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MILITARY HANDBOOK

ELECTRON TUBES, TECHNIQUES FOR APPLICATION OF IN MILITARY EQUIPMENT

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

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FOREWORD

This handbook was prepared under joint Air Force — Navy sponsorship. The gathering of technical data, analysis and presentation of information was performed by Aeronautical Radio, Inc., under joint Services contract NObsr — 64508. Acknowledgement is made to the many persons and activities of the Military Services and the receiving tube manufacturing industry who provided assistance in obtaining technical data and furnishing constructive comments.

ABSTRACT

This handbook is intended to provide guidance to design engineers in the application of electron tubes in military electronic equipment. The philosophy of conservative design and the necessity for awareness of tube-property variability are emphasized throughout the handbook. In Part I, tube properties and statistical concepts relating to them are discussed. Tube properties are classified by ratings, characteristics, and those properties that are detrimental to circuit design. Tube properties and statistical techniques are discussed in relation to circuit design in Part. II. This portion of the book contains check lists of abnormal environmental conditions and important circuit design factors. Part III contains numerical and graphical information and special design data derived from MIL–E–1 specifications, for tube types appearing in MIL-STD–200. Manufacturer's life-test data on the tube-property behavior of these specific tube types are presented in Part. IV.

TECHNIQUES FOR THE APPLICATION OF ELECTRON TUBES IN MILITARY EQUIPMENTS

INTRODUCTION

The objective of this handbook is to provide guidance to design engineers in the application of electron tubes in military electronic equipments.

Electronic equipments and systems have become so complex that the misapplication of a single part can nullify the effectiveness of a whole system. Misapplication of electron tubes is one important cause of system unreliability, and is a problem resulting in large part from a lack of information about the variability of tube properties. A consequence of this lack of information is that the significance of tube variability as an equipment design factor has frequently been overlooked, to the detriment of equipment operational reliability.

It is evident that reliability is influenced not only by the relationship between electron tubes and equipments, but also by environment, manner of application, and maintenance practices. This handbook is confined to a consideration of electronic equipment design as influenced by tube procurement specifications. Application information is given on the 56 receiving tube types listed in Military Standard, MIL-STD-200. Every effort has been made to present information simply, factually, and constructively.

Part I of the handbook is concerned with properties common to all electron tubes. Since many of these properties are random variables exhibiting definable probability distributions, basic statistical information is presented at the end of the discussion as an aid to the understanding of electron tube applications. Part II is concerned with the relationship between tube properties and circuit design, and provides techniques for using specifications information in circuit design. Part III presents a summary of applications information with reference to specific structural or functional categories of tubes. This material is followed by a discussion of the mechanical, electrical, and environmental-response characteristics of specific tube types, and by application notes which are uniquely applicable to specific tube types. Part IV outlines observed behavior of properties in specific tube types.

Data and advice presented in this handbook are not elsewhere available in consolidated form. However, the material is intended to serve only as a guide for the design engineer and should be used with discretion.

GLOSSARY OF STATISTICAL SYMBOLS AND ABBREVIATIONS

(In Order of Appearance in Text)

$f(X)$ = Probability density function. The various values of $f(X)$ give the relative frequencies of occurrence corresponding to the particular values of X.

σ = Population standard deviation.

σ^2 = Population variance.

X = A variable, usually the independent variable; the number of times an observed event occurs in the binomial distribution; length of life of a product in reliability theory.

X_i = The i^{th} observation of the variable X.

A = Parameter of the logarithmico-normal distribution.

M = Population mean value.

A = Parameter of the uniform distribution.

B = Parameter of the uniform distribution.

p = Probability of an event occurring on any trial.

m_j = The j^{th} order moment of the variable X about an arbitrary origin.

Z = Some arbitrary origin about which the moments of the variable X may be computed.

$\overline{X}$ = Sample arithmetic mean of X; an estimate of the population mean.

s^2 = The sample variance; an estimate of the population variance.

$s = \sqrt{s^2}$ = The sample standard deviation; an estimate of the population standard deviation.

n = Number of cases; size of sample.

β_1 = A measure of relative skewness; The value of $P_1 = 0$ for a normal curve.

β_2 = A measure of relative kurtosis (peakedness); the value of $B_2 = 3$ for a normal curve.

F = The sample variance ratio; the ratio of two independent estimates of the same population variance.

n_1 = Degrees of freedom associated with greater mean square of F-ratio.

n_2 = Degrees of freedom associated with smaller mean square of F-ratio.

W = A weighting factor.

X_{ij} = The variate found in the i^{th} row and j^{th} column of a two-way table of classification.

$f_0(X)$ = Probability density function of the null hypothesis.

$f_1(X)$ = Probability density function of the alternative hypothesis.

k = A predetermined constant for acceptance of the null hypothesis; number of a product which fail in time t in reliability theory.

$s_x = \frac{s}{n}$ = Standard error of a sample mean.

α = Probability of rejection; level of significance; risk of an error of the first kind.

$1-\alpha$ = Probability of acceptance; confidence coefficient.

t = The deviation of a variable from its mean divided by an estimate of the population standard deviation based on the sample standard deviation; a distribution.

$t\alpha$ = The α percent point of a t distribution.

$k\alpha$ = The α percent point of the normal probability distribution.

Pr = The probability that.

SS = Sum of squares.

DF = Degrees of freedom.

MS = Mean square = SS/DF.

L_1 = Lower tolerance limit.

L_2 = Upper tolerance limit.

l = Tolerance factor.

K = Scale factor.

Y = A variable, usually the dependent variable.

Y_i = The i^{th} observation of the variable Y.

A = Constant in the population regression equation.

B = Population regression coefficient.

a = Estimate of A; a constant in the sample regression equation.

b = Estimate of B; a sample regression coefficient.

Σ = The summation of.

$\overline{Y}$ = Arithmetic mean of Y.

e = Residual; error; discrepance term.

s_e = Standard error of estimate.

ρ = Population correlation coefficient.

r = Sample correlation coefficient; an estimate of ρ.

r^2 = Coefficient of determination; a measure of the closeness of the relationship between two variables.

X' = A particular value of X.

$\hat{Y}$ = Sample estimate of the mean value of Y obtained from the estimated line of regression.

$\hat{Y}'$ = Confidence limits for the mean of the Y values for a particular value of X.

$\hat{Y}''$ = Confidence limits for an individual Y value.

$\hat{Y}'''$ = Tolerance limits for Y for a given value of X.

SS_y = Sum of squares of all Y_i values about $\bar{Y}$.

SS_e = Sum of squares of the deviations of the Y_i values about the regression line.

$P = 1 - \alpha$ = Value of confidence coefficient.

y = Log Y.

x = Log X.

$\hat{y}$ = Sample estimate of the mean value of y obtained from the estimated regression line.

s_Y = Sample standard deviation of Y.

LAL = Lower limit for X.

UAL = Upper limit for X.

Log = Common logarithm.

T = Time measured from some beginning point.

$R(T) = Pr(X>T)$ = Reliability function; the probability that the length of life of a product will be greater than time "T."

$\hat{R}(T) = \dfrac{n-k}{n}$ = Estimate of R(T).

$R(t) = P(X>t)$ Reliability function obtained by an approach other than that used for R(T).

$\hat{R}(t)$ = Estimate of R(t).

i = The i^{th} ordered failure.

t_i = Time to the i^{th} failure.

$\hat{R}(t_i)$ = Estimate of R(t) at the time of the i^{th} failure.

n_i = Number of survivors beginning the interval which precedes the i^{th} failure.

r_i = Number of failures occurring at the time of the i^{th} failure.

π = The product of.

V = Variance.

W_i = Number of withdrawals (censored observations) during the i^{th} time interval.

PART I

TUBE PROPERTIES

AND

STATISTICAL CONCEPTS

1. TUBE PROPERTIES

The electronic equipment designer may best evaluate the ability of a specific tube type to satisfy a given circuit requirement by considering the following five types of tube properties.

(1) *Ratings:* the set of limiting values defining each operating condition within which the tube type can be expected to yield a nominal period of satisfactory service.

(2) *Controlled Characteristics:* tube properties essential to the operation of the circuit, and having a distinct range of values defined for a given tube type by specifications.

(3) *Uncontrolled Characteristics:* tube properties essential to the operation of the circuit, but existiing within an indeterminate range, owing to lack of specification control.

(4) *Controlled Detriments:* inherent tube properties which must be considered in circuit design because of their detrimental effects upon circuit operation. These properties have no specified range of values; they are restricted by a single specified limit on their magnitude or frequency of occurrence.

(5) *Uncontrolled Detriments:* inherent tube properties which are detrimental to circuit operation and which are not subject to specication control.

Table I indicates the extent to which tube ratings, characteristics, and detrimental properties are controlled by specifications.

1.1 *Tube Ratings as Limitating Values*

Three rating systems are currently in use for defining conditions of operation within which a tube type can be expected to yield a nominal period of satisfactory service. These are the design-center system, the absolute-maximum system, and the design-maximum system. Although military specifications usually employ the absolute-maximum system, the designer must occasionally use a tube type for which no set of absolute ratings is available and must therefore be able to work easily with any of the three systems.

The Design-Center System

The design-center system was developed to control the use of tubes in relatively simple circuits. Because of the complex and critical nature of many present-day circuits, this system is no longer adequate and is not used in military specifications. The design-center maximum ratings allow for a 10-percent increase over rated values to accommodate limited variations in operating conditions. This increase is not always sufficient for modern equipments operated under stringent conditions. An additional inadequacy in the design-center rating system is that no allowance is made for variations in tube characteristics. Tube abuse may result inadvertently if the calculated operating conditions are near a rating value. For proper use of the design-center system, design ratings must be specified sufficiently below the design-center maximum values to allow for variations in tube characteristics.

The Absolute-Maximum System

In the absolute-maximum system, the rated values of a tube must not be exceeded under any specified condition of supply-voltage variation, change in ambient temperature, manufacturing variation in tube or other component, equipment control adjustment, or any combination of these specified condi-

RATINGS	CHARACTERISTICS	DETRIMENTAL PROPERTIES
FREQUENTLY CONTROLLED IN SPECIFICATIONS		
Heater Voltage Anode Voltage (d-c) Screen Grid Voltage (d-c) Heater-Cathode Voltage Anode Dissipation Screen Grid Dissipation Output Current (Rectifiers) Output Voltage (Rectifiers) Peak Current (Rectifiers) Peak Inverse Voltage (Rectifiers) High Impact Shock	Transconductance Plate Current Screen Grid Current Heater Current Inter-Electrode Capacitance Amplification Factor Power Output Emission Conversion Conductance	Control Grid Current at Rated E_f Heater-Cathode Leakage Microphonics Noise Shorts and Continuity Vibration Output
OCCASIONALLY CONTROLLED IN SPECIFICATIONS		
Anode Voltage—Peak Forward Anode Voltage—Peak Inverse Control Grid Voltage Control Grid Resistance Average Cathode Current Bulb Temperature	Dynamic Plate Resistance Bias For Plate Current Cutoff	Electrode Insulation Grid Current at Elevated E_f Change of Characteristics with Life Change of Characteristics with E_f
RARELY CONTROLLED IN SPECIFICATIONS		
Pressure—Temperature Derating Peak-Pulse-Cathode Current	Zero Bias Plate Current Zero Bias Screen Current Plate Current at Multiple Bias Points Screen Current at Multiple Bias Points	Initial-Velocity Electron Current (Contact Potential) Electron Coupling Effects Plate Emission Screen Emission

Table 1. Degree of Specifications Control of Specific Tube Ratings. Characteristics, and Detrimental Properties.

tions. The equipment designer is responsible for determining design values such that the absolute maximum value of any rating will not be exceeded under any combination of anticipated variations in the operating conditions. This rating philosophy requires that the designer take into account the normal variation in tube characteristics and allow for the severest possible condition of signal voltage.

The Design-Maximum System

Under the design-maximum system, the ratings are based upon the behavior of the average tube. In setting these ratings, the tube manufacturer takes the responsibility for manufacturing variation by life-testing at or near the rating value. It is the responsibility of the designer using this system to see that the rating is not exceeded under any possible combination of voltage-supply variation, control misadjustment, or signal-voltage level.

Although ratings are specified by single-valued limits, these limits are not absolute barriers on one side of which satisfactory operation will continue indefinitely and on the other side of which almost immediate degradation of performance will occur. The equipment designer must realize that the expected period of satisfactory performance decreases gradually as the rating is approached and exceeded, and that the life expectancy of the tube is greater if the tube is used conservatively with respect to its ratings. The numerical value specified is usually the value which assures acceptable performance under specified life-test conditions and is not necessarily closely related to field usage. Table 2 summarizes the types (and causes) of tube failure which may result from use of tubes at values approaching common tube ratings.

1.2 Characteristics Essential to Circuit Operation.

Essential characteristics of an electron tube are those properties that support the performance of the tube in the application in which it is employed.

In many cases, the tube properties which are essential to specific circuit performance characteristics are known. For example, the gain of a pentode amplifier circuit is closely related to transconductance (S_m); the gain of a triode amplifier circuit, on the other hand, is related both to transconductance and to the tube amplification factor (μ). In some applications, inter-electrode capacitances can be regarded as essential characteristics, whereas in other applications (for example, low-frequency circuits) these properties are of no consequence.

The optimum situation obtains when the essential characteristics are known, when their variability is adequately defined by the applicable specification, and when a high degree of correlation exists between the variability of the essential characteristics and the variability of performance characteristics of the circuit.

Certain methods used for specification control of variability in essential characteristics are discussed at the end of Part I. Techniques for determining the correlation between essential tube characteristics and circuit performance characteristics are discussed in Part II.

1.3 Properties Detrimental to Circuit Operation.

Detriments are inherent tube properties whose deleterious effect on circuit operation must be taken into consideration in circuit design. These properties have no specified range of values, but are restricted by a single specification limit upon their magnitude or frequency of occurence. Certain detriments manifest themselves upon initial installation of the tube; others become evident only through equipment malfunction with the passage of time.

MAY CAUSE	RESULTING IN / APPROACHING THIS RATING	Max. Anode or Screen Voltage	Max. Peak Forward Anode Voltage	Max. Positive Control Grid Voltage	Max. Negative Control Grid Voltage	Max. Heater Voltage	Min. Heater Voltage	Max. Control Grid Return Resistance	Max. Anode or Screen Dissipation	Max. Heater-Cathode Voltage	Max. Cathode Current	Min. Cathode Current	Max. Output Current for Rectifiers	Max. Output Voltage for Rectifiers	Max. Inverse Voltage for Rectifiers	Max. Bulb Temperature
Increased Operating Temperature of Tube Elements	Accelerated Evolution of Gas (Positive Shifts in Bias and Progressive Loss of Emission)			X		X			X		X		X			X
	Thermal Expansion of Tube Parts (Shorts and Temporary Change of Characteristics)					X			X							X
	Accelerated Formation of Leakage Paths					X										
	Cracks in the Glass Envelope					X			X				X			X
	Changed "Contact Potential"					X										
	Shortened Heater Life					X										
Increased Potential Gradient	Voltage Breakdown of Insulation		X		X					X				X	X	
	Increased Rate of Heater-Cathode Shorts					X				X						
Increased Temperature of Elements and/or Potential Gradient	Increased Effects of Control Grid Emission (Shifts Bias More Positive)			X		X		X	X							X
	Increased Effects of Anode Emission (Arc-Back in Rectifiers or Positive Bias Shift in Amplifiers)		X			X		X	X				X	X	X	X
	Increased Heater-Cathode Leakage					X				X						
	Accelerated Formation of Cathode-Interface Resistance				X	X						X				
	Accelerated Electrolysis Effects (Glass Leakage Current and Possible Loss of Vacuum)	X	X			X			X				X	X	X	X
Accelerated Change in Characteristics With Time		X			X	X			X		X	X	X			X
Increased Initial Variation in Characteristics from Tube to Tube				X		X	X				X	X				
Inadvertently Exceeding Other Ratings		X	X	X	X	X		X	X		X		X	X	X	X

Table 2. Specific Tube Defects Resulting from Operation Under Conditions Closely Approaching Common Tube Ratings.

To obtain maximum utilization of the Essential Characteristics, it is necessary that detriments be recognized as potential contributors to equipment failure. In general, if the equipment designer has properly assessed the nature or mode of equipment malfunction resulting from detrimental properties, he has three means of preventing such malfunction:

(1) By selecting a tube type for which the specification quantitatively defines the undesired property.

(2) By avoiding operation of the tube under conditions which will aggravate the effect of the detriment or accelerate its development.

(3) By designing the circuit so that the presence of the undesired property is tolerated both initially and after extended operation.

The following material describes briefly the source and nature of some generally undesired but often unrecognized properties of present-day electron tubes, the variables involved and their effects upon circuit operation, various methods of reducing the effects of the undesired properties, and certain applicable methods of testing for and simulating the presence of these properties.

1.3.1 *Initial-Velocity Grid Current*

Figure 1 shows a typical relationship between control-grid current and potential resulting from the initial velocity of electrons emitted from the cathode. Tube manufacturers often refer to the value of grid potential producing a current of 0.1 microampere as the "contact potential"* of the tube.

The diagonal lines showing grid current versus grid voltage may be considered plots of the number of electrons emitted per unit time (grid current) with sufficient kinetic energy to move to the grid against a given retarding electrical field. (The retarding field must be considered as the actual potential between the surface of the cathode and the surface of the control grid. This potential includes any separately introduced sources of bias voltage as well as the "contact difference-of-potential" of dissimilar materials in the grid-cathode circuit loop.) The resulting current is consequently a function of grid-cathode potential and cathode temperature, as well as of cathode composition and area.

Cathode area is reasonably constant in tubes of the same type. Cathode temperature is usually dependent upon the operating voltage of the heater. Hence, variations of initial-velocity electron current in a given tube type will occur primarily with changes in heater voltage. However, such variations will also occur from tube and, in particular, from manufacturer to manufacturer.

The circuit designer must consider the fact that initial-velocity grid current in the grid-potential range between 0 and approximately –1.3 volts is manifested in two phenomena which have different effects in different applications. On the one hand, initial-velocity grid current represents a finite dynamic grid impedance with magnitude dependent upon grid potential. The effect of this impedence may appear as loading in tuned input circuits or as extreme distortion at low frequencies in audio amplifiers. On the other hand, initial-velocity grid current represents a direct-current source having high internal resistance, with the negative pole on the grid and the positive pole on the cathode. Where the major portion of grid-return resistance is common to several grids, this direct-current source may cause variations of AVC bias, since the tube having the highest value of initial-velocity grid current will determine the residual bias under no-signal conditions and thereby the

* "Contact potential" must be clearly distinguished from "contact difference of potential" of dissimilar materials.

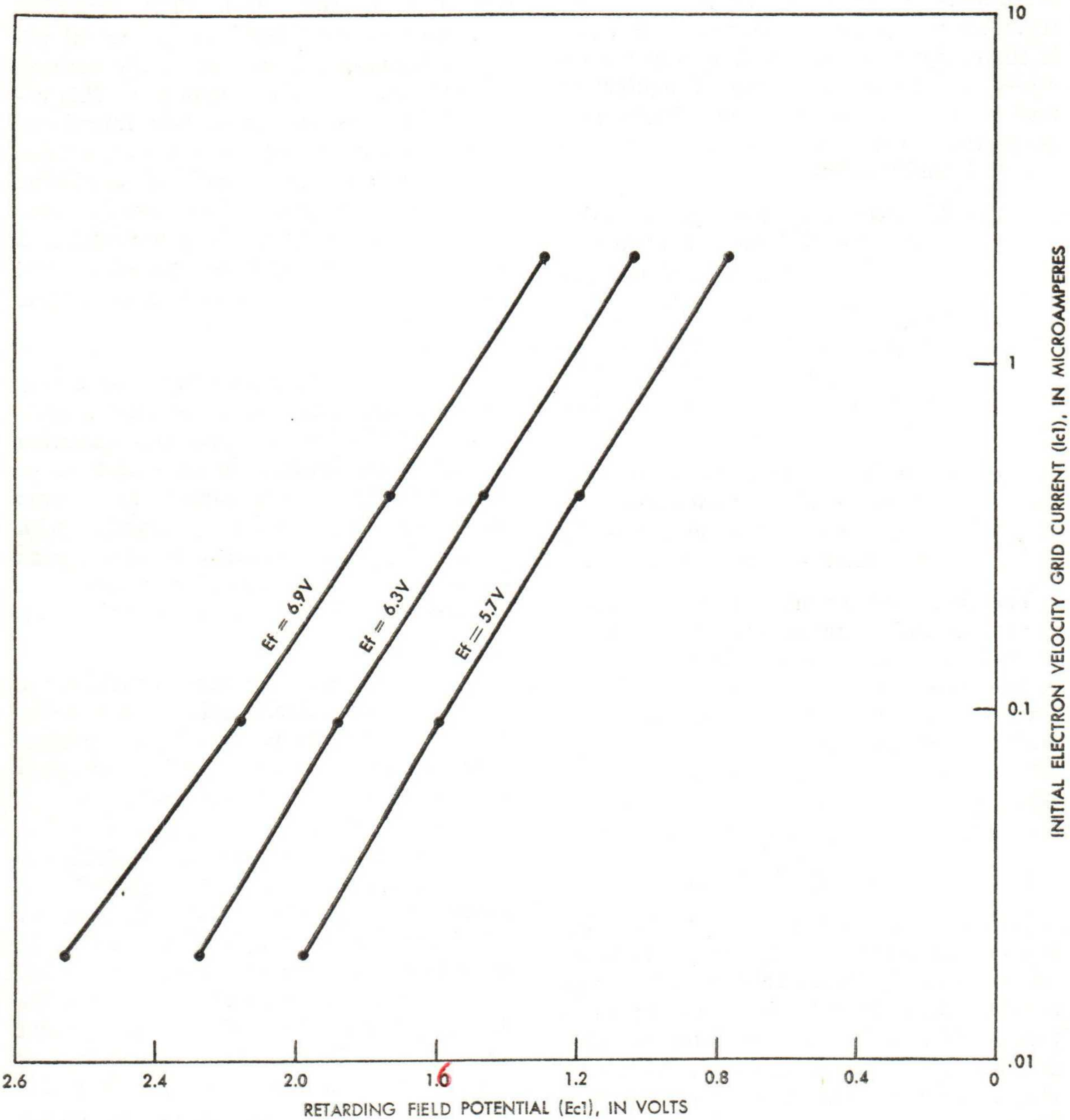


Figure 1. Typical Initial Electron Velocity Grid Current of a Receiving Pentode as a Function of Heater Voltage and Grid Potential. Screen and Plate tied to Cathode.

maximum sensitivity of the equipments involved.

Dyamc impedance and d-c biasing can be reduced by the use of the minimum value of grid-return resistance compatible with circuit function, and by the establishment of cathode or fixed bias sufficient to remove the grid operating potentials from the region where initial-velocity current causes trouble. Usually a bias of 1.3 volts will suffice. Although excessive heater voltage greatly increases the magnitude of the current, reduction of the current by reducing heater voltage far below rated values is not recommended because of adverse effects upon other tube haracteristics. The variation of heater voltage as a laboratory test to simulate variations in "contact potential" is a useful technique, provided the accompanying changes in other tube characteristics are also considered. "Contact potential" is not now controlled by tube specification.

1.3.2 *Ionic Grid Current*

The ions resulting from the collision of electrons and gas molecules can, in some measure, be regarded as normal by-products of cathode current. Positive ions will usually be attracted to the control grid (the most negative region of the tube), where a fraction of them will be intercepted and will constitute an ionic grid current. Ionic grid currents in excess of 3.0 microamperes are sometimes found in receiving-type tubes. The ionic current flows in opposition to the initial-velocity electron current, making the grid more positive if grid-return resistance is utilized. A typical variation of ionic grid current with grid potential is shown in Figure 2. This current is dependent upon grid potential, gas pressure within the tube, current density of the electron stream, and the ability of the grid to intercept ions attracted by its field. The circuit designer must give particular attention to the relationship of grid potential and gas pressure and the geometry of the tube type with which he is dealing.

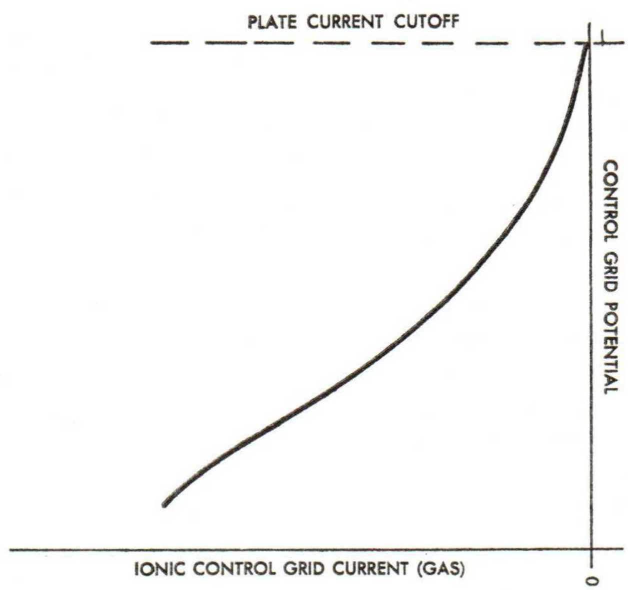


Figure 2. Typical Variation of Ionic Grid Current with Grid Potential.

Ionic grid current has two undesirable effects on circuit function — a finite, negative, dynamic impedance at the grid; and a direct-current source of variable internal resistance, with the positive pole on the grid and the negative pole on the cathode. The second effect is more important than the first in some applications, for the direct-current source may result in an excessive increase in plate current if too much grid resistance is used. The situation can cascade and result in a complete loss of control of plate current by the grid, since $I_g = f(I_p)$.

Both the effects of dynamic impedance and the effects of a positive shift of grid potential can be reduced by avoidance of high operating temperatures and by use of a minimum value of grid-return resistance. It should be borne in mind that gas pressure may increase considerably beyond the initial limit during operation as a result of excessive temperature, cathode current, vibration, or simply the lack of vacuum in the envelope. An unhealthy trend toward helium-gas cooling of tubes in hermetically sealed enclosures has brought about an unusual "gas" problem, in that helium diffuses readily through the thin glass walls of electron tubes.

1.3.3 *Spurious Emission Currents*

Most tube electrodes are capable of emitting some current during operation. The magnitudes of such currents depend, in certain cases, upon electrode temperatures and upon the extent to which the electrode has become contaminated.

In most applications, the major concern is with currents originating at the control grid as primary or secondary emission to some more positive element. A positive shift in bias occurs, dependent upon the value of the grid-return resistance. This shift in bias, like ionic grid current, is capable of cascading into a condition resulting in loss of plate-current control — provided that excessive grid-return resistance is present.

In applications in which the control grid is not maintained as the most negative tube element, the grid may act as an anode and receive emission currents from other elements, with the result that bias shifts in a negative direction. Such an effect frequently occurs in circuits in which the plate or the screen is supplied with alternating current. The effect is usually characterized by a gradual negative drift which requires several minutes after warm-up to reach a quasi-stable state. Any of the spurious emission currents may display short-term variations during warm-up and may increase throughout the life of the tube. They exhibit wide variations in magnitude, depending upon the tube and the conditions under which it is operated. For example, control-grid current of more than 10 microamperes may be experienced in some tubes.

Reduced operating temperatures, low values of grid resistance, and, in particular, the avoidance of increased grid temperature resulting from excessive heater voltage will aid in reducing spurious emission currents. Some tube specifications call for grid-current tests at elevated heater voltage to insure that the tendency for the primary control grid to develop emission is kept to a minimum. Specification control of screen-grid and plate emission is comparatively rare.

1.3.4 *Control-Grid Current*

Under conditions of direct-current or low-frequency operation, undesired currents may flow in the control-grid circuit from at least four different sources within the tube:

(1) electrons of high initial velocity,

(2) ions formed by collision,

(3) inter-element conductive paths (surface leakage), and

(4) undesired electron emission (from elements other than the cathode).

A comparison of these four sources is given in Figure 3, which is intended to show the trend in the current-voltage characteristics of the control grid, rather than the ability of this grid to control plate current. The net grid current may obviously differ widely in different tubes, depending upon the magnitude of each individual current.

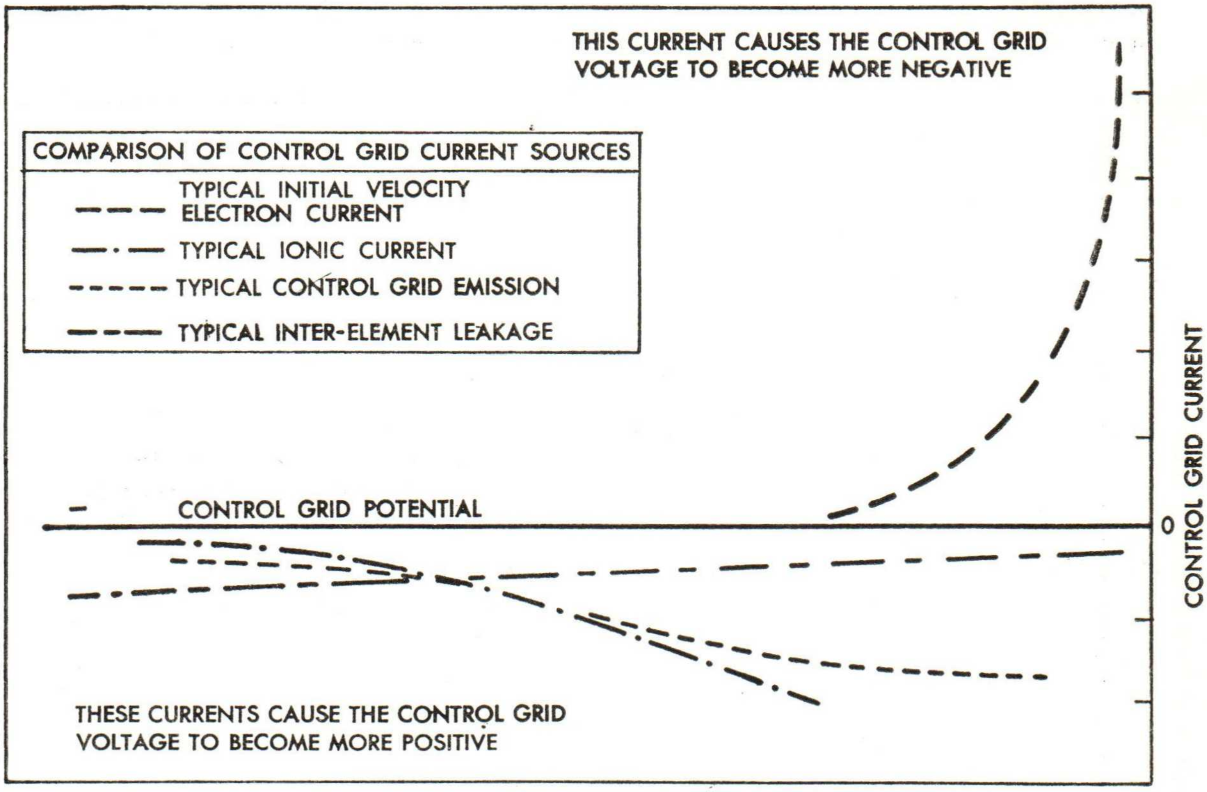


Figure 3. Comparison of Control Grid Current Sources.

The figure indicates that the control grid (a) is capable of producing finite dynamic impedance in the region of negative bias; and (b) is capable of shifting the externally applied bias by means of internal conduction paths and emission sources.

There are two methods of forestalling trouble caused by these sources of grid current. One method is to operate the heater at the correct voltage; the other method is to use the smallest value of grid-return resistance compatible with circuit function.

1.3.5 *Interelectrode Resistive Leakage Currents*

Electrical insulation between elements in electron tubes is usually provided by mica, glass, or ceramic members. During tube manufacture or operation, these insulating materials may receive a light surface coating of conductive material which forms resistive leakage paths between elements.

The formation of leakage paths during operation is usually a function of cathode and getter temperatures. Metals which have sublimed from the cathode sleeve condense on relatively cool surfaces such as those of mica spacers. The resistance of leakage paths so formed usually decreases with an increase in applied voltage. In addition, the resistance value is variable, for the leakage path may open and close intermittently because of loose electrical connection with the electrode.

The resistance of certain types of deposited films is frequency-sensitive. Although the d-c leakage-resistance values appear to be very high, the resistance component at elevated measuring and operating frequencies may cause severe and variable circuit loading. The variation of leakage resistance with frequency of measuring signal is shown in Figure 4. The tubes on which the measurements were made had been operated for several hundred hours in military airborne equipment.

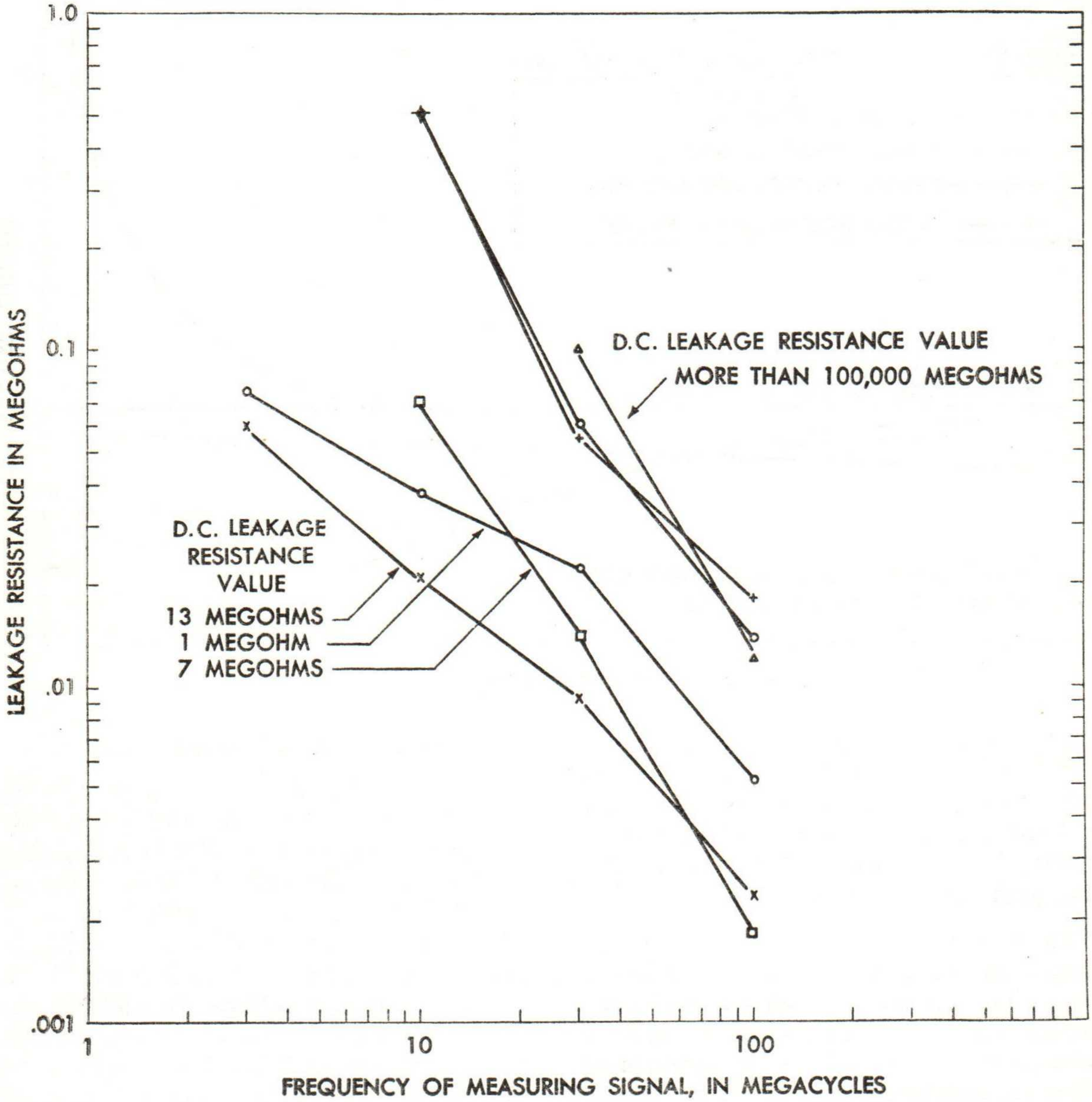


Figure 4. Leakage Resistance Between Grid and All Other Electrodes as a Function of the Frequency of the Measuring Signal.

Although the resistance of a normal tube is usually more than 5000 megohms between plate or grid and all other electrodes when measured at 300 volts, internal leakage may reduce this resistance to less than 5 megohms. Under conditions of high humidity, external leakage paths having a resistance of less than 10 megohms may also appear between pins outside the tube envelope.

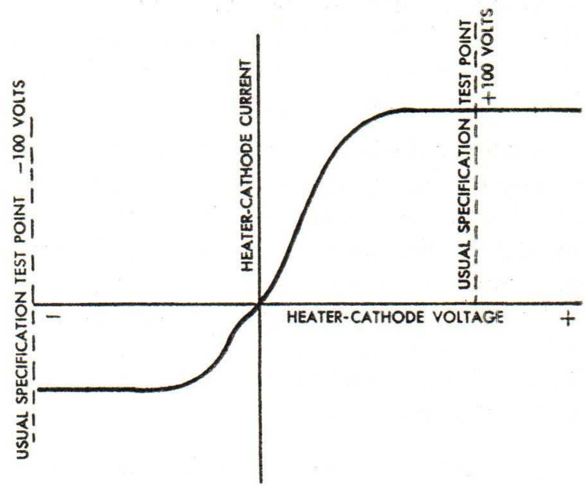
Since high heater voltage and excessive bulb temperature accelerate the formation of internal leakage, the design engineer can reduce leakage by controlling thermal and electrical operating conditions, and by using tube types for which specifications control insulation resistance during life-testing.

1.3.6 *Cross-Currents*

In the manufacture of multi-structure tubes, the anodes are often perforated at one or more points, (for manufacturing purposes) and the apertures remain open after the tube is assembled. Through such openings, cross-currents can flow — for example, from the cathode of one structure to the anode or the side rods of the other — forming a coupling path between supposedly independent circuits. Such currents bring about a condition wherein it becomes impossible to cut off one or more sections completely, regardless of grid voltage or they can act as sources of unwanted signal energy (cross-talk). If the equipment designer uses multi-structure tubes in circuits critical to cross-currents, he should assure himself that the specification adequately defines cut-off both in terms of limit value and in terms of method of test. His only alternative, if specifications do not contain such information, is to design the circuit to tolerate cross-currents.

1.3.7 *Heater-Cathode Leakage*

In most tubes in which the cathode is heated indirectly, the heater is coated with or is enclosed within a ceramic-type material to insulate it electrically from the cathode. During operation, the insulating value of the ceramic may drop, thereby permitting current to flow between heater and cathode. The precise mechanism of heater-cathode leakage is very complex; it is sufficient to note that the current usually increases with an increase in temperature. The relationship between current and voltage is usually non-linear, as shown in Figure 5. This figure illustrates a situation in which leakage current is greater under conditions of positive heater-cathode voltage. The reverse situation, in which leakage current is greater under conditions of negative heater-cathode voltage, also may occur.



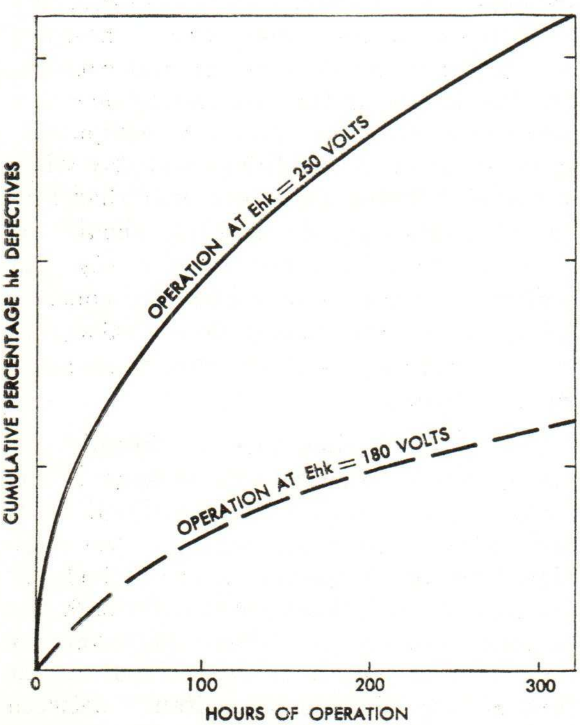
5. Typical Heater-Cathode Voltage and Current Relationship, Indicating the Location of the Usual Specification Test Points.

When alternating voltages are applied between heater and cathode, peak currents greater than those measured for corresponding values of d-c voltage may flow. This phenomenon may result in leakage currents of high harmonic content when sine-wave voltages exist between heater and cathode. The implication is that d-c testing does not furnish complete assurance that equipments operated under a-c conditions will stay within specified limits. Therefore, published limits of heater-cathode leakage should be avoided with a large margin of safety. An additional factor to be taken into consideration is that the magnitude of leakage in any one tube may vary somewhat from reading to reading.

The most common circuit difficulty resulting from heater-cathode leakage is the introduction of an extraneous signal from the heater to the input circuit of the tube. Signal voltage is formed at the cathode by the passage of leakage current through the cathode resistor. A voltage may also be coupled from the heater to the input circuit through the physical capacitance between heater and cathode. The latter phenomenon becomes important if operation or testing occurs at more than one frequency of the a-c heater supply. The reactance of the capacity-coupling at 400 cycles will be less than 1/6 of the reactance at 60 cycles, and the coupled voltage will be correspondingly higher at the higher frequency.

Heater-cathode leakage current is usually measured, for testing purposes, at both plus and minus 100 volts on the heater with respect to the cathode, the higher current reading being recorded. As of June, 1957, initial specification limits for leakage current range from 2 to 100 microamperes. Typical life-test end-point values range from 10 to 120 microamperes.

The effects of heater-cathode leakage can be reduced by avoiding excessive heater voltage and by using the smallest value of cathode resistance compatible with circuit function. A typical illustration of the effect of excessive heater-cathode voltage on tube life is given in Figure 6. The curves are based on the number of tubes failing to



6. Typical Heater-Cathode Defectives on Static Life Test, Illustrating Effect of Excessive Heater-Cathode Voltage.

meet specifications because of excessive heater-cathode leakage or indicated shorts between heater and cathode.

1.3.8 *Thermionic Instability*

Information concerning thermionic instability of tubes consists primarily of observed phenomena rather than of established theory. It has been observed that, in general, (a) the apparent emission capabilities of cathodes decline with life; (b) the *range* of emission capabilities of tubes in a given lot may increase with life; and (c) the variation of emission capabilities with heater voltage increases with life. These three emission phenomena are illustrated in terms of the variation of plate current with operating time in Figure 7.

In addition to the long-term changes in emission described above, there are certain short-term readjustments in the characteristics of an operating cathode which occur if the average cathode-current level is changed from an established operating value. A short-term readjustment may begin as a result of an abrupt change in the operating conditions of the circuit or even upon installation of a new tube. Some specifications incorporate requirements concerning the stability of characteristics of individual tubes during the first hour of life test. To have significance, the results of stability tests on a sample of tubes must be given in terms of values for individual tubes; results given in terms of the sample average do not indicate the extent to which individual tubes are unstable.

The operating value of heater voltage is important to thermionic stability throughout the functional life of the tube. As explained in previous sections, excessive heater voltage may produce detrimental effects such as interelectrode leakage or spurious emission currents. Operating heater voltages which are much less than the rated minimum value can produce equally detrimental ecects on the cathode itself. It has

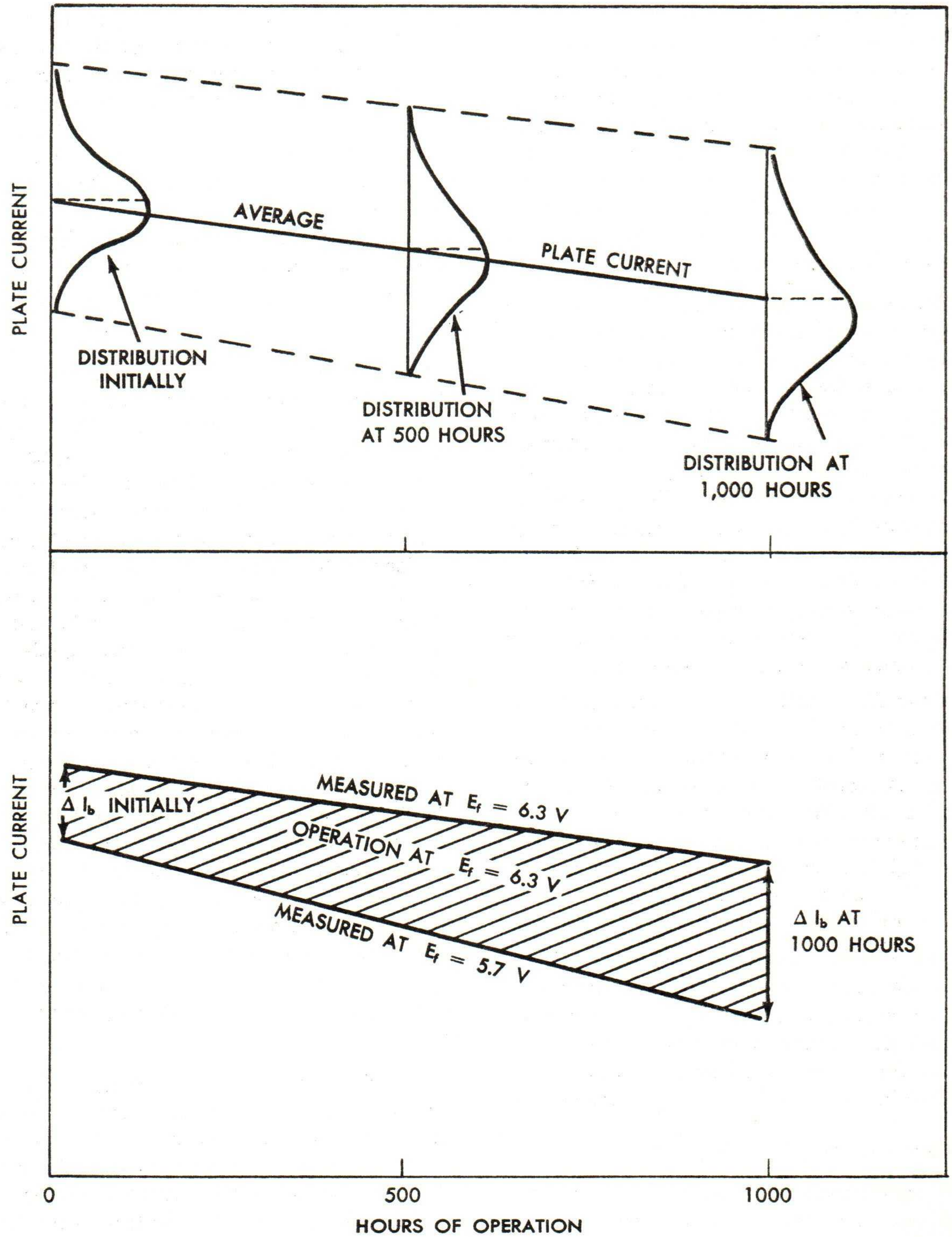


Figure 7. Typical Trend of Plate Current Distribution on Static Life Test; Typical Change of Plate Current With Change in Heater Voltage (General Trend on Static Life Test).

also been observed that operation at very low heater voltages is related to a decline of certain characteristics with life and, under conditions of moderate current density, accentuates the initial differences in characteristics from tube to tube. Both the stability and the uniformity of electron tube characteristics can be increased by maintaining the operational heater voltage close to the design-center value.

Both short-term and long-term variations occur in such electrical characteristics as plate current, screen current, transconductane, and power output. In most instances, there is excellent correlation among variations of these characteristics. For example, a given percentage of change in the static plate current of a tube is likely to be accompanied by a similar percentage of change in transconductance. This relationship becomes a useful concept in circuit design in that stabilization of plate current, in most instances, is accompanied by stabilization of transconductance and power output.

A familiar method of stabilizing plate current is to employ cathode bias. The effects of cathode bias are outlined in the portion of the handbook covering design calculations. Figure 19 shows the effects of limiting cathode current with cathode bias resistance. The stabilization of screen current in pentodes is also a useful method of achieving characteristics stability.

The designer may not always be able to stabilize tube characteristics by means of circuit design alone. However, he can diminish the instability problem by using tube types for which specifications govern the change in characteristics during life-testing.

1.3.9 *Electron Coupling Effects*

If an electrode is so arranged in position and potential that it intercepts electrons from the electron stream, and if the electron stream is modulated, a voltage may be produced at the electrode in phase with the modulation, provided that the electrode load is resistive. If the electrode is so arranged by either position or potential that it does not actually intercept electrons from the electron stream, a voltage may nevertheless result from capacitive coupling between the electrode and the modulated electron stream. In this case, the voltage will not be in phase with the modulation when the electrode load is resistive. The out-of-phase voltage may give rise to undesired effects, particularly if the electrode happens to be a control element.

In the case of pentagrid converters, some observations indicate a variation in conversion gain from the signal grid. This variation is believed to result from capacitive coupling to a space charge in the region between the second and third grids. The density of such a space charge (and hence its charge with respect to the signal grid) varies at the oscillator frequency. These charge variations induce an oscillator-frequency current-component in the signal-grid circuit approximately in quadrature with the voltage of the oscillator grid. Since the signal-grid circuit reactance is usually capacitive at the oscillator frequency, the induced voltage component at the signal grid may be out of phase with the oscillator and may tend to diminish the effect of the oscillator in the region of the signal grid, thereby reducing the conversion gain. Conversion gain can be expected to drop as the frequency of operation is increased. However, a similar effect is often produced at frequencies relatively low with respect to electron transit time.

The effect of electrode coupling to a space charge is largely dependent upon external circuitry. Extreme variations may be expected within the limits set by the tube specification. Consequently, caution should be exercised in the use of capacitive neutralization between the oscillator and the signal grids. Certain individual tubes will require no neutralization; others, of the same type, may require appreciable capacity to compensate for or neutralize all the variables encountered at any one operating point. Moreover, the circuit must maintain neutralization over the range of operating points encountered in functional use.

In the case of high-frequency amplifiers and mixers, the space-charge coupling effect is complicated by tube reactances, by electron transit time, and by phase shifts. The overall effect changes the input conductance of the tube as either the bias or the input frequency is changed. This relationship is such that, if frequency is maintained below the point of tube resonance, the conductance and capacitance usually increase as frequency or cathode current is increased. The change in input conductance is illustrated in Figures 8 and 9. Input-conductance data should be used to determine the relative merits of two tube types, rather than the magnitude of input-conductance in any specific type.

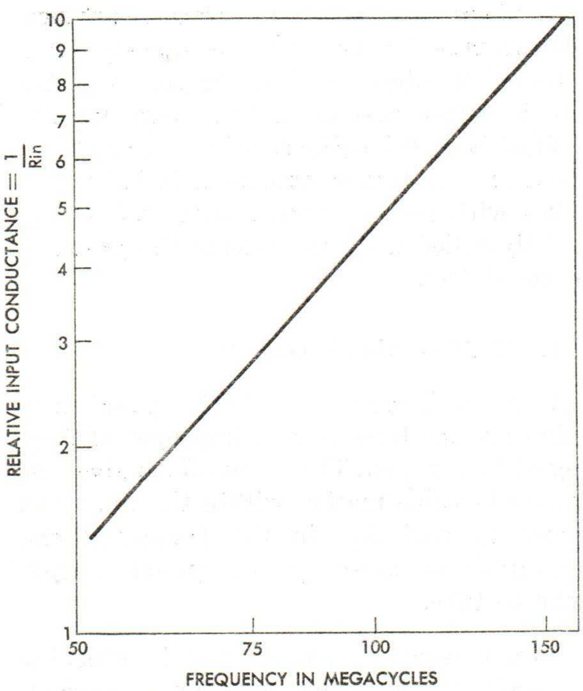


Figure 8. Typical Change of Input Conductance With Frequency (Short-Circuited Output).

