	19.6	18.3	20.0	19.5	19.0	19.3	24.2	24.0	22.0	22.4	22.2	21.2	21.2
% Dist.	1.0	0.9	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5
Esig (1)	0.42	0.61	0.54	0.55	0.71	0.62	0.76	0.93	1.13	1.01	1.26	1.48	1.28	1.52
Eout	8.5	11.7	9.9	10.7	13.5	11.5	14.3	22.5	27.0	22.2	28.0	32.5	26.5	31.5
Gain	20.2	19.2	18.3	19.5	19.0	18.6	18.8	24.2	23.9	21.8	22.2	22.0	20.7	20.7
% Dist.	3.9	5.0	4.9	4.1	4.4	4.8	4.5	4.7	4.8	4.7	4.7	4.6	4.9	4.5

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than ⅛ Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 4

Zero Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	**0.1**		**0.27**			**0.47**		**0.1**		**0.27**			**0.47**	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ib	0.730	0.730	0.300	0.300	0.300	0.181	0.181	2.08	2.08	0.82	0.82	0.82	0.49	0.49
Ec_1	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eb	27.0	27.0	19.0	19.0	19.0	15.0	15.0	42.0	42.0	28.0	28.0	28.0	20.0	20.0
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	2.15	2.3	2.05	2.05	2.10	1.95	2.0	2.81	2.85	2.38	2.50	2.55	2.3	2.40
Gain	21.5	23.1	20.5	20.5	21.0	19.5	20.0	28.1	28.5	23.8	25.0	25.5	23.0	24.0
% Dist.	1.3	1.5	1.5	1.4	1.3	1.4	1.4	1.3	1.3	1.3	1.2	1.1	1.2	1.1
Esig (1)	0.44	0.46	0.41	0.47	0.57	0.47	0.58	0.71	0.74	0.68	0.80	0.90	0.75	0.97
Eout	7.60	9.50	7.50	8.30	10.30	8.20	10.3	18.2	19.0	14.5	17.8	20.0	15.0	21.0
Gain	17.3	20.6	18.3	17.7	18.1	17.5	17.8	25.6	25.7	21.3	22.1	22.2	20.0	21.7
% Dist.	5.0	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9	5.0	5.0

Note (1) Maximum Signal For 5.0 % Distortion

FOR CIRCUIT SEE FIGURE 5

CHART XIX

Resistance Coupled Amplifier Data

Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rc_2	0.27		0.68			1.2		0.27		0.82			1.2	
Rcf	0.27	0.47	0.27	0.47	1.0	0.47	1.0	0.27	0.47	0.27	0.47	1.0	0.47	1.0
Rk	1000	1000	2200	2200	2200	3900	3900	330	330	820	820	820	1200	1500
Ib	.510	.510	.234	.234	.234	.141	.141	1.69	1.69	0.64	0.64	0.64	0.44	0.42
Ic_2	.205	.205	.095	.095	.095	.057	.057	0.67	0.67	0.25	0.25	0.25	0.173	0.170
Ec_1	−.72	−.72	−.72	−.72	−.72	−.77	−.77	−.78	−.78	−.73	−.73	−.73	−.74	−.88
Ec_2	45	45	35	35	35	31	31	69	69	45	45	45	42	46
Eb	49	49	37	37	37	34	34	81	81	77	77	77	43	53
Esig	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Eout	4.6	5.2	4.8	6.0	7.5	5.7	7.5	8.9	10.0	9.4	12.0	15.0	12.0	15.5
Gain	92	104	96	120	150	114	150	178	200	188	240	300	240	310
% Dist.	3.6	3.8	4.2	3.8	3.1	4.4	3.3	1.9	1.9	3.6	3.3	3.4	3.0	2.4
Esig(1)	.07	.07	.06	.07	.08	.06	.09	.15	.20	.08	.08	.08	.12	0.2
Eout	6.4	7.3	5.7	8.4	11.5	6.7	13.0	25.0	38.0	15	19	23.5	27.0	52.0
Gain	92	104	95	120	144	112	145	167	190	188	238	294	225	260
% Dist.	5.0	5.0	4.8	4.9	3.8	5.2	5.1	5.0	5.3	5.3	5.2	4.9	4.4	4.8

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than ⅛ Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 1

CHART XX

Resistance Coupled Amplifier Data

Self Bias Operation

	Ebb = 100 Volts						Ebb = 250 Volts					
Rb	.047		0.1		0.27		.047		0.1		0.27	
Rcf	.1	.27	.1	.47	.27	.47	.1	.27	.1	.47	.27	.47
Rk	1200	1200	2200	3300	6800	8200	560	560	1000	1200	3900	3900
Ib	1.33	1.33	0.70	0.64	.275	.260	3.84	3.84	1.98	1.95	0.76	0.76
Ec_1	-1.6	-1.6	-1.5	-2.1	-1.9	-2.1	-2.2	-2.2	-2.0	-2.3	-3.0	-3.0
Eb	36	36	29	34	24	28	66	66	50	53	42	42
Esig	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Eout	1.25	1.27	1.13	1.22	1.10	1.12	1.45	1.50	1.37	1.44	1.25	1.28
Gain	12.5	12.7	11.3	12.2	11.0	11.2	14.5	15.0	13.7	14.4	12.5	12.8
% Dist.	0.9	0.9	0.9	0.7	0.6	0.6	0.7	0.7	0.7	0.7	0.5	0.5
Esig (1)	0.60	0.63	.60	.98	.88	1.07	1.17	1.17	1.02	1.28	1.65	1.65
Eout	7.4	8.0	6.8	11.5	9.7	12.0	17.0	17.5	14.0	18.5	20.7	21.1
Gain	12.3	12.7	11.3	11.7	11.0	11.2	14.5	15.0	13.7	14.4	12.5	12.8
% Dist.	4.7	4.5	4.6	4.9	4.7	4.3	5.2	5.0	5.0	4.6	4.8	4.2