The magnitude and frequency-variability of input conductance are largely functions of tube geometry and lead configuration and

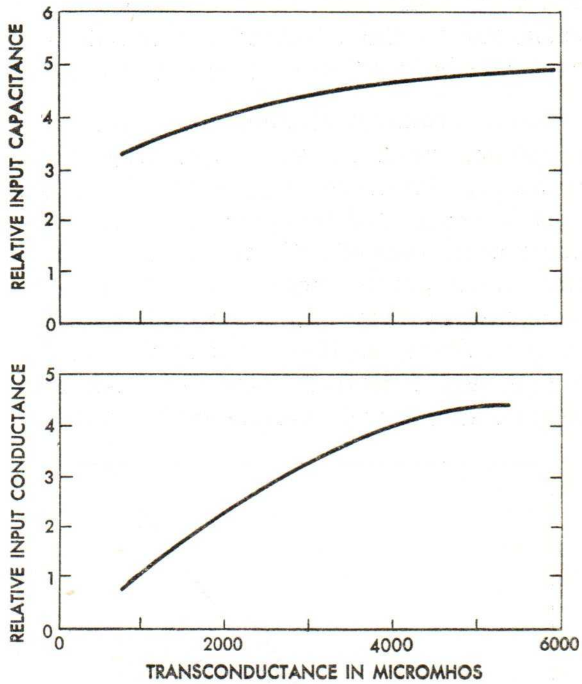


Figure 9. Typical Variation of Input Capacitance and Input Conductance With Transconductance at 100 Megacycles (Output Short-Circuited).

therefore may vary widely within the limits set by the tube specification. Furthermore, since the effect of conductance upon operation is definitely affected by small changes in the circuit constants, extreme caution must be exercised in providing means for compensating or neutralizing the effect — for example, the neutralization of plate inductance. Not only must the circuit provide for the compensation or neutralization of all variables encountered at any one operating point; it must also maintain neutralization of these variables over the entire range of operating points encountered in the application.

1.3.10 *Cathode Interface Resistance*

"Interface resistance" is the name given to a common cathode condition which seems to affect tube behavior in much the same way as would the inclusion of a parallel resistance-capacitance combination in series with the cathode. For purposes of circuit design, the effect of interface resistance is analogous to the effect of a partially by-passed cathode resistor external to the tube.

Under ordinary circumstances, interface resistance develops with operating time. However, interface formation is often greatly accelerated by operation of the tube under conditions of little or no cathode current. Even greater acceleration appears to be caused by operation of the tube at high heater voltage, as illustrated in Figure 10. Accelerated interface formation has also been noted in low-duty-cycle applications.

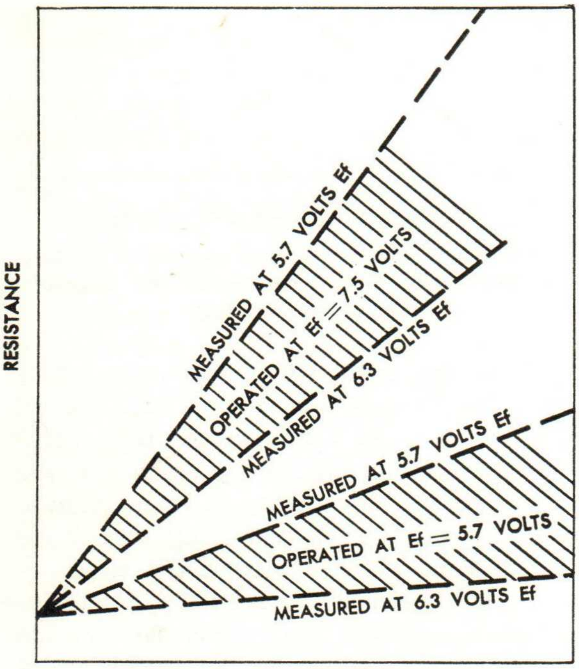


Figure 10. Typical Formation of "Interface Resistance" Under-Cut-Off Condition of Cathode Current.

As indicated above, the measured value of interface resistance is a function of cathode temperature, and hence of the value of a applied heater voltage at time of measurement. The value of a interface resistance is usually greater if the value of applied heater voltage at measurement is reduced. Resistances greater than 300 ohms are not uncommon at rated heater voltage, and resistances several times this value may be experienced at reduced heater voltage. The effect of rated and reduced heater voltage on interface resistance at time of measurement is shown in Figure 10. The equivalent value of the shunting capacity is usually in the range from .001 to .01 microfarads.

The effect of interface resistance upon an operating circuit is best determined in each case by considering the resistance and its shunting capacity as a partially by-passed cathode resistor which limits low-frequency peak currents and distorts pulses and video signals.

The design engineer should attempt to avoid an operating condition in which high-heater-voltage operation is followed by low-heater-voltage operation. The first condition may accelerate the formation of interface resistance, and the second condition may accentuate the effect of the phenomenon. Caution must also be exercised in the choice of tube type, for unless the tube specification adequately defines interface resistance, trouble may develop in the equipment after a period of tube operation. At present, cathode interface resistance is seldom directly defined by specifications. Life-test limits on the change in transconductance in individual tubes with time or with heater voltage are usually relied upon to indicate the presence of the defect.

1.3.11 *Microphonic Output*

In general, the causes of microphonism in tubes are the loose fit and improper anchoring of tube parts. These conditions give rise to considerable motion within the tube, and hence to variation in the frequency and amplitude of noise or microphonic output tube to tube.

Two distinct problems arise in checking a circuit versus a tube type for microphonism. The assurance of satisfactory performance lies in the specification limits for the tube type under study. However, these limits are concerned with the amount of plate signal permitted under conditions of mechanical excitation in a particular test circuit. A preferred technique for testing for microphonism consists of estimating the gain of the test circuit and carrying the plate-signal limit back to the grid circuit as an equivalent grid signal. This value of grid signal may then be extended forward to the intended application by substituting the gain of the actual circuit for that of the test circuit.

Experimental checking for microphonism usually yields overly optimistic results if the phenomenon is evaluated in terms of the average microphonism in a small sample of tubes. There is a preponderant chance that the average value of a small sample of tubes would indicate little or no microphonism in the tubes tested, while the population would exhibit the difficulty to an unsatisfactory degree. If possible, checking should be done with a number of tubes which approach the single maximum value for microphonism.

The mechanical stimulus imparted to the tube elements may be reduced by acoustical or mechanical isolation or, in particular, by damping of chassis resonances.

1.4 Variability in Tube Properties

In general, the variability among items in a group takes the form of a definite probability distribution which may be discerned and plotted (in a histogram) when the items are measured and sorted. The items may be sorted either into two groups — items having values above and below a certain value — or into a number of groups. As the number of measurements and groups increases, the observed histogram becomes smoother and more clearly defined. The pattern eventually approaches that of a theoretical continuous probability distribution. In many instances, the probability distribution may approximate a "normal" curve, although occasionally, and for ascertainable reasons, a non-normal curve is approximated. Whatever the shape of the distribution, the pattern of variation is always well defined in a process in which the conditions are approximately constant.

Figure 11 illustrates the histograms which result from the sorting of 418 type JAN-5814A tubes by transconductance values, first into 2 groups, then into 10 groups, and finally into 45 groups. The curve in the lower right corner of the figure indicates the probability distribution which mathematically describes the variation in transconductance values.

Some of the forms which probability distributions may take are shown in Figure 12. The first three distributions — a normal distribution, a logarithmico-normal distribution, and a uniform distribution — may be taken by properties which are continuously variable. The fourth distribution — a binomial — is the distribution for a discrete variable.

Transconductance in electron tubes is a continuously variable tube property, in that it can assume any value within a wide range of values. However, as illustrated in Figure 11A, transconductance can also be treated as a discrete variable (attribute) by sorting tubes on a "black and white" basis — that is, tubes whose transconductance values fall within a prescribed range are considered good; tubes whose transconductance values do not fall within this range are considered defective.

Other properties of electron tubes are intrinsically "attributes" in nature, since they are not continuously variable over a wide range of values. Such properties either do or do not exist within a given item. For example, either there is heater continuity in a tube or there is not. Attribute properties are measured in terms of the probability of their occurrence in a population of items. Hence, if 3 tubes in 1000 have broken pins, the population of tubes is 0.3 percent defective with regard to broken pins. The probability of occurrence of this attribute in the population is therefore .003. The probability

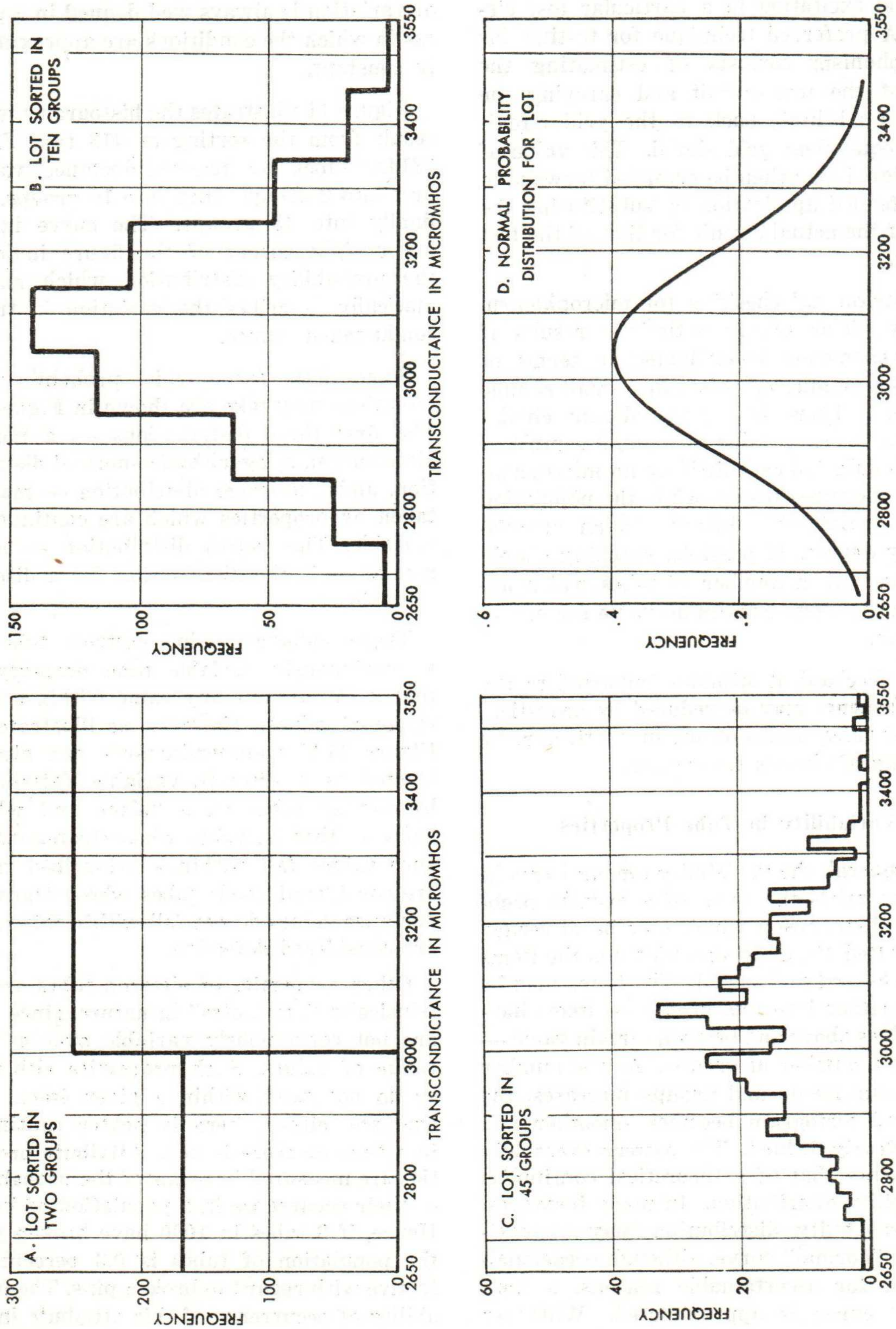
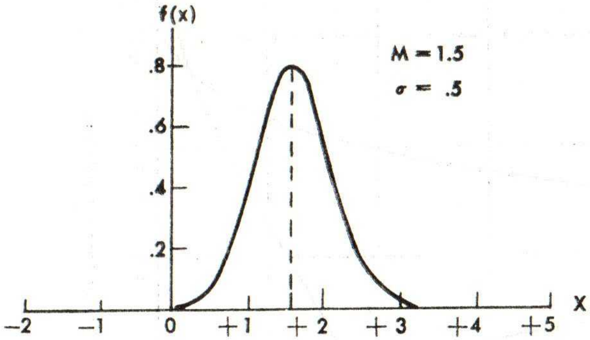


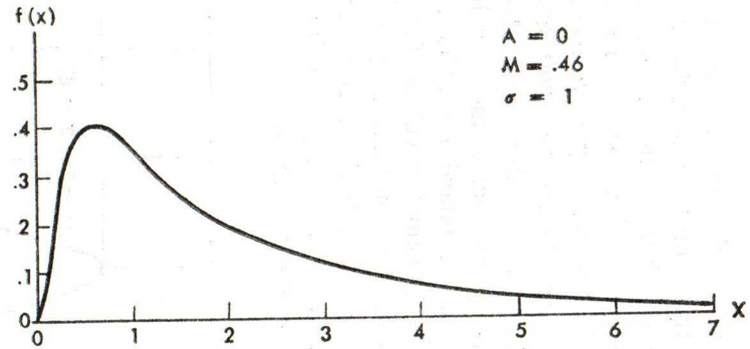
Figure 11. Distribution of Transconductance in a Lot of 418 JAN–5814A Tubes: Patterns Resulting from Sorting Tubes into Progressively Smaller Groups, and Probability Distribution Describing the Values of Transconductance in the Lot.



A. THE NORMAL DISTRIBUTION

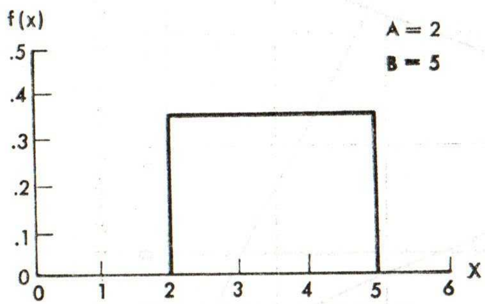
$$f(X) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(X-M)^2/2\sigma^2}$$

$$\text{for } -\infty < X < +\infty$$



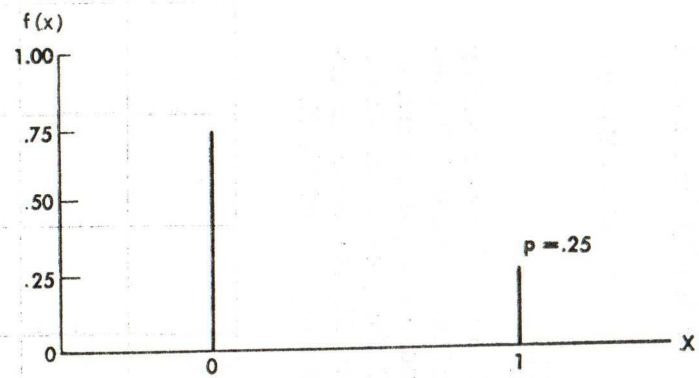
B. THE LOGARITHMICO - NORMAL DISTRIBUTION

$$f(X) = \frac{1}{\sigma(X-A)\sqrt{2\pi}} e^{-[\log(X-A)-M]^2/2\sigma^2} \text{ for } A < X < +\infty$$



C. THE UNIFORM DISTRIBUTION

$$f(X) = \frac{1}{B-A} \text{ for } A \leq X \leq B$$



D. A SPECIAL BINOMINAL DISTRIBUTION

$$f(X) = p^X(1-p)^{1-X} \text{ for } X = 0, 1$$

Figure 12. Probability Distributions for Three Types of Continuous Distributions (Normal, Logarithmico-Normal, and Uniform), and For a Discrete or Attributes Type of Distribution (Binomial).

distribution for an attribute is restricted to the type shown in Figure 12D.

1.4.1 *Populations and Parameters*

A population may be defined mathematically by the density for its probability distribution. For example, the density for a normal distribution is

$$f(X) = \frac{1}{\sigma\sqrt{2\pi}} E^{-(X-M)^2/2\sigma^2}$$

where X is a random variable representing the measurement of the property being described, and M and σ are parameters, or fixed constants of the population. For a normal distribution, M, the mean or expected value of the random variable X, indicates the location of the center of the population; σ, the standard deviation, is a measure of dispersion around the mean of the population.

Different populations having the same type of distribution may have different parameter values. For example, two normally distributed populations, each with a standard deviation of 10, may have such widely different mean values as 1000 and 6000. Conversely, two normally distributed populations having the same mean value may have different standard deviations. Figure 12 gives the parameter values for each of four types of distributions. Figure 13 presents normal distributions for three different populations, each population having different parameter values.

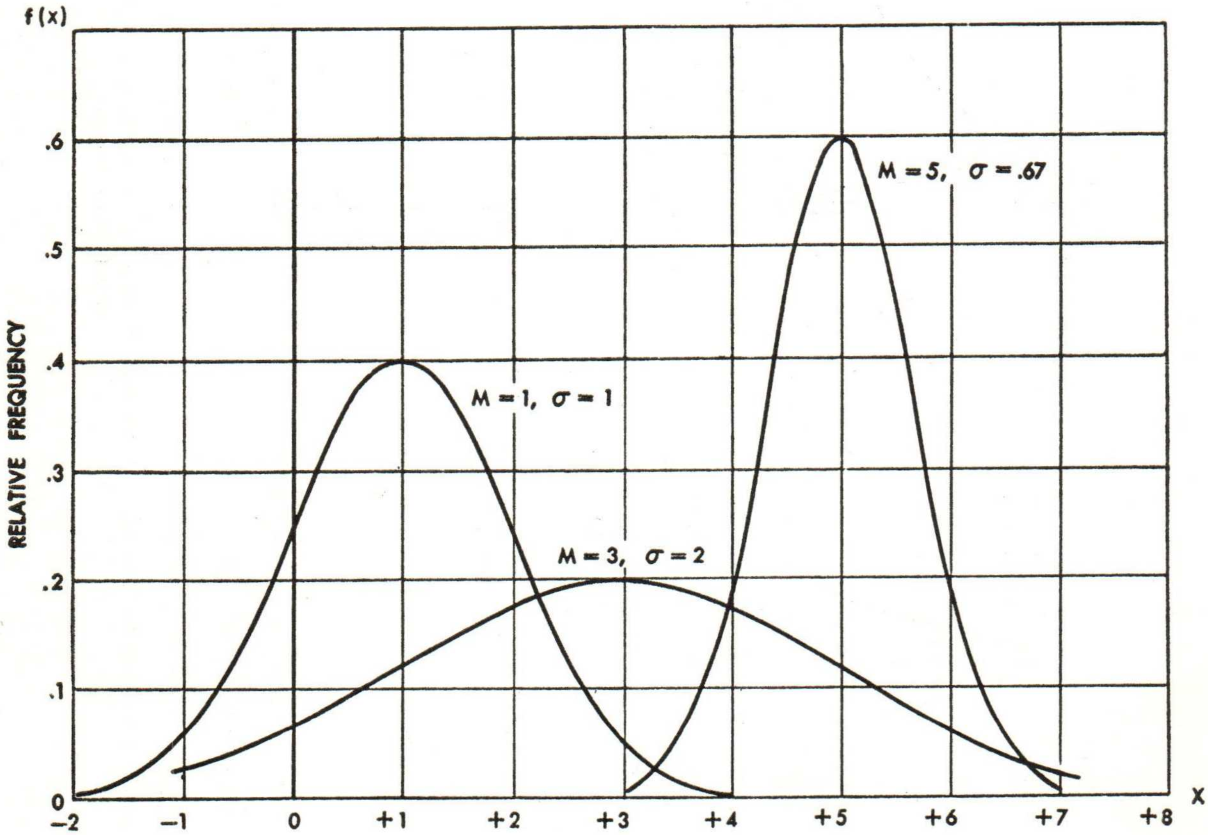


Figure 13. Normal Distribution for Three Populations With Different Parameter Values.

A population consisting of individuals (in this case, tube-property values) which are identical in all respects is completely described by the values for one individual and a value indicating the number of individuals in the population. However, those populations which are of interest in the study of electronic design display variations among individuals, and must be described in terms of the type of distribution and the specific values for the parameters of that distribution. When the parameter values are known, the percentage of the population having values outside specified (or any other) limits can easily be determined.*

When the tube property under consideration is of an attributes nature, a statement of the proportion of defective items in the population completely describes the distribution. The small letter "p", which is generally used to designate this proportion, may take any value between zero and one. For example, if 1 tube in a lot of 1000 tubes has a broken pin, then $p = 0.01$. This value is the estimated proportion of the lot which is defective with regard to broken pins. The symbol p can be used with continuous-variable populations to describe the proportion of defective tubes in the population. However, when used in this manner, p is not usually considered to be a parameter of the population.

1.4.2 *Inspection Lots and Population Stability*

In acceptance inspection of electron tubes, the population of interest may be either the entire lot submitted for acceptance or a portion of the lot associated with some characteristic of the product. When a lot is defined in terms of units of production — for example, 1000 tubes or a week's production — it is usually designated as a "production lot". The production lot does not necessarily provide a satisfactory appraisal of the pattern of variation in the production process. Two production lots made by the same process may exhibit different patterns of variation, either because there is no stable pattern in the production process, or because several patterns are evident. The concepts of production control and homogeneity (sameness) of a lot are closely associated with the stability of the pattern of variation* in the production process.

For purpose of acceptance testing, the population of interest is the "inspection lot", a concept defined in various ways by different organizations. Military Standard MIL-STD-105A states: "Each (inspection) lot shall, as far as practical, consists of units of product of a single type, grade, class, size or composition, manufactured under essentially the same conditions."*

In electron tube acceptance testing, the variation in one characteristic of a tube type over a long period of production is plotted in terms of a "product distribution curve", which describes the population associated with the characteristic. This curve is the sum of many "lot distribution curves", which describe the variations in individual inspection lots. A typical relationship between lot distribution curves and a product distribution curve for a normally distributed characteristic under reasonable inspection control is shown in Figure 14. Although tube specifications and published technical data are based on the product distribution curve, tubes are usually procured and used on a lot-by-lot basis. There may be a considerable difference between the distribution for a lot and the distribution for the product, depending upon the nature of the procurement specifications.

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* Fisher, R.A., *Statistical Methods for Research Workers,* Oliver and Boyd, Ltd., London, 1948.

* Simon, Leslie E., "The Industrial Lot and Its Sampling Implication," *Journal of the Franklin Institute,* Philadelphia, Pa., May 1944, Vol. 237.

* *Military Standard; Sampling Procedures and Tables for Inspection by Attributes* (MIL-STD-105).

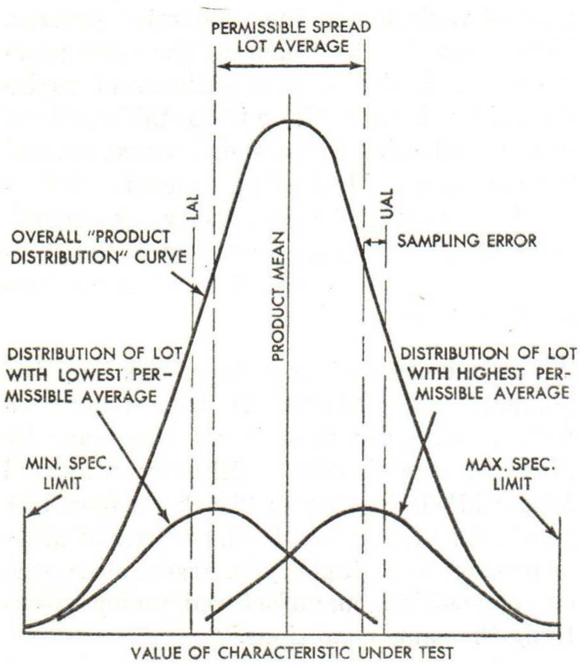

Figure 14. Example of "Normal" Distribution of a Given Tube characteristic "Product Distribution Curve and "Lot Distribution" Curve.

The methods shown in Figure 14 and Table 3 for controlling the variation in tube characteristics from lot to lot represent various systems developed by tube manufacturers for reducing differences between lot and product distributions. It is apparent that some methods are more successful in this respect than others. For example, the "Min-Max" system of limits in no way defines the distribution of the characteristics, but only defines the range within which the characteristic must lie. The "Min–LRLM–URLM–Max" system is better, in that it restricts the median of each sample to a defined range. However, widely dispersed or multimodal (many peaked) distributions are not excluded by the system, even though the medians of the distributions are controlled by the "LRLM–URLM" range. The use of "acceptable lot dispersion" (the parameter σ weighted for the sample size used in the test) to form the "Min–LAL–UAL–Max, ALD" system makes possible a definition of range, sample average, and dispersion of individual samples. An alternate system is the "LRLM–URLM," in which less than 50 percent of the measurements of the sample fall beyond either limit.

Limits of Specification	Controls on "Lot" Basis
Min — Max	Minimum and maximum values only
Min — LRLM — URLM — Max	Minimum and maximum values and sample median
Min — LAL — UAL — Max, ALD	Minimum and maximum values, sample average ($\bar{X}$) and sample dispersion
LRLM = Lower reject limit for sample median	LAL = Lower limit for the sample average ($\bar{X}$)
URLM = Upper reject limit for sample median	UAL = Upper limit for the sample average ($\bar{X}$)
ALD = Acceptable limit for the dispersion (weighted σ)	

Table 3. Specification Limits Used in Controlling Sample Median and Dispersion Values.

In spite of these systems for controlling lot distributions, marked differences may occur between the distributions for the lots and that for the product. It should also be noted that two lots from the same population do not necessarily have the same distributional characteristics. Figure 14 is somewhat misleading in this respect.

So far the discussion of populations has been concerned with only one property of an item. However, a lot is often defined as a population of items having a number of properties. For example, specification MIL–E–1/293C for tube type JAN–5703WA requires tests for more than 50 tube properties. It is possible for a lot to be formed in such a way that the distributions for one group of properties are stable, but the distributions for another group of properties are unstable. Ideally, the inspection lot should be so defined that it will constitute a population in which the distributions of all properties of interest are stable.

1.4.3 *Samples and Sample Estimators of Population Parameters*

One of the most important engineering applications of statistics is that of summarizing a population of primary data so that its essential content can be understood.

When a body of statistical data is voluminous and unwieldy, the prospect of examining each item to determine the uniquely identifying characteristics (parameters) of the whole population may be uninviting. Furthermore, technical and economic considerations may preclude a complete examination of all items. However, a sample from the population can be examined as a means of estimating the character of the population as a whole. If the sample is adequately representative of the whole population, it will contain as much as possible—ideally all—of the relevant information contained in the original data.*

Sampling may be done on any basis; however, in statistical terminology, the term "sampling" is assumed to mean "random sampling." A random sample, as commonly defined, is one in which each item in the population has an equal probability of being included, irrespective of the measured value of the property of the item in question. The statistical measure of the amount of error involved in making a statement or a decision on the basis of sampling is based entirely on the probability theory of random sampling.

The parameters of a population can be estimated on the basis of a random sample drawn from that population. For example, the mean or "first moment" of a sample is an estimator of the mean of the population. If several random samples are drawn from the same population, their means will vary according to a definite pattern, or theoretical probability distribution. Means of samples drawn from a normally distributed population follow a normal distribution which has a mean equal to the mean of the population and a standard deviation equal to the population standard deviation divided by the square root of the sample size. As the sample size increases, the variability of the sample means about the population mean becomes smaller. These relationships are illustrated in Figure 15, which shows, for the same population, the distribution of all the individual items and the distributions of the means of samples consisting of 10 items and 35 items.

Estimation of the parameters of normal and non-normal distributions has been studied by statisticians working in various fields. One technique involves the use of the "moments" of a set of data. It is relatively easy to calculate the moments of such data, but it may be very difficult to determine the exact values of the population parameters. However, the moments of a sample may be used to form estimates of population parameters, and for this reason, it is of value to

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* Fisher, R.A., "Foundations of Theoretical Statistics," *Philosophical Transactions of the Royal Society*, London, 1922, Vol. 222A, p. 309.

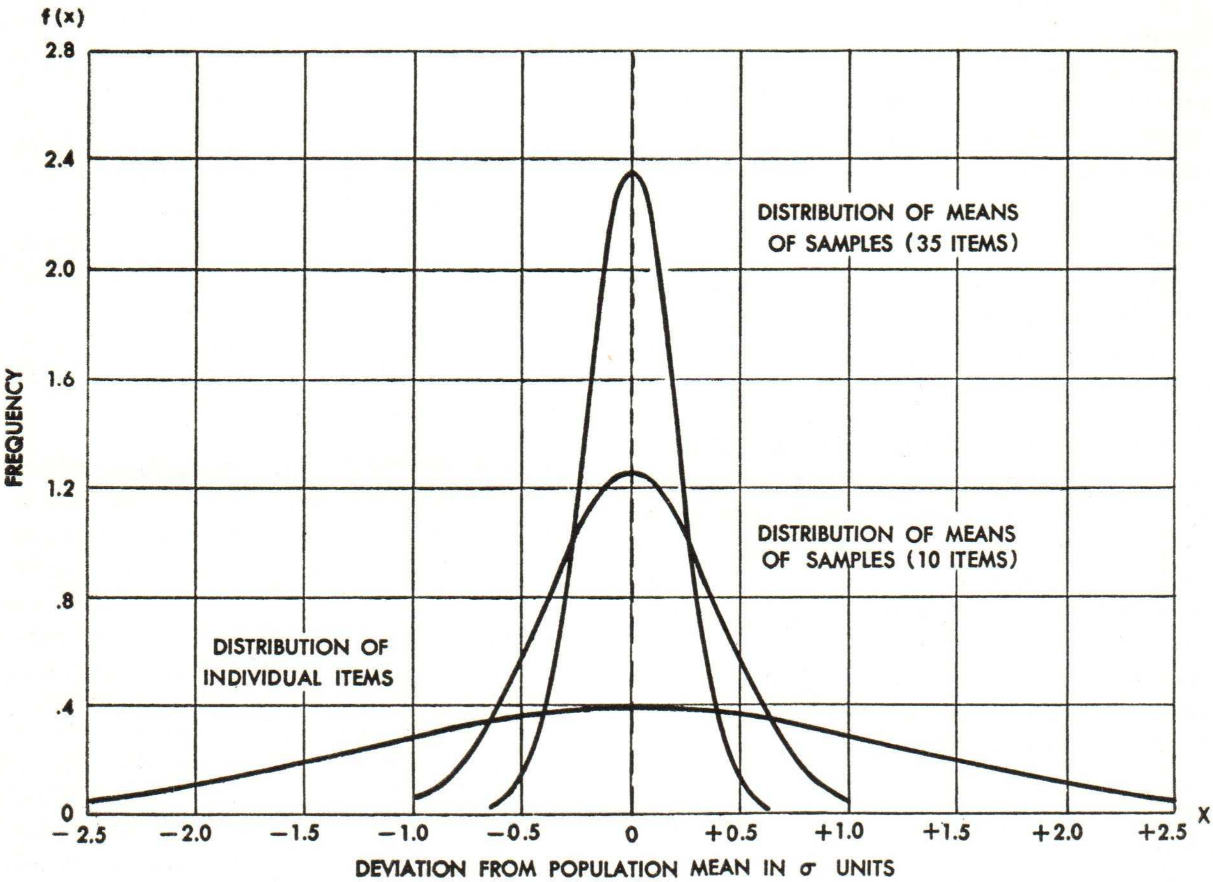

Figure 15. Illustration of Variability of Sample Means About a Population Mean With Change in Sample Size.

explain the moment concept.

The moment of order j about $X = Z$ is given by

$$m_{(j)} = \frac{1}{n} \Sigma (X_i - Z)^j,$$

where X_j represents the n sample values. When $Z = 0$ and $j = 1$, the formula for the arithmetic mean, $\bar{X}$, is

$$\bar{X} = \frac{1}{n} \Sigma X_i$$

For $Z = X$, the moment of order 2 about the mean is

$$s^2 = \frac{1}{n} \Sigma (X_i - \bar{X})^2,$$

also known as the sample variance. The moment of order j about the mean is

$$m_{(j)} = \frac{1}{n} \Sigma (X_i - \bar{X})^j$$

An additional property of moments is perhaps more interesting. Certain ratios of the second, third, and fourth moments describe the shape of the distributions of the data involved. For example, the "skewness" or lopsidedness of a distribution is defined by the parameter $\sqrt{\beta_1}$. As a distribution departs from symmetry, the $\sqrt{\beta_1}$ value increases or decreases from 0. The formula for $\sqrt{\beta_1}$ is

$$\sqrt{\beta_1} = \frac{m_{(3)}}{m_{(2)}^{3/2}}$$

where the sign ($\pm$) of $\sqrt{\beta_1}$ is taken by convention to be identical to the algebraic sign of $m(_3)$. A measure of the flatness or peakedness of a distribution is called "kurtosis." This value equals 3 for the normal distribution, and decreases or increases as the distribution becomes respectively, more flat or more peaked. The formula for the measure of "kurtosis" is

$$\beta_2 = \frac{m(_4)}{m(_2)^2}$$

Additional information on shaping and departure from normality in relation to the parameters β_1 and β_2 is given in Part II.

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PART II

TUBE PROPERTIES AND STATISTICAL TECHNIQUES IN RELATION TO CIRCUIT DESIGN

2. TECHNIQUES OF CIRCUIT DESIGN

One of the problems facing the designer of electronic circuits is to achieve compatibility between the performance requirements of the circuit and the capabilities of the electron tubes used and component parts used. The satisfactory operation of the tubes and components is, in general, assured by procurement specifications only when certain important limiting conditions are not exceeded.

Insofar as electron tubes are concerned, the designer must give particular attention to the three general types of properties described in Part I of this handbook—Tube Ratings, Tube Characteristics and Tube Detrimental Properties. Tube Ratings must be considered in relation to the operating requirements imposed by equipment specifications and component part design. Tube Characteristics (properties essential to the operation of the circuit) must be considered not only in terms of initial values, but also in terms of the effect of a change in these values upon the performance characteristics of the circuit. Finally, the harmful effects of Detrimental Properties must be allowed for, so that inevitable increases in these effects with time do not prove ruinous to circuit operation.

This portion of the handbook is devoted to a discussion of Ratings, Characteristics, and Detriments in relation to specific application problems. Certain statistical and engineering techniques are described for using specification information in developing circuit designs which are compatible with many of the commonly used tube types.

2.1 Ratings.

As defined in Part I, ratings are the set of limiting values defining each operating condition within which a tube can be expected to yield a reasonable period of satisfactory service. Two questions are posed by each rating:

(1) For a given tube application, what manner of operation makes the most severe demands upon the tube?

(2) If operated under these conditions, will the tube exceed its permissible ratings?

Certain techniques of use in determining the answers to these questions are described briefly in the following section. Graphic representations of ratings for four general classes of tube types are given in Figures 3-3, 3-7, 3-13, and 3-19 in Part III.

2.1.1 *Techniques for Using Rating Information in Circuit Design.*

It is evident from the study of triode and pentode circuitry that the judgment of the circuit designer plays an important part in rating analysis. In Class A triode amplifiers, for example, the maximum plate dissipation occurs with no applied input signal. Although the plate dissipation relationship is similar in pentode circuitry, the maximum screen dissipation occurs with maximum input signal. Hence, the ratings for each tube type must be considered in relation to the individual operating conditions which impose the most severe stresses upon the tube.

Figure 16 illustrates a graphic method for determining a value of series resistance that will limit the plate dissipation of a tube to a given "safe" value. Figure 17 presents a general-purpose graph for determining the minimum "R series" value that will limit electrode dissipation to a given "safe" value under given conditions of maximum electrode supply voltage.

It is frequently discovered that both electrode — dissipation and electrode — voltage ratings are exceeded under adverse conditions. A typical circuit in which ratings are interdependent is presented by a screen-voltage-dropping-resistance network designed (a) to limit electrode dissipation to its "safe" value, and (b) to limit possible elec-

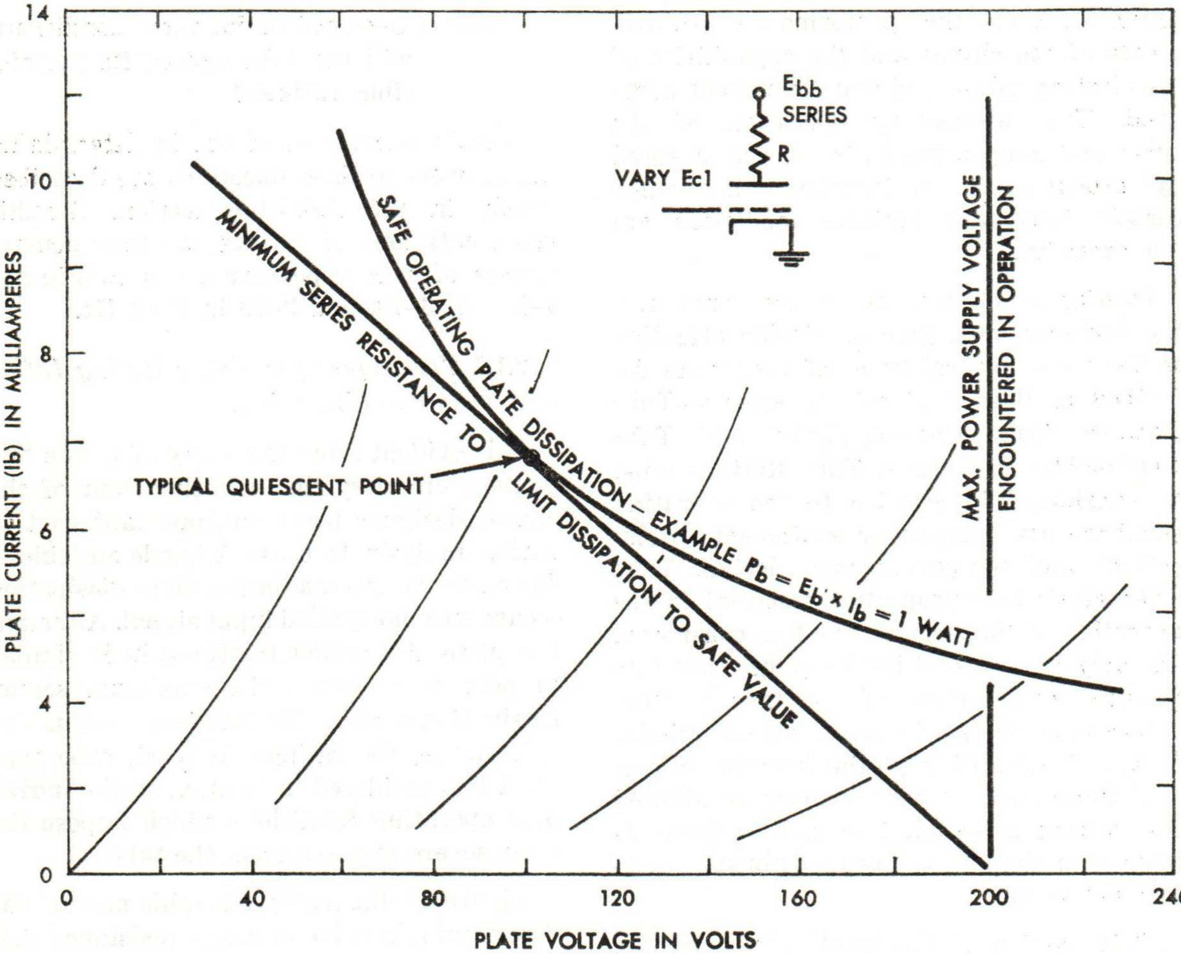


Plate dissipation may be restricted to values less than the safe operating maximum by the use of series resistance between plate and power supply. The minimum value of resistance can be determined by plotting a load line tangential to the curve $E_b \times I_b$ = safe dissipation. If the load line is started at the maximum operating value of supply voltage, its equivalent resistance will limit plate dissipation to a safe value despite variation in tube characteristics, bias and supply voltage. The minimum value of resistance may also be found from the relationship:

$$R_{min} = \frac{(E_{bb})^2}{4 P_b}$$

E_{bb} = maximum supply voltage

P_b = Safe dissipation in watts

Figure 16. Limiting Electrode Dissipation with Series Resistance.

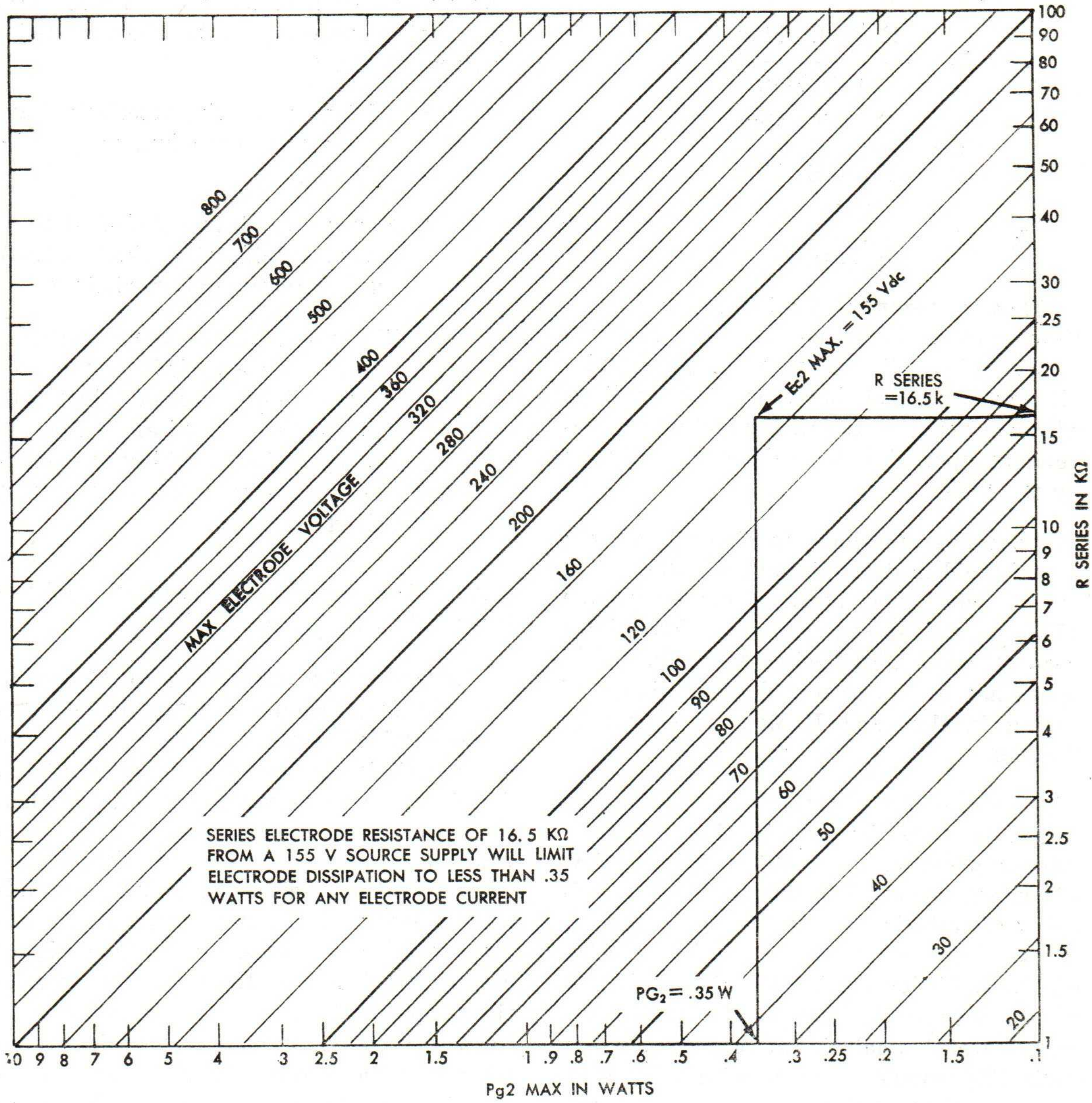


Figure 17. Minimum Series Resistance Needed to Limit Electrode Dissipation to a Given "Safe Value" for Given Conditions of Maximum Electrode Supply Voltage.

trode voltage excursion to its "safe" value.

Equations for the values of R_1, R_2, and R series (see Figure 18), in terms of ratings and supply voltages, are:

$$R_1 = \frac{E_{bb} \times E_{c2}\,\text{Max}}{4\,P_{c2}\,\text{Max}},$$

$$R_2 = \frac{R_1 \times E_{c2}\,\text{Max}}{E_{bb} - E_{c2}\,\text{Max}}, \text{ and}$$

$$R\ \text{series} = \frac{R_1 R_2}{R_1 + R_2},$$

When the technique implied in these equations is used, the actual operating electrode voltage will be limited to a safe level under all conditions, and the value of this voltage will be lower than the rating and will be dependent upon the electrode current drawn by the tube.

The monograph shown in Figure 18 affords a useful aid in determining the values of R_1 and R_2 when the values of supply voltage (E_{bb}) and safe screen voltage (E_{c2}Max) have been stipulated, and when the value of R series has been determined from Figure 17 (using E_{c2}Max and P_{g2}Max as shown in the figure).

The variability of cathode current in electron tubes must be considered in assessing tube application from the point of view of current ratings. It is known that the variabiliy of cathode current from tube to tube is materially reduced by the action of cathode bias. Under conditions of fixed-bias—which increase the spread of cathode current—careful analysis of cathode-current variability should be made with tube- and-cathode-resistor pairs, in order to set the operating point with respect to the plate or the cathode current rating. Figure 19 illustrates the decrease in cathode current variability which can be achieved by using cathode bias rather than fixed bias. The influence of cathode-resistor tolerances on this variability is also shown in the figure.

2.2 Characteristics.

Tube characteristics are defined as those properties which are essential to the satisfactory operation of a circuit. Three questions arise concerning tube characteristics in circuit design:

(1) Which tube characteristics are necessary to the functions of the circuit?

(2) Does the applicable MIL–E–1 technical specification sheet (TSS) define these characteristics?

(3) Will the circuit operate satisfactorily over a period of time with tubes whose range of values both at installation and after a period of operation is within the limits set by the technical specification sheet?

2.2.1 *Techniques for Using Characteristics Information in Circuit Design.*

The "spread" or range of performance in a simple circuit should be computed in terms of the specified upper and lower limits of the characteristics of the tubes involved. When the circuit becomes more complex, or when the number of related characteristics increases, the probability that the characteristics will all have either maximum or minimum values becomes exceedingly small. Under such circumstances, the circuit designer can relate circuit performance characteristics to specified tube characteristics by using certain effective statistical techniques developed in the field of biophysics. Linear regression techniques, statements of inference (decision-making), and analysis of variance are three statistical methods which are easily adapted for use in circuit analysis.

1) Linear regression techniques often aid the designer in selecting components that will permit "good" tubes (i.e., those which meet

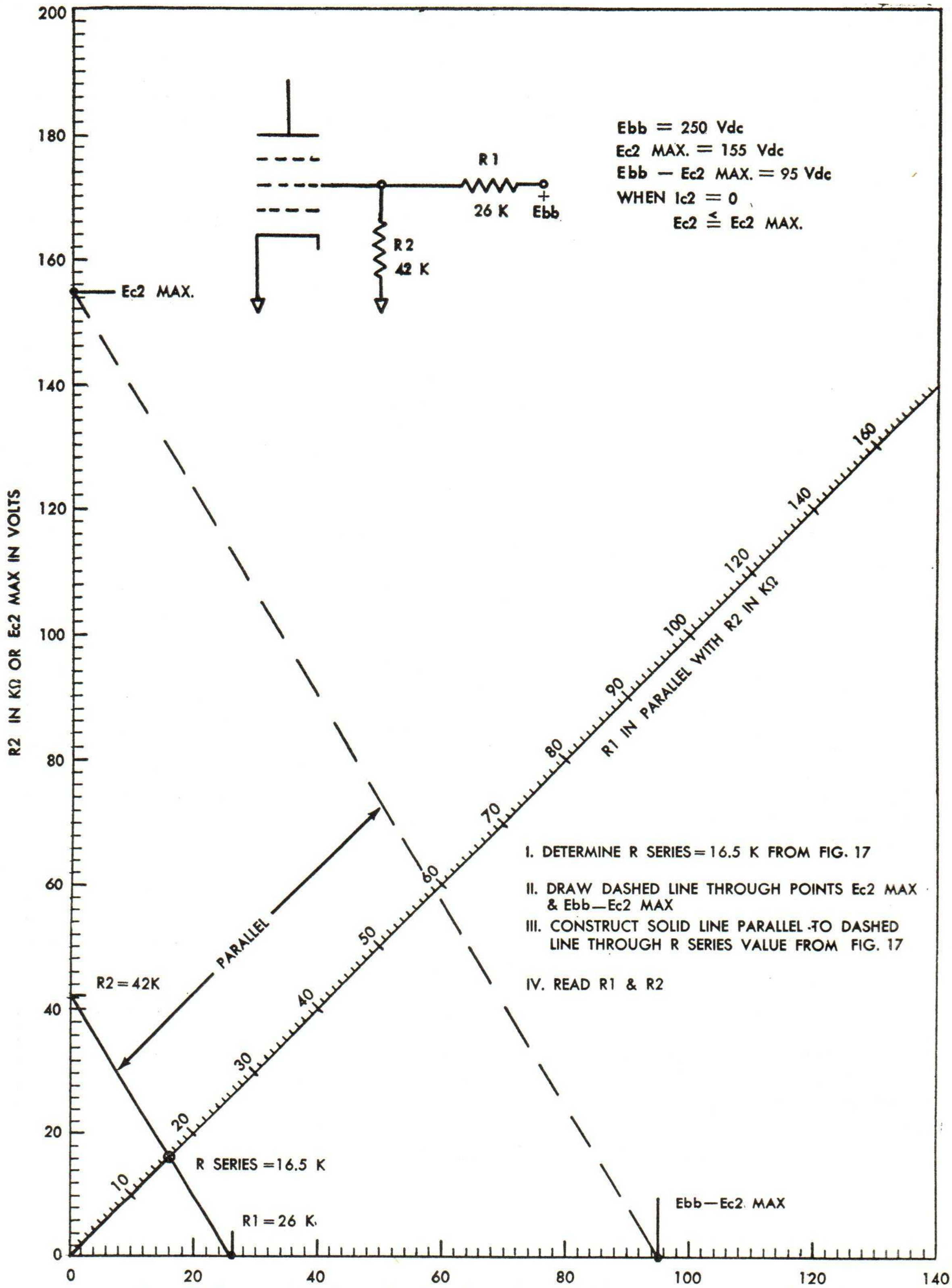
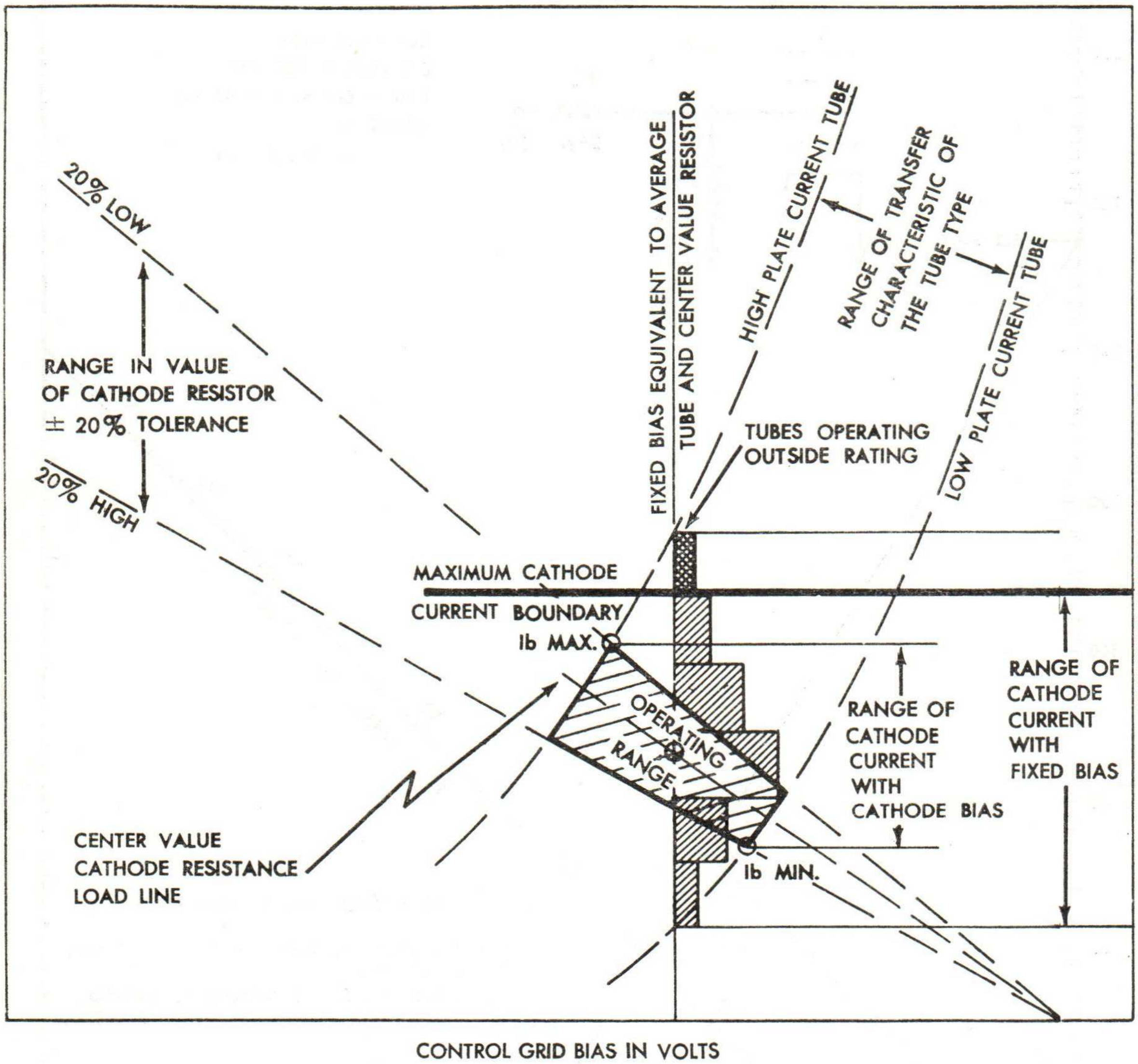


Figure 18. Nomograph for Determining R1 and R2 When Ebb and Ec2 Maximum are Stipulated.



The operating range of quiescent plate current in circuits utilizing cathode bias will depend upon cathode resistance and cathode current as illustrated above. It should be noted that the operating range of cathode current is materially reduced by the use of cathode bias as opposed to fixed bias. Reference to the tube rating of maximum cathode current will determine if any portion of the operating range lies at or near the rating.

Figure 19. Limiting Cathode Current with Cathode Bias Resistance.

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specifications) to operate satisfactorily in a given circuit.

2) When decisions must be reached, it is often necessary to make statements of inference based upon the analysis of experimental data. Subsequent sections of the handbook describe the role of experimental sample size and confidence and tolerance limits in making statements of inference.

3) Analysis of variance, which is also explained in a subsequent section, is an extremely versatile technique which can be applied in the design and analysis of electronic circuits. In brief, the technique permits the variability in circuit output to be related directly to the variability in tube or component characteristics.

Certain additional techniques are useful if the design of an electronic equipment must fulfill predetermined reliability as well as functional requirements. As a first step in assuring that an equipment will perform satisfactorily in the field, a determination or verification must be made of the reliability of the design. Some notes and techniques relating to design verification were recently published in a RETMA document, and are included in Part II as an aid to the interpretation of data presented in the following sections of the handbook.

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2.3 Detrimental Properties

Detriments are inherent tube properties which must be considered in circuit design because of their harmful effect on circuit operation. They pose two important questions for the designer:

(1) What is the maximum value that any detriment can reach and still permit the circuit to operate satisfactorily?

(2) Does the applicable JAN or MIL specification adequately define the detriments of the tube type selected for the design?

In considering the effects of tube detriments upon circuit performance, it must be borne in mind that detriments, by definition, may or may not occur in every tube. A circuit which is designed to compensate for effects which do not happen to occur in the particular tubes employed is inherently unreliable. ? The problem of detriments should be approached only in terms of the range of detriment-values the circuit can tolerate without impairment of operation. It therefore becomes necessary for the circuit designer to determine the permissible limit for those detriments which affect the performance of the circuit being designed.

If only a few randomly selected tubes are used to check the compatibility between tube detriments and circuit design, the conclusion reached is nearly always overly optimistic. A more realistic appraisal is achieved if checking is done with many tubes whose detriments are known to have values within the limits allowed by specifications, or with tubes whose detriment-values are simulated by the test circuit.

The following methods may be used to determine the compatibility between the tube detriments and required circuit performance.

2.3.1 *Techniques for Using Detriments Information in Circuit Design*

One method is to test in the circuit a number of tubes which exhibit the detriment in varying degrees, and to note those tubes ~~which perform satisfactorily and those~~ which perform satisfactorily and those which do not. A graph similar to the one shown in Figure 20 can then be drawn to show the distribution of tubes which do and do not operate satisfactorily.

Figure 20 represents a group of tubes distributed on the basis of heater-cathode-leakage values. It will be observed that tubes begin to fail in the equipment when leakage current is greater than four microamperes. To be able to design with confidence, the design engineer must be sure that the specification limit on this type of leakage current is less than four microamperes. Moreover, he must be sure that the life-test end-point on heater-cathode leakage is less than four microamperes.

Four microamperes represents the highest value of heater-cathode leakage that this particular equipment will tolerate. If the tube specification does not limit leakage to less than four microamperes, a more tolerant circuit must be designed.

The method outlined above is based on the assumption that the tube either operates or does not operate in the circuit, depending upon the amount of heater-cathode leakage present. Frequently, the problem is not so clear-cut. Instead, a degrading effect on performance is observed, and the design engineer must decide what "good enough" performance is, and where to establish the limits on satisfactory and unsatisfactory performance.

Figure 21 indicates the nature of the "variables" approach to the problem of deciding where to establish limits on detriments in relation to circuit performance. For example, if the performance of a circuit is evaluated in terms of hum output resulting from heater-cathode leakage, the values of hum output could be plotted versus the values of heater-cathode leakage. If 15 millivolts is established as the maximum limit for hum output, the limit on heater-cathode leakage should be less than 10 microamperes to assure satisfactory circuit operation.

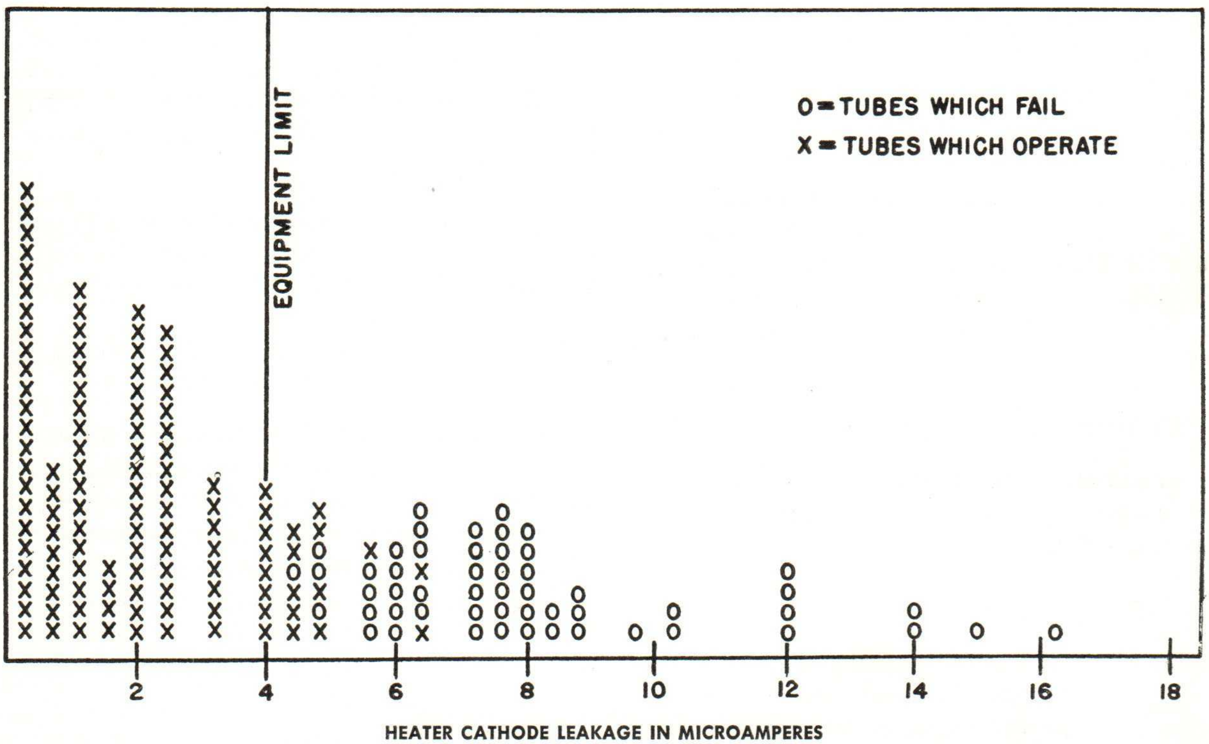

Figure 20. Attributes Distribution of Tubes with Various Values of Heater-Cathode Leakage Current, Showing Equipment Limit Value.

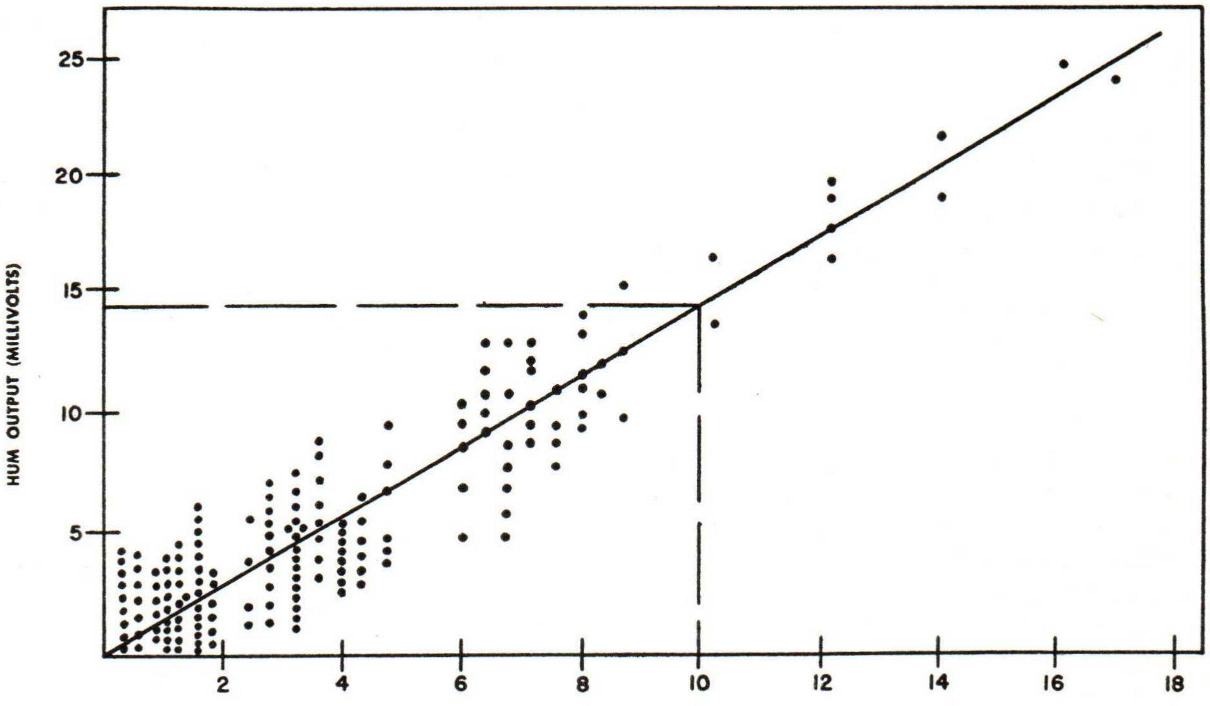

Figure 21. Variables Distribution of Tubes with Various Values of Heater-Cathode Leakage Current: Heater-Cathode Leakage Versus Hum Output.

2.4 Application of Specific Statistical Techniques to Circuit Design Problems

As indicated in Part I, acceptance testing is usually done on the basis of random sampling. Since most statistical techniques are based upon the premise of a random sample, it goes without saying that if the sample is not randomly selected, the techniques cannot be expected to yield valid results. The following example illustrates a procedure for selecting random samples.

Suppose that the circuit designer wishes to withdraw 50 tubes of a certain type from a stock of 1000 tubes (10 boxes each containing 100 tubes) in order to establish an experimental relationship between tube and circuit. A totally incorrect procedure would be to withdraw all 50 tubes from the first box. However, this is the procedure usually followed when a standard requisition form is sent to the average stockroom.

A preferable procedure would be to withdraw five tubes from each box. However, even in this event it would be unwise to leave the choice to the stock clerk, because it is conceivable that the manufacturer has sorted tubes of various date codes by boxes in a particular geometric manner. If tubes are categorized by box in any manner — that is, by manufacturer, date code, or container — the sample must be withdrawn in the same proportion from each box in order to be representative of the stock.

The withdrawal of tubes according to an exact randomization scheme can be facilitated by random number tables*, in which each number has an equal probability of being selected. If it is desired to withdraw 5 tubes from a box of 100, the individual making the selection ned merely number the

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* The Rand Corporation, *A Million Random Digits,* Free Press Publishers, Glencoe, Ill., 1955.

10 x 10 array of tubes in some sequential manner from 00 to 99, and then remove the first 5 tubes according to the first 5 random digit pairs which appear on any page of the random number tables.

When conducting the experiment, it is also important that reading order be randomized. If it is necessary to repeat, or "replicate", the readings made on a group of tubes, it is absolutely essential to compile a separate random reading order for each replication.

The time factor must also be taken into consideration in any experiment involving several hundred readings made on 50 tubes. For example, electrical and thermal interactions in the test equipment are time functions. A-C line voltage is also likely to be a time function. If all 50 tubes are read in the same sequence on several consecutive days, it is certain that the first tube will always be subjected to a thermal and electrical environment different from that imposed upon the fiftieth tube.

It has often been found that time and thermal effects of this nature are more important than different levels in the quality of test equipment. If a correct randomization procedure has been carried out *prior* to each group of measurements, fortuitous effects which might otherwise bias the results will largely cancel out. The validity of the statistical procedures described in the following sections depends upon data which are not biased by non-measurable effects.

2.4.1 *Analysis of Variance*

The analysis of variance offers a potentially effective technique for use in solving problems in electronic design. This technique permits the arithmetic means of a set of ordered data to be analyzed to determine whether they are significantly different. After the variability or homogeneity of the set of data has been determined, the technique affords a comparison of the variability of the means both wish and without the inclusion of chosen factors. Thus, the variables that affect the data most significantly can be defined, while those having no effect can be ignored.

Symbols and formulas used in analysis of variance are as follows:

(a) n = the sample size;

(b) $\bar{X} = \frac{\Sigma X_i}{n}$, the sample mean;

(c) $s^2 = \frac{\Sigma (X_i - X)^2}{n-1}$, the sample variance

(d) $s^2 = \frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}{n-1}$, a computational formula for the variance s^2;

(e) $s = \sqrt{s^2}$ = the sample standard deviation.

A. *Decomposition of the Variance of a Single Variable Classification*

For purposes of illustration, the reader is asked to consider a set of data obtained from a test made on tubes of different specification dates in a severe mechanical environment. The data represent the number of hours to failure of each tube in the test. The question asked by the investigator is: are the tubes procured under the three specifications significantly different?

The data can be arranged for analysis as follows:

Specification letter:	*A*	*B*	*C*
Hours to failure:	5	6	10
	6	6	9
	4	3	8
	5	5	5
Total:	20	20	32
Means:	5	5	8

Grand Total: 72
Grand Mean: 6

The sum of squares of the deviation of the data from the grand mean (6 hours) may be written as follows:

$(5 - 6)^2 + (6 - 6)^2 + (10 - 6)^2 + (6 - 6)^2 + (6 - 6)^2 + (9 - 6)^2 + (4 - 6)^2 + (3 - 6)^2 + (8 - 6)^2 + (5 - 6)^2 + (5 - 6)^2 + (5 - 6)^2 = 1 + 0 + 16 + 0 + 0 + 9 + 4 + 9 + 4 + 1 + 1 + 1 = 46.$

The sum of squares of deviations from individual column means may be written as follows:

$$(5 - 5)^2 + (6 - 5)^2 + (4 - 5)^2 + (5 - 5)^2 \quad \text{Column A}$$
$$+ (6 - 5)^2 + (6 - 5)^2 + (3 - 5)^2 + (5 - 5)^2 \quad \text{Column B}$$
$$+ (10 - 8)^2 + (9 - 8)^2 + (8 - 8)^2 + (5 - 8)^2 \quad \text{Column C}$$
$$= 0 + 1 + 1 + 0 + 1 + 1 + 4 + 0 + 4 + 1 + 0 + 9 = 22$$

The weighted sum of squares of the deviations of the column means from the grand mean are then computed. The column mean deviations squared are weighted (multiplied) by the number of observations in each column as follows:

$$4\,[(5-6)^2 + (5-6)^2 + (8-6)^2] = 4\,(1 + 1 + 4) = 24.$$

An arithmetic check may be instituted at this point, since the sum of squares of deviations from column means + the weighted sum of squares of deviations from the grand mean = the total sum of squares of deviations from the grand mean, or

$$22 + 24 = 46.$$

In actual computation, these sums of squares of deviations, which are usually abbreviated as "Sum of Squares" (or symbolically, "SS"), may be calculated more readily by utilizing the numerator of the formula for s^2 i.e., $= \Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}$ .For example, the total sum of squares is

$$5^2 + 6^2 + 10^2 + 6^2 + 6^2 + 9^2 + 4^2 + 3^2 + 8^2 + 5^2 + 5^2 + 5^2 - \frac{72^2}{12} = 478 - 432 = 46.$$

The weighted sum of squares of the column mean deviations, often known as the Sum of Squares due to columns, is

$$4(5^2 + 5^2 + 8^2) - \frac{72^2}{12} = 24.$$

The within columns sum of squares, also known as the Residual Sum of Squares, is commonly obtained by subtraction:

$$46 - 24 = 22.$$

B. *Testing for a Significant Difference*

It must be assumed that the experimental error associated with each observation is a random quantity drawn from a population with a mean of zero and a variance of σ^2. An estimate of σ^2 is calculated by dividing the within-column sum of squares (22) by the appropriate number of degrees of freedom. Since there were four tubes for each specification, there are 4 — 1, or 3 degrees of freedom contributed to the Residual SS by each specification letter; therefore, there are a total of 3 x 3, or 9 degrees of freedom for the Residual SS. The mean square estimates are found dividing each respective SS by its degrees of freedom

The results of the computations so far can be summarized in the following table.

Table 4. Sum of Squares, Degrees of Freedom, and Mean Squares for Samples of Tubes Made According to Three Specifications.

Source of Variation	Sum of squares	Degrees of freedom	Mean squares
Columns	24	3—1 = 2	24/2 = 12.00
Within Columns (Residual)	22	3(4—1) = 9	22/9 = 2.44
Total	46	12—1 = 11	46/11 = 4.18

It can be hypothesized (this is the "null hypothesis") that the data were drawn from the same population, that the variance component of the column means is zero, and that the population column means are the same. If this hypothesis were true, the mean square of columns would not be very different from the Within Columns Mean Square (Residual). If the mean square due to columns was much larger than the within columns mean square, the probability of this occurrence would be small if the null hypothesis were true so that one would feel safe in rejecting the null hypothesis and concluding that the specification did produce different grades of tubes.

To test the hypothesis, use is made of the fact that the ratio of two variances (under the null hypothesis) is distributed as F. The F distribution is described at the end of this section (see Table 9).

$$F = \frac{12}{2.44} = 4.92$$

In looking up critical values in the F table, it must be remembered that there are two degrees of freedom in the numerator and nine degrees of freedom in the denominator. Reference to Table 9 reveals that the probability of exceeding an F value of 4.26 with these degrees of freedom is less than 5 percent.

Therefore, it is safe to reject the null hypothesis and conclude that the calculated F value of 4.92 is not due to chance, and that significant differences do exist in relation to the letter on the specification.

C. *The Two-Way Classification*

It will now be assumed that the tubes manufactured under specification letters A, B and C were supplied for the test by four manufacturers. A new table, showing how the hours to failure are distributed by specification and manufacturer, is prepared.

Table 5. Hours to Failure of Tubes of Three Different Specications and Four Different Manufacturers.

Manufacturer (Rows)	Hours to failure, by specification letter Columns)			Total hours to failure	Mean
	A	B	C		
1	5	6	10	21	7
2	6	6	9	21	7
3	4	3	8	15	5
4	5	5	5	15	5
Total	20	20	32	72	
Mean	5	5	8	Grand Mean = 6	

The weighted sum of squares of deviations of the row means from the grand mean is

$$3[(7-6)^2 + (7-6)^2 + (5-6)^2 + (5-6)^2] = 12$$

The weight 2 is obviously the number of observations in each row. The value of 12 could also have been calculated by

$$W\Sigma X_i - \frac{(\Sigma X_i)^2}{n} = 3(7^2 + 7^2 + 5^2 + 5^2)$$

$$-\frac{72^2}{12} = 12,$$

or by using row totals instead of row means, as follows:

$$(1/3)\ (21^2 + 21^2 + 15^2 + 15^2) - \frac{72^2}{12}$$
$$= 12,$$

where 3 is the number of observations in each total. Adding the weighted sum of squares of

TABLE 9

5% (a) and 1% (b) Points for the Distribution of F

n_2 \ n_1		1	2	3	4	5	6	7	8	9	10	12	16	20	30	50	100	∞
1	a	161	200	216	225	230	234	237	239	241	242	244	246	248	250	252	253	254
	b	4052	4999	5403	5625	5764	5859	5928	5981	6022	6056	6106	6169	6208	6258	6302	6334	6366
2	a	18.51	19.00	19.16	19.25	19.30	19.33	19.36	19.37	19.38	19.39	19.41	19.43	19.44	19.46	19.47	19.49	19.50
	b	98.49	99.00	99.17	99.25	99.30	99.33	99.34	99.36	99.38	99.40	99.42	99.44	99.45	99.47	99.48	99.49	99.50
3	a	10.13	9.55	9.28	9.12	9.01	8.94	8.88	8.84	8.81	8.78	8.74	8.69	8.66	8.62	8.58	8.56	8.53
	b	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.34	27.23	27.05	26.83	26.69	26.50	26.35	26.23	26.12
4	a	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.84	5.80	5.74	5.70	5.66	5.63
	b	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.54	14.37	14.15	14.02	13.83	13.69	13.57	13.46
5	a	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.78	4.74	4.68	4.60	4.56	4.50	4.44	4.40	4.36
	b	16.26	13.27	12.06	11.39	10.97	10.67	10.45	10.27	10.15	10.05	9.89	9.68	9.55	9.38	9.24	9.13	9.02
6	a	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.92	3.87	3.81	3.75	3.71	3.67
	b	13.74	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.72	7.52	7.39	7.23	7.09	6.99	6.88
7	a	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.63	3.57	3.49	3.44	3.38	3.32	3.28	3.23
	b	12.25	9.55	8.45	7.85	7.46	7.19	7.00	6.84	6.71	6.62	6.47	6.27	6.15	5.98	5.85	5.75	5.65
8	a	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.34	3.28	3.20	3.15	3.08	3.03	2.98	2.93
	b	11.26	8.65	7.59	7.01	6.63	6.37	6.19	6.03	5.91	5.82	5.67	5.48	5.36	5.20	5.06	4.96	4.86
9	a	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.13	3.07	2.98	2.93	2.86	2.80	2.76	2.71
	b	10.56	8.02	6.99	6.42	6.06	5.80	5.62	5.47	5.35	5.26	5.11	4.92	4.80	4.64	4.51	4.41	4.31
10	a	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.97	2.91	2.82	2.77	2.70	2.64	2.59	2.54
	b	10.04	7.56	6.55	5.99	5.64	5.39	5.21	5.06	4.95	4.85	4.71	4.52	4.41	4.25	4.12	4.01	3.91
12	a	4.75	3.88	3.49	3.26	3.11	3.00	2.92	2.85	2.80	2.76	2.69	2.60	2.54	2.46	2.40	2.35	2.30
	b	9.33	6.93	5.95	5.41	5.06	4.82	4.65	4.50	4.39	4.30	4.16	3.98	3.86	3.70	3.56	3.46	3.36
16	a	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.33	2.28	2.20	2.13	2.07	2.01
	b	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.55	3.37	3.25	3.10	2.96	2.86	2.75
20	a	4.35	3.49	3.10	2.87	2.71	2.60	2.52	2.45	2.40	2.35	2.28	2.18	2.12	2.04	1.96	1.90	1.84
	b	8.10	5.85	4.94	4.43	4.10	3.87	3.71	3.56	3.45	3.37	3.23	3.05	2.94	2.77	2.63	2.53	2.42
30	a	4.17	3.32	2.92	2.69	2.53	2.42	2.34	2.27	2.21	2.16	2.09	1.99	1.93	1.84	1.76	1.69	1.62
	b	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.06	2.98	2.84	2.66	2.55	2.38	2.24	2.13	2.01
50	a	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.02	1.95	1.85	1.78	1.69	1.60	1.52	1.44
	b	7.17	5.06	4.20	3.72	3.41	3.18	3.02	2.88	2.78	2.70	2.56	2.39	2.26	2.10	1.94	1.82	1.68
100	a	3.94	3.09	2.70	2.46	2.30	2.19	2.10	2.03	1.97	1.92	1.85	1.75	1.68	1.57	1.48	1.39	1.28
	b	6.90	4.82	3.98	3.51	3.20	2.99	2.82	2.69	2.59	2.51	2.36	2.19	2.06	1.89	1.73	1.59	1.43
400	a	3.86	3.02	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85	1.78	1.67	1.60	1.49	1.38	1.28	1.13
	b	6.70	4.66	3.83	3.36	3.06	2.85	2.69	2.55	2.46	2.37	2.23	2.04	1.92	1.74	1.57	1.42	1.19
∞	a	3.84	2.99	2.60	2.37	2.21	2.09	2.01	1.94	1.88	1.83	1.75	1.64	1.57	1.46	1.35	1.24	1.00
	b	6.64	4.60	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32	2.18	1.99	1.87	1.69	1.52	1.36	1.00

the row means and the column means gives

$$12 + 24 = 36.$$

This value, subtracted from the total sum of squares, leaves a residual of 10. This term is representative of interaction effects and error.

The two-way table of variation can now de constructed. The degrees of freedom for the Discrepance (Residual) is the product of the degrees of freedom for rows and columns.

Table 6. Two-Way Table of Variation in Hours to Failure of Tubes of Three Specifications and Four Manufacturers.

Source of Variation	Sum of squares	Degrees of freedom	Mean square
Columns (Specification Effects)	24	$3 - 1 = 2$	$24/2 = 12$
Rows (Manufacturers Effects)	12	$4 - 1 = 3$	$12/3 = 4$
Residual	10	$2 \times 3 = 6$	$10/6 = 1.67$
Total (as check)	46	$12 - 1 = 11$	

Assuming that there is no interaction effect, the F ratios may be obtained from Table 9. The mean squares of rows and columns can be compared to the mean square of the residual. For columns,

$$F = \frac{12}{1.67} = 7.19 \qquad F_{.05}(2,6) = 5.14$$

Since $F = 7.19 > F_{.05}(2,6)$, the null hypothesis is rejected and it may be concluded that there is a difference in hours to failure due to differences in specifications.

Again, forming F for the row effects,

$$F = \frac{4}{1.67} = 2.40 < F_{.05}(3,6) = 4.76,$$

In this case, the null hypothesis is not rejected, and it may be concluded that there is no significant row effects — that is, there is no discernible difference in hours to failure between manufacturers. However, in coming to this conclusion, one must realize that an insignificant F value may be caused by one of two things.

(1) There is no difference between the population row means.

(2) There is a difference but the sample size was too small to detect it.

Many statistical texts contain designs for analyses of variance on a much more elaborate scale than that illustrated here. Several WADC publications on the subject are:

(1) Mentzer, Eldo G., *Tests by the Analysis of Variance* (WADC–TR 53-23), January 1953.

(2) Harter, H. Leon, and Lum, Mary D., *Partially Hierarchal Models in the Analysis of Variance* (WADC–TR 55-33), March 1955.

(3) *Analysis of Variance: Preliminary Tests, Pooling and Linear Models* (WADC–TR 55-244) March 1956:

Volume I: Bozovich, Helen; Bancroft, T. A.; Hartley, H. O.; and Huntsberger, David V., "Preliminary Tests of Significance and Pooling Procedures for Certain Incompletely Specified Models."

Volume II: Wilk, M. B., and Kempthorne, O., "Derived Linear Models and

Their Use in the Analysis of Randomized Experiments."

(4) Rider, Paul R., Harter, H. Leon, and Lum, Mary D., *An Elementary Approach to the Analysis of Variance.* (WADC-TR 56-20), February 1956.

(5) Olds, Edwin G., Mattson, Thomas B., and Odeh, Robert E., *Notes on the Use of Transformations in the Analysis of Variance* (WADC-TR 56-308), July 1956.

The reader of these publications will become aware that the data and formulae presented in this section of the handbook were taken from publication number 4 above. It is hoped that the wide distribution which the handbook receives will justify the removal of this material from its context.

D. *Replication*

In the analysis described in the foregoing section, it became apparent that nothing further could be done to decrease the "residual" term for the given sample size. Moreover, it is unwise from an engineering point of view to base important conclusions on data from one tube of one specification date and one manufacturer, since there is no measure of interaction. The following material illustrates how the technique of analysis of variance can be applied to a series of identical types of readings (replications). The technique is usually more effective when more than one sample of readings is involved.

Table 7. Two-Way Table of Variation for Two Sets of Readings of Hours to Failure of Tubes of Three Specifications and Four Manufacturers

Specification date	A	B	C	Total	Mean
Manufacturer					
1	5	6	10		
	4	6	11		
	9	12	21	42	7
2	6	6	9		
	5	4	6		
	11	10	15	36	6
3	4	3	8		
	7	4	10		
	11	7	18	36	6
4	5	5	5		
	4	6	5		
	9	11	10	30	5
Total	40	40	64	144	
Mean	5	5	8	Grand Mean = 6	

Now the total weighted sum of squares of the 12 averages $9/2 = 4.5$, $12/2 = 6$, $21/2 = 10.5$, etc., is found.

$$2\,[\,(4.5 - 6)^2 + (6 - 6)^2 + (10.5 - 6)^2 + (5.5 - 6)^2 + (5 - 6)^2 + (7.5 - 6)^2 + (5.5 - 6)^2 + (3.5 - 6)^2 + (9 - 6)^2 + (4.5 - 6)^2 + (5.5 - 6)^2 + (5 - 6)^2\,] = 90$$

A short-cut computation of the above is related again to the formula.

$$(\tfrac{1}{2})\,[9^2 + 12^2 + 21^2 + 11^2 + 10^2 + 15^2 + 11^2 + 7^2 + 18^2 + 9^2 + 11^2 + 10^2] - \frac{(144)^2}{24} = 90.$$

The weighted sum of squares of the column means, the specification effects, become

$$8[(5-6)^2 + (5-6)^2 + (8-6)^2] = 48.$$

The short computational form is

$$(1/8)\ (40^2 + 40^2 + 64^2) - \frac{144}{24} = 48.$$

Similarly, for the rows, the manufacturer effects are computed thus:

$$6\,[(7-6)^2 + (6-6)^2 + (6-6)^2 + (5-6)^2] = 12.$$

The short form is

$$(1/6)\ (42^2 + 36^2 + 36^2 + 30^2) - \frac{144}{24} = 12.$$

Thus, the interaction sum of squares is

$$90 - 48 - 12 = 30.$$

There is still more information in the data, since the total sum of squares of the individual deviations from the grand mean is

$$(5-6)^2 + (4-6)^2 + (6-6)^2 + (6-6)^2 + (10-6)^2 + (11-6)^2 + (6-6)^2 + (5-6)^2 + (6-6)^2 + (4-6)^2 + (9-6)^2 + (6-6)^2 + (4-6)^2 + (7-6)^2 + (3-6)^2 + (4-6)^2 + (8-6)^2 + (10-6)^2 + (5-6)^2 + (4-6)^2 + (5-6)^2 + (6-6)^2 + (5-6)^2 + (5-6)^2 = 106.$$

The short-cut form, $\sum_{k}^{2}\sum_{j}^{3}\sum_{i}^{4} (X_{ijk})^2 - \frac{144^2}{24}$ furnishes the same result: 106.

It can be seen that there is an unaccounted-for sum of squares,

$$106 - 48 - 12 - 30 = 16.$$

Actually, this value is the sum of the squares of the deviations of the individual values from their cell averages. This term is sometimes known as the "Error Sum of Squares." Thus,

$$(5-4.5)^2 + (4-4.5)^2 + (6-6)^2 + (6-6)^2 + \ldots\ldots = 16.$$

A refinement of the summary table becomes necessary, using the following abbreviations:

SS = sum of squares

DF = degrees of freedom

MS = mean square

After the mean squares have been calculated, each is divided by the error MS to find F.

Table 8. Sum of Squares, Degrees of Freedom, Mean Squares and F for Two Replications: Hours to Failure of Tubes of Three Specification Dates and Four Manufacturers.

Source	SS	DF	MS	F	F(.05)
Columns (Effect of Specification)	48	$3-1=2$	24	$\frac{24}{1.33} = 18.05$*	3.88
Rows (Effect of Manufacturer)	12	$4-1=3$	4	$\frac{4}{1.33} = 3.01$	3.49
Interaction	30	$(3-1)\ (4-1) = 6$	5	$\frac{5}{1.33} = 3.76$*	3.00
Error	16	$12\ (2-1) = 12$	1.33		
Total (check)	106	$24-1=23$			

* Denotes that the variability is significantly greater than random error.

The DF of the error term is the number of observations per cell minus one, times the number of cells.

The existence of the interaction term in the calculations requires some explanation. An interaction is the condition of dependence between two or more factors. This condition is determined by testing whether the effects of one factor (that is, the differences between two or more levels of this factor) are the same for every level of the other factor or factors.

2.5 Choice of Sample Size

Experimentation and decision-making become necessities in most cases involving advanced electronic design. For example, in solving the tolerance problem, the production engineer is often faced with the question: How large a sample must be tested in order to establish operating tolerances? When reliability is a consideration, the sample size is of major concern, for the time and manpower involved in life-testing and field testing are very expensive. Another factor to be considered is that life-tests and field tests usually result in the destruction of the items tested. If an expensive test yields non-representative data because of inadequate attention to sample size, the false sense of security developed in the analysis is much more harmful in the long run than the lack of a test would prove to be.

A. *Testing Hypotheses*

The choice of sample size will be dictated by the magnitude of the Type I and Type II errors (to be defined later) which the experimenter is willing to tolerate, and by the economics of the test situation. Successful engineers often develop an intuitive approach to the problem of sample size, based on an understanding of the amount of experimentation required and of the amount of decision-making that will be involved in arriving at adequate test results. For those persons who are less experienced in conducting large-scale statistical tests, it is often helpful to realize that a formal, logical procedure is available to reduce the risk of error to a predetermined level.

In many experiments, the sample size can be determined by setting up two hypotheses — the null and the alternative — concerning the population value under study. The investigator allows for a sufficient number of items in the sample to enable one of the two hypotheses to be accepted. The testing procedure is such that every measurement furnishes evidence favoring one or the other of the hypotheses.

The term "accept" requires explanation. The investigator "accepts" the null hypothesis, H_0, only in the sense that he does not find sufficient evidence to reject it. He "accepts" the alternative hypothesis, H_1, only in the sense that he rejects the null hypothesis. Under certain circumstances, H_0 is not tested against a single alternative, H_1, but against a whole class of alternatives, H_i.

Figure 22 presents a simplified graphic illustration of the procedure involved in accepting or rejecting hypotheses. The problem is to determine whether a property is distributed according to $f_0(X)$ or according to $f_1(X)$. The first case corresponds to the null hypothesis; the second case corresponds to the alternative hypothesis.

In the simplest case, with a sample consisting of a single item, the null hypothesis could be accepted if the sample value X were less than k, a predetermined criterion for acceptance based on a given value of Type I error. The null hypothesis would be rejected if X were greater than k.

In the testing of hypotheses or in decision-making, there are only two general types of error that can be made:

Type I — the probability of rejecting the null hypothesis when it is actually true.

Type II — the probability of accepting the null hypothesis when it is actually false.

In an instance such as that illustrated in Figure 22, there is almost no probability of making an erroneous decision. Figure 23 illustrates the kind of situation which occurs

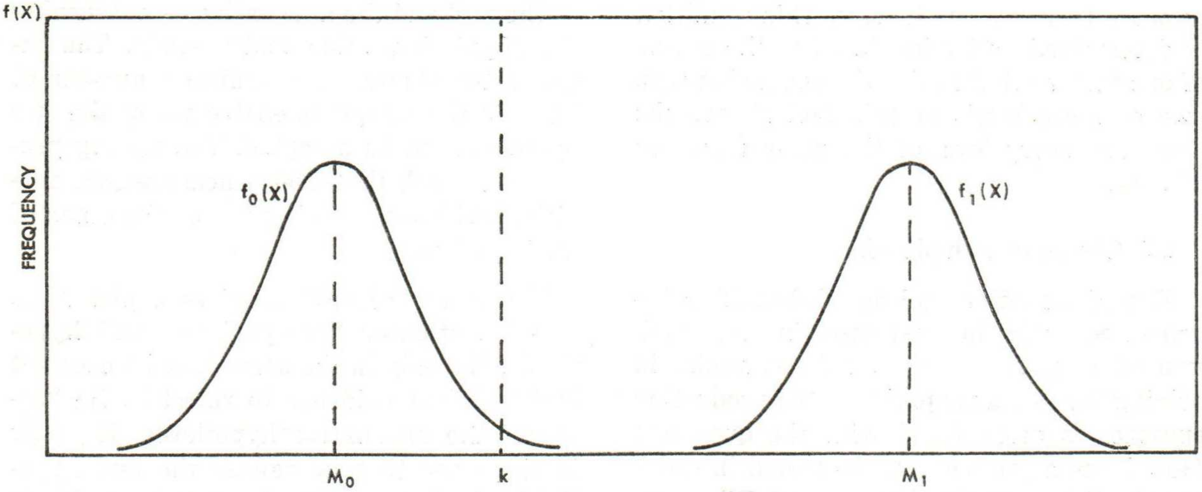

Figure 22. Hypothetical Situation in which the Distribution, $f_0(x)$, Specified Under the Null Hypothesis, Is Known to be Distinct from the Single Distribution, $f_1(x)$, Specified Under the Alternative Hypothesis.

much more frequently — a situation in which there is a distinct probability of making either a Type I or a Type II error. As in the previous example, a sample of one item will be used to illustrate the procedure. The test calls (a) for acceptance of the null hypothesis that X belongs to the $f_0(X)$ distribution if X is less than k; and (b) for rejection of the hypothesis that X belongs to the $f_0(X)$ distribution if X is greater than k.

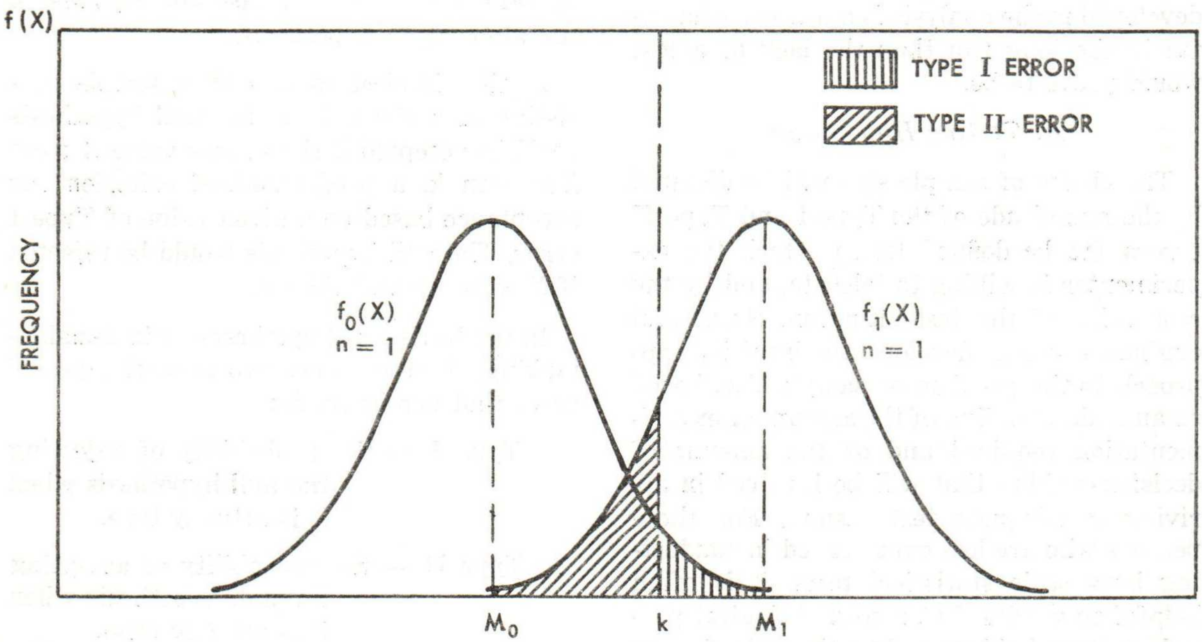

Figure 23. Hypothetical Situation in Which the Distribution, $f_0(x)$, Specified under the null Hypothesis, Is Known to Overlap the Single Distribution, $f_1(x)$, Specified under the Alternative Hypothesis.

In this illustration, the Type I error is a measure of the area under curve $f_0(X)$ which falls to the right of k; the Type II error is a measure of the area under curve $f_1(X)$ which falls to the left of k.

Figure 24 describes a specific situation in which the probability of the Type II error can be decreased, for a given probability of the Type I error, by the expedient of increasing the sample size. For samples of greater size than one, the sample average, $\overline{X}$, is used in place of the value of a single observation. The acceptance criteria now become: (a) accept the hypothesis that the sample is drawn from the $f_0(X)$ distribution if the sample mean, $\overline{X}$ is less than k; and (b) reject the hypothesis if the sample mean is greater than k. The probability of error decreases markedly as n increases. Note that if k were moved to the left, the Type I error would increase appreciably, while the Type II error would not be greatly affected.

For the examples in Figure 24, the normal distribution has been plotted. In Part A, $f_0(X)$ and $f_1(X)$ are distributions of samples of size one, with means $M_0 = 0$ and $M_1 = 1$, respectively, and standard deviations $\sigma = 1$. Part B presents two distributions of means of samples of size four, where $f_0(X)$ has a mean of 0 and a standard deviation of $\frac{1}{2}$, and $f_1(X)$ has a mean of 1 and a standard deviation of $\frac{1}{2}$. Part C presents distribution of means of samples of size nine. The mean of the $f_0(X)$ distribution is 0, and the mean of the $f_1(X)$ distribution is 1. The standard deviation of both distributions is $\frac{1}{3}$.

In all three cases illustrated in Figure 24, k is chosen to give a probability of Type I error of .05. As the sample size is increased, the probability of the Type II error is decreased, and there is a corresponding increase in the ability to distinguish between the two distributions. Note that k is moved to the left with each increase in sample size, to keep the Type I error constant.

By selecting k properly, it is possible to determine the minimum sample size for which the risks would be equal to, or less than, any specified values of Type I and Type II errors. Two references which afford concrete assistance relating to the procedures discussed in this section are cited in the footnote below.*

B. *Estimating Population Parameters*

The logic of hypothesis-testing can be carried over into the estimation of population parameters. Figure 24 indicates the relative dispersion of estimates of a mean value based on one, four, and nine observations. Since the standard error of a sample mean is the sample standard deviation divided by the square root of n, the sample size, the precision of an estimate will increase in proportion to the square root of n. To double the precision of an estimate, the sample size must be quadrupled. The formula for the standard error of the mean of a group of X_i values is given as

$$\frac{s}{\overline{X}} = \frac{s}{\sqrt{n}} = \frac{\sqrt{\dfrac{\Sigma Xi^2 - (\Sigma Xi)^2/n}{n - 1}}}{\sqrt{n}}$$

2.6 Confidence Limits and Tolerance Limits

Tolerance limits should not be confused with confidence limits. Confidence limits are constructed to encompass a population parameter with a given probability. Tolerance limits are constructed to include a desired minimum proportion of the population with a given probability.

Confidence limits for the mean are of the form

$$\overline{X} \pm t\alpha \frac{S}{\sqrt{n}},$$

and are computed in such a way that for a fraction $1 - \alpha = .95$, or 95 percent, of the samples used, the limits will encompass the

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* Cochran, W. G., and Cox, G. M., *Experimental Designs*, John Wiley & Sons, New York, 1950; and Kempthorne, O., *The Design and Analysis of Experiments*, John Wiley & Sons, New York, 1952.

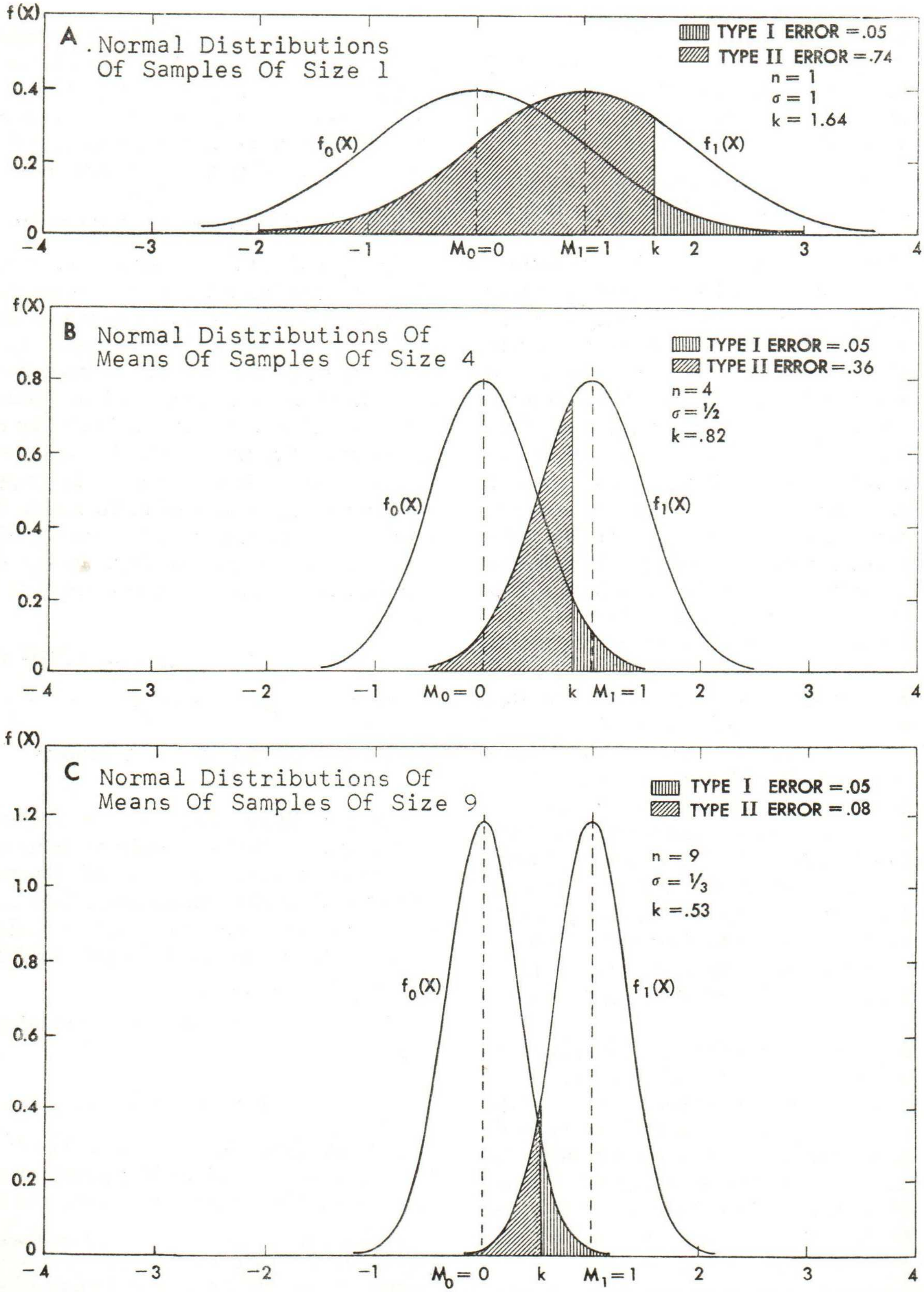


Figure 24. Illustration of the use of Increased Sample Sizes to Reduce the Type II Error When the Type I Error is Held Constant.

true mean of the population.* Tolerance limits, on the other hand, are computed so that for a fraction $1 - \alpha = .95$, or 95 percent, of the samples, at least P percent of the population will be included within the limits. As the sample size increases, the confidence interval diminishes toward zero, whereas the tolerance limits tend to move toward the value which would be used if the true values of M and σ were known.

A. *Confidence Limits on the Mean of a Population*

Two illustrative examples are used in the following material. In the first case, the population standard deviation, σ, is assumed to be known. In the second case, the value of σ is unknown, and the sample estimate s must be used instead. In both cases, it is necessary to assume that the distribution is normal, although other distributions could be treated wih analogous methods.

For the sake of convenience, a normally distributed variable such as transconductance might be considered. The mean and the standard deviation of the lot are known. Sample estimates of the mean are normally distributed about the true value of the mean, and the standard deviation of distribution of means is $\sigma/\sqrt{n}$. The following probability statement can be made concerning $\overline{X}$:

$$\text{(I)} \quad \Pr\left(M - \frac{k\alpha\sigma}{\sqrt{n}} < \overline{X} < M + \frac{k\alpha\sigma}{\sqrt{n}}\right) = 1 - \alpha$$

Pr = the probability that:

$1-\alpha$ = the assigned probability or confidence coefficient

$k\,\alpha$ = the constant obtained from table of "percentage points of the normal distribution" which corresponds to α

The foregoing inequality simply states that there is a probability $1 - \alpha$ that the mean of a sample will fall in the interval defined by

$$\text{(II)} \quad M \pm \frac{k\alpha\sigma}{\sqrt{n}}$$

This is a fundamental property of the normal distribution.