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than 1/8 Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 4

CHART XXI

RESISTANCE COUPLED AMPLIFIER DATA

Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	.1		.27			.47		.1		.27			.47	
Rc_2	.27		.68			1.2		.27		.68			1.2	
Rcf	.27	.47	.27	.47	1.0	.47	1.0	.27	.47	.27	.47	1.0	.47	1.0
Rk	1200	1200	2700	2700	2700	4700	4700	470	470	1000	1000	1200	1500	1800
Ib	.57	.57	.246	.246	.246	.143	.143	1.74	1.74	.74	.74	.72	.44	.42
Ic_2	.24	.24	.106	.106	.106	.063	.063	.68	.68	.30	.30	.29	.18	.175
Ec_1	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0	−1.1	−1.1	−1.0	−1.0	−1.2	−0.9	−1.1
Ec_2	41	41	28	28	28	25	25	66	66	46	46	52	34	40
Eb	46	46	34	34	34	33	33	76	76	50	50	55	43	52
Esig	.05	.05	.05	.05	.05	.05	.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	5.8	6.0	5.6	6.9	8.3	6.4	8.5	19.0	20.0	20.5	25.0	29.8	25.1	31.0
Gain	116	120	112	138	166	128	170	190	200	205	250	298	251	310
% Dist.	3.6	3.7	3.9	3.3	2.4	4.7	3.5	2.7	2.5	3.4	1.1	0.8	2.2	0.7
Esig (1)	.07	.07	.06	.09	.11	.05	.07	.32	.32	.26	.22	.29	.14	.22
Eout	8.0	8.3	6.6	12.0	16.5	6.4	11.5	54.0	56.0	37.0	47.7	67.0	34.0	57.5
Gain	114	119	110	133	150	128	164	169	185	185	217	231	243	261
% Dist.	5.1	4.9	4.7	4.9	3.5	4.7	4.7	4.9	3.3	5.1	2.6	3.3	3.5	3.7

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than 1/8 Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 1

CHART XXII
RESISTANCE COUPLED AMPLIFIER DATA

Triode Section
Self Bias Operation

	Ebb = 100 Volts						Ebb = 250 Volts					
Rb	.047		0.1		0.27		.047		0.1		0.27	
Rcf	0.1	0.27	0.1	0.47	0.27	0.47	0.1	0.27	0.1	0.47	0.27	0.47
Rk	1000	1200	1800	2700	4700	5600	470	470	820	1200	2700	3300
Ib	1.2	1.1	0.64	0.56	0.26	0.25	3.5	3.5	1.86	1.73	0.72	0.68
Ec	-1.2	-1.3	-1.2	-1.5	-1.2	-1.4	-1.6	-1.6	-1.5	-2.1	-1.9	-2.2
Eb	43	47	35	43	29	32	84	84	63	75	54	64
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	2.0	2.10	1.98	2.05	1.96	2.00	2.45	2.63	2.38	2.45	2.25	2.25
Gain	20.0	21.0	19.8	20.5	19.6	20.0	24.5	26.3	23.8	24.5	22.5	22.5
% Dist.	1.4	1.2	1.5	1.0	1.2	1.0	0.8	0.8	0.9	0.7	0.7	0.6
Esig (1)	.37	.49	.35	.62	.40	.53	.78	.78	.66	1.04	1.02	1.25
Eout	7.4	10.0	6.9	12.5	7.7	10.5	19.1	20.3	15.7	25.5	22.5	28.0
Gain	20.0	20.4	19.7	20.1	19.2	19.8	24.5	26.1	23.8	24.5	22.1	22.4
% Dist.	4.6	5.1	4.5	5.1	4.2	4.1	4.8	4.4	4.5	4.7	4.9	4.7

(1) At Grid Current Point, Less Than ⅛ Microampere Grid Current Through 0.27 Megohm Grid Resistor.