The inequality may be treated as follows without changing the probability statement: Subtract M from each element and then divide each element by $\sigma/\sqrt{n}$. This computation gives

$$\text{(III)} \quad \Pr\left(-k\alpha < \frac{\overline{X} - M}{\sigma/\sqrt{n}} < k\alpha\right) = 1 - \alpha$$

The inequality solved for M gives

$$\text{(IV)} \quad \Pr\left(\overline{X} - \frac{k\alpha\sigma}{\sqrt{n}} < M < \overline{X} + \frac{k\alpha\sigma}{\sqrt{n}}\right) = 1 - \alpha$$

Care is necessary in the interpretation of the last statement. It should be noted that for each individual sample of size n, there will be a corresponding interval.

$$\overline{X} \pm \frac{k\alpha\sigma}{\sqrt{n}}\,\overline{X}$$

such that, in repeated sampling, 100 $(1-\alpha)$ percent of the intervals can be expected to include the population mean M. In practice, only one sample is usually available, and the interval defined by the sample either contains or does not contain the true population mean. Equation IV, then, does *not* hold for the case where $\overline{X}$, the sample mean, is already determined, because the interval does or does not contain M with a probability of 1 or 0, respectively. It is common practice, however, to make the following statement:

Assuming that the factor $(1 - \alpha)$, the confidence coefficient, equals .95, the 95-percent confidence limits for M are therefore given by the inequality

* In this expression, t_α is the value of the distribution of t for given values of α and n, shown in Figure 25.

$$\text{(V)} \quad \bar{X} - \frac{1.96\sigma}{\sqrt{n}} < M < \bar{X} + \frac{1.96\sigma}{\sqrt{n}}$$

In most cases, the experiment does not know the true value of the population standard deviation and must use instead the sample estimate s. When the sample standard deviation is used, the 100 $(1 - \alpha)$ percent confidence limits for M are given by

$$\text{(VI)} \quad \bar{X} - \frac{t\alpha s}{\sqrt{n}} < M < \bar{X} + \frac{t\alpha s}{\sqrt{n}}$$

Formula VI differs from Formula V in that α is replaced by s, and $k\alpha$ is replaced by $t\alpha$. The last term refers to a percentage point of the "Student's t Distribution." The value of t depends upon α and on the sample size.

A graphic plot of "Student's t" for various degrees of fredom is shown in Figure 25. The appropriate number of degrees of freedom in this case is $n - 1$. It will be noted that t is numerically larger than k for the normal distribution. However, the difference is so small for degrees of freedom greater than 30 that the percentge points of the normal distribution may be used.

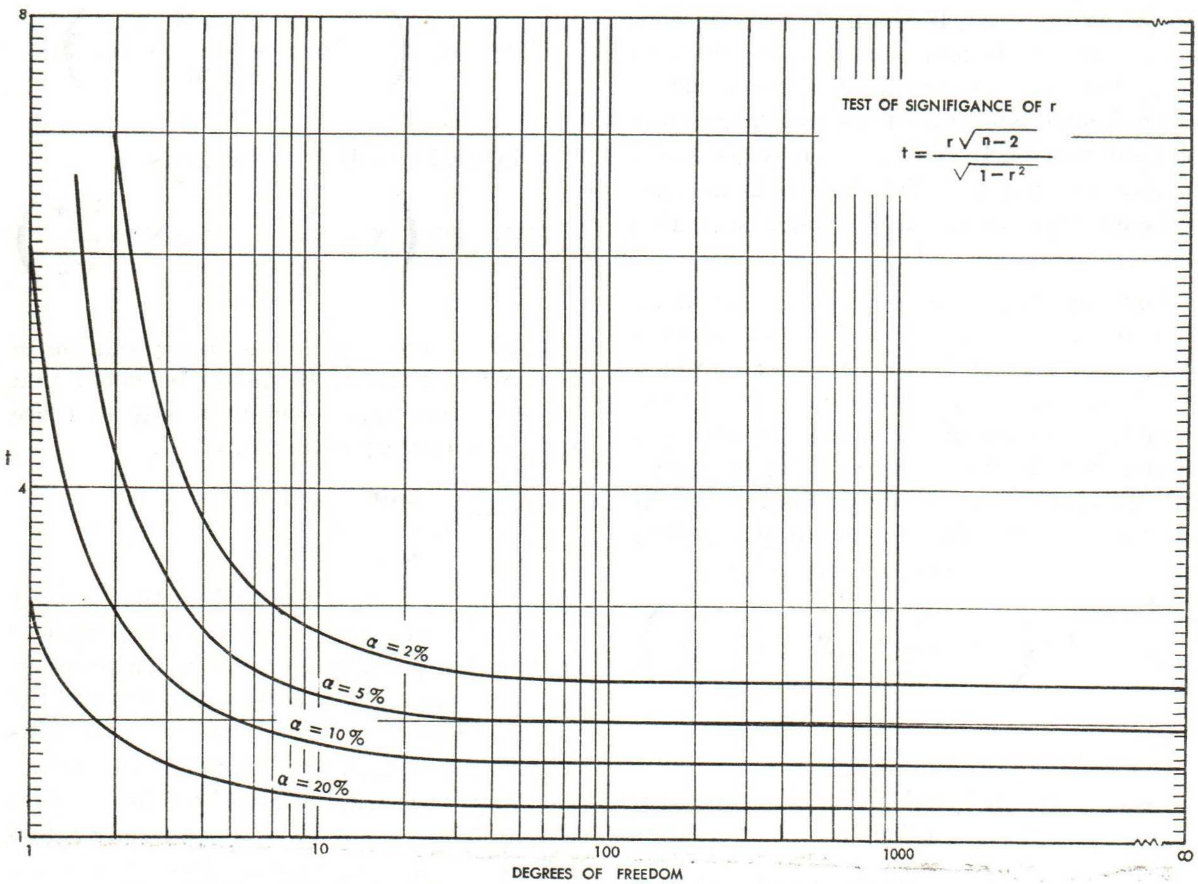


Figure 25. Plot of "Student's t" for Type I Errors of 2 Percent, 5 Percent, 10 Percent and 20 Percent.

B. *Tolerance Limits on a Normally Distributed Population*

A problem frequently encountered in engineering statistics is to set tolerance limits L_1 and L_2 (based on sampling information) which will include a given percentage of the population with a given probability. If M and σ are known, the 95-percent tolerance limits are given by $M \pm 1.96\sigma$ with a probability of 1.

When the population parameters are replaced by $\overline{X}$ and s, the variability of these estimates must be taken into account, and the tolerance limits are more widely separated. Furthermore, it is not possible to state with certainty that a given proportion of the population will fall between the limits. Under these circumstances, the observer states with some "confidence" that some percentage of the population lies between L_1 and L_2. For example, with a sample of 10 observations and a confidence coefficient of .95, the interval including at least 95 percent of a normal population is defined by

$$\overline{X} \pm 3.379s$$

or, stated in terms of L_1 and L_2,

$$L_1 = \overline{X} - 3.379s$$

$$L_2 = \overline{X} + 3.379s$$

The value of 3.379 may be called the tolerance factor. It has been computed, and can be found in tabular form, in at least two books.* A portion of the table from Hald's book is reproduced as Figure 26.

In order to use Figure 26 to obtain a tolerance factor, it is necessary to decide upon a confidence coefficient and upon the proportion of the population to be included within the tolerance limits. The tolerance factor is given corresponding to a given sample size. For example, with a sample size of 30 and degrees of freedom of n — 1, or 29, it is desired to establish 90 percent tolerance limits with a confidence of .95. Figure 26 was drawn only on the basis of a .95 confidence coefficient. The degrees of freedom are plotted on the abscissa. To obtain the tolerance factor, l, the observer reads the point on curve $\alpha = 10$ percent which corresponds to 29 degrees of freedom. The tolerance factor for this abscissa value is approximately 2.15.

C. *Usefulness of Estimates of* σ

The foregoing material on confidence and tolerance limits pertains specifically to normally distributed data. Similar techniques have been developed for dealing with several non-normal distributional forms, but no general all-inclusive theory has been devised. Often, if the data are not normally distributed, it is possible to transform them into a normally distributed form or into some other recognizable form which is amenable to tabulation, whereupon tolerance statements can again be made.

Figure 27 illustrates criteria for determining tolerance limits (a) when the data are symmetrically distributed, and (b) when the form of the distribution is not known. The figure relates the tolerance percentage falling outside of selected limits by means of $\pm Ks$, where s is the sample standard deviation of the data and K is a scale factor. The advantage of knowing that the data are normally distributed is obvious. If the data are known to be distributed symmetrically and unimodally, the second, wider tolerance criterion may be used.

If nothing whatsoever is known about the data—except for the sample standard deviation—the third criterion may be used to place tolerance limits about the mean of the data. This method, which was developed by Tchebycheff, is quite general.

2.7 The Technique of Linear Regression

The technique of linear regression is a statistical tool which can be used to advantage by the electronic designer to determine tube-to-circuit compatibility. The technique is applicable in designs where the operating points are somewhat removed from the MIL-E-1 test point.

Two methods for using the technique are described in the following discussion. The

* Eisenhart, C., Hastay, M. W., and Wallis, W. A., *Techniques of Statistical Analysis*, McGraw-Hill Book Co., New York, 1947; and Hald, A., *Statistical Theory with Engineering Applications*, John Wiley & Sons, New York, 1952.

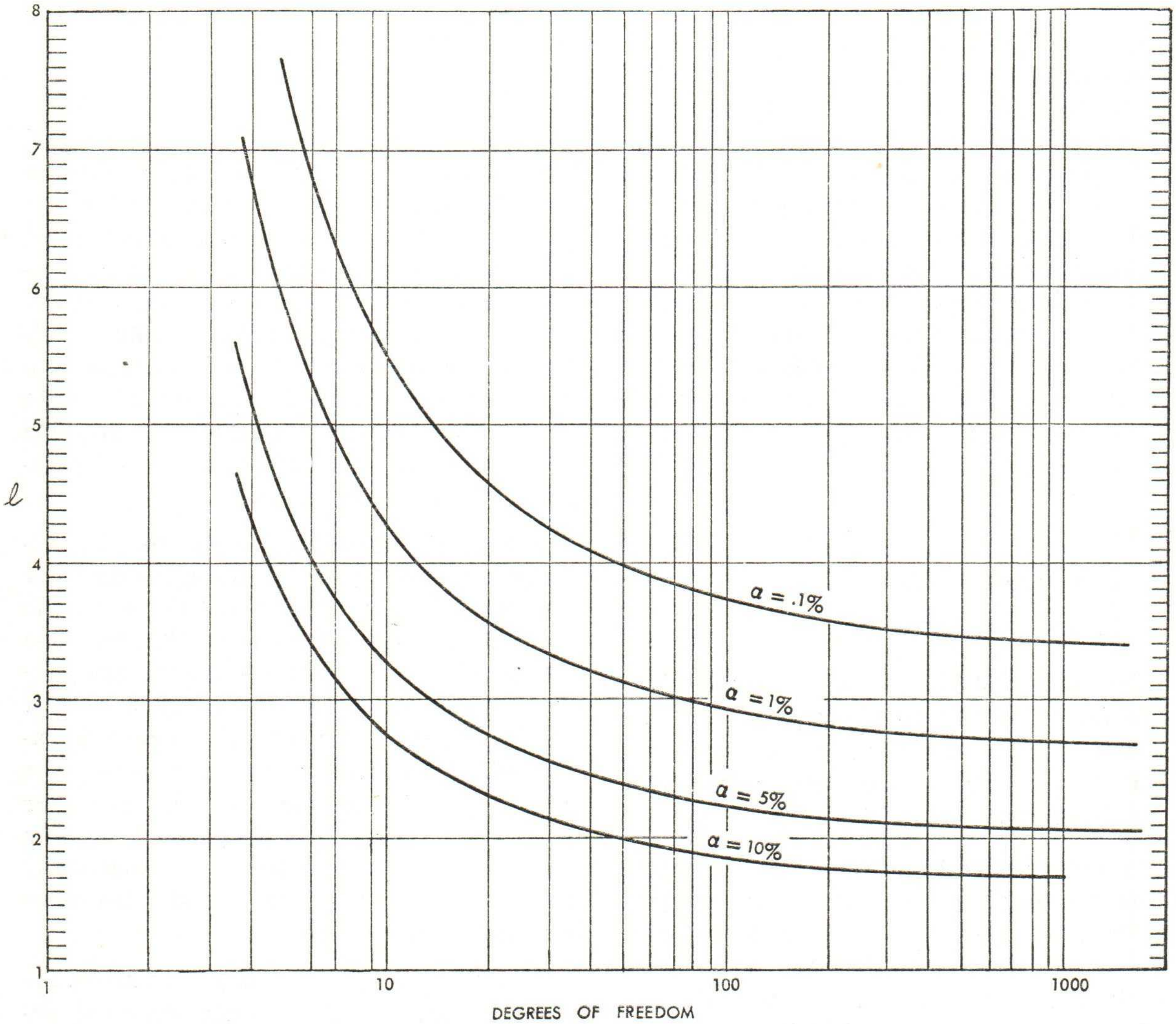


Figure 26. Plot of the Tolerance Factor at the 95--Percent Confidence Level for Tolerance Limits on the Normal Distribution.

first method involves a series of computations resulting in an estimating equation, an estimate of the degree of correlation between two sets of values, a determination of the importance or significance of the calculated correlation, and the establishment of tolerance limits. On the basis of these computations, a prediction can be made of the compatibility of tubes purchased under MIL-E-1 specifications.

The second method involves a straightforward graphic technique which, although it yields only approximate results, may provide sufficient information about the relationship between circuit performance and measured tube characteristics to permit the prediction of tube-to-circuit compatibility.

2.7.1 *The Computational Technique.*

The analysis of experimental data collected by the circuit designer is based, in the first instance, upon the premise that the expected value of circuit output, Y, can be expressed by a linear relationship with a tube characteristic, X, whose values during life are defined by specification. The analysis may be extended to include more than one tube characteristic, but the following description

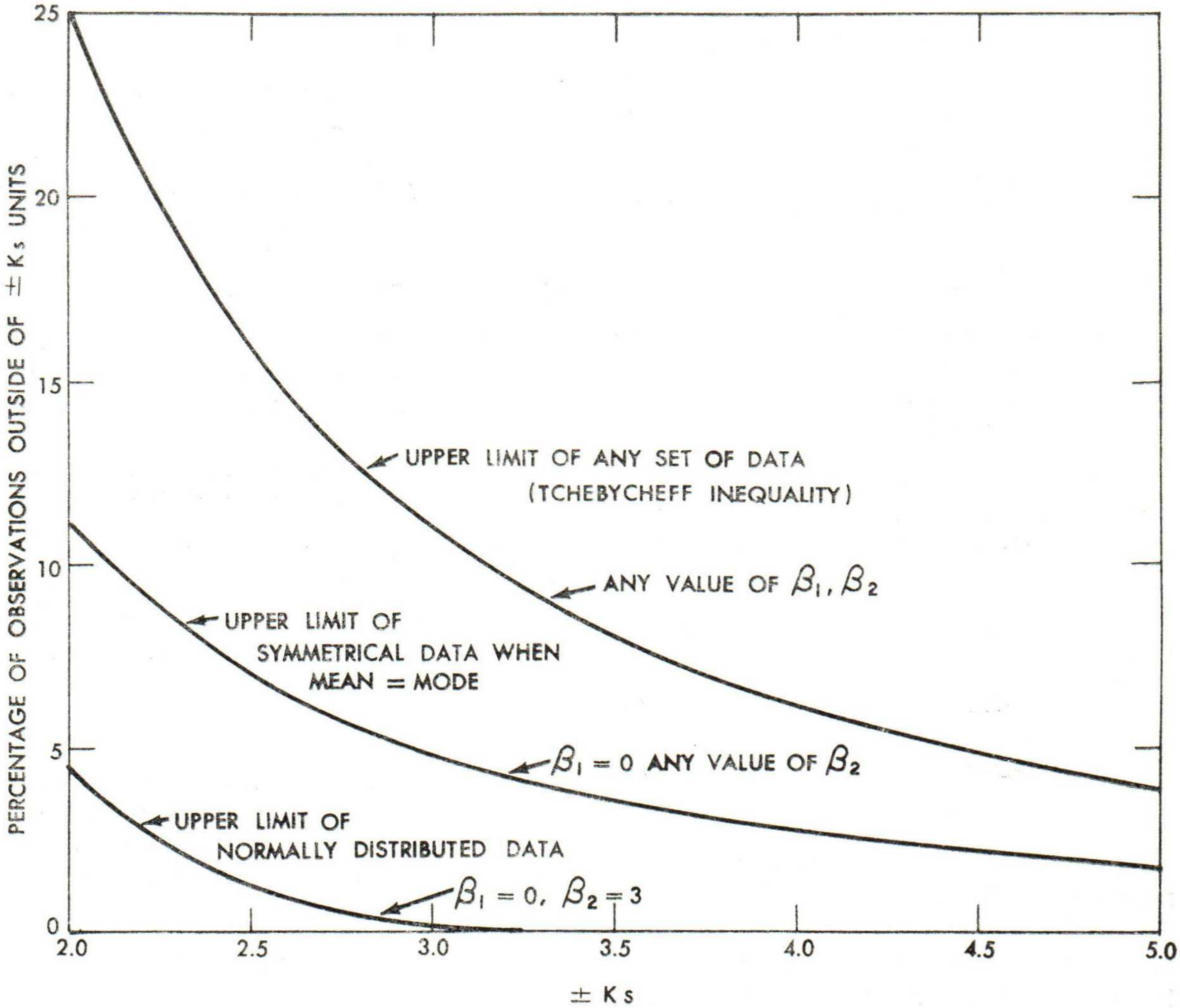


Figure 27. Plot of the Percentage of Observations Falling Within the Range ±Ks Units.

of the technique is limited to one.

The relationship between X and Y may be expressed as

$$Y = A + BX,$$

where A and B are constants of the regression. The true values of A and B cannot be determined by a sampling technique, but estimates of these values can be obtained by means of the general technique of "least squares."*

The estimating equation or model for the relationship of circuit performance to the tube characteristic becomes

$$\hat{Y} = a + bX,$$

where a and b are the estimated values determined from a set of data taken by sampling tubes and circuits in some random manner.

A. *Assumptions Underlying Linear Regression*

Before giving the data-reduction equation, it is prudent to list some of the assumptions upon which the normal regression technique is based:

* Bennentt, C. A., and Franklin, N. L., *Statistics Analysis,* John Wiley & Sons, New York, 1954.

(1) For each value of X, the values of Y should be normally distributed about the regression line. No assumptions are necessary regarding the distribution of the X values. Therefore, the X's may be determined arbitrarily within the physical limitations of the experiment.

(2) As stated previously, the mean value of Y corresponding to a given value of X is a linear function of X.

(3) The variance of the distribution of Y for a fixed value of X is independent of X—i.e., is constant for all values of X.

(4) The observations must be independent; that is, any particular value of Y must be independent of, and not influenced by, any other value which Y may happen to take.

In view of the foregoing assumptions, it is necessary to describe the relative effect on the results of the analysis of failure to meet any of the four requirements. The relative importance of the assumptions is evaluated on an item-by-item basis below:

(1) The consequences of failure to comply with the first assumption are not serious. The tests of significance involving the use of "t" and "F" distributions require that the data be normally distributed about the regression line. Some validity is lost if this requirement is not met. However, the least-squares line of Y on X is an unbiased estimate of the true relationship.

(2) If the mean of the Y's, given X, is not a linear function of X, a different approach — for example, curvilinear regression—may be taken.

(3) If the varience of Y is not constant with all values of X, statements of tolerance and confidence will not be valid, unless they are weighted by the inverse functional relationship between the variance and the X variable.

(4) If the observations are not independent, the estimate of the correlation coefficient will be either optimistic or pessimistic, depending upon the nature of the relationship destroying the independence.

When data are sparse, approximate compliance with the assumptions may be assumed if no outstanding exceptions, such as those relating to the second and third assumptions, are present.

B. *Formula of Linear Regression*

The procedure involving the derivation of the "Normal Equations" of estimation may be found in many statistical texts,* and results in the following simultaneous equations:

$$na + b\,\Sigma X_i = \Sigma Y_i$$

$$a\Sigma X_i + b\Sigma X_i^2 = \Sigma X_i Y_i$$

Solution of these equations for the regression coefficient yields

$$a = \overline{Y} - b\overline{X}$$

$$b = \frac{\begin{vmatrix} n & \Sigma X_i \\ \Sigma X_i & X_i^2 \end{vmatrix}}{\begin{vmatrix} n & \Sigma Y_i \\ \Sigma X_i & \Sigma X_i Y_i \end{vmatrix}}$$

Several measures of variation must be mentioned in connection with this technique: SSy = the sum of squares of all the Y_i values about $\overline{Y}$

$$SSy = \Sigma\ (Y_i - \overline{Y})^2,$$

or, in computational form:

* Bennett, C. A., and Franklin, N. L., *Op. Cit.*

$$SSy = \Sigma Y_i^2 - (\Sigma Y_i)^2/n.$$

SSe = the sum of squares of the deviations of the Y_i values about the regression line. This term is also known at the discrepance, or the residual sum of squares.

$$SSe = \Sigma(Y_i - a - bX_i)^2,$$

or, in computational form:

$$SSe = SSy - b\ [\Sigma X_i Y_i - \frac{(\Sigma X_i)\ (\Sigma Y_i)}{n}].$$

A measure of the residual variability is known as the standard error of estimate s_e. s_e is the root mean square of the residual error, with a loss of two degrees of freedom (since the regression coefficients, a and b, have been estimated from the sum data).

$$s_e = \sqrt{SSe/(n\text{-}2)}$$

s_e is used later in computing confidence and tolerance limits.

A useful measure of the relative value of the regression line in predicting circuit performance is the population correlation coefficient p. An estimate of p, denoted by the letter r, is given by the following formula:

$$r = \sqrt{1 - SSe/SSy.}$$

A direct computational form for r is:

$$r = \sqrt{b\ \frac{\Sigma X_i Y_i - (\Sigma X_i)(\Sigma Y_i)/n}{\Sigma Y_i - (\Sigma Y_i)^2/n}}$$

By convention, the algebraic sign of r is chosen to be identical to the sign calculated for the slope b.

A property of the correlation coefficient which is of considerable interest to the circuit designer is the value of r^2. This value is, in a sense, the proportion of the variability of circuit output, Y, which is explained by the variation of the tube characteristic, X, since

$$r^2 = 1 - \frac{SSe}{SSy}$$

SS_e, in this context, is a measure of the random error involved. The ratio $\frac{SSe}{SSy}$ remains as the proportion of total variation (SSy) left unexplained by the regression (functional relationship) existing between the tube characteristic and circuit performance.

To obtain a further measure of the value of the correlation coefficient, r, it is possible to compare it to the "t" distribution for a given sample size and Type I error α. (In this circumstance, 100α percent of the time the analyst erroneously decides that correlation exists when it does not.)

$$t = r\ \sqrt{n - 2}\ /\ \sqrt{1 - r^2}$$

The calculated value of t may be compared to a value interpolated from figure 25 at n — 2 degrees of freedom. If the calculated value of t exceeds the graphic value, r may be assumed to be significant at the level selected, and a real linear relationship may be assumed to exist between X and Y.

C. *Determination of Significance of Correlation*

Three possible conclusions may be drawn from the determination of the significance of the correlation:

(1) The significance level may be high, but the correlation coefficient may be too low for practical application. Perhaps less than 50 percent of the variation in circuit output is explained by the selected tube characteristic. In this case, different variables or more variables should be used to increase r^2 to a useful level.

(2) The correlation coefficient may be high, but not significant, thereby indicating that more data must be taken to enable information derived from the analysis to be used with confidence.

(3) The correlation may be highly sig-

nificant, but may involve properties or conditions which were not controlled or measured during the test. Such spurious correlation an be detected only if the investigator is observant and exercises good judgment.

It is well, in this connection, to remember that statistical analysis is not a substitute for engineering ability. However, statistics can become an effective aid in design when used with professional restraint.

D. *Confidence and Tolerance Limits About the Regression Line*

Since the Y values are normally distributed about the regression line, it is possible to compute confidence limits and tolerance limits for these values.

The confidence limits for the mean of the Y values for a particular value of X = X' are given by

$$\hat{Y}' = a + bX' \pm t\alpha\, s_e \sqrt{\frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_i^2 - (\Sigma X_i)^2/n}}.$$

The confidence limits for an individual Y value are given by

$$\hat{Y}'' = a + bX' \pm t\alpha\, s_e \sqrt{1 + \frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_i^2 - (\Sigma X_i)^2/n}}.$$

In both of the foregoing notations, t α is the appropriate constant from the "Student's t Distribution" (see Figure 25). To obtain the 100 (1—α) percent tolerance limits of Y for a given value of X*, with confidence coefficient P = (1 —α), the following formula is used:

$$\hat{Y}''' = a + bX' \pm l\, s_e \sqrt{1 + \frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_i^2 - (\Sigma X_i)^2/n}}.$$

In this notation, l is the tolerance factor interpolated from Figure 26. As indicated previously, Figure 26 is drawn for P = .95.

From the three formulae immediately above, it can be seen that the limits spread out as observations depart from the mean of the X values. The reason for this is that the uncertainty due to the error in estimating the slope of the regression line increases as the X value departs from its mean.

E. *Example of Linear Regression Technique*

A logical first step in any regression problem is to make a scatter-plot of the data. Table 10 gives plate-current readings for a sample of tubes, as taken under the conditions specified in the MIL–E–1 technical specification sheet (TSS). These readings are recorded with the corresponding readings for circuit output current. Figure 28 is a point-for-point plot of the data given in the table.

The figure indicates that linear relationship exists between the MIL–E–1 test-point values for plate current and circuit output current. A case of non-linear relationship is discussed later. The linear regression technique will be applied to this relationship after a transformation of the linear estimating equation has been made.

After the scatter-plot has been made, the sums of squares and cross-products of the two variables may be tabulated or totaled directly with a suitable calculator. Table 11 illustrates how the listing may be made. In computing sums of squares and cross-products, it is imperative to use as many significant figures as possible. In later subtractions

* Hald, A., *Op. Cit.*

Tube #	Plate Current	Circuit Current	Tube #	Plate Current	Circuit Current	Tube #	Plate Current	Circuit Current
1	8.10	4.54	18	8.00	4.50	35	7.80	4.42
2	8.90	4.90	19	8.40	4.61	36	7.20	4.26
3	7.40	4.29	20	7.30	4.30	37	7.50	4.36
4	7.00	4.14	21	8.25	4.57	38	7.40	4.32
5	7.80	4.54	22	7.20	4.24	39	7.00	4.26
6	7.75	4.47	23	7.15	4.34	40	7.15	4.32
7	7.25	4.38	24	7.70	4.38	41	7.40	4.38
8	7.80	4.44	25	7.70	4.53	42	6.80	4.17
9	7.40	4.40	26	7.55	4.40	43	8.00	4.50
10	8.90	4.78	27	7.70	4.46	44	7.10	4.26
11	7.55	4.49	28	8.65	4.80	45	7.15	4.21
12	8.00	4.56	29	6.75	4.10	46	7.75	4.46
13	7.75	4.44	30	7.45	4.34	47	7.00	4.20
14	8.10	4.64	31	7.80	4.52	48	7.40	4.36
15	8.40	4.69	32	7.15	4.28	49	7.45	4.44
16	7.10	4.30	33	7.20	4.30	50	7.60	4.44
17	8.15	4.68	34	7.10	4.22			

Table 10. Plate-Current and Circuit-Current Readings Forming Basis of Linear Regression Analysis.

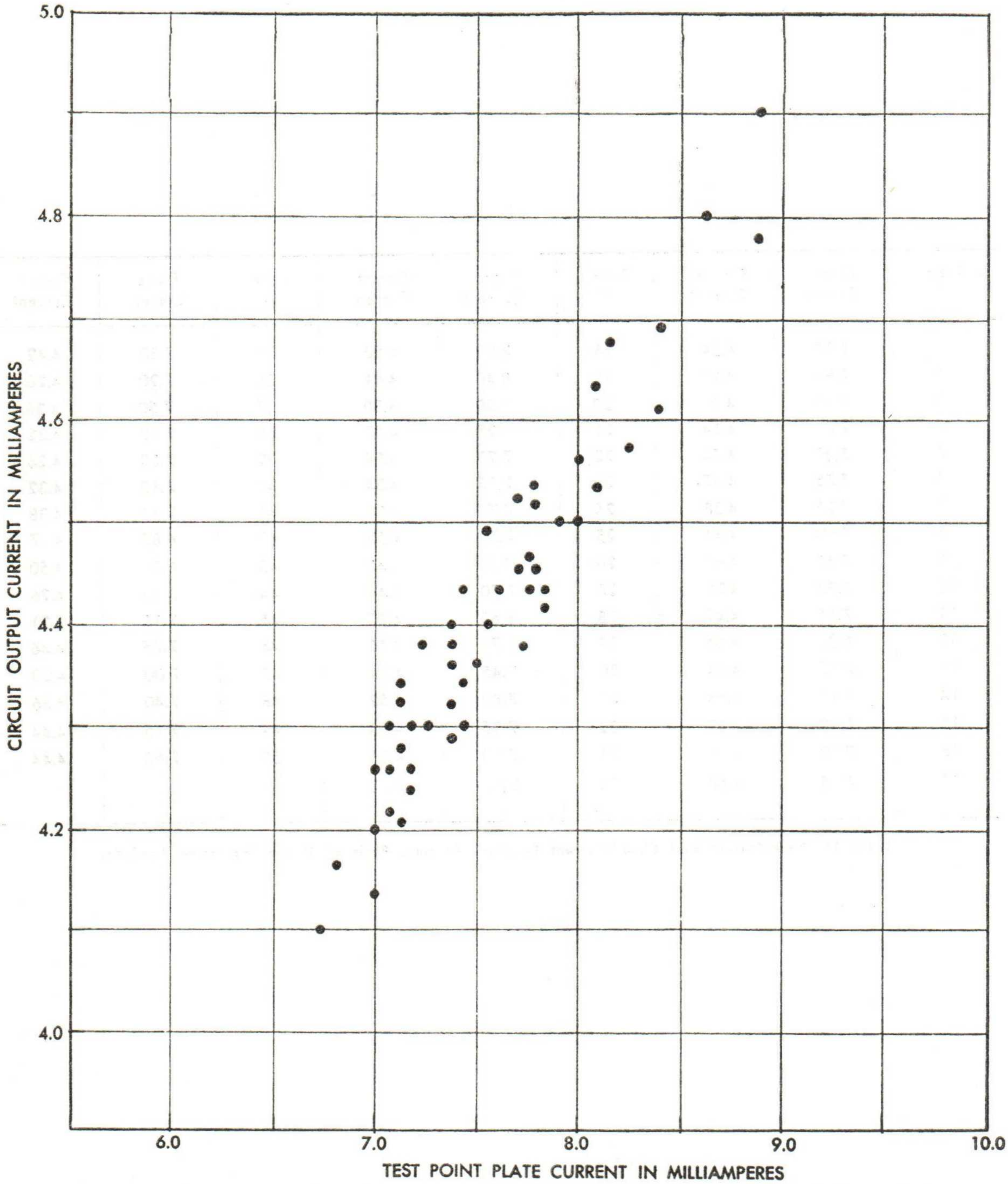


Figure 28. Scatter Plot Showing a Linear Relationship Between Test-Point Plate Current and Circuit Output Current.

of nearly identical numbers, the entire calculation can be thrown into error if too few significant figures are used. Cross-products must be computed by machine, as slide-rule accuracy is insufficient for this task. Barlow's Table* is a good source for squares of numbers.

* *Barlow's Table of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of All Integers Up to 12,500,* L. J. Courie Chemical Publishing Co., Inc., New York, 1954.

Sums of Squares and Cross-Products of Plate-Current and Circuit-Current Readings Used in Linear Regression Analysis

Tube #	X	X^2	Y	Y^2	XY
1	8.10	65.6100	4.54	20.6116	36.7740
2	8.90	79.2100	4.90	24.0100	43.6100
3	7.40	54.7600	4.29	18.4041	31.7460
4	7.00	49.0000	4.14	17.1396	28.9800
5	7.80	60.8400	4.54	20.6116	35.4120
6	7.75	60.0625	4.47	19.9809	34.6425
7	7.25	52.5625	4.38	19.1844	31.7550
8	7.80	60.8400	4.44	19.7136	34.6320
9	7.40	54.7600	4.40	19.3600	32.5600
10	8.90	79.2100	4.78	22.8484	42.5420
11	7.55	57.0025	4.49	20.1601	33.8995
12	8.00	64.0000	4.56	20.7936	36.4800
13	7.75	60.0625	4.44	19.7136	34.4100
14	8.10	65.6100	4.64	21.5296	37.5840
15	8.40	70.5600	4.69	21.9961	39.3960
16	7.10	50.4100	4.30	18.4900	30.5300
17	8.15	66.4225	4.68	21.9024	38.1420
18	8.00	64.0000	4.50	20.2500	36.0000
19	8.40	70.5600	4.61	21.2521	38.7240
20	7.30	53.2900	4.30	18.4900	31.3900
21	8.25	68.0625	4.57	20.8849	37.7025
22	7.20	51.8400	4.24	17.9776	30.5280
23	7.15	51.1225	4.34	18.8356	31.0310
24	7.70	59.2900	4.38	19.1844	33.7260
25	7.70	59.2900	4.53	20.5209	34.8810
26	7.55	57.0025	4.40	19.3600	33.2200
27	7.70	59,2900	4.46	19.8916	34.3420
28	8.65	74.8225	4.80	23.0400	41.5200
29	6.75	45.5625	4.10	16.8100	27.6750
30	7.45	55.5025	4.34	18.8356	32.3330
31	7.80	60.8400	4.52	20.4304	35.2560
32	7.15	51.1225	4.28	18.3184	30.6020
33	7.20	51.8400	4.30	18.4900	30.9600
34	7.10	50.4100	4.22	17.8084	29.9620
35	7.80	60.8400	4.42	19.5364	34.4760
36	7.20	51.8400	4.26	18.1476	30.6720
37	7.50	56.2500	4.36	19.0096	32.7000
38	7.40	54.7600	4.32	18.6624	31.9680
39	7.00	49.0000	4.26	18.1476	29.8200
40	7.15	51.1225	4.32	18.6624	30.8880

Sums of Square and Cross-Products of Plate-Current and Circuit-Current Readings Used in Linear Regression Analysis (Cont'd)

Tube #	X	X^2	Y	Y^2	XY
41	7.40	54.7600	4.38	19.1844	32.4120
42	6.80	46.2400	4.17	17.3889	28.3560
43	8.00	64.0000	4.50	20.2500	36.0000
44	7.10	50.4100	4.26	18.1476	30.2460
45	7.15	51.1225	4.21	17.7241	30.1015
46	7.75	60.0625	4.46	19.8916	34.5650
47	7.00	49.0000	4.20	17.6400	29.4000
48	7.40	54.7600	4.36	19.0096	32.2640
49	7.45	55.5025	4.44	19.7136	33.0780
50	7.60	57.7600	4.44	19.7136	33.7440
TOTAL	380.10	2902.2000	220.93	977.6589	1683.6380
MEAN	7.6020		4.4186		

X = Test-point plate current in milliamperes

Y = Circuit output current in milliamperes

E. *Use of Computed Regression Data to Determine the Range of Circuit Performance Values*

If a proper selection of circuit performance characteristics and specified tube characteristic was made in the foregoing analysis, (a) the regression equationwas established, (b) the correlation coefficient was calculated, (c) the significance of the correlation coefficient was determined, and (d) the sets of points for confidence and tolerance limits wer computed and plotted. The results of these calculations are presented in Table 12 and Figure 29.

This information should be superimposed upon a plot of the specified characteristic limits, as shown in Figure 30. Assuming that the sample values did not extend through the specified acceptable region, the regression line and the tolerance limits must be extrapolated to intersect both the minimum an dmaximum specification limits.

2.7.2 *The Approximate Graphic Technique of Linear Regression.*

The second method for determining the coefficient of correlation consists in drawing the line of estimation by inspection. With a little practice, this can be done fairly easily but not very accurately. The equation for the estimated line can be written from the two-point form of the equation for a straight line. This equation is included in Table 13 for reference purposes.

Two lines are drawn parallel to the line of estimation in such a way that $1/6$ of the points are above the top line, and $1/6$ of the points are below the bottom line. The vertical distance between these lines is approximately $2s_e$. Approximately $2/3$ of the items are in the range bounded by these two lines.

The next step in the procedure is to draw two lines parallel to the X axis so that $1/6$ of the points are above the top line, and $1/6$ of the points are below the bottom line. The range between these two lines representing approximately twice the standard deviation of Y, $2s_y$, and contains approximately $2/3$ of the items. The procedure being described is illustrated in Figure 31. The approximate coefficient of correlation (r) is calculated from the equation

$$r^2 = 1 - s_e^2/s_y^2,$$

as indicated in Table 13.

TABLE 12

COMPUTATIONS IN THE TECHNIQUE OF LINEAR REGRESSION

Model: $\hat{Y} = a + bX$

$n = 50$

$\Sigma X_i = 380.10$ $\quad \Sigma X_i^2 = 2902.2000$ $\quad (\Sigma X_i)^2 = 144{,}476.0100$

$\Sigma Y_i = 220.93$ $\quad \Sigma Y_i^2 = 977.6589$ $\quad (\Sigma Y_i)^2 = 48{,}810.0649$

$\Sigma X_i Y_i = 1683.6380$ $\quad (\Sigma X_i)(\Sigma Y_i) = 83{,}975.4930$

$$\overline{X} = \frac{\Sigma X_i}{n} = 7.6020 \qquad \overline{Y} = \frac{\Sigma Y_i}{n} = 4.4186$$

COMPUTATION OF THE REGRESSION

$$b = \frac{\begin{vmatrix} n & \Sigma Y_i \\ \Sigma X_i & \Sigma X_i Y_i \end{vmatrix}}{\begin{vmatrix} n & \Sigma X_i \\ \Sigma X_i & \Sigma X_i^2 \end{vmatrix}} = \frac{\begin{vmatrix} 50 & 220.93 \\ 380.10 & 1683.6380 \end{vmatrix}}{\begin{vmatrix} 50 & 380.10 \\ 380.10 & 2902.2000 \end{vmatrix}} = \frac{206.4070}{633.9900} = 0.3256$$

$$a = \overline{Y} - b\overline{X} = 4.4186 - (0.3256)(7.6020) = 1.9434$$

Regression line is: $\hat{Y} = 1.9434 + 0.3256X$

Computation of the Variations

$$SS_Y = \Sigma Y_i^2 - \frac{(\Sigma Y_i)^2}{n} = 977.6589 - \frac{48810.0649}{50} = 1.4576$$

$$SS_e = SS_Y - b\left[\Sigma X_i Y_i - \frac{\Sigma(X_i)(Y_i)}{n}\right] = 1.4576 - 0.3256\left(1683.6380 - \frac{83{,}975.4930}{50}\right) = 0.1135$$

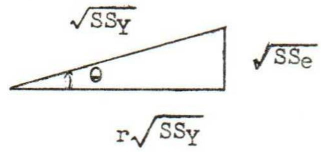
$$s_e = \sqrt{\frac{SS_e}{n-2}} = \sqrt{\frac{0.1135}{48}} = \sqrt{0.002365} = 0.04863$$

TABLE 12 continued

Computation of the Correlation Coefficient

$$r = \text{Cos } \theta = \sqrt{1 - \text{Sin}^2 \theta}$$

$$r = \sqrt{1 - \frac{SS_e}{SS_Y}}$$



$$= \sqrt{1 - \frac{0.1135}{1.4576}} = \sqrt{1 - 0.07787} = \sqrt{0.9221} = 0.9603$$

Test of Significance of the Correlation Coefficient

Null hypothesis is that $\rho = 0$

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{0.9603 \sqrt{48}}{\sqrt{1-0.9221}}$$

$$t = 23.838$$

Critical value of $t_{.05(DF = n-2 = 48)} = 2.007$ (Figure 25)

Therefore the null hypothesis is rejected. The conclusion can be drawn that the correlation is significantly greater than zero with a possible chance of error of 5%.

Tolerance and Confidence Limits on the Mean Y Values, the Individual Y Values, and the Population of Y Values at the .95 Level (Type I Error, $\alpha = .05$)

Formulas:

Confidence limits on the mean of Y's for a given X = X'.

$$\hat{Y}' = a + bX' \pm t_{.05}\, s_e \sqrt{\frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{n}}}$$

TABLE 12 continued

Confidence limits on an individual Y value, given X'

$$\hat{Y}'' = a + bX' \pm t_{.05}\, s_e \sqrt{1 + \frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}}$$

Tolerance limits including 95% of all Y's at the .95 confidence level

$$\hat{Y}''' = a + bX' \pm \ell\, s_e \sqrt{1 + \frac{1}{n} + \frac{(X' - \bar{X})^2}{\Sigma X_i^2 - (\Sigma X_i)^2}}$$

$a = 1.9434$

$s_e = 0.04863$

$t_{.05} = 2.007$

$b = 0.3256$

$\ell = 2.379$

$\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n} = 12.6798$

$t_{.05} s_e = 0.09760$

$\ell s_e = 0.1157$

TABLE 12 (Continued)

Choose Several Convenient X Values

X'	6.5	7	7.5	8	8.5	9
(1) = $X' - \bar{X}$	-1.1020	-0.6020	-0.1020	0.3980	0.8980	1.3980
(2) = $(1)^2$	1.2144	0.3624	0.01040	0.1584	0.8064	1.9544
(3) = $(2)/\left(\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{N}\right)$	.09577	.02858	.0008202	.01249	.06360	.1541
(4) = $\frac{1}{n} + (3)$	.1158	.04858	.02082	.03249	.08360	.1741
(5) = (4) + 1	1.1158	1.04858	1.02082	1.03249	1.0836	1.1741
(6) = $\sqrt{(4)}$	.3403	.2204	.1443	.1802	.2891	.4173
(7) = $\sqrt{(5)}$	1.0563	1.0240	1.0104	1.0161	1.0410	1.0836
(8) = $t_{.05}\, s_e(6)$	.03321	.02151	.01408	.01759	.02822	.04073
(9) = $t_{.05}\, s_e(7)$	.1031	.09994	.09862	.09917	.1016	.1058
(10) = $\ell s_e(7)$	.1222	.1185	.1169	.1176	.1204	.1254
(11) = bX'	2.1164	2.2792	2.4420	2.6048	2.7676	2.9304
(12) = a + (11)	4.0598	4.2226	4.3854	4.5482	4.7110	4.8738
Mean of Y Values as f(X)						
(13) = (12) + (8)	4.0930	4.2441	4.3995	4.5658	4.7392	4.9145
(14) = (12) - (8)	4.0266	4.2011	4.3713	4.5306	4.6828	4.8331
Individual Y Values as f(X)						
(15) = (12) + (9)	4.1629	4.3225	4.4840	4.6474	4.8126	4.9796
(16) = (12) - (9)	3.9567	4.1227	4.2868	4.4490	4.6094	4.7680
Population Y Values as f(X)						
(17) = (12) + (10)	4.1820	4.3411	4.5023	4.6658	4.8314	4.9992
(18) = (12) - (10)	3.9376	4.1041	4.2685	4.4306	4.5906	4.7484

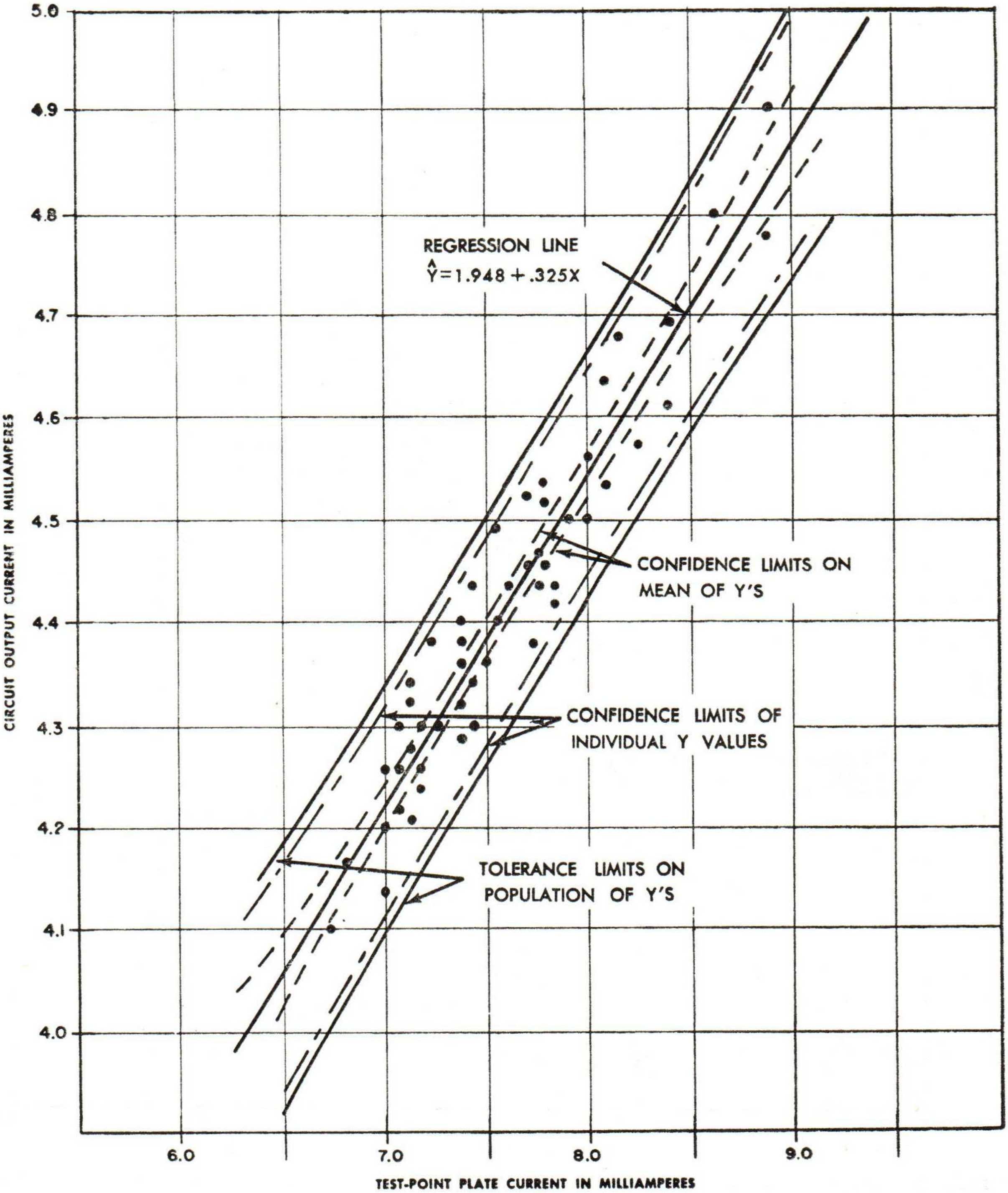


Figure 29. Scatter Plot Showing Confidence and Tolerance Limits for Test-Point Plate Current Versus Circuit Output Current.

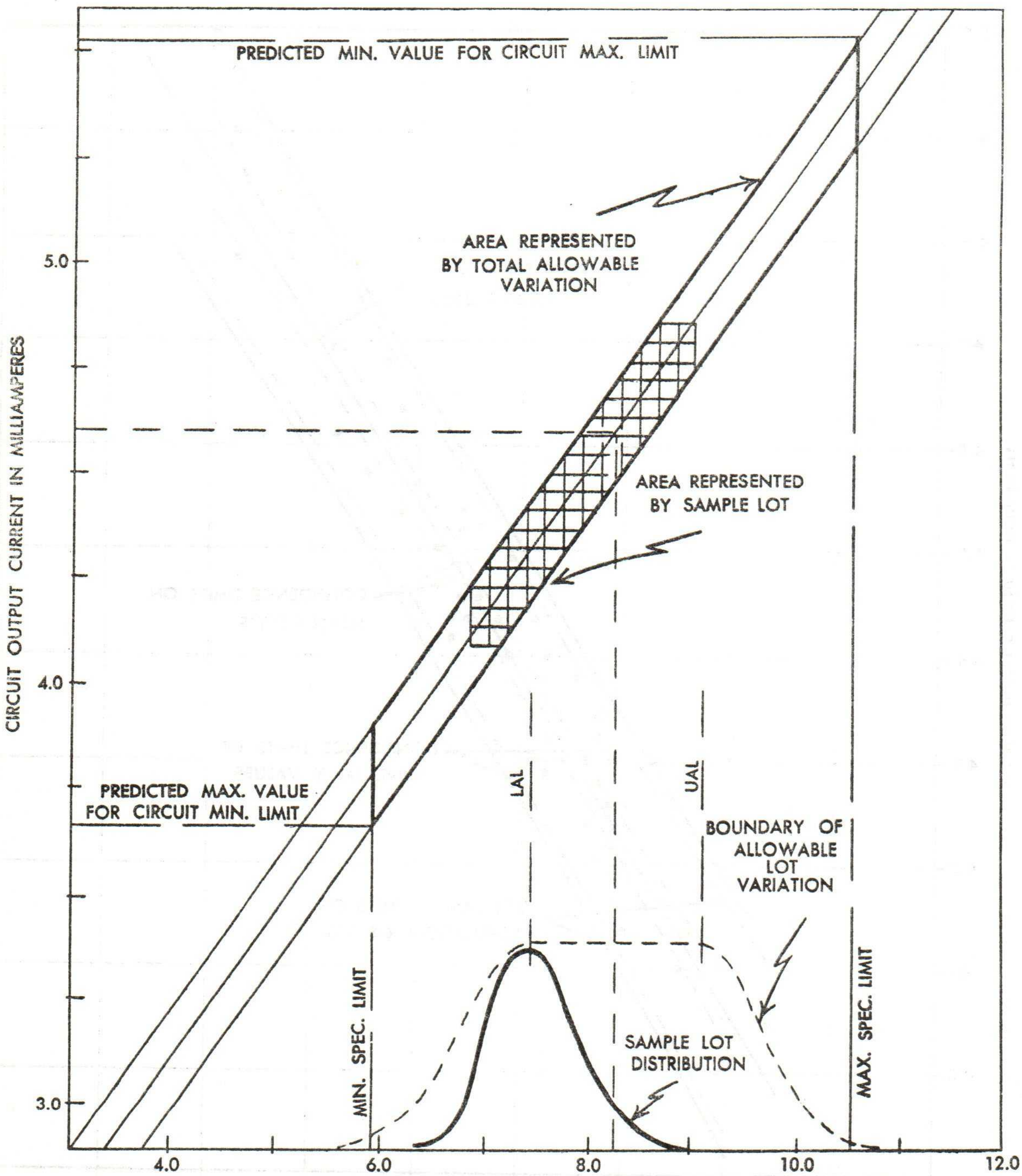


Figure 30. Relationship of Observed Co-Variation in Circuit Output Current and Test-Point Plate Current Expended to Include Expected Circuit Current Limits, Given the Plate Current Specication Limits.

TABLE 13

CALCULATIONS USING APPROXIMATE METHOD

Coefficient of Correlation

$2\ s_e = 0.105$ By inspection, see text.

$2\ s_y = 0.330$ By inspection, see text.

$$r^2 = 1 - \frac{s_e^2}{s_y^2} = 1 - \left(\frac{0.105}{0.330}\right)^2 = 0.899$$

$$r = \sqrt{0.899} = 0.948$$

Determining the Formula of the Estimating Equation
by the 2 Point Method

$$\left.\begin{array}{l}\text{Let } X_1 = 7.0, \text{ then } Y_1 = 4.19 \\ \text{Let } X_2 = 9.0, \text{ then } Y_2 = 4.92\end{array}\right\}\text{From Fig. 31}$$

$$\hat{Y} - Y_1 = \left(\frac{Y_1 - Y_2}{X_1 - X_2}\right)(X - X_1)$$

$$\hat{Y} - 4.19 = \left(\frac{0.73}{2}\right)(X - 7.0)$$

$$\hat{Y} - 4.19 = \frac{0.73}{2} \times - \left(\frac{0.73}{2}\right)(7.0)$$

$$\hat{Y} = 1.635 + 0.365X$$

Approximate 95% Confidence Limits About the Individual Y Values

$$\hat{Y}'' = a + bX \pm 2s_e$$

$a = 1.635$ $b = 0.365$

$$\text{Upper Limit } \hat{Y}'' = 1.740 + 0.365X$$

$$\text{Lower Limit } \hat{Y}'' = 1.530 + 0.365X$$

Test of Significance of the Correlation Coefficient

Null Hypothesis: $\rho = 0$

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{0.948\sqrt{48}}{\sqrt{0.318}} = 11.65$$

The correlation is significant since the critical value

$$t_{.05}\ (DF = n - 2 = 48) = 2.007$$

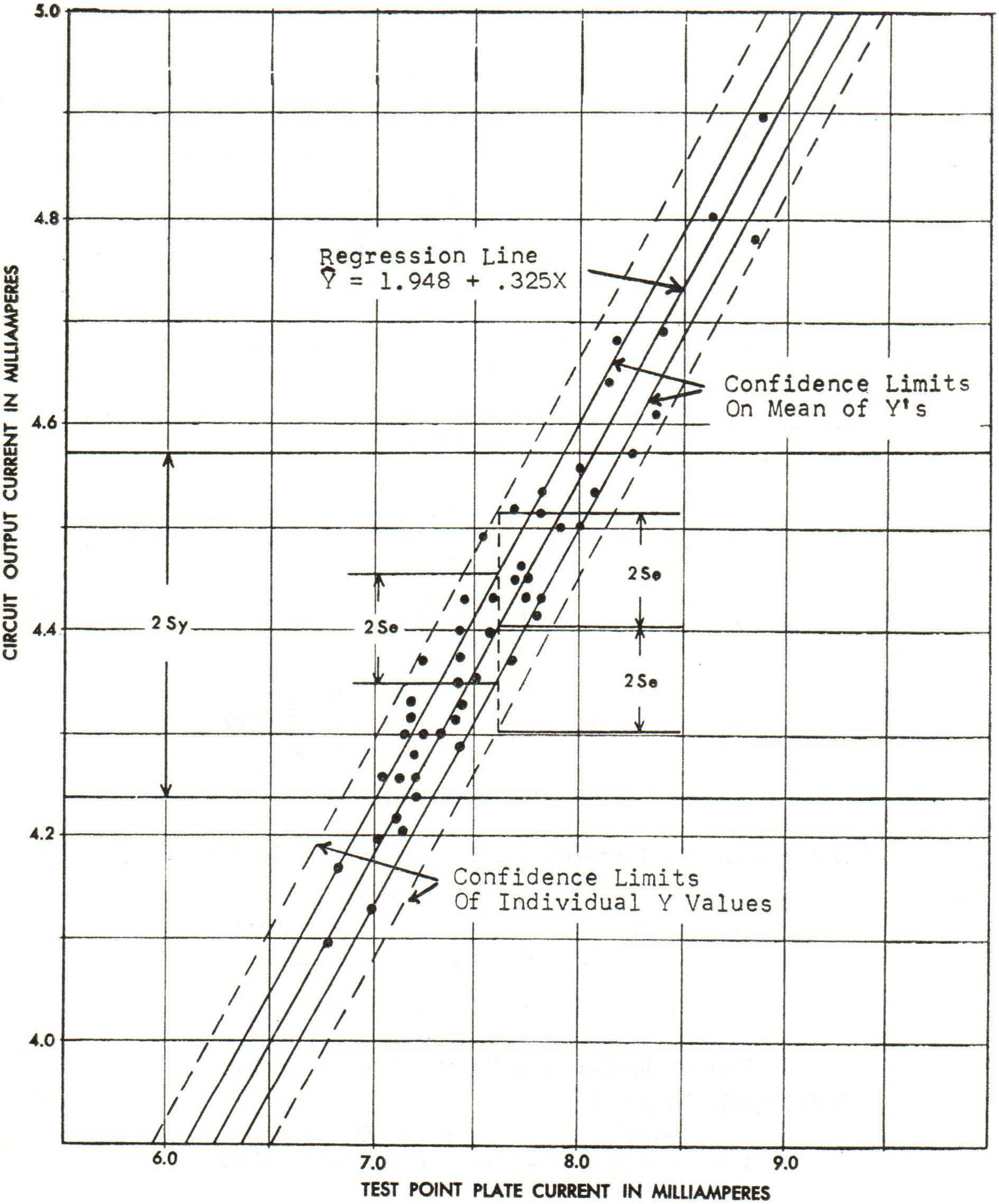


Figure 31. Plot of Test-Point Current Versus Circuit Output Current Illustrating Approximate Method of Determing Correlation.

The test of significance is calculated as before, and the confidence limits are drawn parallel to the line of estimation and shifted along the Y axis $2s_e$ (above and below it), as indicated in Figure 31. This procedure has the obvious advantage of simplicity, and yields satisfactory results for most practical problems. The accuracy of the method improves as the coefficient of correlation approaches unity. The confidence limits obtained may be used, as before, in determining the performance limits of the circuit.

2.7.3 *Conclusions.*

In the example used to demonstrate the two methods for determining the coefficient of correlation, the plate-current values, as measured under specified conditions, were compared with measurements of circuit performance. For the obvious reason that specified conditions are the only conditions for which there are related characteristic limits, the circuit designer should always attempt to correlate circuit performance with tube characteristics which are measured under specified conditions. Occasionally, it is impossible to correlate performance with characteristics measured under such conditions. When characteristics are measured under other than specified conditions, and when good correlation is observed to exist, it is to the advantage of the designer to change his circuit so that tests can be run on tubes whose characteristic limits are defined in terms of specified conditions.

When the circuit cannot be changed, and when the analysis seems to require the addition of a new test condition, the designer should have the addition made to the tube specification by going through the usual military and industrial channels established for this purpose. However, additions to the specification should be made only when correlation does not exist between circuit performance and tube characteristics measured under normally specified test conditions.

2.7.4 *Non-Linear Regression.*

Frequently, the points on a scatter-diagram cluster more closely about a curved line than about a straight line. To determine the relation between two variables which behave in such a manner, it is sometimes desirable to plot some function of the variables which will yield a linear diagram. A number of transformations involving the use of logarithms can be used with good success.

If it is desired too determine the correlation between the time delay of a circuit and the static plate current of a tube as measured under standard test conditions, a good first step, as in all regression problems, is to prepare a table and a scatter-plot of the data as shown in Table 14 and Figure 32. It will be observed that the data assume a curvilinear relationship. If the logarithms of the variables (given in Table 15) are plotted in a new figure (Figure 33), a better approximation of a linear relationship is observed. The transformation

$$y = \log Y \text{ and } x = \log X$$

is then made. The procedure for thus achieving simple linear correlation is outlined in Table 16.

After the transformation is made, either the computational method or the approximate method can be used. The procedure for determining confidence limits, line of estimation, coefficient of correlation, and circuit performance limits is the same as that used for simple correlation. It must be remembered, however, that the correlation is between the logarithms of the variables rather than between the variables themselves. When limits are established in terms of the variables, the transformation must be taken into account.

2.7.5 *Multiple and Partial Correlation.*

Table 14. Readings of Plate Current Versus Time: 14-Tube Sample Used in Non-Linear Regression Analysis.

Tube #	Y	X	Tube #	Y	X
1	40.0	427	8	59.1	376
2	99.3	333	9	112.7	324
3	72.4	344	10	50.2	376
4	44.3	384	11	57.0	356
5	43.9	375	12	73.2	342
6	98.0	343	13	56.0	376
7	47.6	406	14	76.5	356

Y = Plate Current (Microamperes)
X = Time (Milliseconds)

Table 15. Logarithms of Readings of Plate Current Versus Time.

Tube No.	Y	X	Y (Log Y)	X (Log X)	y2	x2	xy
1.	40.0	427	1.6021	2.6304	2.5667	6.9190	4.2142
2.	99.3	333	1.9970	2.5224	3.9880	6.3625	5.0372
3.	72.4	344	1.8597	2.5366	3.4585	6.4343	4.7173
4.	44.3	384	1.6464	2.5843	2.7106	6.6786	4.2548
5.	43.9	375	1.6425	2.5740	2.6978	6.6255	4.2278
6.	98.0	343	1.9912	2.5353	3.9649	6.4277	5.0483
7.	47.6	406	1.6776	2.6085	2.8143	6.8043	4.3760
8.	59.1	379	1.7716	2.5786	3.1386	6.6492	4.5682
9.	112.7	324	2.0519	2.5106	4.2103	6.3031	5.1515
10.	50.2	376	1.7007	2.5752	2.8924	6.6317	4.3796
11.	57.0	356	1.7559	2.5514	3.0832	6.5096	4.4800
12.	73.2	342	1.8645	2.5340	3.4764	6.4212	4.7246
13.	56.0	376	1.7482	2.5752	3.0562	6.6317	4.5020
14.	76.5	356	1.8837	2.5514	3.5483	6.5096	4.8061
TOTAL			25.1930	35.8679	45.6062	91.9080	64.4876
MEAN			1.7995	2.5620			

X = Time (Milliseconds)

Y = Plate Current (Microamperes)

Table 16. Computations in the Technique of Linear Regression With A Non-Linear Model.

$y = \text{Log } Y \qquad x = \text{Log } X$

Model: $\text{Log } Y = a + b \text{ Log } X$

$n = 14$

$\Sigma x_i = 35.8679 \qquad \Sigma x_i^2 = 91.9080 \qquad (\Sigma x_i)^2 = 1286.5063$

$\Sigma y_i = 25.1930 \qquad \Sigma y_i^2 = 45.6062 \qquad (\Sigma y_i)^2 = 634.6872$

$\Sigma x_i y_i = 64.4876 \qquad (\Sigma x_i)(\Sigma y_i) = 903.6200$

$$\bar{x} = \frac{\Sigma x_i}{n} = 2.5620 \qquad \bar{y} = \frac{\Sigma y_i}{n} = 1.7995$$

Computation of the Regression Coefficients

$$b = \frac{\begin{vmatrix} n & \Sigma y_i \\ \Sigma x_i & \Sigma x_i y_i \end{vmatrix}}{\begin{vmatrix} n & \Sigma x_i \\ \Sigma x_i & \Sigma x_i^2 \end{vmatrix}} = \frac{\begin{vmatrix} 14 & 25.1930 \\ 35.8679 & 64.4876 \end{vmatrix}}{\begin{vmatrix} 14 & 35.8679 \\ 35.8679 & 91.9080 \end{vmatrix}} = \frac{-0.7936}{0.2057} = -3.8580$$

$$a = \bar{y} - b\bar{x} = 1.7995 + (3.8580)(2.5620) = 11.6837$$

The Regression Equation is: $y = 11.6837 - 3.8580\, x$ or in terms of the original variables:

$$\text{Log } Y = 11.6837 - 3.8580 \text{ Log } X$$

Computation of the Variations

$$SS_y = \Sigma y_i^2 - \frac{(\Sigma y_i)^2}{n} = 45.6062 - 45.3348 = 0.2714$$

$$SS_e = SS_y - b\left[\Sigma x_i y_i - \frac{(\Sigma x_i)(\Sigma y_i)}{n}\right] = 0.2714 + 3.8580\ (64.4876 - 64.5443)$$

$$= 0.02714 + 3.8580\ (-0.0567) = 0.05265$$

$$S_e = \sqrt{\frac{SSe}{n-2}} = \sqrt{\frac{0.05265}{12}} = \sqrt{0.004389} = 0.06625$$

TABLE 16 continued

CORRELATION COEFFICIENT

Formula: $r = \sqrt{1 - \frac{SS_e}{SS_y}} = \sqrt{1 - 0.1940}$

$= \sqrt{0.8060} = -.8978*$

* r is negative because the slope, b, is negative

SIGNIFICANCE OF THE CORRELATION COEFFICIENT

Formula: $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{-.8978\sqrt{12}}{\sqrt{0.1940}} = \frac{-3.1401}{0.4405} = -7.060$

$n = 14 \qquad r = -.8978$

Critical value (Figure 25), for $t_{.05}(DF=n-2=12) = 2.18$. Correlation coefficient is significantly different from zero since $|7.06| > 2.18$

COMPUTATION OF TOLERANCE LIMITS

Formula:

Tolerance limits for 95% of the y's with a confidence of 95% for a given x = x' are

$$y''' = a + bx' \pm \ell s_e \sqrt{1 + \frac{1}{n} \frac{(x' - \bar{x})^2}{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}}$$

Where: $a = 11.6837$ $\qquad \ell = 3.012$ (Figure 26) $\qquad s_e = 0.1995$

$b = -3.8580 \qquad s_e = 0.06625 \qquad \Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n} = 0.01470$

TABLE 16 continued

Choose Several Convenient x Values					
x'	2.50	2.54	2.58	2.62	2.64
(1) $x' - \bar{x}$	-.0620	-.0220	.0180	.0580	.0780
(2) $(1)^2$	.003844	.0004840	.0003240	.003364	.006084
(3) $\frac{(2)}{\Sigma x_i^2 - (\Sigma x_i)^2/n}$	.2615	.03293	.02204	.2288	.4139
(4) $1 + \frac{1}{n} + (3)$	1.3329	1.1043	1.0934	1.3002	1.4853
(5) $\sqrt{4}$	1.1545	1.0509	1.0457	1.1403	1.2187
(6) ℓs_e (5)	.2303	.2097	.2086	.2275	.2431
(7) bx'	-9.6450	-9.7993	-9.9536	-10.1080	-10.1851
(8) $\hat{y} = a + (7)$	2.0387	1.8844	1.7301	1.5757	1.4986
Upper 95% Tolerance Limits					
(9) (8) + (6)	2.2690	2.0941	1.9387	1.8032	1.7417
Lower 95% Tolerance Limits					
(10) (8) - (6)	1.8084	1.6747	1.5215	1.3482	1.2555

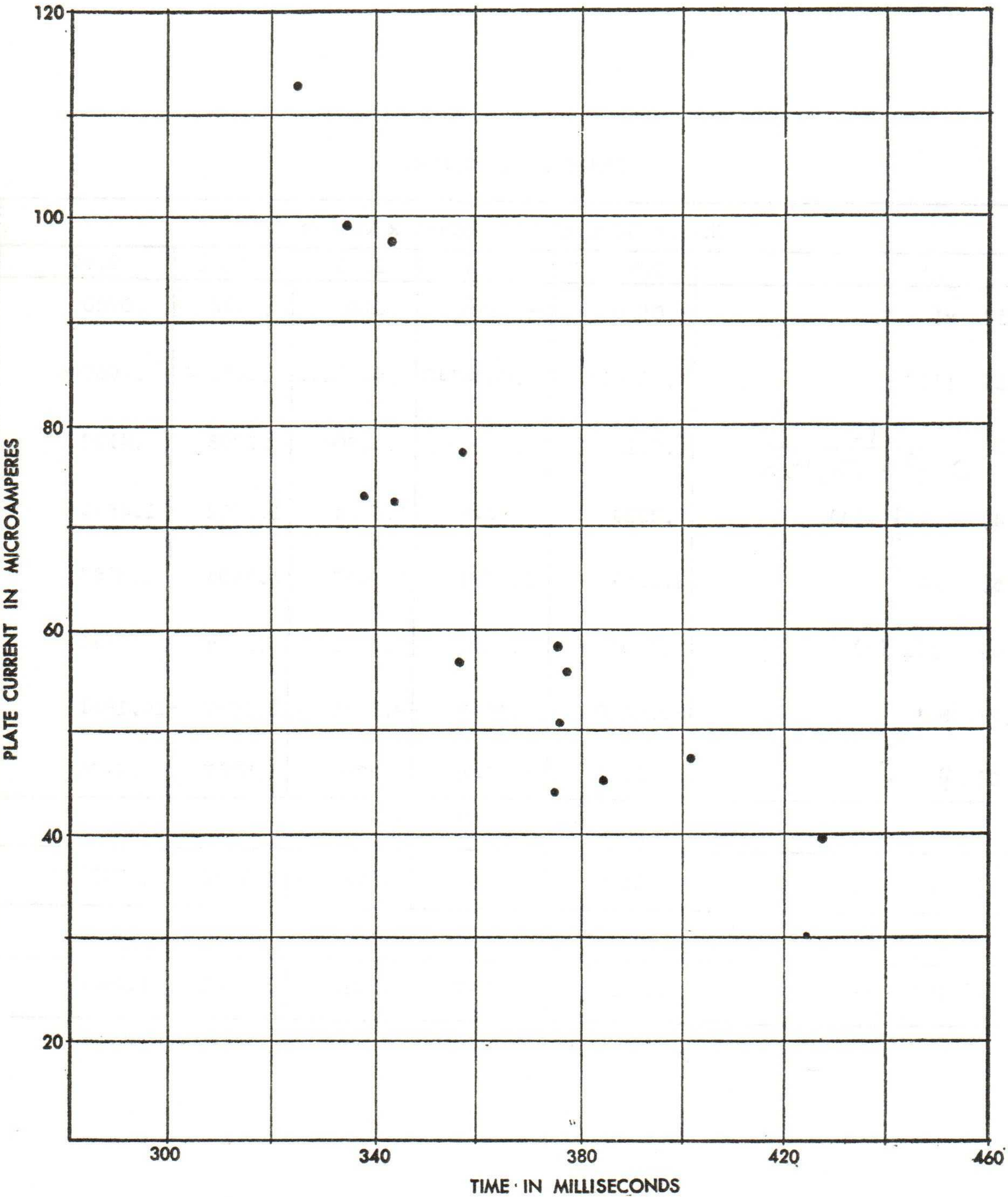


Figure 32. Typical Scatter Plot Showing Tendency Toward Non-Linear Relationship.

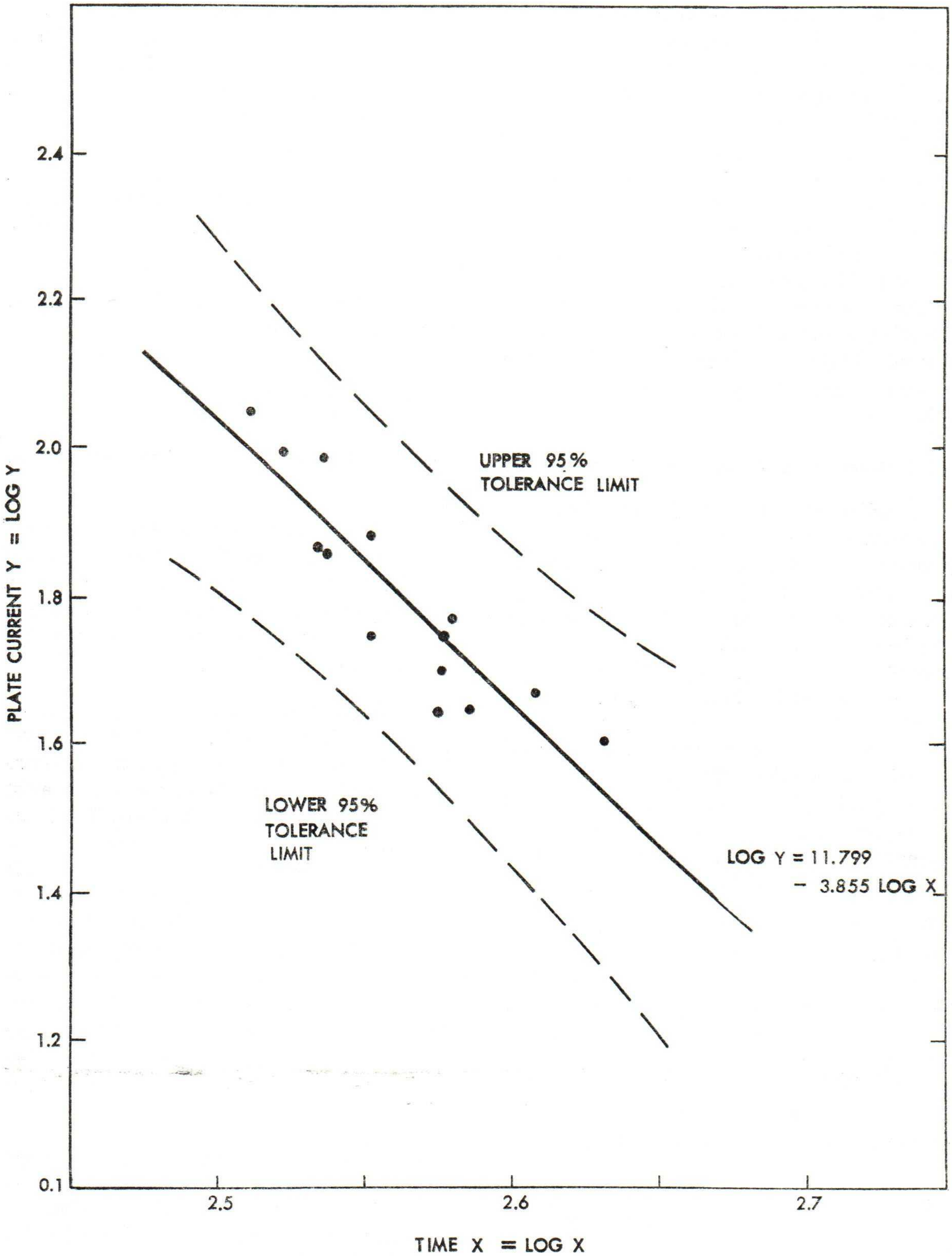


Figure 33. Scatter Plot, With Upper and Lower Tolerance Limits, Showing Effect of Logarithmic Transformation of Variables.

In some instances, circuit performance depends to nearly the same degre upon two or more tube characteristics. Some correlation may be observed between circuit performance and each individual tube characteristic. However, better correlation can sometimes be obtained if the combined effects of various tube characteristics are considered. In the determination of multiple correlation, the combined effects of two or more independent variables are considered simultaneously. In the determination of partial correlation, the effect of one independent variable is considered while the other independent variable is maintained at some constant average value.

2.8 Description of Frequency Distributions

As indicated in Part I, the description of a population is given by the formula for the frequency distribution (also known as "density function") of the population. Descriptions of the shape of the distribution may also be given by certain moment ratios. For example, β_1 or $\sqrt{\beta_1}$ may describe the "skewness" of the distribution; β_2 may describe its "kurtosis." The first two moments of a group of data are equal to the mean and standard deviation of the data. The β_1 and β_2 coordinates of all normal distributions are 0 and 3, respectively. A test of departure from normality, using the values of $\sqrt{\beta_1}$ and β_2 is described in the following section.

When the β_1 and β_2 coordinates depart from 0 and 3, certain changes in the "smooth shape" of the distribution can be detected. The value of β_1 indicates whether the distribution is lopsided, but does not indicate whether the skewness is to the right or to the left of the Value of $\overline{X}$. This information is given by the value of $\sqrt{\beta_1}$, as indicated by the nature of the formula for this term:

$$\sqrt{\beta_1} = \frac{m_3}{m_2{}^{3/2}} = \sqrt{n} \cdot \frac{\Sigma(X_i - X)^3}{[\Sigma(X_i - X)^2]^{3/2}}$$

Since the denominator is squared before the summation takes place, it will always be positive. The numerator, on the other hand, will be positive only when X_i exceeds the value of $\overline{X}$. When a distribution is skewed to the left, there will be a few values of X_i which are much smaller than the value of $\overline{X}$. These values will so weight the sum that m_3 and $\sqrt{\beta_1}$ will be negative. Skewness to the right will be characterized by a positive $\sqrt{\beta_1}$.

The measure of kurtosis, β_2, is calculated by means of the formula

$$\beta_2 = \frac{m_4}{m_2{}^2}$$

Sinceboth m_2 and m_4 are always positive, β_2 is also always positive.

When B_2 is smaller than the value computed for the normal distribution ($\beta_2 = 3$), the distribution becomes more flat; when β_2 is larger than the value determined for the normal distribution, the distribution becomes more peaked.

No distribution will ever have a pair of β_1, β_2 coordinates which exceed the level $\beta_2 - \beta_1 - 1 = 0$ (see Figure 34). Figure 34 shows the density functions which exist at three points in the β_1, β_2 plane. The locus of all so-called "logarithmico-normal" distributions is also shown in the figure. This line reveals the fallacy involved in the attempt to characterize the time-varying data by a particular density function. Study of the values of $\sqrt{\beta_1}$ and β_2 for the property-description charts given in Part IV will indicate that these values generally take some curvilinear path through β_1, β_2 space, beginning in the vicinity of the points 0 and 3.

One interesting property of the moment ratios β_1 and β_2 is related to the transformation of lopsided or peaked distributions to the unit-normal form. The reader who desires further discussion of this matter is

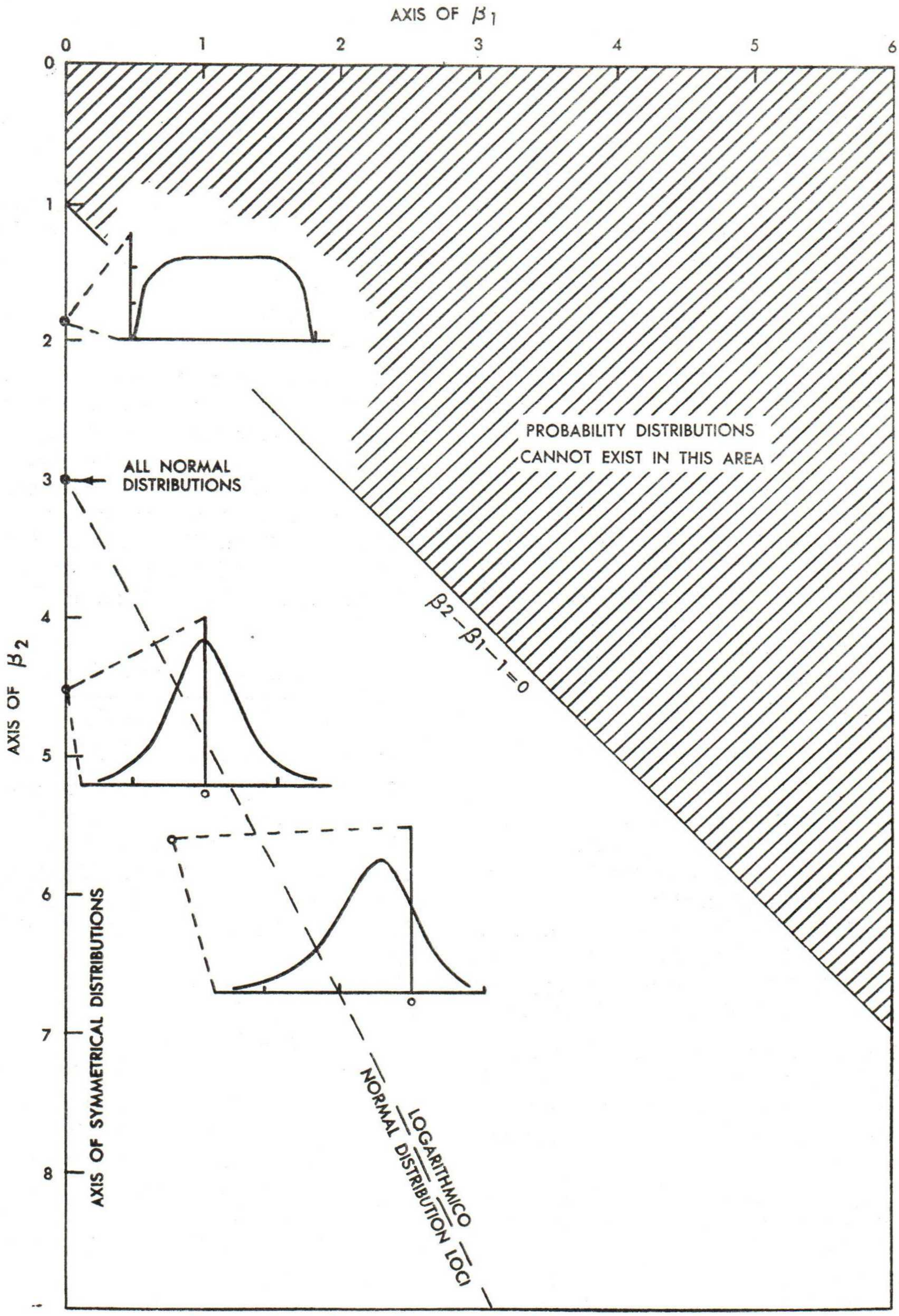


Figure 34. Density Functions Existing at Three Points in the β^1, β^2 Plane.

directed to the article* cited in the footnote below.

2.9 Tests for Departure from Normality

A test for departure from normality may also be made with the parameters $\sqrt{\beta_1}$ and β_2. As has been pointed out, the $\sqrt{\beta_1}$ and β_2 coordinates of the normal distribution are 0 and 3, respectively. However, repeated sampling from a normally distributed population yields distributions of the $\sqrt{\beta_1}$ and β_2 estimates. The 1-percent and 5-percent boundaries of these distributions are given in Tables 17 and 18. Certain selected pairs of the parameters are plotted in Figure 35. If the $\sqrt{\beta_1}$ and β_2 coordinates of a sample distribution of size n lie inside the limits, non-normality cannot be shown. The alternative is to conclude, with some reservations, that normality exists. However, if the coordinates fall outside the percentage boundaries—for example, the 1-percent boundary—the probability is less than 1 percent that a sample drawn from a normal distribution would yield such a result.

2.10 Estimation of Observed Reliability Functions

The inoperative probability of survival curves for certain tube types discussed in Part IV were computed on the basis of the technique described in this section. Formulae 3 and 4 are particularly applicable to the discussion in Part IV. The material on observed reliability functions first appeared in the monograph cited in the footnote.*

Given a random sample of lifetimes, the reliability function may be estimated in either of two ways: (a) by noting the percentage or fraction of the sample which survives after a given time T, or (b) by noting the time at which a given percentage or fraction of the sample still survives.

If the reliability function were presented graphically, the first approach would be analogous to selecting a value on the abscissa (time) and determining the corresponding value on the ordinate (probability of survival). The second approach would be analogus to selecting a value on the ordinate and determining the corresponding value on the abscissa.

Although the two approaches appear to be identical, they are based upon different theoretical procedures. The first approach involves the estimation of the theoretical percent or probability R(T). This procedure is equivalent to estimating the parameter of a binomial distribution, since if T is fixed, the number surviving T is a random variable. The appropriate estimate of R(T) is given by

$$\hat{R}(T) = \frac{\text{Number surviving time T}}{\text{Initial sample size}} = \frac{n-k}{n}$$

where k is the number which fail in time T.

The second approach involves a procedure in which the random variable is the time to failure or time between malfunctions. At the time of each failure or malfunction, the expected percentage surviving is known. This approach leads to an estimate of R(t) which is given by

$$\hat{R}(t_i) = \frac{n-i+1}{n+1}$$

where i represents the ith ordered failure t_i represents the time to the ith failure. (The term "ordered" means that the times to failure are numbered in ascending order of magnitude; t_1 is the shortest lifetime; t_n is the longest lifetime.) The function $R(t_i)$ may be plotted by plotting the points

$$\left(\frac{n-i+1}{n+1}, t_i\right), i = 1, 2, \ldots n.$$

* Johnson, N. L., "Systems of Frequency Curved Generated by Methods of Translation," *Biometrika*, Cambridge University Press, London, June 1949, Vol. XXXVI, p. 149.

* Herd, G. R., *Estimation of Reliability Functions* (Monograph No. 3), Aeronautical Radio, Inc., Washington, D. C., May 1, 1956, pp. 8-10.

Table 17. Percentage Points of The Distribution of $\sqrt{\beta_1} = m_3/m_2^{3/2}$

Size of Sample n	Percentage Points 5%	1%	Standard Deviation s	Size of Sample n	Percentage Points 5%	1%	Standard Deviation s
25	.711	1.061	.4354	200	.280	.403	.1706
30	.661	.982	.4052	250	.251	.360	.1531
35	.621	.921	.3804	300	.230	.329	.1400
40	.587	.869	.3596	350	.213	.305	.1298
45	.558	.825	.3418	400	.200	.285	.1216
50	.533	.787	.3264	450	.188	.269	.1147
				500	.179	.255	.1089
60	.492	.723	.3009	550	.171	.243	.1039
70	.459	.673	.2806	600	.163	.233	.0995
80	.432	.631	.2638	650	.157	.224	.0956
90	.409	.596	.2498	700	.151	.215	.0922
100	.389	.567	.2377	750	.146	.208	.0891
				800	.142	.202	.0863
125	.350	.508	.2139	850	.138	.196	.0837
150	.321	.464	.1961	900	.134	.190	.0814
175	.298	.430	.1820	950	.130	.185	.0792
200	.280	.403	.1706	1000	.127	.180	.0772

Table 18. Percentage Points of The Distribution of $\beta_2 = m_4/m_2^{2}$

Size of Sample n	Percentage Points Upper 1%	Upper 5%	Lower 5%	Lower 1%
200	3.98	3.57	2.51	2.37
250	3.87	3.52	2.55	2.42
300	3.79	3.47	2.59	2.46
350	3.72	3.44	2.62	2.50
400	3.67	3.41	2.64	2.52
450	3.63	3.39	2.66	2.55
500	3.60	3.37	2.67	2.57
550	3.57	3.35	2.69	2.58
600	3.54	3.34	2.70	2.60
650	3.52	3.33	2.71	2.61
700	3.50	3.31	2.72	2.62
750	3.48	3.30	2.73	2.64
800	3.46	3.29	2.74	2.65
850	3.45	3.28	2.74	2.66
900	3.43	3.28	2.75	2.66
950	3.42	3.27	2.76	2.67
1000	3.41	3.26	2.76	2.68
2000	3.28	3.18	2.83	2.77
3000	3.22	3.15	2.86	2.81
4000	3.19	3.13	2.88	2.84
5000	3.17	3.12	2.89	2.85

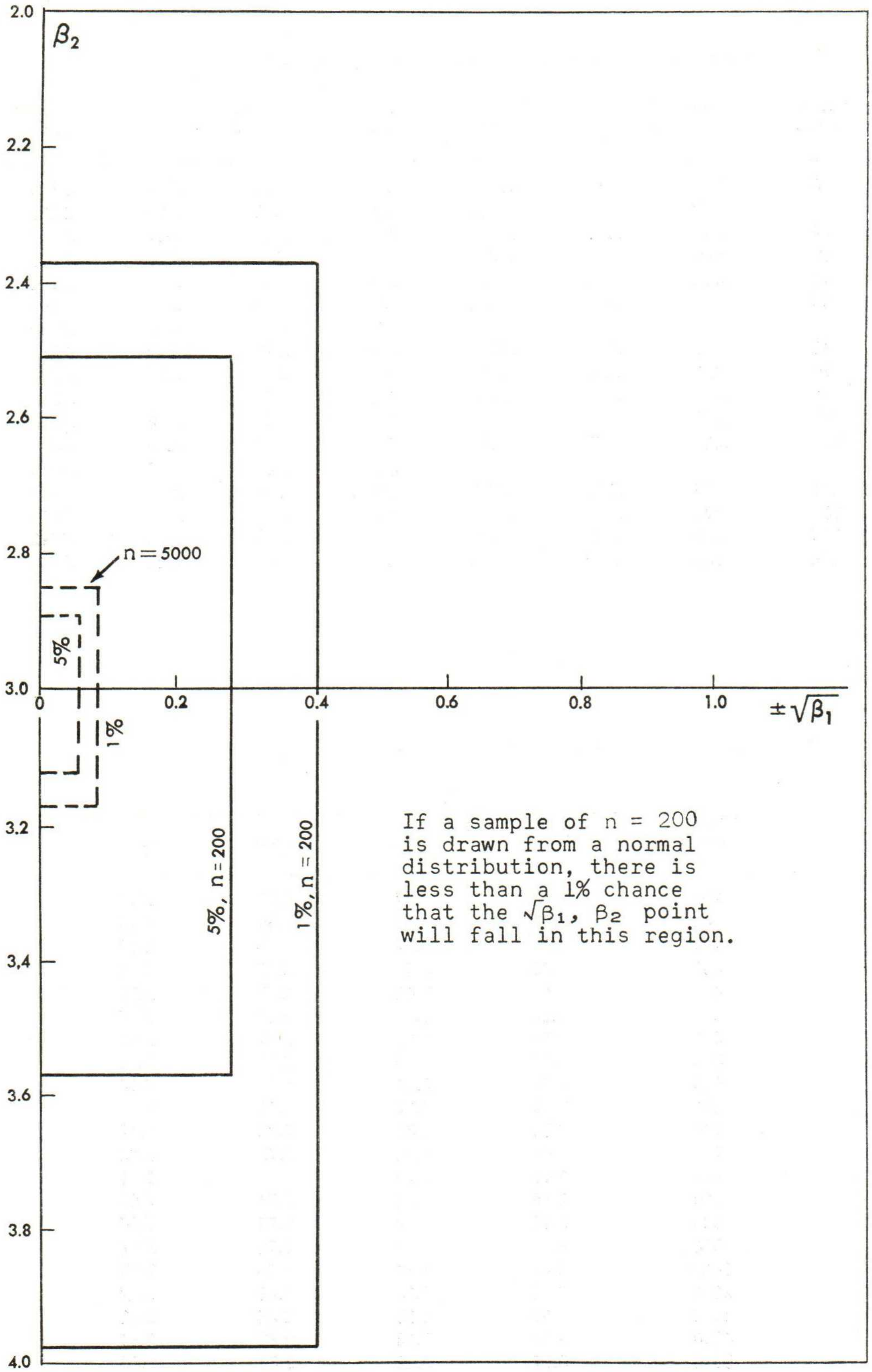


Figure 35. Relationship of Various Values of β_2, $\sqrt{\beta_1}$, and Sample Size to Specified Degrees of Chance that Non-Normality Will be Assumed Incorrectly.

Either of these procedures can be used to present the observed reliability function, since they are equivalent if used in connection with large samples. However, the second procedure is more advantageous than the first when the problem involves lost or terminated observations.

It can be shown that, if terminated observations occur at the same time as failures, and if the number of terminations is specified in advance, an estimate of R(t) at the time of the k^{th} failure is given by

$$\hat{R}(t_k) = \frac{n_1 - r_1 + 1}{n_1 + 1} \cdot \frac{n_2 - r_2 + 1}{n_2 + 1} \cdots \frac{n_i - r_i + 1}{n + 1} \cdots \frac{n_k - r_k + 1}{n_k + 1} = \prod_{i=1}^{K} \left(\frac{n_i - r_i + 1}{n_i + 1} \right) \quad (3)$$

in which n_i is the number of survivors beginning the interval which preceeds the i^{th} failure, and r_i is the number of failures occuring at the time of the i^{th} failure. It is reasonable to present a reliability function by plotting the expected fraction surviving as a function of the observed times.

An example given in *ARINC Monograph No. 3** indicated that, when censorship occurs, the exact observed reliability function cannot be determined. Instead, it is necessary to estimate this function bythe method given in Equation 3. This is a non-parametric, or distribution-free, method of estimation. The variance of the estimate is

$$V\,[\hat{R}(t_k)] = \prod_{i=1}^{K} \left(\frac{n_i - r_i + 1}{n_i + 2} \right) - \prod_{i=1}^{K} \left(\frac{n_i - r_i + 1}{n_i + 1} \right)^2 \quad (4)$$

Two methods of estimating the reliability function are available to the investigator who can observe only the numberof failures occuring within an interval, rather than the exact times at which failures occur, and who must take account of censored observations. The method of estimation for situations in which censorship occurs at the end-points of time intervals is the same as that given in Equation 3. However, if censorship happens to occur within the time interval between observed failures, it may be advisable to adjust the sample size for the interval to allow for the reduction in accumulated life. To obtain a reliability function in a situation characterized by censorship within the time interval between failures, the estimate of R(t) at the time of the k^{th} failure is given by

$$\hat{R}(t_k) = \prod^{K} \left(\frac{n_i - W_i/2 - r_i + 1}{n_i - W_i/2 + 1} \right) \quad (5)$$

In this equation, W_i is the number of withdrawals (censored observations) during the i^{th} time interval; the other symbols are the same as those used in previous equations. The variance of this estimator is given by Equation 4, with $(n_i - W_i/2)$ substituted for n_i.

The estimating technique given in Equations 3 and 5 has two advantages: (a) the computations are simple, and (b) the basic technique remains the same, whether or not censored observations are involved, except that censored observations necessitate a slight increase in the number of computations.

Example: The failure data presented in Table 19 are from a sample of 49 items of which 32 were withdrawn from test at various times during the test. Table 19 presents the observed times when failures occurred, the number of withdrawals (censored observations),

* Herd, G. R., *Op. Cit.*

the contribution of each interval between failures to the estimated reliability, and the estimated reliability function. The experiment was designed so that withdrawals would be made at the same time that failures occurred. Therefore, equation 3 was used to estimate the reliability function.

Table 19. Computation of Non-Parametric Reliability Function. Failure Data of 17 Tubes From Sample of 49.

(1)	(2)	(3)	(4)	(5)	(6)
t_i	n_i	r_i	W_i	$\frac{n_i - r_i + 1}{n_i + 1}$	$\hat{R}(t_i)$
1187	49	1	2	.980	.980
2397	46	1	0	.979	.959
2564	45	1	0	.978	.938
3024	44	1	3	.978	.917
3364	40	1	4	.976	.895
3395	35	1	0	.972	.870
3597	34	1	3	.971	.845
3753	30	1	2	.968	.818
3855	27	1	2	.964	.789
3936	24	1	0	.960	.757
4132	23	1	0	.958	.725
4137	22	1	0	.957	.694
4291	21	1	2	.955	.663
4320	18	1	0	.947	.628
4349	17	1	1	.944	.593
4464	15	1	1	.938	.556
4523	13	1	12	.929	.517
		17	32		

t_i = time of the i^{th} failure

n_i = number of survivors before the i^{th} time interval = $n_{i-1} - r_{i-1} - W_{i-1}$

r_i = number of failures at time t_i

W_i = number of withdrawals at time t_i

$\hat{R}(t_i)$ = estimated probability of survival at t_i

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2.11 Check List of "Abnormal Environmental Conditions Frequently Encountered in Reliability Studies

Power	Poor voltage or frequency regulation Instability, transients Excessively high or low voltage Improper frequency Interruptions
Temperatures (Ambient)	Improper ventilation Failure of heating or air-conditioning systems Wide range in heating or cooling cycle, due to overnight or weekend shutoff
Temperatures (Equipment)	Improper installation (obstruction of intake or exhaust ducts) Proximity to heater, engines, or other heat-producing equipment
Humidity or Moisture	Periodic access of rain or flood High local humidity Local atmospheric conditions causing chemical deterioration of plating, colder joints, insulation, etc. (salt air, etc.)
Altitude or Pressure	Excessive pressure resulting in leaking seams or seals Corrosion due to corona Insulation breakdown because of arc-over
Dust	Improper installation Abnormal local conditions Poor maintenance
Vibration or Shock	Impairment due to collision Mishandling Improper installation Abnormal local conditions Vibration or shock transmitted from associated systems or components

2.12 Circuit Designer's Check List

RATINGS—Does the operation of the tube approach any absolute rating under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself?

Heater Voltage	Max......	Min......
Anode Voltage (dc)	Max......	
(Peak forward)	Max......	
(Peak inverse)	Max......	
Screen Grid Voltage	Max......	
Control Grid Voltage	Max......	Min......
Suppressor Grid Voltage	Max......	Min......
Heater-Cathode Voltage	Max......	
Control Grid Resistance	Max......	
Cathode Current (average)	Max......	Min......
(peak)	Max......	
Anode Dissipation	Max......	
Screen Grid Dissipation	Max......	
Bulb Temperature	Max......	

CHARACTERISTICS–Does the specification of the tube type selected define the required characteristics? Will the circuit operate satisfactorily with tubes having the range of characteristics allowable in the specification?

Transconductance (life-test end point)	Max......	Min......
Transconductance (at reduced heater voltage)	Max......	Min......
Plate Current (life-test end point)	Max......	Min......
Screen Grid Current	Max......	Min......
Heater Current	Max......	Min......
Interelectrode Capacitance	Max......	Min......
Dynamic Plate Resistance	Max......	Min......
Amplification Factor	Max......	Min......
Power Output (life-test end point)	Max......	Min......

DETRIMENTS—Does the specification of the tube type selected adequately define detriments? Will the circuit operate satisfactorily with having the detriment value allowable in the specification?

Electrode Insulation (life-test end point)		Min......
Grid Current at Rated E_f (life-test end point)	Max......	
Grid Current at Elevated E_f (life-test end point)	Max......	
Plate Current Cutoff	Max......	Min......
Heater-Cathode Leakage	Max......	
RF Noise, AF Noise, Noise and Microphonics	Max......	
Change of Characteristics with Life (I_b, P_o, S_m)	Max......	
Change of Characteristics with Heater Voltage	Max......	

BASIC LIMITATIONS–Is operation of the circuit satisfactory considering the basic limitations of electron tubes? Does circuit function depend upon any unspecified property of the tube?

Initial-Velocity-Electron Current
Spurious Emission Current
"Interface Resistance" Effect
Thermionic Instability
Electron Coupling Effects

PART III

APPLICATION INFORMATION AND SPECIFICATION ASSURANCE

APPLICATION INFORMATION AND SPECIFICATON ASSURANCE

3. INTRODUCTION

General tube properties and circuit design treatment have been presented in preceding parts of this handbook. Part III contains information of the specific tube types listed in MIL-STD-200 and includes MIL-E-1 specification data.

Military Standard MIL-STD-200 lists preferred electron tube types that have been selected by the U. S. Army, Navy and Air Force, jointly, to fulfill the majority of electron tube applications. Purpose of this standard is twofold:

(a) To guide military equipment designers and manufacturers in the choice of tube types that represent the highest quality tubes available for military use.

(b) To provide for a minimum tube maintenance stock by making extensive use of a minimum number of tube types.

The current list is included here as Table 3-1 for information purposes. Reference to the most recent issue of MIL-STD-200 should always be made since it is subject to revision and re-issue.

Military Specification MIL-E-1 are controls intended to provide assurance that the equipment designer using electron tubes can expect comparatively uniform initial characteristics, relatively stable characteristics throughout life, and a high attribute quality level. Parenthetically, it follows that there is no assurance of satisfactory operation of tubes when they are used under conditions incompatible with test conditions and ratings set forth in this specification. Both the quiescent operating point and the dynamic operating requirements must be considered in relation to these ratings.

Specification data applicable to the receiving types of MIL-STD-200 are presented in Table 3-2 which includes a summary of specification controls and a list of properties tested by variables.

Table 3-1. Receiving Tubes.

MIL–STD–200C, 5 October 1955
Listing by Structure and Heater Voltage

Structure \ Heater Voltages	1.25 and 1.4 (volts)	5.0 (volts)	6.3 (volts)	
Diodes	#1A3		2B22 *5647 #5726/6AL5W	*5829WA #*5896
Triodes			#2C40 #6C4W *5703WA	#*5718 #*5719 *5744WA *6533
Twin Triodes	#3A5		#12AT7WA #5670 #5751 #5814A	*6021 *6111 *6112
Pentodes Remote			#5749/6BA6W #*5899	
Sharp	#*1AD4 *1AH4		#6AH6 #6AU6WA #5654/6AK5W	#*5639 *5702WA #*5840
Mixers and Converters			*5636 #5725/6AS6W	#5750/6BE6W *5784WA
Power Output Pentodes	#3B4 3V4 #*5672 #*6088		#2E30 6AG7 6BG6G #6L6WGB	5686 #*5902 #6005/6AQ5W 6094
Triodes			#5687	6080WA
Rectifiers	#1B3GT #1Z2	#5R4WGA #5Y3WGTA	#6X4W #*5641	6203

Also U.S. tubes on NATO priority list of electronic tubes (valves).
* Subminiature.

Table 3-2. Receiving Tubes of MIL-STD-200.

Tube Type JAN-	Specification Serial Number	Specification Sheet Dated	Method of Specification Definition of Characteristics	Characteristics Defined By Variables Techniques	Characteristics Defined During Life Characteristics
1A3	MIL-E-1/19	5 Feb 1953	M - M		Io
*1AD4	MIL-E-1/20A	9 July 1953	M - M		Sm2
*1AH4	MIL-E-1/316	14 Aug 1953	M - M		Sm1, Ic1
1B3GT	MIL-E-1/749A	23 Dec 1955	M - M		Is
1Z2	MIL-E-1/29	5 Feb 1953	M - M		Is
2B22	MIL-E-1/736	17 Dec 1954	M - M		Etd
2C40	MIL-E-1/737	17 Dec 1954	M - M		Po
2E30	MIL-E-1/32	5 Feb 1953	M - M		Δ_{Ef}Ip, Ic2
3A5	MIL-E-1/33A	14 Jan 1954	M - M		Sm
3B4	MIL-E-1/34B	17 Dec 1954	M - M		Δ_{Ef}Ep, Ic2, ep
3V4	MIL-E-1/343	14 Aug 1953	M - M		Po1
5R4WGA	MIL-E-1/116A	4 March 1954	M - M		Io2
.5Y3WGTA	MIL-E-1/1021	28 June 1956	M - M		Io
6AG7Y	MIL-E-1/45C	14 May 1956	M - M		Po
6AH6	MIL-E-1/46	5 Feb 1953	M - M		Sm1
6AU6WA	MIL-E-1/1	13 Jan 1953	M-LRLM-URLM-M	If, #Ihk, #Ic1, Ib1, Ic2, Sm1, #Sm2, #Cg1p, Cin, Cout, #Ep	Rg1-all, Rp-all, If, Ihk, Ic1, Sm1, Δ Avg Sm1
6BG6G	MIL-E-1/53A	14 Jan 1954	M - M		Is
6C4W	MIL-E-1/55B	14 Jan 1954	M - M		Sm1, Ic
6L6WGB	MIL-E-1/197	20 May 1953	M - M		Po, Sm
6X4W	MIL-E-1/64A	20 May 1953	M - M		Io
12AT7WA	MIL-E-1/3A	23 Aug 1955	M-LRLM-URLM-M	If, #Ihk, #Ic, Ib1, Sm1, #Sm2	Rg-all, Rp-all, If, Ihk, Ic, Sm1, Δ Avg Sm1
*5636	MIL-E-1/168C	23 June 1955	M-LAL-UAL-M-ALD	If, Ibl, Sm1	Icl, If, Δ_t Sm1, Δ_{Ef}Sm, Ihk, Rp-all, Rg-all, Avg Δ_tSm1
*5639	MIL-E-1/169C	23 June 1955	M-LAL-UAL-M-ALD	If	Ic1, If, Δ_t Sm1, Δ_{Ef}Sm, Ihk, Rp-all, Rg-all, Avg Δ_t Sm1
*5641	MIL-E-1/170A	26 Oct 1954	M-LAL-UAL-M-ALD	If	If, Ihk, Io
*5647	MIL-E-1/204C	18 June 1956	M-LAL-UAL-M-ALD	If	If, Io, Δ_tIo, Ihk, Rp-all
5654/ 6AK5W	MIL-E-1/4A	5 Dec 1955	M-LAL-UAL-M-ALD	If, Ibl, Sm1, Ic2, #Sm2, Cin, Cout	Rg-all, Rp-all, If, Ihk, Ic1, Sm1, Avg Δ Sm1, Δ_tSm, Δ_{Ef}Sm
5670	MIL-E-1/5A	5 Dec 1955	M-LAL-UAL-M-ALD	If, Ib1, Sm1, Mu	If, Ihk, Ic, Δ_{Ef}Sm, Sm1, Avg Δ Sm1, Δ_tSm1, Rg-all, Rp-all
*5672	MIL-E-1/280	9 July 1953	M - M		Po1, Ic1
5686	MIL-E-1/171	20 May 1953	M - M		Po1, Ic
5687	MIL-E-1/80C	14 May 1956	M - M		Ib1, Sm
*5702WA	MIL-E-1/82B	25 July 1956	M-LAL-UAL-M-ALD	Ib1, Sm1, Ic2	If, Ihk, Ic, Sm1, Δ_tSm1, Δ_{Ef}Sm, Rg-all, Rp-all
*5703WA	MIL-E-1/293C	5 Aug 1955	M-LAL-UAL-M-ALD	Ib1, Sml	If, Ihk, Ic1, Ic2, Δ_tSm1, Δ_{Ef}Sm, Rg-all, Rp-all

* Subminiature Tube. # Refers to asymmetric limits.

Table 3-2. Receiving Tubes of MIL-STD-200—(Cont'd.)