FOR CIRCUIT SEE FIGURE 4

Pentode Section
Self Bias Operation

	Ebb = 100 Volts							Ebb = 250 Volts						
Rb	0.1		0.27			0.47		0.1		0.27			0.47	
Rc_2	.27		.68			1.2		.33		.82			1.2	
Rcf	.27	.47	.27	.47	1.0	.47	1.0	.27	.47	.27	.47	1.0	.47	1.0
Rk	1000	1000	2200	2200	2700	3300	3900	390	470	820	1000	1200	1800	1800
Ib	.65	.65	.28	.28	.27	.17	.16	1.75	1.70	.74	.73	.72	.46	.46
Ic_2	.26	.26	.12	.12	.11	.07	.07	.62	.61	.270	.265	.260	.183	.183
Ec_1	-.9	-.9	-.9	-.9	-1.0	-.8	-.9	-.9	-1.0	-.8	-1.0	-1.0	-1.2	-1.2
Ec_2	30	30	18	18	25	16	16	46	49	29	33	37	30	30
Eb	35	35	24	24	27	20	25	75	80	50	53	55	34	34
Esig	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Eout	7.9	9.0	8.2	9.8	11.5	9.9	12.4	14.2	15.3	15.7	18.9	22.0	16.7	25.0
Gain	79	90	82	98	115	99	124	142	153	157	189	220	167	250
% Dist.	2.7	2.1	2.9	1.0	.46	2.3	.80	2.4	2.2	2.2	1.5	.82	1.9	2.8
Esig (1)	.18	.18	.14	.14	.23	.12	.17	.27	.38	.18	.27	.35	.30	.35
Eour	13.5	15.0	11.2	13.5	22.6	11.6	19.3	36.2	52.0	27.1	45	63	43.8	67
Gain	75	83.2	80	96.5	98.3	96.6	113	134	137	150	167	180	146	191
% Dist.	4.2	2.9	4.1	1.7	4.0	3.2	2.7	4.3	4.5	3.9	3.9	4.8	5.0	4.5

Note (1) For Self Bias Operation This is Taken at the Grid Current Point With Less Than ⅛ Microampere Grid Current.

FOR CIRCUIT SEE FIGURE 1

SYLVANIA ELECTRIC PRODUCTS INC.

PRODUCT DIRECTORY

RADIO TUBE DIVISION

Emporium, Pennsylvania

Receiving Tubes • Test Equipment

TELEVISION PICTURE TUBE DIVISION

Seneca Falls, New York

Cathode Ray Tubes • Television Picture Tubes

RADIO & TELEVISION DIVISION

254 Rano Street, Buffalo 7, New York

Radio Receivers • Television Receivers

ELECTRONICS DIVISION

100 Sylvan Rd., Woburn, Massachusetts

Specialized Electronics Equipment • Germanium and Silicon Diodes — Magnetrons — Thyratrons — TR Tubes

PHOTOFLASH DIVISION

Broad Street, Mountoursville, Pennsylvania

Photoflash Lamps • Photoflood Lamps

LIGHTING DIVISION

60 Boston Street, Salem, Massachusetts

Fluorescent & Incandescent Lamps • Sign Tubing
Lamp Fixtures & Accessories

TUNGSTEN & CHEMICAL DIVISION

Towanda, Pennsylvania

Tungsten Products • Fluorescent Chemicals

PARTS DIVISION

208 East Street, Warren, Pennsylvania

Wire Parts, Welds • Plastics

ELECTRONIC SYSTEMS DIVISION

100 First Street, Waltham, Massachusetts

Special Electronic Equipment

For information on specific products, address inquiries to the appropriate division.

SYLVANIA PLANTS, LABORATORIES, AND OFFICES LOCATED IN—

Alexandria, Va.
Altoona, Pa.
Atlanta, Ga.
Batavia, N. Y.
Bayside, N. Y.
Boston, Mass.
Brookville, Pa.
Buffalo, N. Y.
Burlington, Iowa
Charlotte, N. C.
Cincinnati, Ohio
Cleveland, Ohio
Dallas, Texas
Danvers, Mass.
Dayton, Ohio
Denver, Colorado
Detroit, Mich.
Drummondsville, P. Q., Canada
DuBois, Pa.
Dunnville, Ontario
Emeryville, Cal.
Emporium, Pa.
Flushing, N. Y.
Fullerton, Cal.
Hatboro, Pa.
Hicksville, N. Y.
High Point, N. C.
Houtzdale, Pa.
Huntington, W. Va.
Ipswich, Mass.
Kansas City, Kansas
Kew Gardens, N. Y.
Los Angeles, Cal.
Melrose Park, Ill.
Mill Hall, Pa.
Milwaukee, Wis.
Minneapolis, Minn.
Montoursville, Pa.
Montreal, P. Q., Canada
Mountain View, Cal.
Naugatuck, Conn.
Nelsonville, Ohio
New York, New York
Newton, Mass.
Ottawa, Ohio
Philadelphia, Pa.
Pittsburgh, Pa.
Point Pleasant, W. Va.
Salem, Mass.
San Francisco, Cal.
Seattle, Wash.
Seneca Falls, N. Y.
Shawnee, Okla.
Smethport, Pa.
St. Louis, Mo.
St. Marys, Pa.
Teterboro, N. J.
Toronto, Ontario, Canada
Towanda, Pa.
Troy, Pennsylvania
Union City, N. J.
Waldoboro, Maine
Waltham, Mass.
Warren, Pa.
Washington, D. C.
Wheeling, W. Va.
Williamsport, Pa.
Winchester, Kentucky
Woburn, Mass.
York, Pa.