Tube Type JAN-	Specification Serial Number	Specification Sheet Dated	Method of Specification Definition of Characteristics	Defined By Variables Techniques	Characteristics Defined During Life
*5718	MIL-E-1/172B	5 Aug 1955	M-LAL-UAL-M-ALD	If, Ibl, Sm1	Ic, If, Δ_tSm1, Δ_{Ef}Sm1, Ihk, Rg-all, Rp-all, Avg Δ_tSm1
*5719	MIL-E-1/173C	5 Aug 1955	M-LAL-UAL-M-ALD	If, Sm1	Ic, If, Δ_tSm1, Δ_{Ef}Sm1, Ihk, Rg-all, Rp-all, Avg Δ_tSm1
5725/ 6AS6W	MIL-E-1/6C	25 July 1956	M-LAL-UAL-M-ALD	If, Ibl, Sm1	Rg1-all, Rg3-all, Rp-all, If, Ihk, Ic1, Sm1, Avg Δ Sm1, Δ_tSm1, Δ_{Ef}Sm1
5726/ 6AL5W	MIL-E-1/7A	3 May 1954	M-LRLM-URLM-M	If, #Ihk, #Io, #Is, #C(1p to 2p), C(1p to H+1k + sds.), C(2p to h+2k + sds.), C(1k to h+1p + sds.), C(2k to h+2p + sds.), #Ep	
*5744WA	MIL-E-1/84C	25 July 1956	M-LAL-UAL-M-ALD	Ib1, Sm1, Mu	If, Ihk, Ic1, Ic2, Δ_tSm1, Δ_{Ef}Sm1, Rg-all, Rp-all
5749/ 6BA6W	MIL-E-1/8	13 Jan 1953	M-LRLM-URLM-M	If, #Ihk, #Ic1, Ib, Sm1, #1c2, #Sm2, Sm3, #Ep	Rg1-all, Rp-all, If, Ihk, Ic1, Sm1, Δ Avg Sm1
5750/ 6BE6W	MIL-E-1/9	13 Jan 1953	M-LRLM-URLM-M	If. #Ihk, #Ic3, Sc1, Ic1, Ib2, #Ic2+4, Ik, Sm1, #Sm2, #Ep	Rg1-all, Rg3-all, Rp-all, If, Ihk, Ic3, Sc1, Ic1, Δ Avg Sc1
5751	MIL-E-1/10	13 Jan 1953	M-LRLM-URLM-M	If, #Ihk, #Ic, Ib1, #Ep (ac ampli.), #Ib2, Sm1, #Sm2, Mu, Cgp, Cin, Clout, C2out, #Ep	Rg-all, Rp-all, If, Ihk, Ic, ACA, Δ Avg ACA
*5784WA	MIL-E-1/88C	25 July 1956	M-LAL-UAL-M-ALD	Ib1, Sm1	If, Ihk, Ic1, Δ_tSm1, Δ_{Ef}Sm1, Rgl-all, Rg3-all, Rp-all
5814A	MIL-E-1/12A	23 Dec 1955	M-LAL-UAL-M-ALD	If, Ib1, Sm1, Mu	Rg-all, Rp-all, If, Ihk, Ic1, Sm1 Avg Δ Sm1, Δ_tSm1, Δ_{Ef}SM1
*5829WA	MIL-E-1/292A	23 Dec 1955	M-LAL-UAL-M-ALD	#Io, #Is	Rp-all, If, Ihk, Io, Δ_tIo
*5840	MIL-E-1/140B	5 Aug 1955	M-LAL-UAL-M-ALD	If, Ib1, Sm1	Ic1, If, Δ_tSm1, Δ_{Ef}Sm1, Ihk, Rg-all, Rp-all, Avg Δ_tSm1
*5896	MIL-E-1/174C	23 June 1955	M-LAL-UAL-M-ALD	If	If, Io, Δ_tIo, Ihk, Rp-all

* Subminiature Tube. # Refers to asymmetric limits.

Table 3-2. Receiving Tubes of MIL-STD-200—(Cont'd.)

Tube Type JAN-	Specification Serial Number	Specification Sheet Dated	Method of Specification Definition of Characteristics	Characteristics Defined By Variables Techniques	Defined During Life Characteristics
*5899	MIL–E–1/97C	23 June 1955	M–LAL–UAL–M–ALD	If, Ib1, Sm1	Ic1, If, Δ_tSm1, Δ_{Ef}Sm, Ihk, Rp-all, Rg-all, Avg Δ_tSm1
*5902	MIL–E–1/175C	14 May 1956	M–LAL–UAL–M–ALD	If, Ibl, Sm	If, Ihk, Ic1, Δ_tPo1, Avg Δ_tPo1, Rp-all, Rg-all, Δ_{Ef}Po1
6005/ 6AQ5W	MIL–E–1/13A	20 May 1953	M–LRLM–URLM–M	If, #Ihk, #Ic1, #Ic2, #Po1, Ib, #Po2, #Cglp, Cin, Cout	If, Ihk, Ic1, Po1, Δ Avg Po1
*6021	MIL–E–1/188B	23 Aug 1955	M–LAL–UAL–M–ALD	If, Ib1, Sm1	If, Ihk, Ic, Δ_tSm1, Avg Δ_tSm1, Rg-all, Rp-all, Δ_{Ef}Sm1
6080WA	MIL–E–1/510B	5 Dec 1955	M–LAL–UAL–M–ALD	Ib1, Sm1	Ic, Δ_{Ef}Sm, Ihk, If, Sm, Rg-all, Rp-all
*6088	MIL–E–1/694	3 May 1954	M – M		Po1
6094	MIL–E–1/821B	23 Dec 1955	M–LAL–UAL–M–ALD	Ib, #Ic2, #Po, Sm	If, Ic1, Po, Δ_{Ef} Po, Ihk, Rg1-all, Rp-all, Avg Δ_tPo
*6111	MIL–E–1/189B	23 Aug 1955	M–LAL–UAL–M–ALD	If, Ib1, Sm1	If, Ihk, Ic, Δ_tSm1, AVg Δ_tSm1, Rg1-all, Rp-all, Δ_{Ef}Sm1
*6112	MIL–E–1/190C	14 May 1956	M–LAL–UAL–M–ALD	If, Sm1	Ic, If, Δ_tSm1, Δ_{Ef}Sm1, Ihk, Rg-all, Rp-all, Avg Δ_tSm1
6203	MIL–E–1/262A	23 June 1955	M–LAL–UAL–M–ALD	If	Δ_tIo, If, Ihk
6533	MIL–E–1/975	5 Dec 1955	M–LAL–UAL–M–ALD	If, Sm	If, Ihk, Ic, Δ_t Sm, Avg Δ_tSm, Rg-all, Rp-all, Δ_{Ef}Sm

* Subminiature Tube. # Refers to asymmetric limits.

3.1 Application of Triodes

This section discusses triode properties and methods of treating them in circuit design. Triode types are shown on a field of constant Mu lines for comparison purposes in Figures 3-1 and 3-2. The test conditions under which these characteristics were determined are those listed in the applicable specifications. Tube properties under actual usage may vary considerably from the values shown. The conditions under which the acceptance tests are performed for various triodes are given with other information in the section on specific tube types where a treatment of acceptable limits, characteristics variability, and permissible areas of operation appears.

3.1.1 *Permissible Operating Conditions.* The permissible operating conditions are considered in relation to the ratings. In general, as the operating condition approaches the ratings, the reliability of the design will be adversely affected, since these define the limiting conditions beyond which there is a complete absence of operating assurance.[1] Figure 3-3, an average plate characteristic plot for a typical triode, shows such a permissible area of operation bounded by heavy lines representative of the absolute maximum ratings of the type.

3.1.2 *Questionable Areas of Operation.* Note should be taken of Regions 1 and 2 indicated by line shading. Though operation in these regions is permissible it is nonetheless questionable for certain applications. Region 1 is located near the zero bias line. Tube characteristics in this region are subject to considerable variability primarily due to grid currents resulting from such causes as contact potential and ionic gas currents. These properties are rarely subject to complete specification control and are therefore unpredictable; as a result, tube characteristics in this region may vary more widely than is indicated by the specification limits. Grid currents may, in addition, cause loading of the input circuit, resulting in wide variation of apparent stage gain over short periods of time.

3.1.3 *Low Current Region.* The second area (2) appears in the low plate current region of the tube. In some specifications, a minimum cathode current appears as a rating. Unless otherwise indicated on the individual electron tube specification sheets, operation below this rated value is decidedly uncertain since in this low current region, particularly under conditions of fixed bias, currents may vary widely from tube to tube or between sections in dual types. Furthermore, circuit operation is not assured when the tube, after being held at low or no plate current with its heater energized for an appreciable length of time, is subjected to higher current demands.

3.1.4 *Area Adjacent to Maximum Plate Dissipation Boundary of Permissible Area of Operation.* The third (3) area deserving consideration is adjacent to the maximum plate dissipation boundary of the permissible area of operation. A definite relationship exists between the plate dissipation, the bulb temperature, and the effective environmental temperature. Under certain conditions, the maximum rated bulb temperature may be exceeded unless the plate dissipation is reduced. In many cases, the proper choice of shield, socket[1] and/or mounting clamp (subminiature) will materially aid in the solution of this particular problem.

3.1.5 *Other Design Considerations*

In addition to the limitations discussed above, other design considerations not immediately apparent from the specification are treated below for triode application.

(a) Supply Voltages. A note concerning the use of supply voltages in excess of

[1] Reference Table 1-2 in Part. I.

[1] See WADC Report 53-174, June 1953

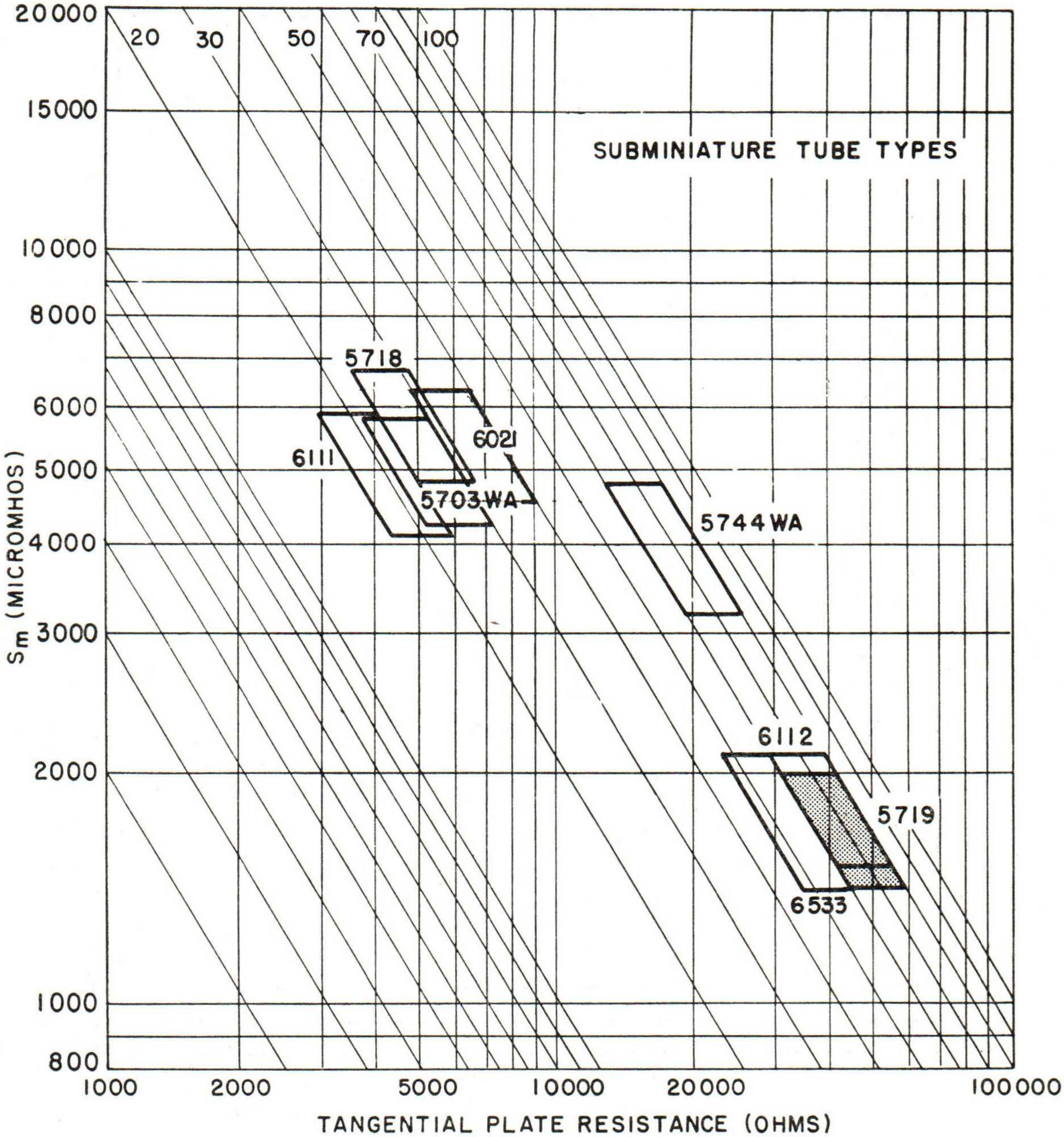

Figure 3-1. Triode Properties of Subminiature Tube Types.

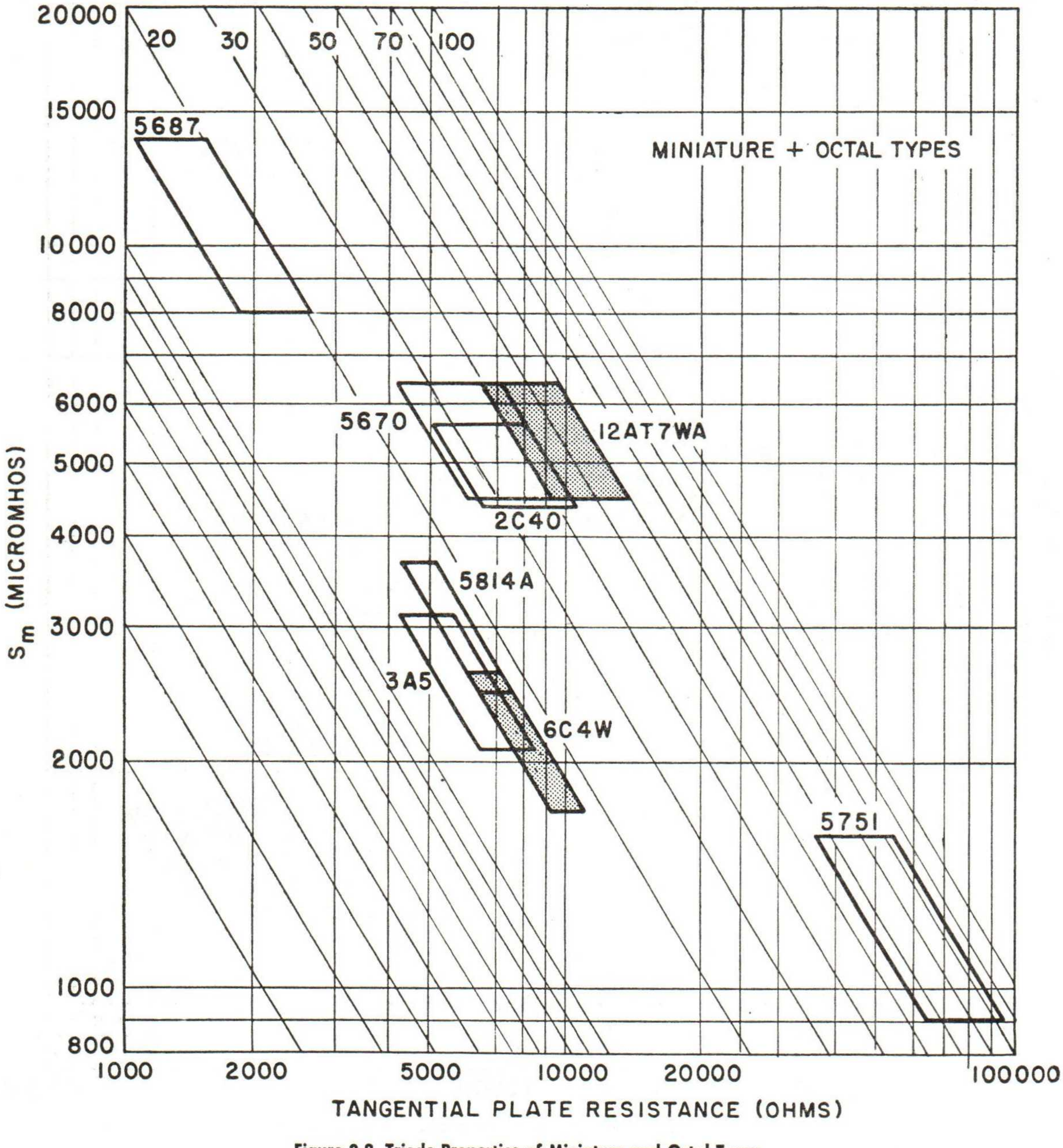

Figure 3-2. Triode Properties of Miniature and Octal Types.

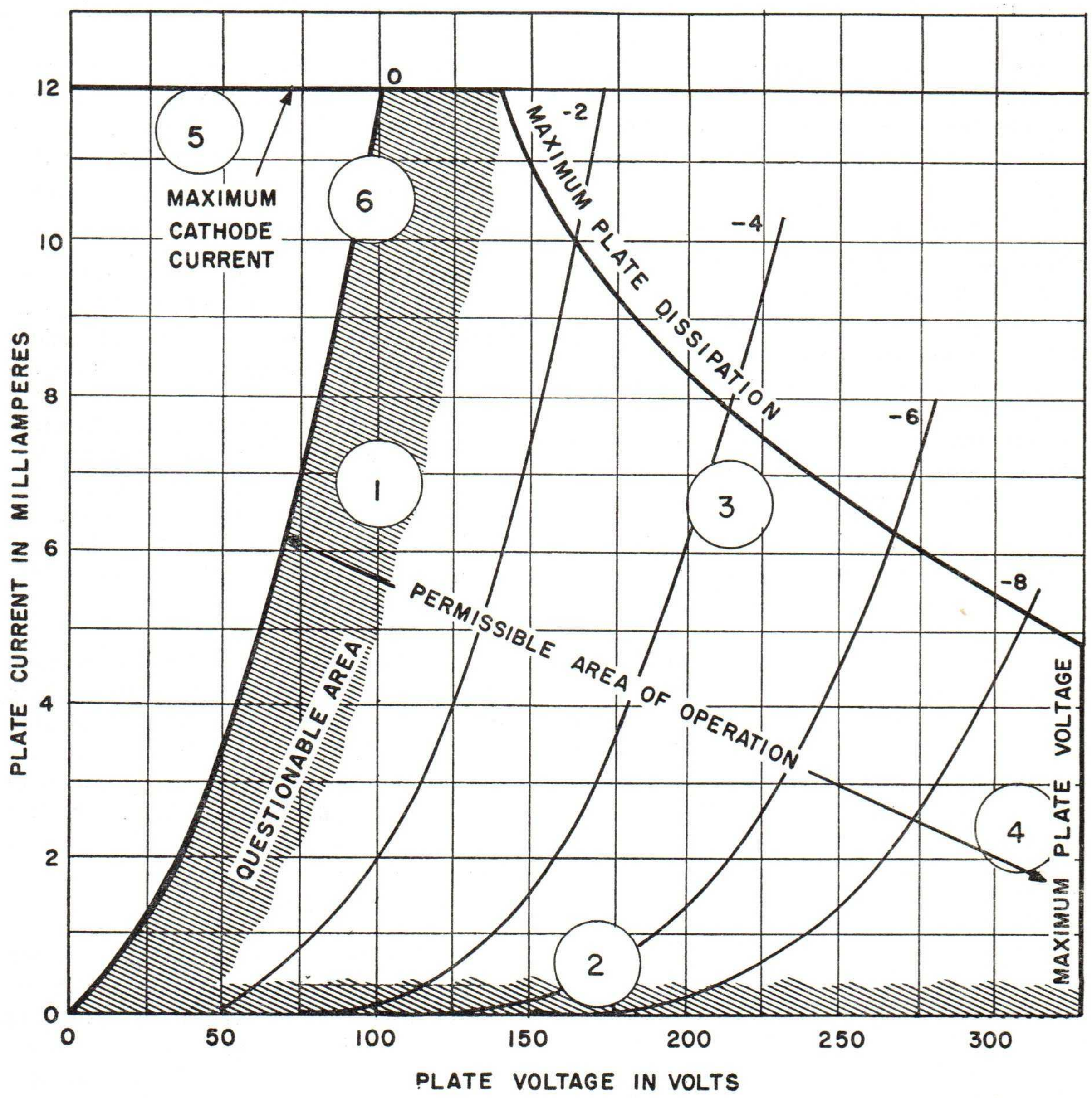

Figure 3-3. Plate Characteristic Plot for a Typical Triode.

the rated maximum appears in MIL-E-1, as follows: "Unless otherwise specified on the tube specification sheet, when the load impedance is of such type that the instantaneous voltage at the plate never exceeds the supply voltage, the supply voltage may be twice the maximum rated dc plate voltage, provided the maximum rated average dissipation is never exceeded on any electrode."

(b) Low Electrode Current. Unless otherwise noted in individual tube type sections, circuit operation is not assured when the tube, after being held at a low value of plate current for appreciable periods of time, is subjected to higher current demands. Examples of this service are all types of intermittent operation wherein heaters remain energized under conditions of very low or no plate current.

(c) A-C Plate Operation. Considerable caution should be exercised in the supplying of plate potential from alternating voltage sources. In such applications, the negative excursions of the plate afford an opportunity for electron emission from plate to control grid, resulting in a negative shift of bias. In addition, the positive alternating voltage peaks may draw cathode current sufficient to impair the operation of the tube.

(d) Heater Operation. Attention should be given to heater voltage tolerance ratings. Life and reliability of performance are directly rated to the degree that heater voltage is maintained at center rated values. The importance of good heater voltage regulation on the useful life of the tube is evident from Table 1-2 (Part I). Here it is apparent that excessive heater voltage will hasten deterioration within almost every electron tube defect category.

(e) Bias Conditions. The apparent variability of characteristics of many triode tube types, as reflected in the specification, is greatly reduced through the use of cathode bias for measurement test conditions. It can be expected therefore, in applications employing fixed bias, that characteristic variability will exceed that which is evident for such types under MIL-E-1 test conditions.

(f) Grid Return Resistance. Caution should be exercised in the choice of grid resistors. Specification assurance on life is lost if the resistance chosen has a value greater than that specified in the intermittent life test conditions.

(g) Pulse Operation. In general, the testing of all electron tubes is performed at discret operating points only and unless specific tests provide assurance of pulse behavior, no assumptions may be made for such conditions of operation. Specification assurance of characteristic uniformity rarely exists in the positive grid region. The attention of the designer is again directed to the observations concerning low electrode currents typical of operation in pulse circuitry (paragraph

(h) Low Supply Voltage Operation. There is no assurance of characteristic uniformity when the plate is operated at a low voltage, as, for example, from 28-volt d-c aircraft supplies. With a very low plate voltage, the cutoff value of bias approaches the value of the "contact potential" effects. Operation in this area must be regarded as extremely unpredictable.

(i) Microphonic Behavior Under Shock and Vibration. Vibration testing and measurement is rarely performed at operating points where characteristic assurance is already available by means of other acceptance tests. The specification limits of vibration noise wherever such tests are made on triode tubes are shown in figures 3-4 and 3-5. In these figures the microphonic noise limits are referred back to the respective grids of the tubes involved by consideration of the operating level of the tube under test and the characteristics of the average tube of each type.

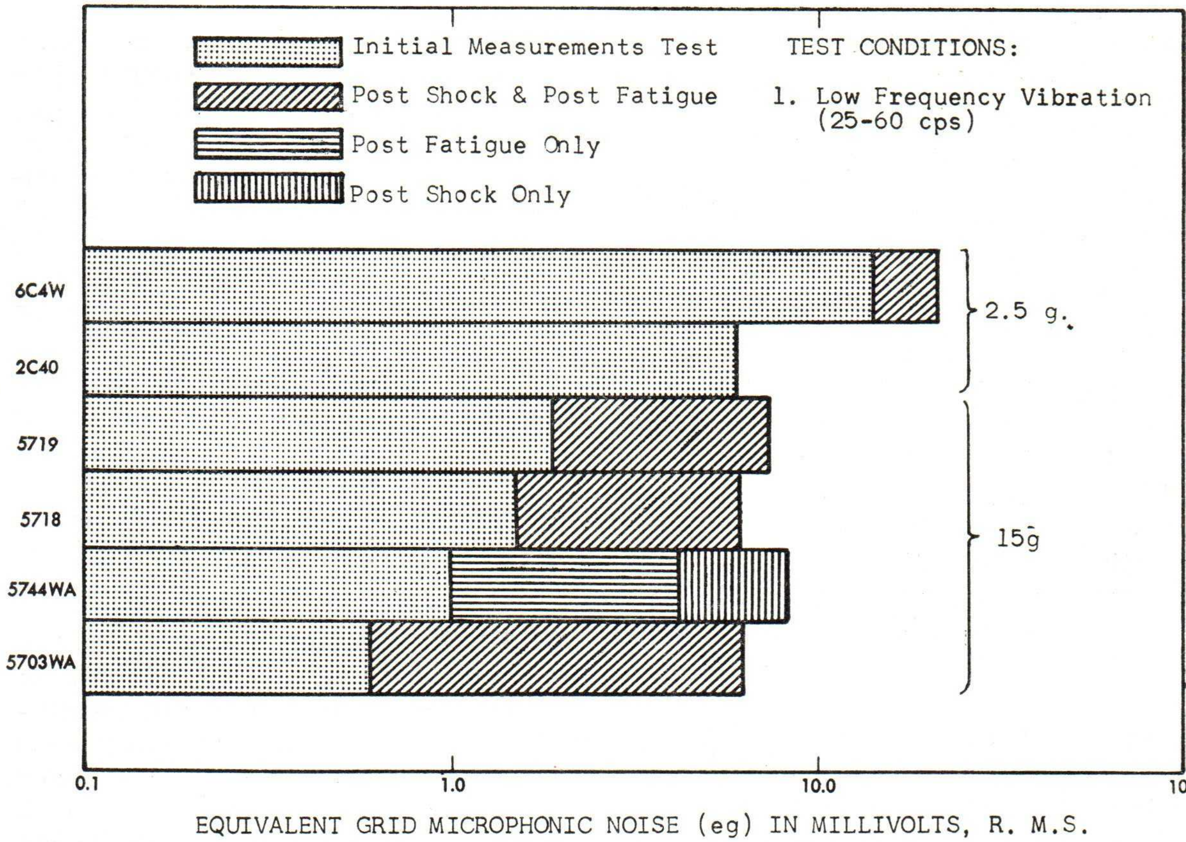

Figure 3-4. Equivalent Grid Microphone Noise Limits for Single Triodes.

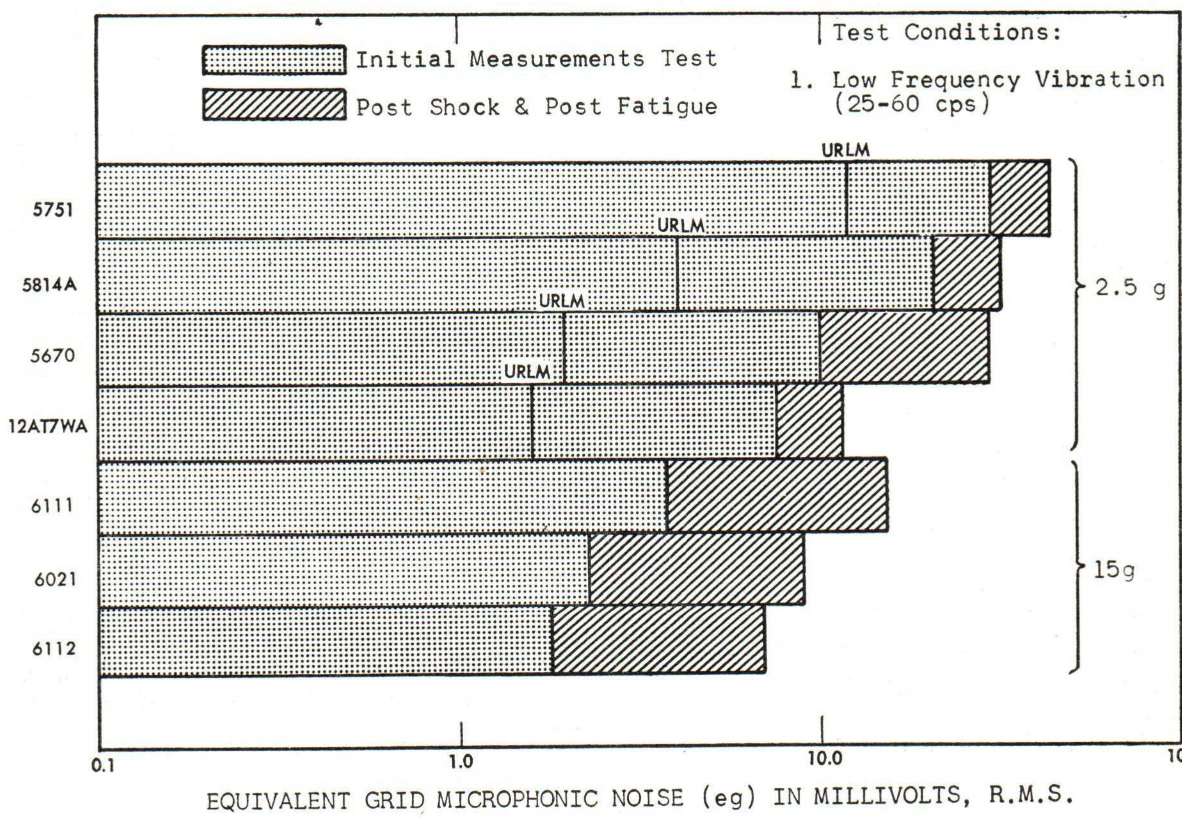

Figure 3-5. Equivalent Grid Microphonic Noise Limits for Dual Triodes.

3.2 Application of Pentodes

This section discusses pentode properties and methods of treating them in circuit design. Factors of merit are presented for receiving pentodes in Figure 3–6. The factors and characteristics shown have a direct relationship to pentode applications and are presented for comparison purposes. The test conditions under which the characteristics were determined are those listed in the applicable specifications. Tube properties under actual usage may vary considerably from the values shown. The conditions under which the acceptance tests are performed for various pentodes is given with other information in the section on specific tube types where a treatment of acceptable limits, characteristic variability, and permissible areas of operation appears.

3.2.1 *Permissible Operating Conditions.* The permissible operating conditions are considered in relation to the ratings. In general, as the operating condition approaches the ratings, the reliability of the design will be adversely affected, since these define the limiting conditions beyond which there is a complete absence of operating assurance.[1] Figure 3–7, a plate characteristic plot of a typical pentode, shows such a permissible area of operation bounded by heavy lines, representative of the absolute maximum ratings of the type.

3.2.2 *Maximum Screen Dissipation.* Boundary 1 indicates the maximum screen dissipation for the tube. It is obtained by consideration of rising screen current as constant screen voltage in the regions of low plate voltage. Screen currents are quite variable, particularly under conditions of fixed bias and low screen current source impedance. Accordingly, this rating should be considered even when the operation of the tube appears to lie well within this boundary.

[1] Reference Table 1-2 in Part. I.

3.2.3 *Temperature Problem.* The general remarks concerning triodes apply to pentodes, namely, that a functional relationship exists between the bulb temperature, plate dissipation and environment, and under certain conditions, the maximum rated bulb temperature may be exceeded unless the plate dissipation is reduced. In many cases, the proper choice of shield, socket[2] and/or mounting clamp (subminiature) will materially aid in the solution of the temperature problem.

3.2.4 *Maximum Plate Voltage Boundary.* The maximum plate voltage boundary (3) is subject to the restrictions mentioned in paragraph

3.2.5 *Minimum Plate Current Region.* Under the usual specification requirements for electron tubes, circuit operation in the minimum plate current region or boundary (4) is not assured when for an appreciable period of time little or no plate current flows with the heater energized. Tube properties are seldom specified in this region and the operational variability may be greater than indicated by the acceptance test limits.

3.2.6 *Questionable Areas of Operation.* Note should be taken of the two areas (5 and 6) indicated by line shading. Although operation is permissible in these areas, it is questionable for certain applications. Area (5) is that area near or below the plate current knee for the particular value of bias concerned. Tube characteristics in this region are subject to much wider variations than are indicated by the specification limits at the test points. It has been observed that the plate characteristics curves may display unusual shapes in this area giving rise to regions of low dynamic plate resistance as illustrated in Figure 3–8. The consequent loading of the plate circuit may cause wide variation in stage gain from tube to tube. Also the possibility of inadvertently exceed-

[2] See WADC Report 53–174, June 1953.

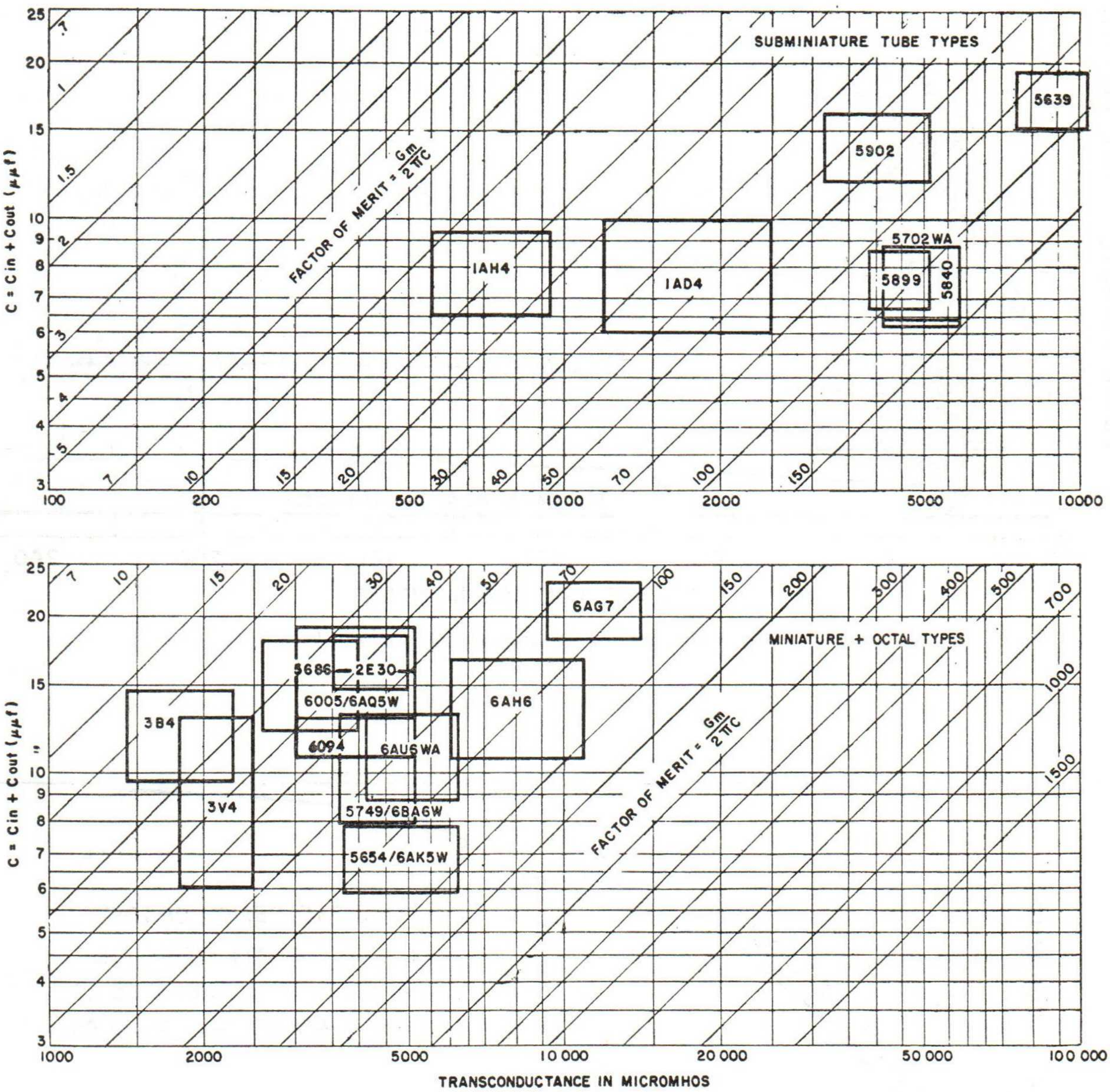

Figure 3-6. Factors of Merit of Receiving Pentodes.

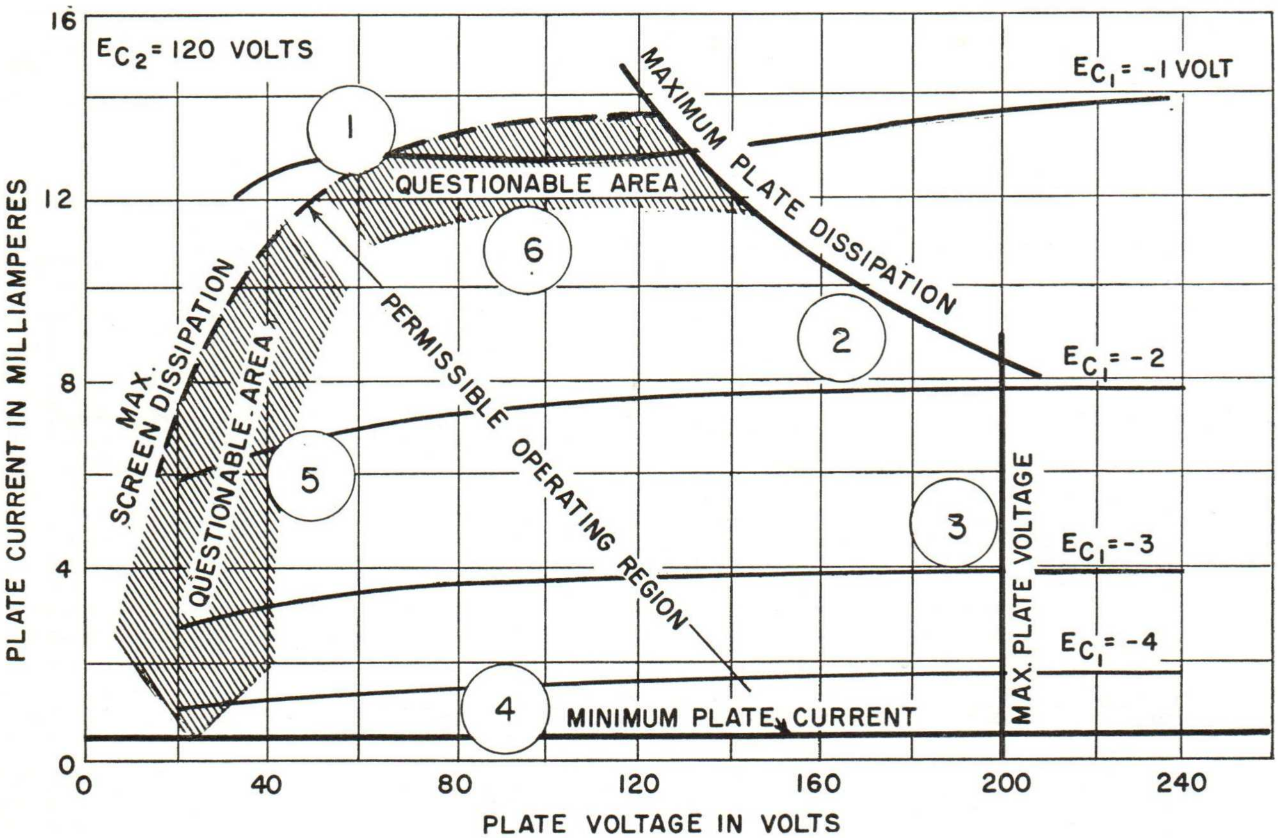

Figure 3-7. Plate Characteristic Plot for Typical Pentode.

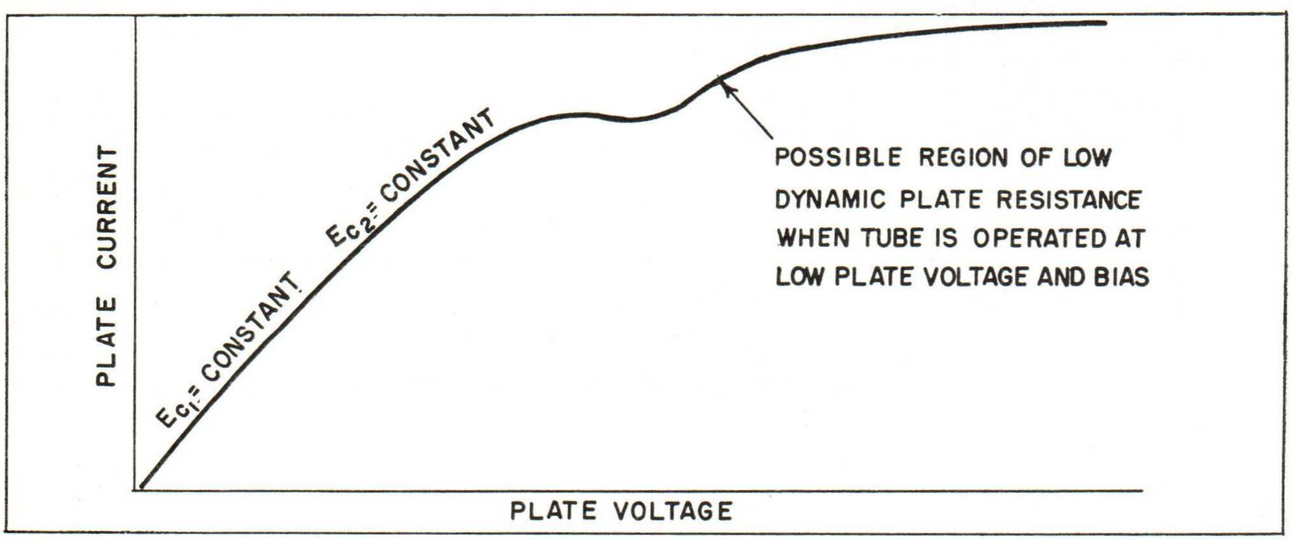

Figure 3-8. Plate Characteristic Curve in Questionable Area of Operation.

dit geldt alleen voor oxyd-kathoden.

ing the screen dissipation ratings exists in the low plate voltage region of this area.

3.2.7 *Screen Voltages Larger Than Plate Voltage.* Caution should be exercised in application of screen voltages larger than the plate voltage, particularly if low values of control grid bias are likely. Wide variation in characteristis (including possible negative resistance effects) as well as excessive screen dissipation may result.

3.2.8 *Initial Velocity Electron Current.* Another questionable area may be considered as containing any value of grid bias at which "initial velocity electron current" may flow in the control grid areas (5 or 6). Tube characteristics in this region are subject to considerable variability primarily due to grid currents resulting from such causes as contact potential and ionic gas currents. The input circuit loading represented by this grid current will vary widely among tubes, and in addition, variations in other characteristics can be expected.

3.2.9 *Other Design Considerations*

In addition to the limitations of the permissible area of operation discussed above, other design considerations not immediately apparent from the specification are treated below for pentode application.

(a) Supply voltages. A note concerning the use of supply voltages in excess of the rated maximum appears in MIL-E-1 as follows: "Unless otherwise specified on the tube specification sheet, when the load impedance is of such type that the instantaneous voltage at the plate never exceeds the supply voltage, the supply voltage may be twice the maximum rated dc plate voltage, provided the maximum rated average dissipation is never exceeded on any electrode."

(b) Low Electrode Current. Unless otherwise noted in individual tube-type sections, circuit operation is not assured when the tube, after being held at a low value of plate current for appreciable periods of time, is subjected to higher current demands. Examples of this service are all types of intermittent operation wherein heaters remain energized under conditions of very low or no plate current.

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(c) Heater Operation. Attention should be given to heater voltage tolerance ratings. Life and reliability of performance are directly related to the degree that the heater voltage is maintained at center rated values. The importance of good heater voltage regulation on the useful life of the tube is evident from Table 1-2 (Part I). Here it is apparent that excessive heater voltage will hasten deterioration within almost every electron tube defect category.

(d) Bias Conditions. The apparent variability of characteristics of many pentode tube types, as reflected in the specification, is greatly reduced through the use of cathode bias under test conditions. It can be expected therefore, in applications employing fixed bias, that characteristic variability will exceed that which is evident for such types under MIL-E-1 test conditions.

(e) Grid Return Resistance. Caution should also be exercised in the choice of grid return resistance. Specification assurance on life is lost if the resistance chosen has a value greater than that specified in the intermittent life test conditions.

(f) Screen Dropping Resistance. While MIL-E-1 test conditions normally employ a fixed value of screen supply voltage, the use of a screen dropping resistance is a particular circuit application may result in reduced characteristics variability from that which is evident from consideration of the specification limits. In addition, the use of a screen resistance will reduce the possibility of inadvertently exceeding the screen dissipation rating.

(g) A-C Operation of Plate and Screen. Considerable caution should be exercised in supplying plate or screen potentials from alternating voltage sources. In such applications, the negative excursions afford an opportunity for electron emission to the control grid, resulting in a negative shift of bias. In addition, the positive alternating voltage peaks may draw cathode current sufficient to impair the operation of the tube.

(h) Pulse Operation. In general, the testing of all electron tubes is performed at discret test points and unless specific tests provide assurance of pulse operation, assumptions may not be made regarding such operation. Specification assurance of characteristic uniformity rarely exists in the positive grid region. The attention of the designer is again directed to the observations concerning low electrode currents typical of operation in pulse circuitry discussed in paragraph 3.2.9 (b).

(i) Triode Connection. Specification assurance of uniformity in characteristics is lost when pentode tubes are operated as triodes.

(j) Low Supply Voltage Operation. There is no assurance of characteristic uniformity when the tube is operated from very low plate and screen supplies such as 28 volts dc. In addition, low values of screen voltage reduce the control grid bias required for cutoff of plate current. With very low values of screen voltage, the cutoff value of bias may approach the "contact potential" of the tube causing operation in the questionable area of "initial velocity electron current."

(k) Screen Grid Circuit Protection. Designers should insure that plate and screen supply voltages are supplied from a common chassis plus or preferably a common terminal within each individual chassis to prevent the accidental removal of plate voltage without concurrent removal of screen grid voltage. Removing the plate supply voltage with the screen grid voltage remaining on can result in excessive screen grid current and screen dissipation, resulting in severe deterioration of electrical characteristics, or even destruction of the screen.

(l) Microphonic Behavior Under Shock and Vibration. Vibration testing and measurement is rarely performed at operating points where characteristic assurance is already available by means of other acceptance tests. The specification limits of vibrational noise wherever such tests are made on pentodes and dual control tubes are shown in Figures 3–9 and 3–10. In these figures the microphonic noise limits are referred back to the respective grids of the tubes involved by consideration of the operating level of the tube under test and the characteristics of the average tube of each type.

Similar comparisons have been made between filamentary types and also between power output types both triodes and pentodes. These comparisons are made in Figure 3–11 and 3–12.

3.3 Application of Rectifiers

This section discusses rectified properties and methods of treating them in circuit design. In Figures 3–13 and 3–14 rectifier tube types taken from MIL–STD–200 electron tube list are graphically compared in relation to their output current and inverse peak voltage ratings. The chart is presented for comparison purposes only since it is not wholly descriptive of the limiting conditions of operation. The conditions under which the acceptance tests are performed for various rectifiers are given with other information in the section on specific tube types where a treatment of acceptance limits, characteristic behavior, and permissible areas of operation appears.

3.3.1 *Permissible Operating Conditions.* The permissible operating conditions are considered in relation to the ratings. In general, as the operating condition approaches the ratings, the reliability of the design will be adversely affected, since these define the limiting conditions beyond which

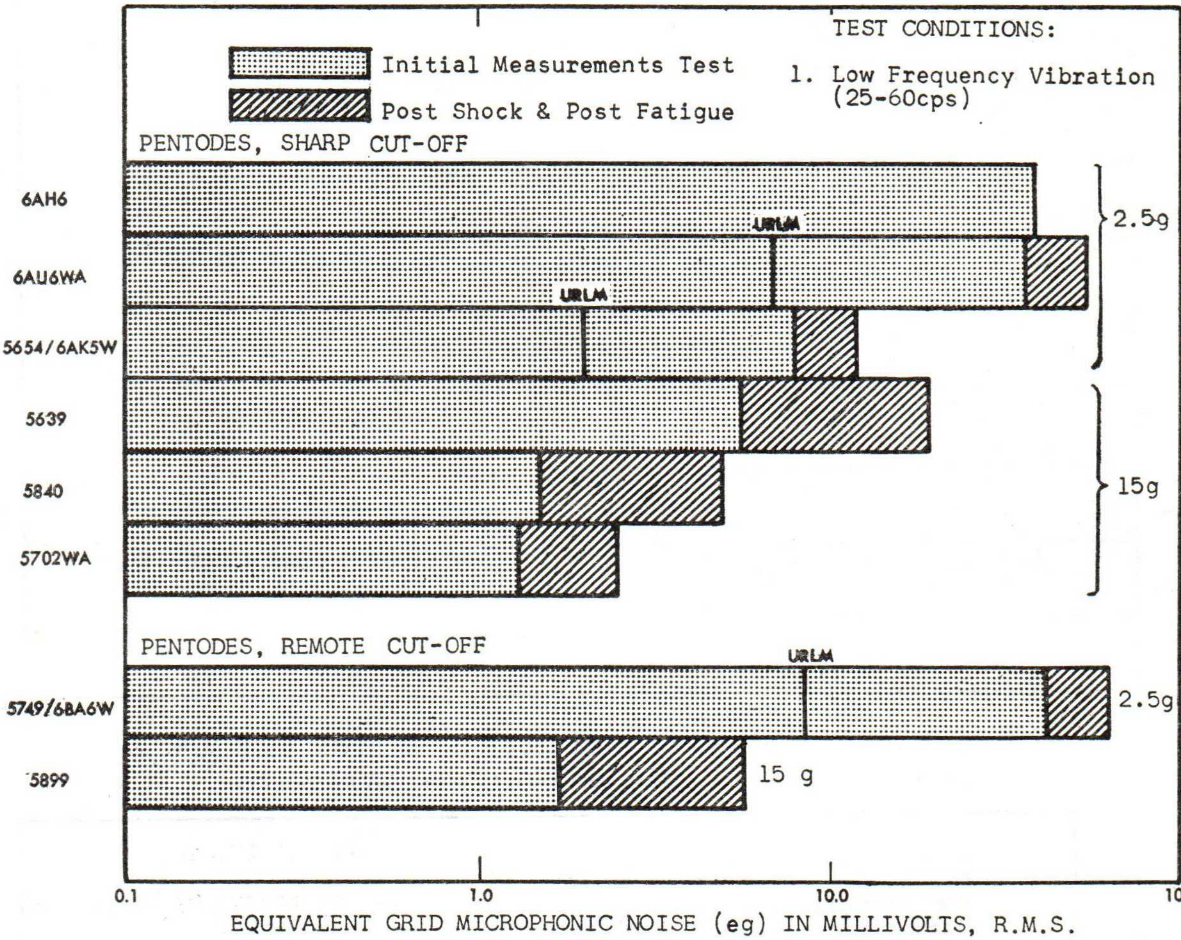


Figure 3-9. Equivalent Grid Microphonic Noise Limits for Receiving Pentodes.

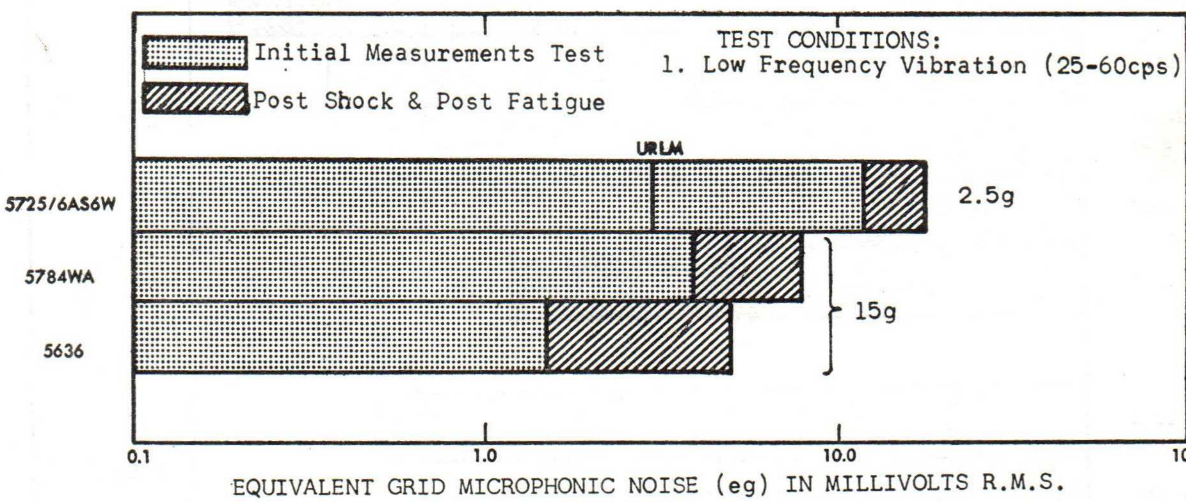


Figure 3-10. Equivalent Grid Microphone Noise Limits for Dual Control Tubes.

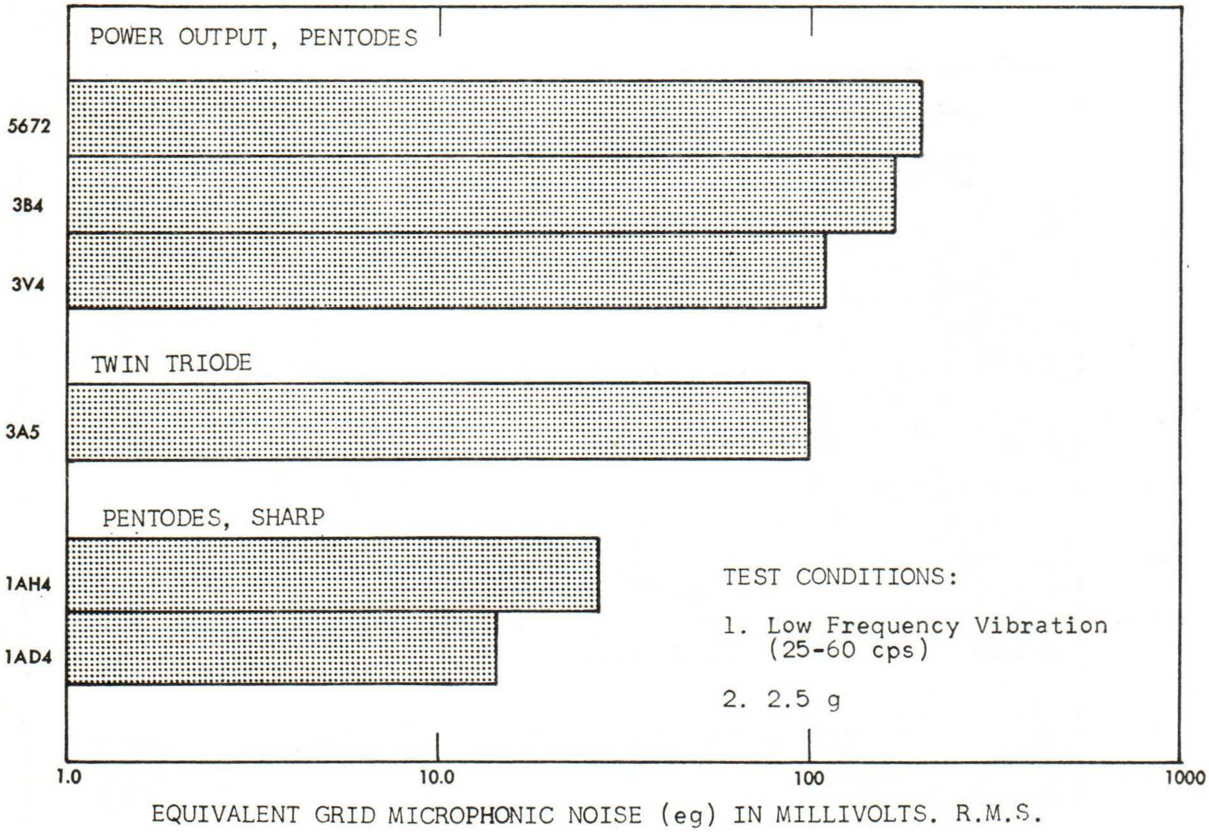


Figure 3-11. Equivalent Grid Microphonic Noise Limits for Filamentary Receiving Tubes.

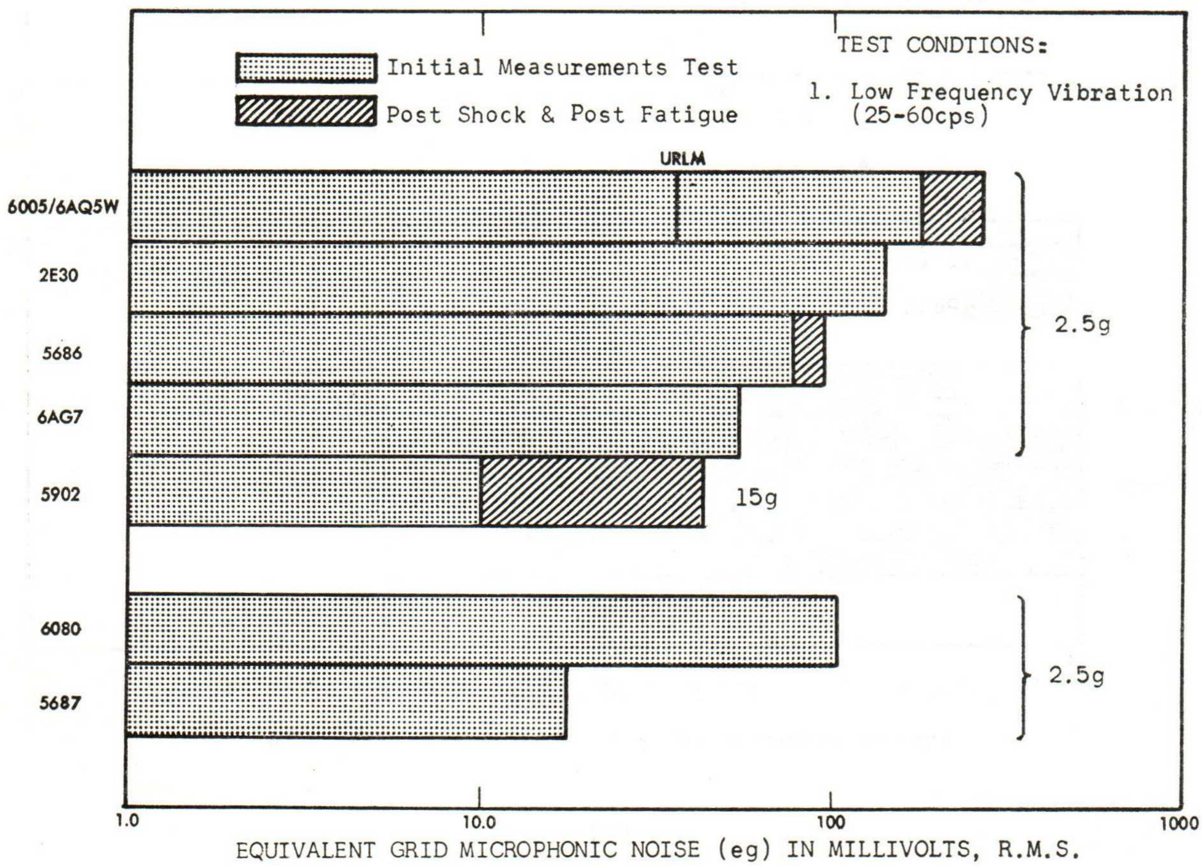


Figure 3-12. Equivalent Grid Microphonic Noise Limits for Power Output Triodes and Pentodes.

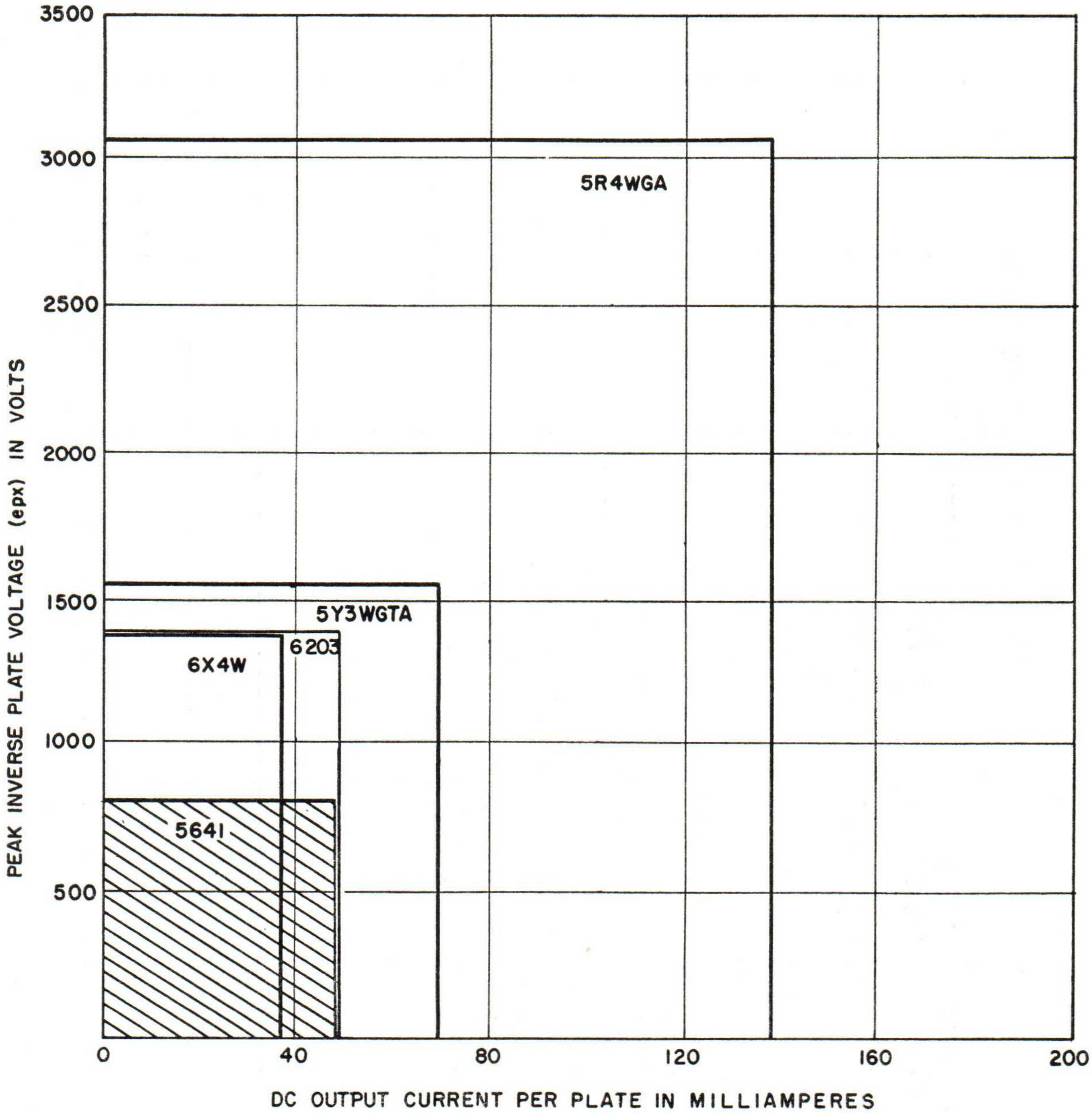


Figure 3-13. Comparison of Output Currents and Inverse Peak Voltage Ratings for Rectifier Tube Types.

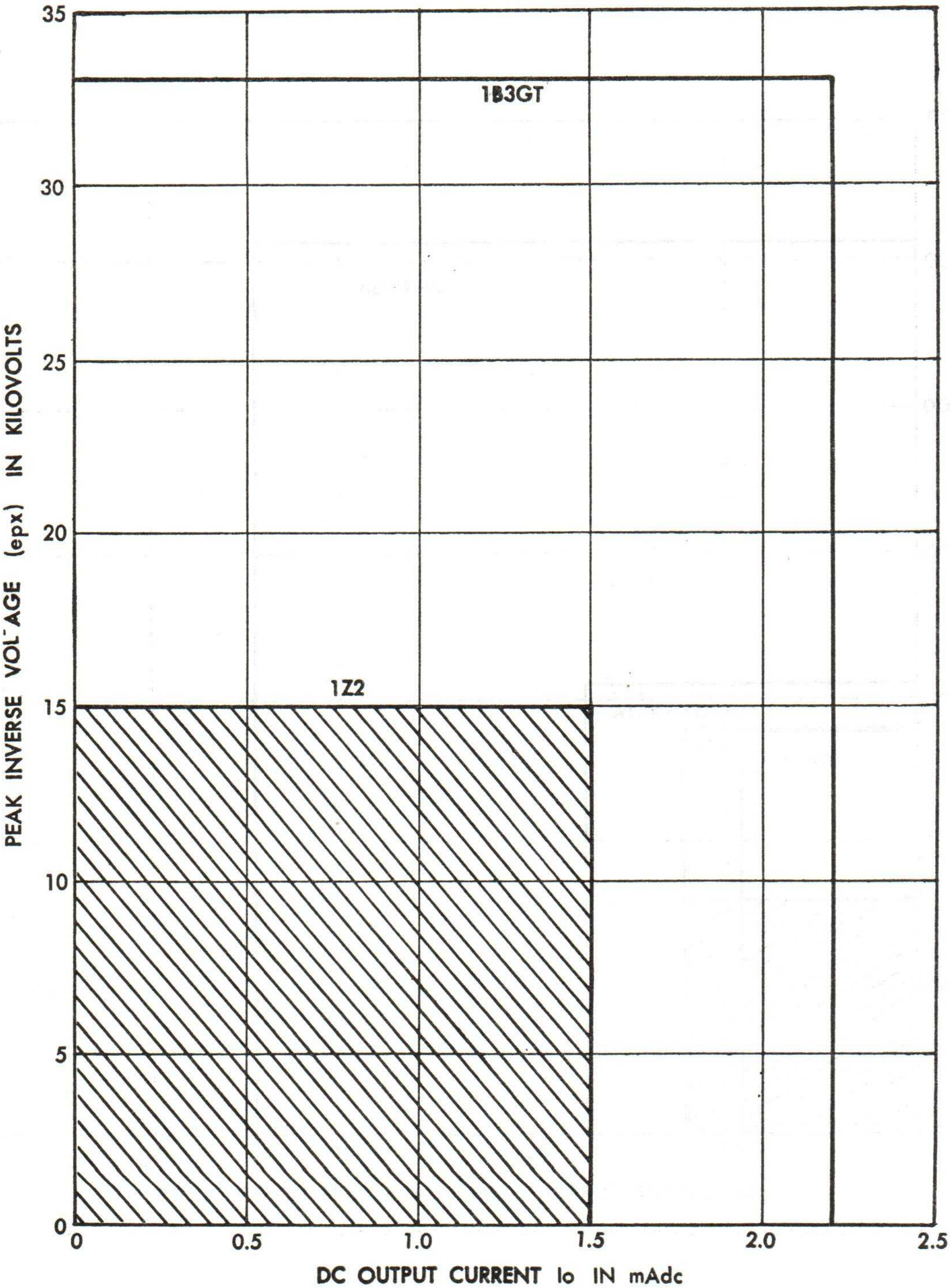


Figure 3-14. Comparison of Output Current and Inverse Peak Voltage Ratings for High Voltage Rectifier Types.

there is a complete absence of operating assurance.[1]

3.3.2 *Rating Charts.* Inasmuch as the observance of correct rectifier operation depends on the choice of several circuit parameters external to the tube, more than one permissible operating area may be required to define properly the region within the ratings. Commonly, three or more "rating charts" are employed for such purposes. It must be emphasized that the use of a rectifier within its ratings implies that it is operating in the permissible areas of each of its rating charts. Consideration of all ratings and rating charts is therefore important in the choice of an operating point. It should be borne in mind that all ratings are based on the "absolute maximum system" and are not to be exceeded under any service condition (see paragraph 1.1). The rating charts which follow exemplify the corresponding charts for the specifi crectifier tube types discussed later. Rating Charts I, II, and III are derived from the specification ratings by methods given in the "Manual of Practice" for the Joint Electron Tube Engineering Council. Rating Charts I and II must be used in combination, in connection with the design of capacitive input filter applications. Hence, they are presented side by side to permit easy projection of points from one to the other.

(a) Rating Chart I. A typical Rating Chart I is shown in Figure 3–15. Here the permissible operating area for both choke and capacitor input circuits is defined by the maximum rated d-c output current (per plate) and the RMS plate voltage. Point E corresponds to the intermittent life test condition given in the applicable MIL–E–1 specification. Point C corresponds to the conditions of maximum inverse peak voltage and maxmium dc output current, as given by the rating.

(b) Rating Chart II. An example of Rating Chart II is shown in Figure 3–16. This chart is applicable only to capacitor input filter operation and defines the permissible operating area by the maximum rated d-c output current per plate and the rectification efficiency corresponding to maximum rated steady-state peak plate current as given in the applicable specification. Rectification Efficiency is defined as:

$$\frac{\text{DC Output Voltage (Eo)}}{\text{Peak Plate Voltage } (\sqrt{2}\text{Epp/p})}$$

(c) Rating Chart III. Figure 3–17 shows the permissible operating area as defined by Rating Chart III. This chart gives the minimum allowable resistance effectively in series with each plate of the rectifier tube for any allowable a-c plate voltage. The boundary conditions are derived from the maximum instantaneous surge current rating for the tube. The effective series plate supply resistance per plate, Rs, may be calculated from circuit measurements:

$$Rs = Rsec + N^2Rpri + Ra$$

Where: Rsec = d-c resistance of transformer secondary/section.

Rpri = d-c resistance of transformer primary.

Ra = d-c resistance added in series per plate.

N = transformer voltage step-up ratio per section.

3.3.3 *High Altitude Operation.* Caution should be exercised in the design of rectifier circuits which will operate in unpressurized enclosures at high altitudes. Freedom from arc-over is not assured by the specification if operation at pressures lower than that equivalent to the maximum rated altitude is attempted. In addition, convection cooling of the rectifier envelope may be reduced at low atmospheric pressures and endanger the operation due to excessive envelope temperature. High altitude derating is specified for some rectifier types by suitable rating charts set forth in the individual specification.

[1] Reference Table 1-2 in Part I.

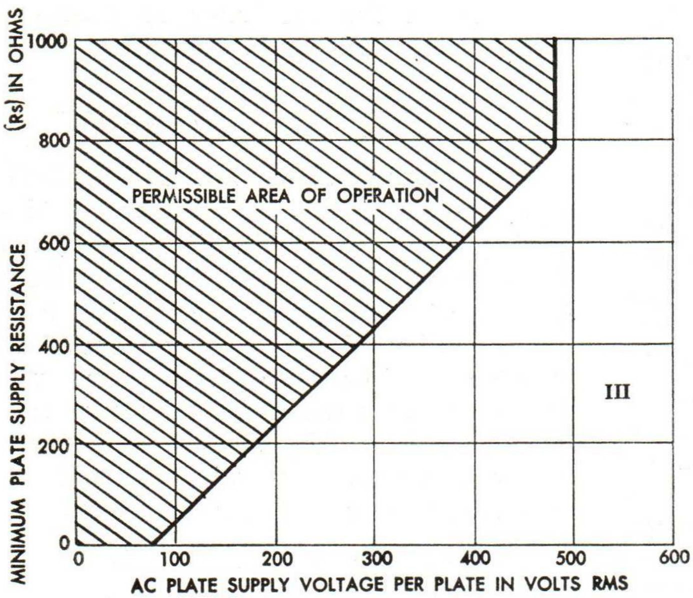


Figure 3-17. Raitng Chart III for Rectifier Tube Types with Capacitor Input Filter Operation.

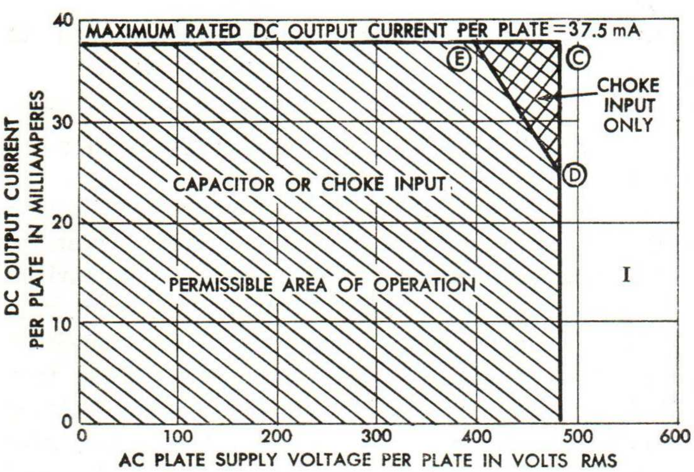


Figure 3-15. Rating Chart I for Rectifier Tube Types.

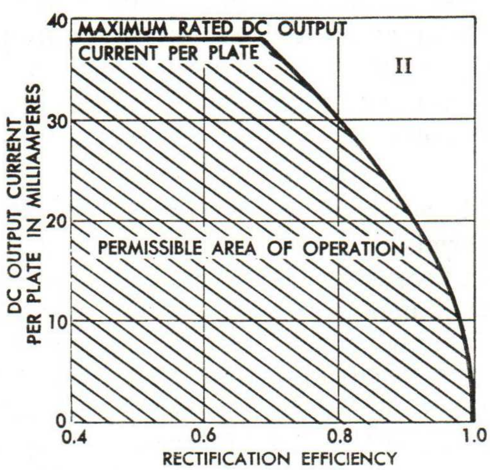


Figure 3-16. Rating Chart II for Rectifier Tube Types.

3.3.4 *Time Delay Rating.* The simultaneous application of plate and heater voltage may result in excessive cathode bombardment and materially shorten the useful life of the tube. When this factor is to be considered in circuit application, time delays appear as ratings in the applicable specification. In some cases, this rating is also presented by a rating chart, defining more completely the conditions of input voltage and output current for which the application of plate voltage should be delayed.

3.3.5 *Heater Operation.* Attention should be given to heater voltage tolerance ratings. Life and reliability of performance are directly related to the degree that the heater voltage is maintained at center rated values. The importance of good heater voltage regulation on the useful life of the tube is evident from Table 1-2 (Part 1). Here it is indicated that excessive heater voltage will hasten deterioration within almost every electron tube defect category.

3.4 Application of Diodes

This section discusses diode properties and methods of treating them in circuit design. Diode types included in MIL-STD-200B are compared graphically in Figure 3-18 in relation to their respective output current and inverse peak voltage ratings. The chart is presented for comparison purposes only and is not wholly descriptive of the limiting conditions of operation. The conditions under which the acceptance tests are performed for various diodes is given with other information in the sections on specific types where a treatment of acceptance limits, characteristic variability, and permissible areas of operation appears.

3.4.1 *Permissible Operating Conditions.* The permissible operating conditions are considered in relation to the ratings. In general as the operating condition approaches the ratings, the reliability of the design will be adversely affected, since these ratings define limiting conditions beyond which there is a complete absence of operating assurance.[1] Figure 3-19, an average plate characteristic plot of a typical diode, shows the permissible limits of operation bounded by heavy lines representative of the absolute maximum ratings of the type. Limit (1) is the maximum peak-plate current (ib) rating. Limit (2) is the maximum d-c output current per plate rating.

Normal application of diodes in signal rectifier service — modulators, demodulators, limiters, clippers, clampers, etc., requires attention to the shaded region indicated as Area 3 on the chart. Area 3, though well within the limits of permissible operation, is a questionable area for small signal applications. Initial uniformity of electrical characteristics in this area and stability of these characteristics through life is adversely affected by heater voltage variation. Although individual specifications may enforce control of plate current balance between sections of dual diodes in this region under conditions of design center heater voltage, no assurance of balance through life may be afforded.

3.4.2 *Rating Charts.* Although the diodes discussed herein are used primarily in signal rectification applications, at low signal levels, there are other applications in large signal and supply voltage rectifier service wherein rectifier Rating Charts I, II and III become applicable. On the basis of their absolute maximum ratings, such charts have been developed for individual types within the signal diode category. Refer to paragraphs 3.3.2 through 3.3.2 (c) for a general discussion of these charts.

3.4.3 *Other Design Considerations*

Design considerations other than the limitations discussed above, which are not immediately apparent from the specification include the following:

(a) Low Electrode Current. Unless

[1] Reference Table 1-2 in Part. I.

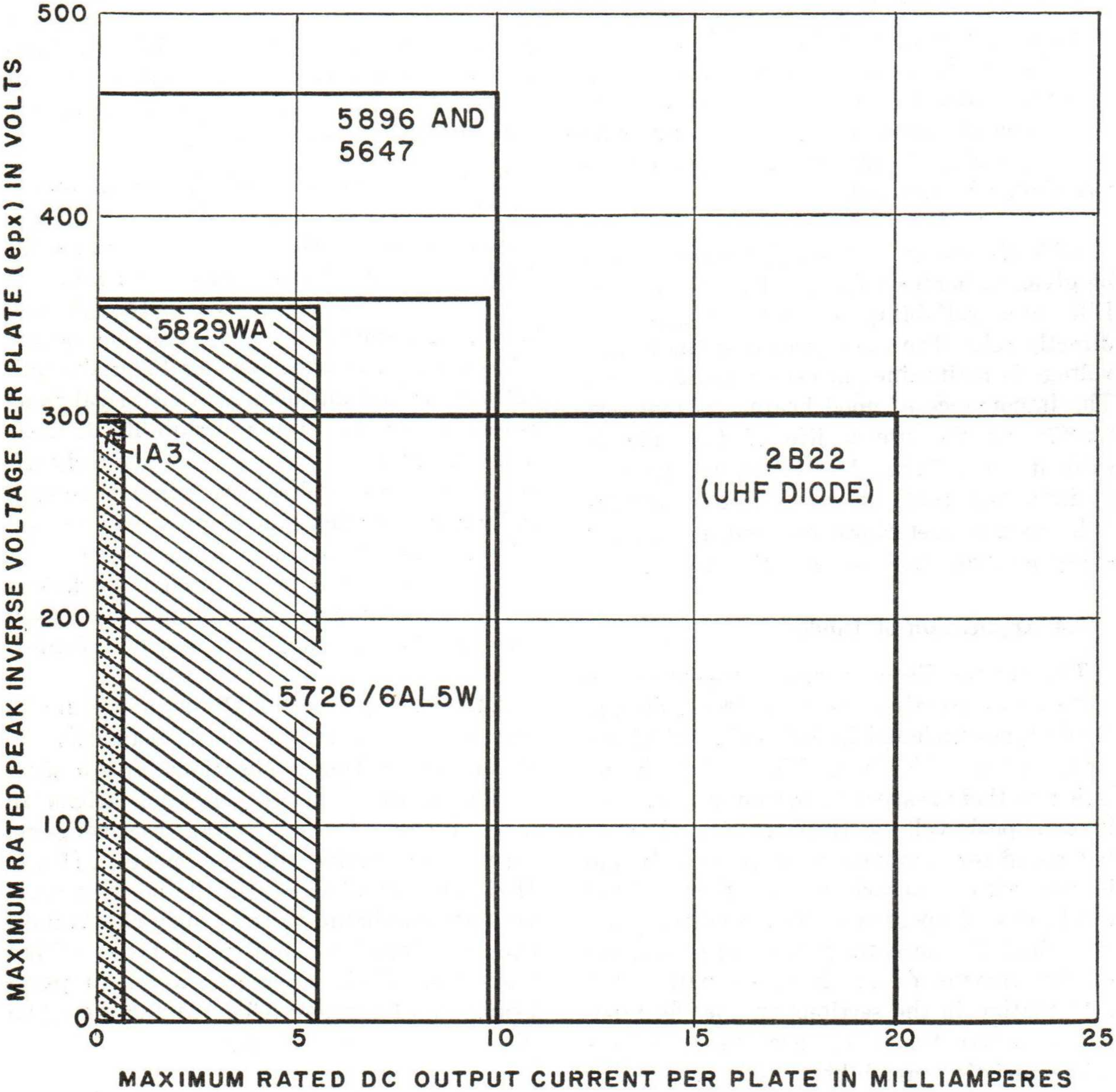


Figure 3-18. Comparison of the Receiving Diodes.

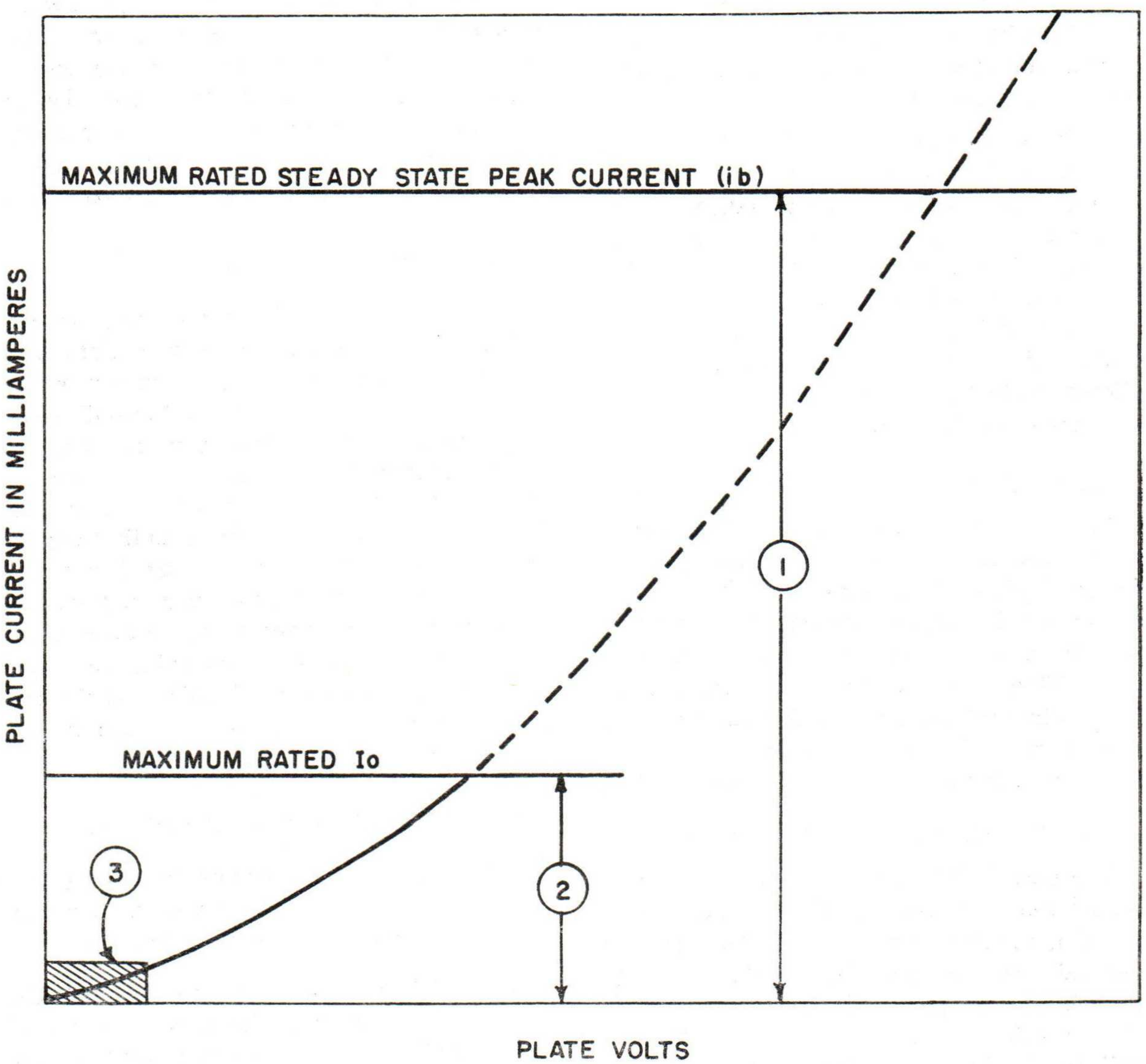


Figure 3-19. Typical Rating Chart A for Receiving Diodes.

otherwise noted in individual tube type sections, circuit operation is not assured when the tube, after being held at a low value of plate current for appreciable periods of time, is subjected to higher current demands. Examples of this service are all types of intermittent operation wherein heaters remain energized under conditions of very low or no plate current.

(b) Heater Operation. Attention should be given to heater voltage tolerance ratings. Life and reliability of performance are directly related to the degree to which the heater voltage is maintained at center rated value. Specifications for some types enforce a control of heater current toward a design center value through maximum limits on the allowable shift of lot averages and a limit on the spread or dispersion.

3.5 Application of Converters and Mixers

This section discusses mixer and converter properties and methods of treating them in circuit design. In general, the factors and design considerations discussed have a direct relationship to converter or mixer performance. Where test conditions are mentioned, it is to be understood that the conditions of measurement in use in the applicable specification is implied, unless otherwise stated.

3.5.1 *Permissible Operating Region*

The permissible operating region must be considered in relation to the published specification maximum ratings of the type. In general, as the operating conditions approach one or more of these ratings, life of the tube in its operating environment will be shortened and the reliability of its equipment will be impaired. The specified ratings define boundaries of operation beyond which there is absolutely no assurance of satisfactory performance. Reference to the Data of Part III concerning the specific tube types; 5636, 5725/6AS6W, 5750/6BE6W, and 5784WA will portray figures of the permissible operating region outlined and so labeled.

3.5.2 *Maximum Screen Dissipation*

All of the types mentioned posses limitations of operation imposed by the screen dissipation rating. In converter applications, where high values of AVC voltage may be applied to the outer signal grid, the total space current may be drawn to the screen (oscillator anode). Protective circuitry in the form of biasing resistance or current limiting resistance should be considered in order that this rating need not be exceeded.

3.5.3 *Temperature Problem*

The general remarks concerning triodes and pentodes are applicable to mixers and converters. A functional relationship exists between elements of the tube, the bulb temperature and the effective environment. In effect, specification life tests define safe internal element temperatures by demanding fixed input power and fixed bulb temperatures, irrespective of the external environment. The life of a tube operating within ratings will, in general, be improved by proper cooling of the glass bulb. In many cases, proper choice of shields, sockets and mounting clamps[2] can materialy aid in the solution of a temperature problem.

3.5.4 *Electrode Voltage Boundaries*

Although more applicable in gating circuitry than in mixer or converter services, MIL-E-1 states in paragraph 6.5.1.1:

> "Unless otherwise specified in the tube specification sheet, when the load impedance is of such type that the instantaneous voltage at the plate never exceeds the supply voltage, the supply voltage may be twice the maximum rated dc plate voltage, provided the maximum rated average dissipation is never exceeded on any electrode."

3.5.5 *Minimum Plate Current Region*

[2] WADC Technical Report 53-174.

Under standard specification requirements in this category of electron tubes, circuit operation in the minimum space current region is not assured for protracted periods of time. Tube properties are rarely specified in this region and variability of performance may be considerably different from that indicated by the specification limits.

3.5.6 *Questionable Areas of Operation*

Discussion of the questionable areas of operation of the dual control mixer type, in general, reverts to the discussion applicable to pentode tubes, paragraph 3.2.6.

3.5.7 *Initial Velocity Electron Current*

Another questionable area may be considered as any value of grid bias at which initial velocity electron current may flow in the inner grid circuitry. Inner grid behavior of a tube operated in this manner is subject to considerably more variation than otherwise expected. A severe and variable loading effect may be imposed upon inner grid circuitry as well, if the tube is operated in this region.

3.5.8 *Other Design Considerations*

In addition to the limitations in applications imposed by the foregoing conditions, other design considerations, not immediately apparent from the specification, are important to the equipment designer.

(a) *Space Charge Coupling.* A phenomenon known as space charge coupling is found in application of multiple grid converter tubes. This effect is manifested by an apparent lack of isolation of signal and oscillator circuits resulting in "pulling" of the oscillator or radiation of oscillator energy from the signal grid circuitry. In addition, certain loading effects of high Q signal circuitry may result from this phenomenon, prohibiting the use of tubes of these types at elevated frequencies.

(b) *Low Electrode Current.* Unless otherwise noted in individual tube type sections, circuit operation is not assured when the tube, after being held at a low value of plate current for appreciable periods of time, is subjected to higher current demands. Examples of this service area all types of intermittent operation wherein heaters remain energized under conditions of very low or no plate current.

(c) *Heater Operation.* Attention should be given to heater voltage tolerance ratings. Life and reliability of performance are directly related to the degree that heater voltage is maintained at center rated values. The importance of good heater voltage regulation on the useful life of the tube is evident from Table 1-2 (Part I). Here it is apparent that excessive heater voltage will hasten deterioration within almost every electron tube defect category.

(d) *Bias Conditions.* The apparent variability of characteristics of many pentode tube types, as reflected in the specification, is greatly reduced through the use of cathode bias under test conditions. It can be expected, therefore, in applications employing fixed bias, that characteristic variability will exceed that which is evident or such types under MIL-E-1 test conditions.

(e) *Grid Return Resistance.* In general, assurance of operation is lost if the application departs from those values utilized in the test circuits of the specification. However, high frequency mixer and converter operation gives rise to several unusual effects such as Flutter and Superregeneration. These effects are influenced by choice of proper grid circuit resistance. Flutter is a descriptive term denoting two ills of converter operation, both resulting from the voltage sensitive frequency stability of the oscillator section. Common coupling through the internal impedance of the plate supply has been known to produce Flutter due to small audio signal detuning effects carried back to the oscillator section by its anode circuit. These audio fluctuations may cause a detuning of the oscillator such that the "flutter" may become self-sustaining. A second flutter is related to the AVC action reducing the plate current drain, with resultant rise in supply voltage and detuning of the oscillator. These effects may often be corrected by increasing and stabilizing the oscillator grid return resistor, since such effects are related to it. Superregeneration is usually confined to the upper frequencies and is related to the choice of time constant in the oscillator grid circuit. Insertion of a small carbon resistor (27-56 ohms) in the grid circuit tends to reduce and stabilize the oscillator drive at the high frequency end of each band, thus reducing the tendency to superregenerate. In converter and mixer applications in which a negatively biased signal grid is situated between two positive grids, "blocking" may occur if the circuit resistance in the signal grid circuit is too high. A momentary highly positive transient on the signal grid can result in secondary emission which may produce sufficient potential drop in the grid circuit to cause the grid to block itself at a stable positive voltage.

(f) *Pulse Operation.* Inasmuch as certain applications of these types in gating circuitry involve pulse signals, it is well to recall that: In general, the testing of all electron tubes is performed at discret test points and unless specific tests provide assurance of pulse operation, assumptions may not be made regarding such operation. Specifiication assurance of characteristic uniformity rarely exists in the positive grid region. The attention of the designer is again directed to the observations concerning low electrode currents typical of operation in pulse circuitry discussed in paragraph 3.2.9 (b).

(g) *Triode Connection.* Unless specifically provided for in the individual test specification sheet, no assurance of performance of these types exists when they are connected in manners other than provided for by the specification i.e., triode connection for space charge operation.

(h) *Low Supply Voltage Operation.* There is no assurance of characteristic uniformity when the tube is operated from very low plate and screen supplies such as 28 volts dc. In addition, low values of screen voltage reduce the control grid bias required for cutoff of plate current. With every low values of screen voltage, the cutoff value of bias may approach the "contact potential" of the tube causing operation in the questionable area of "initial velocity electron current".

(i) *Screen Grid Circuit Protection.* Designers should insure that plate and screen supply voltages are supplied from a common chassis plug or preferably a common terminal within each individual chassis to prevent the accidental removal of plate voltage without concurrent removal of screen grid voltage. Removing the plate supply voltage with the screen grid voltage remaining on can result in excessive screen grid current and screen dissipation, resulting in severe deterioration of electrical characteristics, or even destruction of the screen.

3.6 Applications and Specification Data for the Receiving Tube Types of MIL-STD-200.

This section consists of specific information for all receiving tubes of MIL-STD-200. The rating charts previously discussed are shown, together with limit information derived from the specification and design center information supplied by the original RETMA registrant of each particular tube type.

Since the symbols and notations used in electron tube specification work are somewhat different than those presented by other standards in the electronics industry, a list of these is included. Since this handbook places an emphasis upon the specification MIL-E-1, these symbols are used wherever applicable.

3.6.1 *Abbreviations and symbols.* For the purpose of simplification, the following abbreviations and symbols are used herein and on the tube specification sheets wherever practicable.

Å.......... Angstrom unit
A.......... Amperes (may be either ac rms or dc)
a........... Amperes (peak value) or anode
Aac........ ac amperes (rms)
α (alpha)... Attenuation constant
ac.......... Alternating current
Adc........ dc amperes
ALD....... Acceptance limit for sample dispersion
AQL....... Acceptable quality level
β (beta).... Phase constant
B/Yo....... Tuning susceptance
c........... Velocity of light
C.......... Capacitance
°C.......... Degrees centigrade
cb.......... Centibels
Cgk, Cgp, Cpk, etc... Tube capacitance between the electrodes indicated
Cin......... Input capacitance
Ck.......... Capacitor between cathode and ground
CL......... Load capacitance
cm......... Centimeter r
Cout........ Output capacitance
cps......... Cycles per second
CRO....... Cathode ray oscilloscope
ct.......... Center tap
CW......... Continuous wave
△ (delta)... A change in the value of the indicated variable. When expressed in percent the difference in readings is divided by the initial reading and multiplied by 100
db.......... Decibels
D1,2,3,4..... Deflection plates
dc.......... Direct current
DF......... Deflection factor in volts per inch
$\frac{dik}{dt}$......... Rate of rise of cathode current pulse
Du......... The product of time of pulse and pulse repetition rate (duty cycle)
dy.......... Dynode
EB......... Ballistic deflection
Eb,Eb1,2,3.. dc voltage on respective anodes or plates. In the case of multiplex tubes containing more than one operating unit, the number of the unit concerned is inserted between the voltage symbol and the element symbol. For example, E2b, E1p, E1c2, etc. The number of the unit is the number of the plate in that unit
eb.......... Peak dc anode or plate voltage
Ebb......... dc anode or plate supply voltage
Eb/Ib....... Adjust plate voltage to produce the specified plate current
Ec,Ec1,2,3... dc voltage on respective grids
Ecc,Ecc1,2,3. ac supply voltage to respective grids
Ec/Ib....... Adjust grid voltage for the specified plate current
Eco......... dc cut-off grid voltage
ed.......... Voltage peak between anode No. 2 and any deflection plate in cathode ray tubes
Edy........ dc voltage of anode producing secondary emission
Ee......... End-of-plateau voltage
Ef......... Filament or heater voltage
Ef/Po...... Adjust filament potential (with other potentials held constant) to reduce the power output obtained on oscillation by the amount specified
Eg1,2,3..... rms value of ac component of input voltage for respective grids
egk......... Peak voltage drop between grid and cathode
egy,egy1,2,3. Peak forward grid voltage
egx......... Peak inverse grid voltage
Ehk........ Heater-cathode voltage (sign to indicate polarity of heater with respect to cathode)
Eid......... Ignitor voltage drop
Eo.......... dc component of output voltage of rectifiers
EO......... Overvoltage for radiation counter tubes
eo.......... Pulse amplitude
Ep......... rms value of the ac component of plate voltage with respect to cathode
Epp........ ac anode or plate supply voltage
epx......... Peak plate inverse voltage

epy......... Peak forward anode or plate forward voltage

Er.......... Reflector voltage

ER......... Reservoir voltage

Ers......... Resonator voltage

Es.......... dc emission voltage

Es.......... Starting voltages for radiation counter tubes

Esd......... External shield voltage

Esh......... Shell voltage

Esig........ Applied signal voltage

Eta......... Target voltage

Etd......... Average voltage drop between anode and cathode

etd......... Peak voltage drop between anode and cathode

Ez......... Ionization, breakdown, or striking voltage

f........... Filament

F........... Frequency (in cps)

FA......... Maximum frequency above which receiving tube performance deteriorates seriously and sharply

F1......... Maximum frequency at which maximum ratings apply

F2......... Frequency at which maximum plate voltages and plate input are limited to 50 percent of the ratings for F1. For frequencies between F1 and F2 the maximum plate voltage and plate input will be reduced in the correct proportion so that at the frequency F2 these factors will not exceed 50 percent of their maximum ratings

fct......... Filament center tap

fk.......... Filament-cathode return

Fsg......... Frequency of signal generator

ft. L........ Foot lamberts

G........... Acceleration of gravity

G/Yo....... Equivalent conductance

γ (gamma).. Propagation constant

g, g1,2,3..... Grid (number to identify grids, starting from cathode)

g2+4....... Grids having common pin connection

GA......... Gas amplification

Gr......... Gas ratio

H.......... Field strength in gauss

hct......... Heater center tap

ht.......... Heater tap

Ia.......... Anode current

Ib,Ib1,2,3.... dc current of respective anodes or plates

ib.......... Peak value of dc anode or plate current. When used in reference to pulses, the maximum peak current excluding spike

Ic,Ic1,2,3.... dc current of respective grid

ic.......... Peak grid current

Idy......... Current of anode producing secondary emission

If.......... Filament or heater current

if.......... Intermediate frequency

Ig.......... rms value of ac component of grid current

Ihk......... Heater-cathode leakage current

Ii.......... Ignitor current

Ik.......... dc cathode current

ik.......... Peak cathode current

iL.......... Peak load current

int.con...... Internal connection

Io........... dc component of output current of rectifiers per tube

Ip.......... rms value of ac component of plate current

Ir.......... Reflector current

IR.......... Reservoir current

Irs......... Resonator current

Is.......... dc emission current

is.......... Peak emission current

Isg......... dc component of primary emission from grid indicated

Ita......... dc target current

Iz.......... Ionization current

K.......... Degrees Kelvin

k........... Cathode

kc.......... Kilocycles

kMc........ Kilo-megacycles

KTB....... Theoretical resistance noise power

kv.......... Peak kilovolts

kVA........ Kilovolt-amperes

kva......... Peak kilovolt-amperes

kVac....... ac kilovolts (rms)

kVdc........ dc kilovolts

kW......... Kilowatts

kw......... Peak kilowatts

L.......... Lamberts

LAL........ Lower acceptance limit for sample average or sample median

λ (lambda) Wavelength

xo .... Resonant wavelength

Lc.......... Conversion loss or gain (ratio of available signal power to the available intermediate frequency power)

LIb......... Leakage current

Li.......... Insertion loss

*l*m.......... Lumens

LRLM...... Lower reject limit median for a sample of tubes

LS1........ Standardized light source supplied by a coiled tungsten lamp with a lead or lime glass envelope operated at a color temperature of 2,870°K

LSLA...... Lower specification limit for average of acceptable lots

M.......... Figure of merit, or one million

m.......... Meter, or one-thousandth

mA......... ac (rms) or dc milliamperes

ma......... Peak milliamperes

mAac....... ac milliamperes (rms)

mAdc....... dc milliamperes

Mc......... Megacycles

Meg........ Megohms

mftL....... Millifoot lamberts

mH......... Millihenry

mL......... Millilamberts

mr.......... Milliroentgen

MRSD...... Maximum rated standard deviation

ms......... Milliseconds

Mu or u..... Amplification factor

mVac....... ac millivolts (rms)

mVdc....... dc millivolts

mv......... Peak millivolts

MW........ Megawatts

Mw......... Peak megawatts

mW........ Milliwatts

mw......... Peak milliwatts

N.......... Counts for radiation counter tubes

nc.......... No connection

NF......... Noise figure

Npm....... Counts per minute

Nps........ Counts per second

Nr......... Output noise ratio (ratio of noise power output to resistance noise power)

p........... Plate

/p.......... Per plate

Pb......... Plate breakdown factor (epx x prr x lb)

Pd......... Average drive power

pd......... Peak driver power

Pg1,2,3..... Power dissipation of respective grids

Pi.......... Power input (plate)

pi.......... Peak power input

Pj.......... Reactive power in watts

Pl.......... Plateau length

Pn......... Noise output

P'o......... Intrinsic P

Po......... Average power output

Po/Du.......... Peak leakage power

ΔPo, etc./Ef..... Change in Po, etc. of an individual tube, caused by the specified change in Ef

ΔPo, etc./t..... Change in Po, etc. caused by a test (life, shock, fatigue, etc.)

po.......... Peak power output

Pp......... Plate or anode power dissipation

prr......... Pulse recurrence rate in pulses per second

Ps.......... Relative plateau slope

Q.......... Quality of a circuit

QL......... Loaded Q

Qo......... Intrinsic Q or quality of a circuit without external loading

r........... Reflector

r........... Roentgen

R.......... Resistance

Rb......... dc resistance of external plate circuit (by-passed)

Rc......... dc resistance of external grid circuit (by passed)

Rc.......... Reference resistor for noise ratio measurements (for crystal rectifiers)

rf.......... Radio frequency

Rf.......... Resistance in series with filament or heater

Rg.......... Resistance in series with grid

rg.......... Dynamic internal grid resistance

Rk......... Resistance in series with cathode

Rka1, Rka2, Rkrs, Rfrs, etc. Tube resistance between the electrodes indicated

RL......... Load resistance (Unity power factor. Negligible dc resistance.)

rms........ Root mean square

Rp.........	Resistance in series with plate or anode
rp..........	Dynamic internal plate resistance of tube
rs..........	Resonator
Rv..........	Video impedance
S...........	Static sensitivity (phototubes)
s...........	Dynamic sensitivity (phototubes)
se..........	Starter electrode
Sc..........	Conversion trasconductance
Sd..........	Spectral distribution
sd..........	Shield
Sg1, g2, etc.	Transconductance between the elements indicated
sh..........	Shell
σ (sigma)...	"Input" standing-wave ratio in voltage
σ' (sigma) prime)......	"Output" standing-wave ratio in voltage
Sm.........	Transconductance (control grid-plate)
ΔSm, etc.... Ef	Change in Sm, etc. of an individual tube, caused by the specified change in Ef
ΔSm, etc..... t	Change in Sm, etc. caused by a test (life, shock, fatigue, etc.)
Sr..........	Sensitivity ratio (max. Ib to min. Ib)
T..........	Temperature (degrees centigrade)
t...........	Test duration (seconds, unless otherwise specified)
TA.........	Ambient temperature
ta..........	Target
tad.........	Anode delay time. A time interval between the point on the rising portion of the grid pulse which is 26 percent of the maximum unloaded pulse amplitude and the point where anode conduction takes place
Δtad.......	Anode delay time drift
TE.........	Envelope temperature
tf..........	Time of fall. The time duration of pulse to fall from 70.7 percent of the maximum pulse amplitude to 26 percent of the maximum pulse amplitude, excluding spike, in microseconds
THg........	Temperature of condensed mercury in °C
tj..........	Variation in firing time
tk..........	Cathode conditioning time (in seconds) necessary before the application of high voltage. In TR tubes, time delay between application of ignitor voltage and rf power
tp..........	Pulse duration (excluding magnetrons). The time interval between the points on the trace envelope at which the instantaneous amplitudes are equal to 70.7 percent of the maximum amplitude excluding spike. For magnetrons, see 4.16.3.3
tr..........	Time constant of rise (excluding magnetrons). The time duration of a pulse to rise from 26 percent of the maximum pulse amplitude to 70.7 percent of the maximum pulse amplitude, excluding spike, in microseconds
trc.........	Time of rise of current pulse in microseconds (for magnetrons, see 4.16.3.3)
trv.........	Time of rise of voltage pulse in microseconds (for magnetrons, see 4.16.3.3)
u...........	Amplification factor
ua..........	Microamperes, peak value
uAac.......	ac microamperes (rms)
uAdc.......	dc microamperes
UAL.......	Upper acceptance limit for sample average or sample median
umhos......	Micromhos
uf..........	Microfarads
uh..........	Microhenries
URLM......	Upper reject limit median of a sample of tubes
us..........	Microseconds
USLA......	Upper specification limit for averages of acceptable lots
uuf.........	Micromicrofarads
uVac.......	ac microvolts (rms)
uVdc.......	dc microvolts
uW.........	Microwatts
V..........	Volts (may be either ac rms or dc)
v...........	Volts, peak value
VA.........	Volt-amperes
va..........	Peak volt-amperes
Vac........	ac volts (rms)
Vdc.........	dc volts
v/in........	Volts, peak value, per inch of deflection

Vj.......... Amplitude jitter
VSWR...... Voltage standing wave ratio
VU......... Volume units
Vx......... Extinguishing voltage
W.......... Watts
w.......... Peak watts
Ws......... Spike leakage energy
X1......... The orientation of a tube rigidly mounted for mechanical tests with the main axis of the tube and the major cross-section of the tube elements normal to the direction of the accelerating force
X2......... The orientation of a tube rigidly mounted for mechanical tests with the main axis of the tube normal and the major cross-section parallel to the accelerating force
x........... Denoting peak inverse value
Y1.......... The orientation of a tube rigidly mounted for mechanical tests with the main axis of the tube parallel to the direction of the accelerating force. (When Y1 is referred o for shock tests, the principal base of the tube is toward the hammer)
Y2......... The orientation of a tube (for shock test only) which is the same as Y1 except that the principal base of the tube is away from the hammer
y........... Denoting peak forward value
Z........... Impedance
Zd.......... Impedance to anode of deflection plate circuit at power-supply impedance
Zg.......... Impedance of the grid circuit
Zgg......... Impedance between grids of pushpull circuit
Zgk......... Impedance between grid and cathode
Zi.......... Input impedance
ZL......... Load reactance (with negligible dc resistance)
Zm......... Modulator frequency load impedance
Zo.......... Output impedance and characteristic impedance
Zp.......... Impedance in plate circuit
Zpp......... Impedance between plates in pushpull circuit
1D2........ Deflection produced by the deflection plates near the screen (for cathode-ray tubes)
3D4........ Deflection produced by the deflection plates near the base (for cathode-ray tubes)
**.......... Qualification test
*........... Standard design test
#.......... Special design test
†........... Test to be performed at the conclusion of the holding period (See 4.5)
←......... Indicates change on tube specification sheet
←o....... Indicates deletion from the tube specification sheet

SECTION

TUBE TYPE JAN–1A3

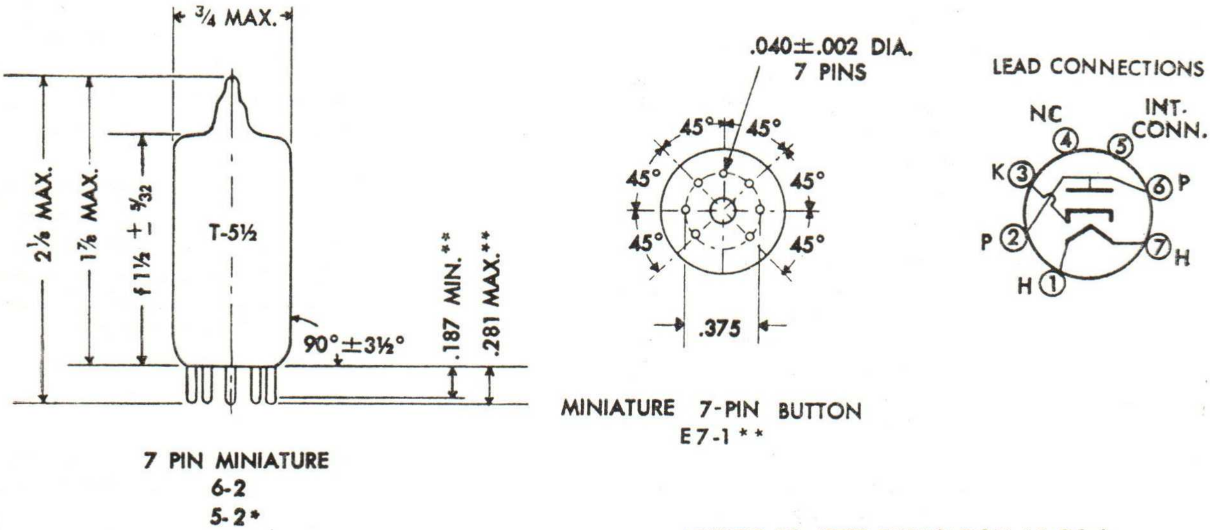
DESCRIPTION.

The JAN–1A3 [1] is a seven pin, button base miniature, heater-cathode type U.H.F. diode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	1.4 Vdc
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-20. Outline Drawing and Base Diagram of Tube Type JAN-1A3.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	1.4 Vdc ± 15%
Peak Inverse Plate Voltage	365 v
Steady State Peak Plate Current	5.5 ma
DC output current	0.55 mAdc
Heater Cathode Voltage	100 V
*Altitude Rating	10,000 ft

* No test for this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/19 dated 5 February 1953.

TEST CONDITIONS AND CHARACTERISTICS

Test conditions and characteristics are as follows:

Heater Voltage, Ef	1.4 Vdc
Secondary Voltage to Plate, Epp.	50 Vac
Series Resistance, Rp	0.1 Meg
Load Capacitor, CL	2 uf

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/19 dated 5 Feburary 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		138	162	—	—	mAdc
Operation	Io	Ef = 1.1 V	0.36	—	0.30	—	mAdc
Emission	Is	Eb = 10 Vdc Ef = 1.1. V	0.8	—	—	—	mAdc
Heater-Cathode Leakage	Ihk	Ehk = Eo	0	20	—	—	uAdc
Resonant Frequency		F = 500 mc	(See specification for limits)				
Capacitance (Unshielded)	Cpkl	Ef = 0	0.2	0.6	—	—	uuf
	Cph	Ef = 0	0.6	1.0	—	—	uuf
	Chk	Ef = 0	0.4	0.8	—	—	uuf

APPLICATION

SIGNAL RECTIFIER SERVICE: In the application of JAN-1A3 in signal rectifier and discriminator service, Chart "A" relates boundaries to permissible operation and the questionable area of operation, to the plate characteristic.

Permissible steady state peak plate current is limited to 5.5 milliamperes, to define boundary (1), and dc output current is limited to 0.55 milliamperes, to define boundary (2). Area (3) is defined as questionable from the standpoint of uniformity and stability of plate current in low-level signal applications. Reference should be made to Section 1.3.4 for a review of the behavior of initial electron velocity and contact potential in tubes in general, where the control grid currents discussed are equivalent to plate currents in signal diode application.

SUPPLY VOLTAGE RECTIFIER SERVICE: Rating Charts for supply voltage rectifier service are not provided for the JAN-1A3.

OTHER CONSIDERATIONS.
HEATER VOLTAGE: See paragraph 3.4.3.
LOW ELECTRODE CURRENT: See paragraph 3.4.3.

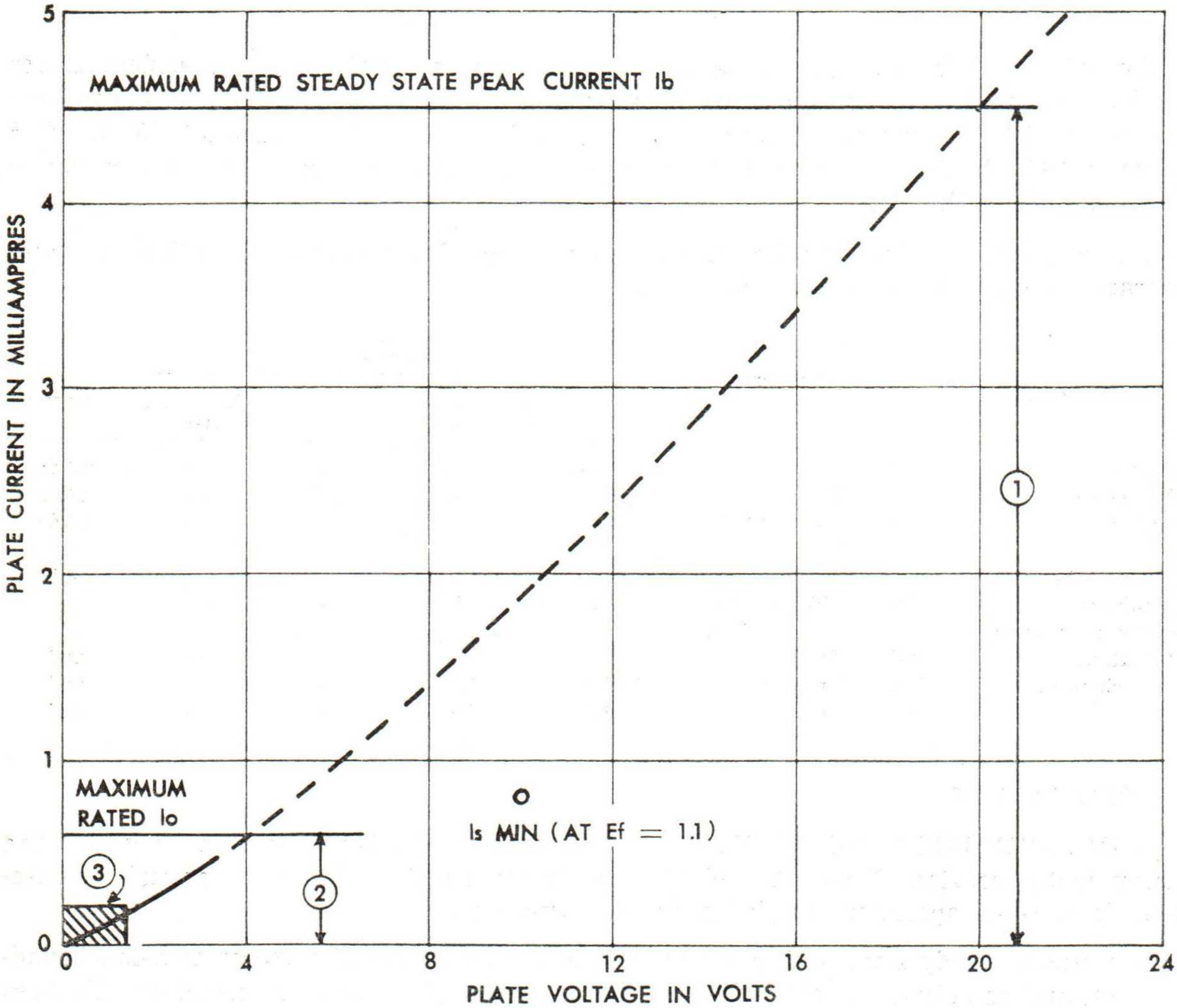


Figure 3-21. Permissible Limits of Operation for Tube Type JAN 1A3.

TYPICAL CHARACTERISTICS

The chart below presents the Static Plate Characteristic of JAN-1A3, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

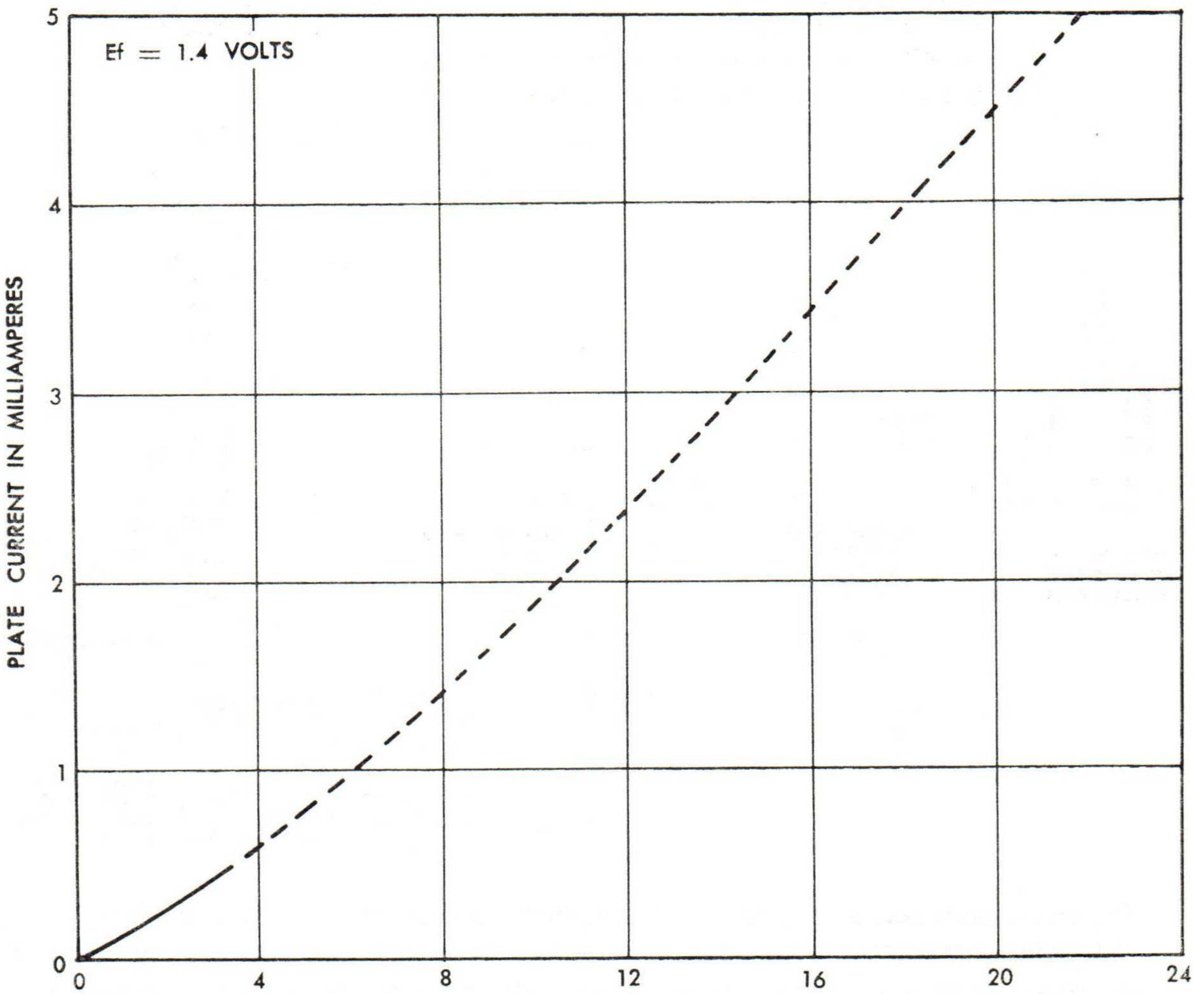


Figure 3-22. Typical Plate Characteristics for Tube Type JAN-1A3.

SECTION

TUBE TYPE JAN-1AD4

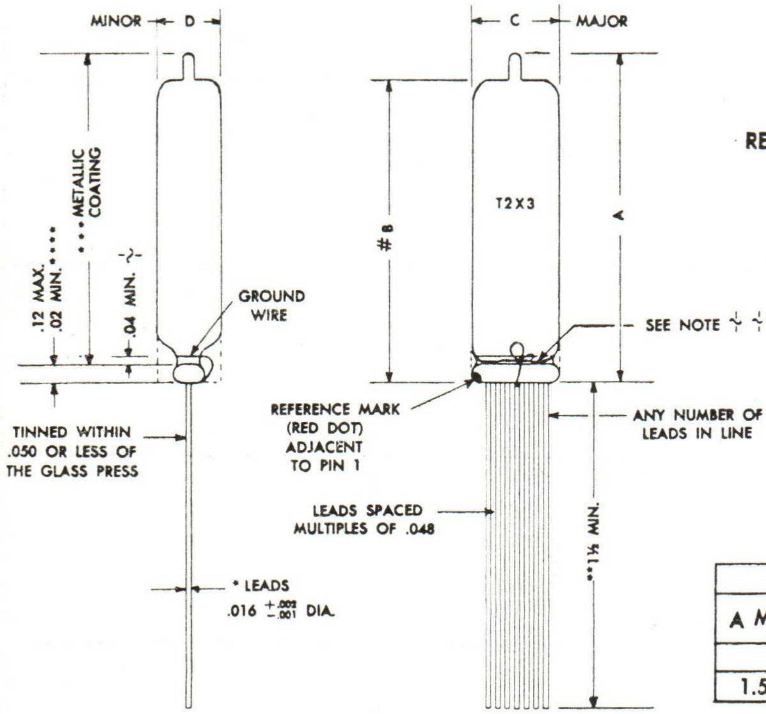
DESCRIPTION.

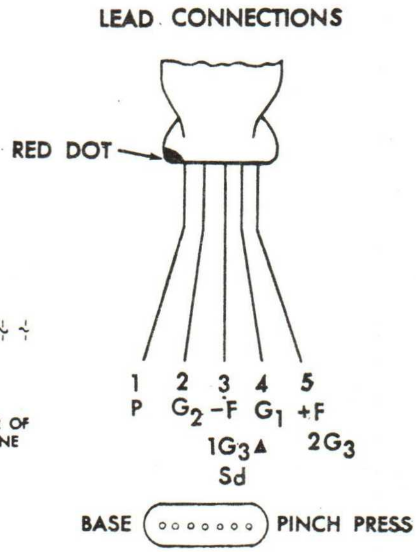
The JAN-1AD4[1] is a 5 lead, pinch press, subminiature RF sharp cut-off filamentary receiving pentode with a metallic shield coating.

ELECTRICAL. The electrical characteristics are as follows:

Filament Voltage .... 1.25 Vdc
Filament Current .... 88 – 112 mAdc
Cathode .... Coated Filament

MOUNTING. Any type of mounting is adequate.





DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

*** WHEN SPECIFIED ON THE TSS

**** APPLIES TO PINCH PRESS TYPES ONLY (.02 MIN.)

† GROUND LEAD OVERLAPPED BY SHIELD BY A MINIMUM OF .04

†† SHIELD TO GROUND WIRE MAY BE FROM EITHER SIDE OF THE MAJOR DIMENSION. ALTERNATIVE CONSTRUCTION: UNUSED OR EXTRA RANDOM LEAD IN PRESS OR BUTTON MAY BE FOLDED BACK AND WRAPPED AROUND BULB TO MAKE CONTACT WITH SHIELD.

▲ GRID 3 IS COMPOSED OF 2 SEPARATE DEFLECTOR PLATES, ONE OF WHICH IS CONNECTED TO PIN 3 AND THE OTHER TO PIN 5

Figure 3-23. Outline Drawing and Base Diagram of Tube Type JAN-1AD4.

[1] The values and specification comments presented in this section are related to MIL-E-1/20A dated 9 July 1953.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Filament Voltage	1.25 ± 0.25 Vdc
*Plate Voltage	100 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
*Screen Grid Voltage, Maximum	100 Vdc
*Cathode Current, Maximum	7.0 mAdc
*Altitude Rating	10,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	1.25 Vdc
Control Grid Voltage, Ec1	0 Vdc
Plate Voltage, Eb	45 Vdc
Screen Voltage, Ec2	45 Vdc
Control Grid Series Resistance	2 Meg

* No test of operation at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/20A dated 9 July 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		88	112	—	—	mA
Transconductance (1)	Sm	Ef = 1.0 Vdc	1200	2500	—	—	umhos
Transconductance (2)	Sm		1500	2500	1200	—	umhos
Plate Current (1)	Ib		1.9	4.1	—	—	mAdc
Screen Grid Current	Ic2		0.5	1.3	—	—	mAdc
Plate resistance	Rp		0.2	—	—	—	Meg
Capacitance	Cgp		—	0.01	—	—	uuf
	Cin		3.0	5.0	—	—	uuf
	Cout		3.0	5.0	—	—	uuf
Grid Current	Ic	Ec1 = −0.5 Vdc Rg1 = 0.1 Meg	—	—0.5	—	—	uAdc

APPLICATION OF JAN-1AD4

The chart below shows the permissible operating area for JAN-1AD4 as defined by the ratings in MIL-E-1/20A dated 9 July, 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.8.

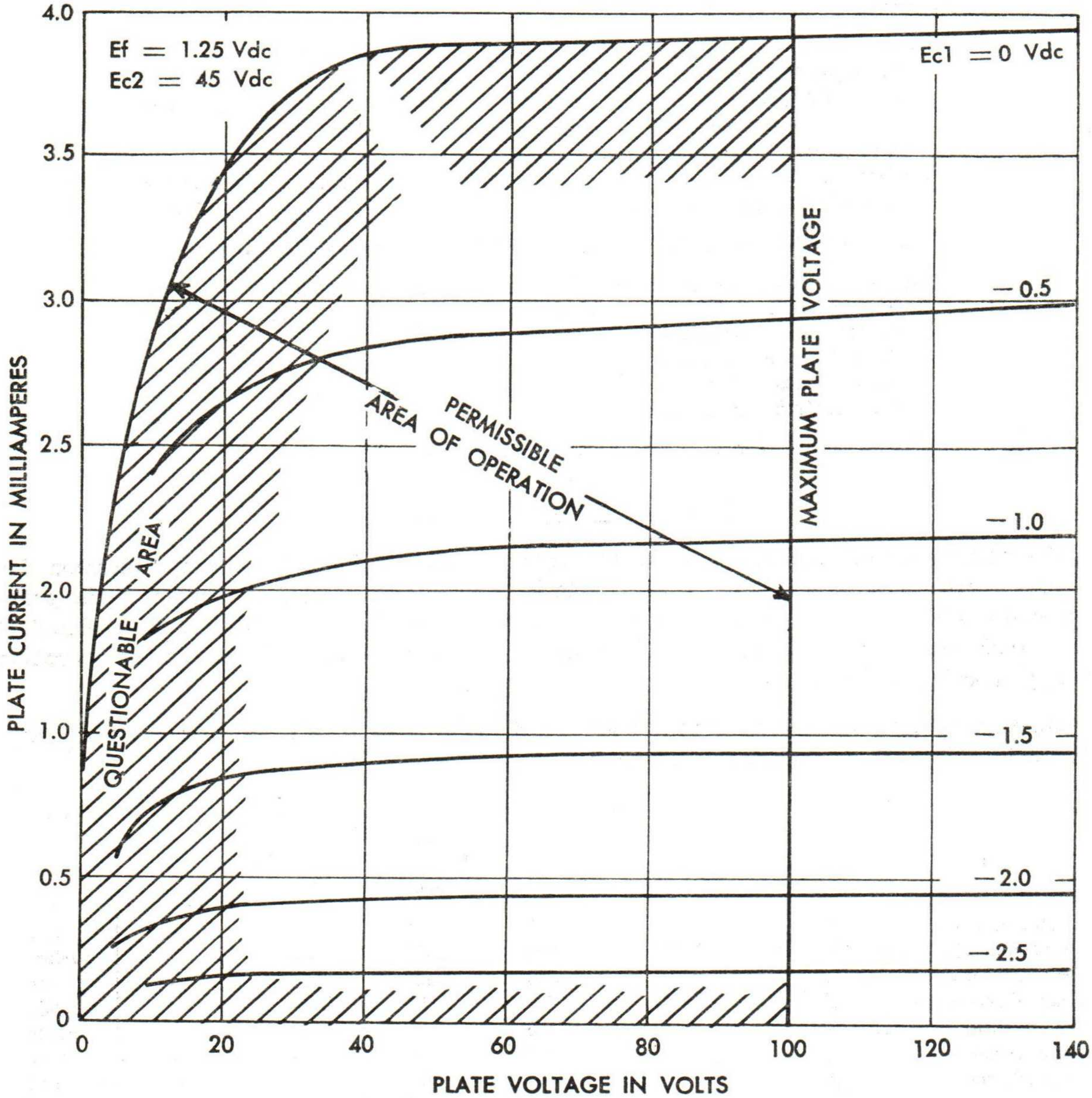


Figure 3-24. Typical Static Characteristics of Tube Type JAN 1AD4; Permissible Area of Operation.

The fololowing table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:

High, 3.2.9

Low, 3.2.2, 3.2.6

28 Volts, 3.2.9

AC Operation, 1.3.3, 3.2.9

Screen Grid:

Supply, 3.2.7

Protection, 3.2.9

Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.3.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-1AD4 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The charts below present the limit behavior of static plate characteristics for JAN-1AD4 as defined by MIL-E-1/20A dated 9 July 1953.

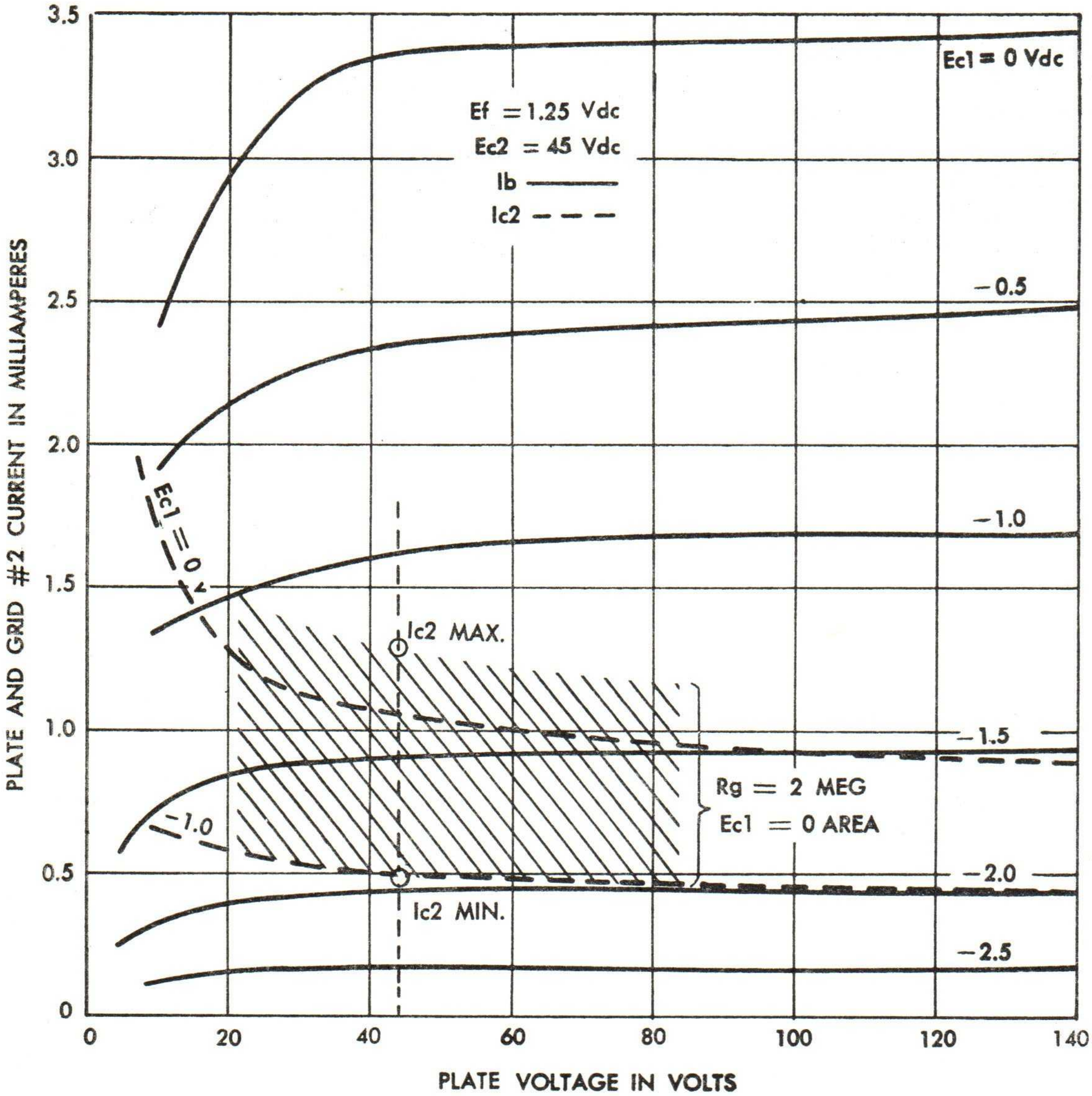


Figure 3-25. Limit Plate Characteristics of Tube Type JAN-1AD4; Variability of Ic2.

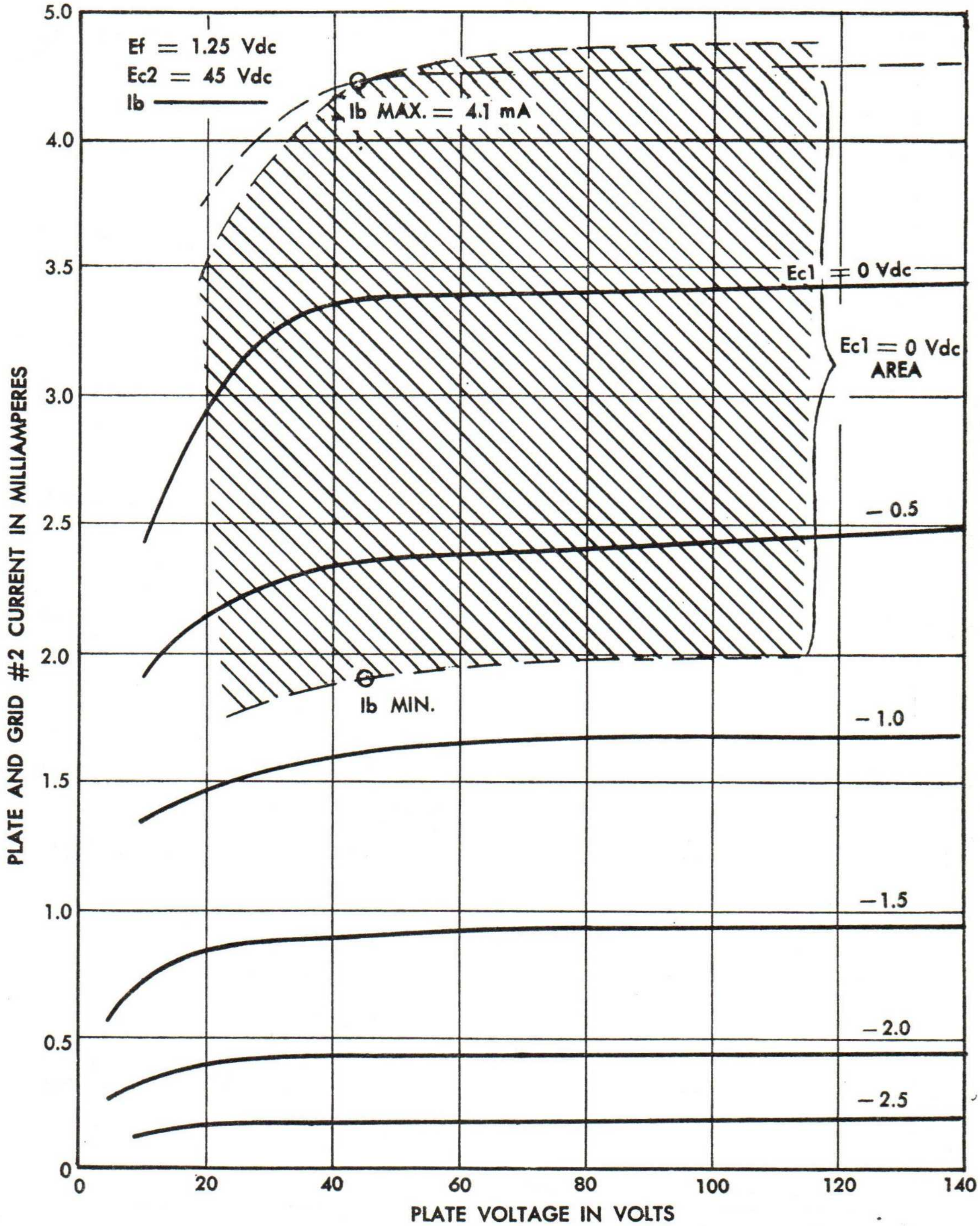


Figure 3-26. Limit Plate Characteristics of Tube Type JAN-1AD4; Variability, Ib.

The chart below presents the limit behavior of transfer data for JAN-1AD4 as defined by MIL-E-1/20A dated 9 July 1953.

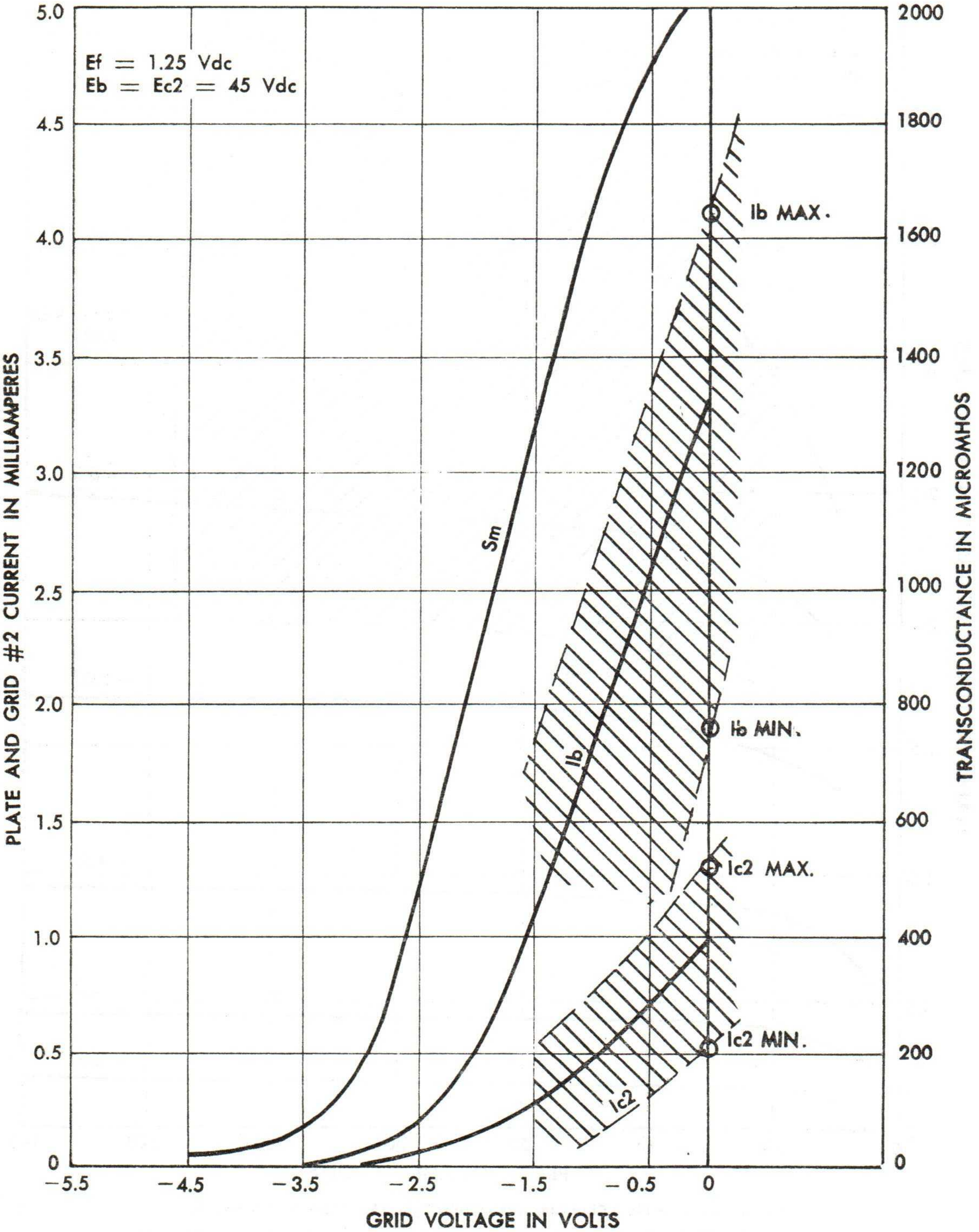


Figure 3-27. Limit Transfer Characteristics of Tube Type JAN 1AD4; Variability of Ib and Ic2.

DESIGN CENTER CHARACTERISTICS OF JAN–1AD4

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN–1AD4.

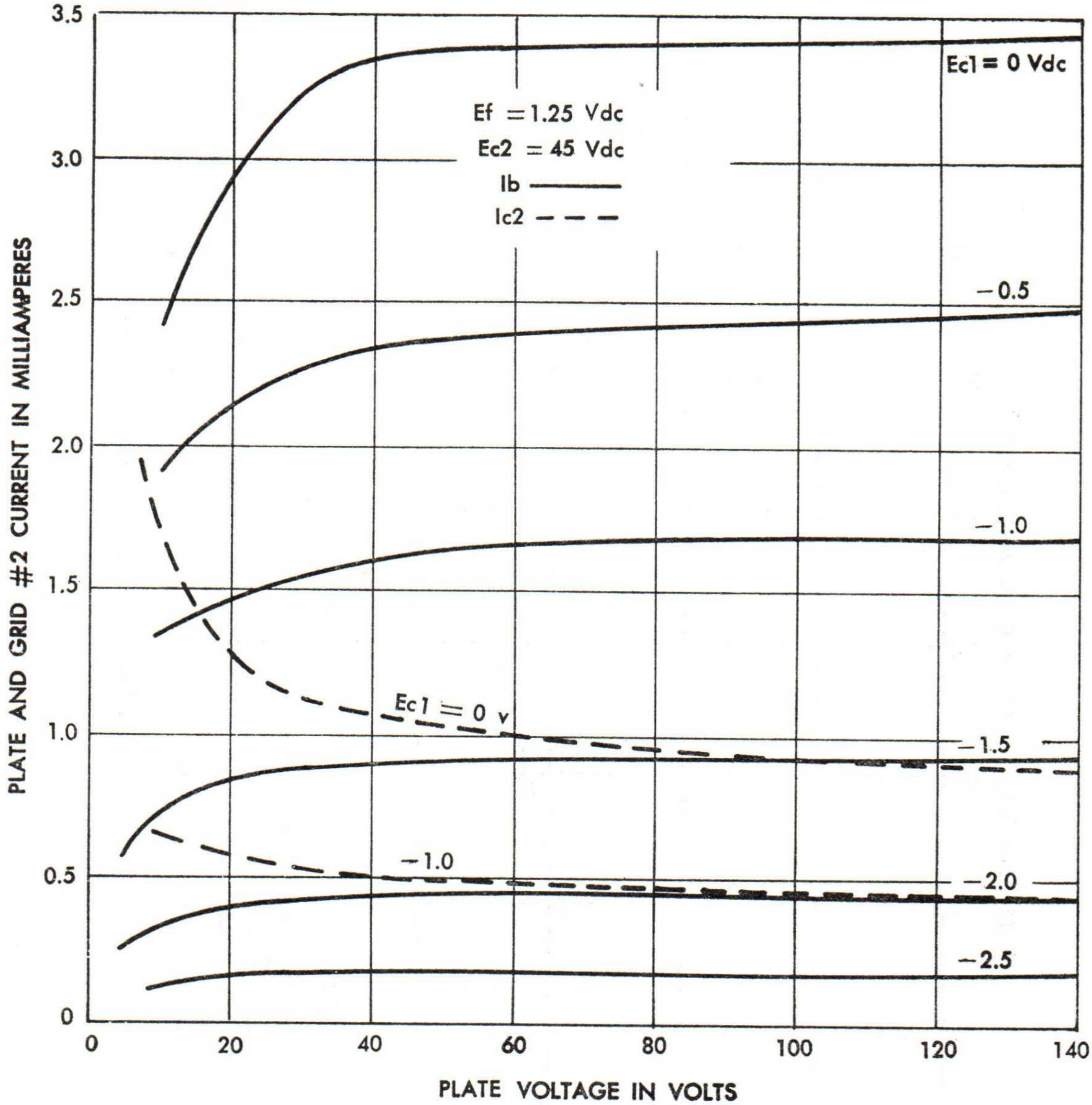


Figure 3-28. Typical Static Plate Characteristics for Tube Type JAN-1AD4.

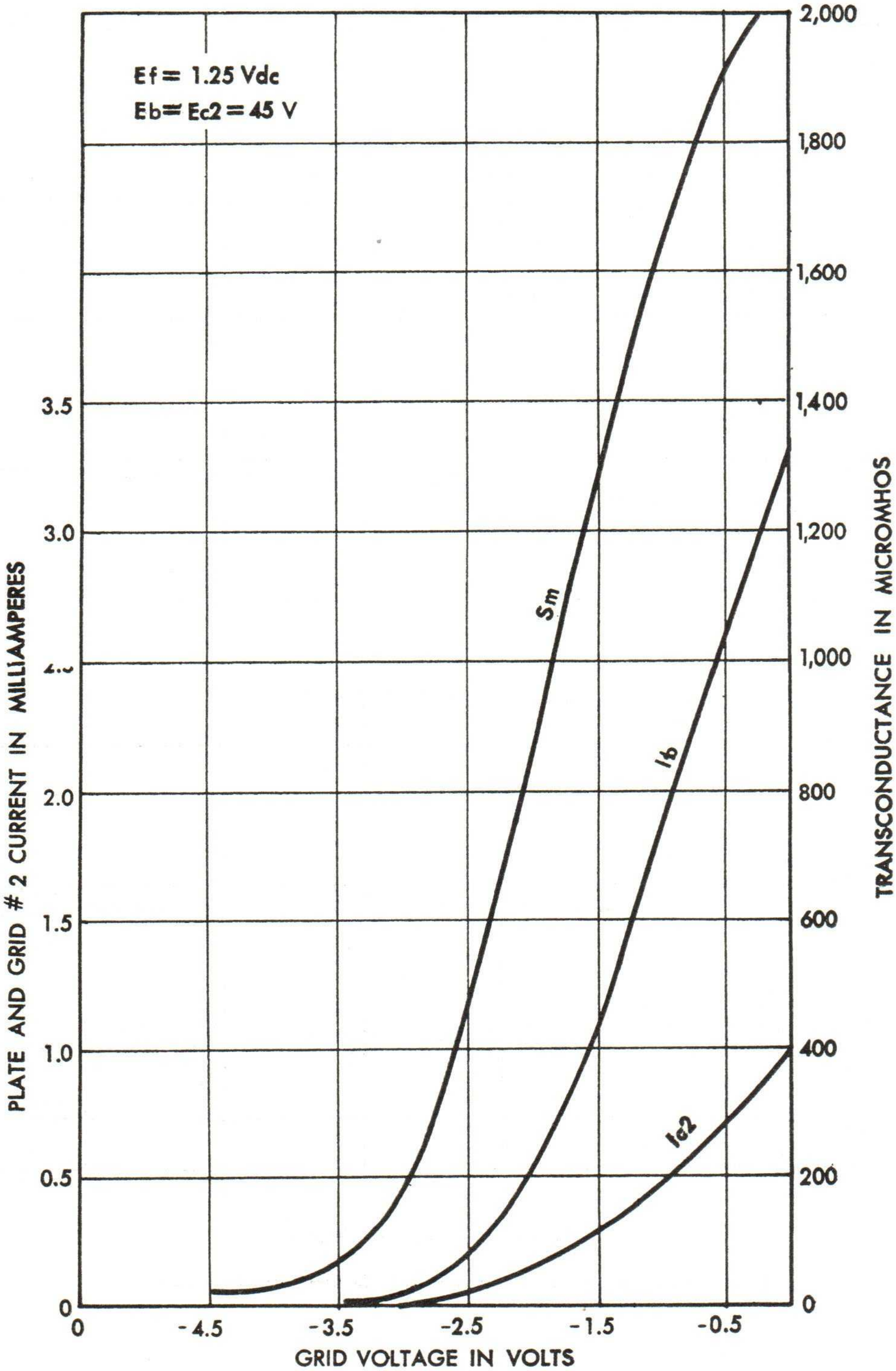


Figure 3-29. Typical Transfer Characteristics of Tube Type JAN-1AD4.

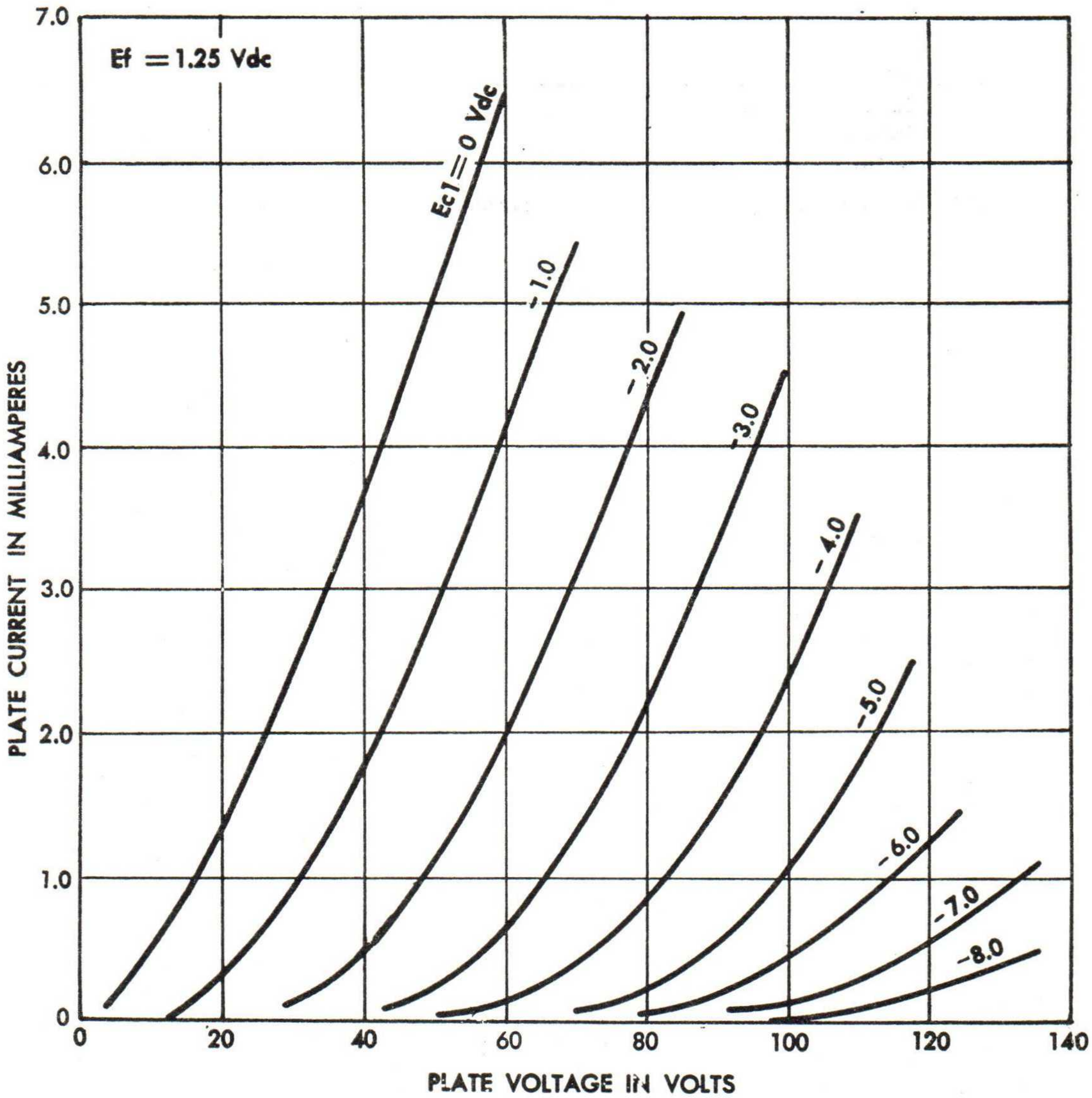


Figure 3-30. Typical Average Plate Characteristics of Tube Type JAN-1AD4; Triode Connected.

SECTION

TUBE TYPE JAN–1AH4

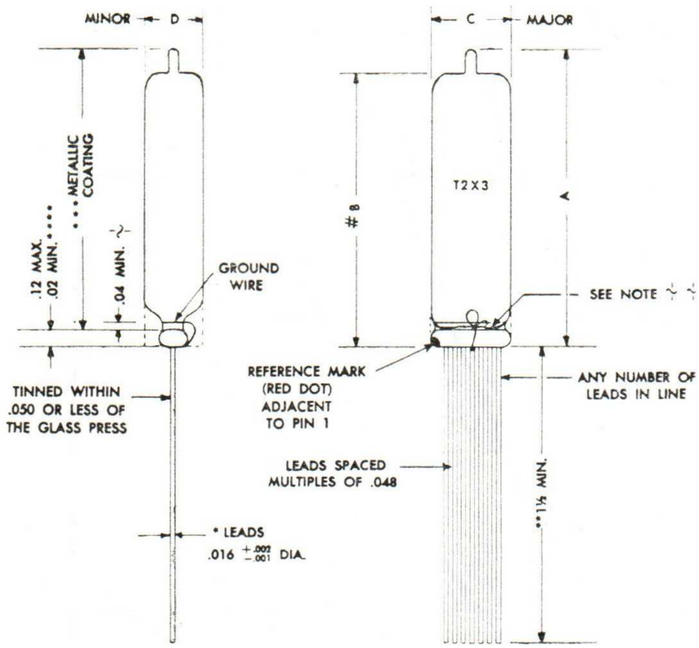
DESCRIPTION.

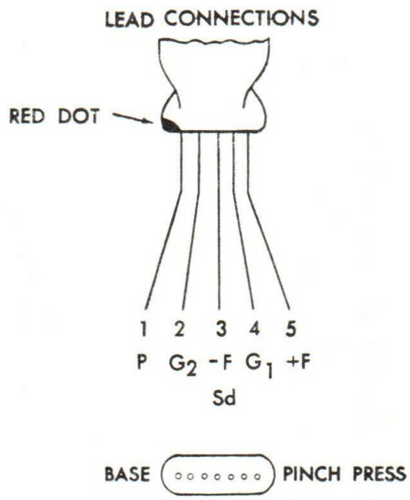
The JAN–1AH4 [1] is a 5 lead, pinch press, subminiature, pentode, with a metallic shield coating.

ELECTRICAL. The electrical characteristics are as follows:

Filament Voltage	1.25 Vdc
Filament Current	36–44 mA
Cathode	Coated Filament

MOUNTING. Any type of mounting is adequate.





DIMENSIONS				
A MAX.	B DIM	B TOL. ±	DIAMETER MAX. C MAX	DIAMETER MAX. D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

*** WHEN SPECIFIED ON THE TSS

**** APPLIES TO PINCH PRESS TYPES ONLY (.02 MIN.)

† GROUND LEAD OVERLAPPED BY SHIELD BY A MINIMUM OF .04

†† SHIELD TO GROUND WIRE MAY BE FROM EITHER SIDE OF THE MAJOR DIMENSION. ALTERNATIVE CONSTRUCTION: UNUSED OR EXTRA RANDOM LEAD IN PRESS OR BUTTON MAY BE FOLDED BACK AND WRAPPED AROUND BULB TO MAKE CONTACT WITH SHIELD.

Figure 3-31. Outline Drawing and Base Diagram of Tube Type JAN-1AH4.

[1] The values and specification comments presented in this section are related to MIL-E-1/316 dated 14 August 1953.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Filament Voltage	1.25 ± 0.25 Vdc
*Plate Voltage	100 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
*Screen Grid Voltage	100 Vdc
*Altitude Rating	10,000 ft

TEST CONDITIONS.

Test conditions are as follows:

Heater Voltage , Ef	1.25 Vdc
Plate Voltage, Eb	45 Vdc
Control Grid Voltage, Ec1	0 Vdc
Screen Grid Voltage, Ec2	45 Vdc
Control Grid Series Resistor	5 Meg

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/316 dated 14 August 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		36	44	...	...	mA
Transconductance(1)	Sm		550	950	400	...	umhos
Transconductance(2)	Sm	Ef = 1.0 V	450	...	...	...	umhos
Plate Current	Ib		0.45	1.1	...	...	mAdc
Screen Grid Current	Ic2		0.12	0.28	...	...	mAdc
Capacitance	Cgp		...	0.01	...	...	uuf
	Cin		2.7	4.2	...	...	uuf
	Cout		3.8	5.2	...	...	uuf
Grid Current	Ic1	Ec1 = 0.5 Vdc Rg1 = 0.5 Meg. Max.	...	—0.5	...	—1.0	uAdc

APPLICATION OF JAN-1AH4

The chart below shows the permissible operating area for JAN-1AH4 as defined by the ratings in MIL-E-1/316, dated 14 August, 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.27 of this manual.

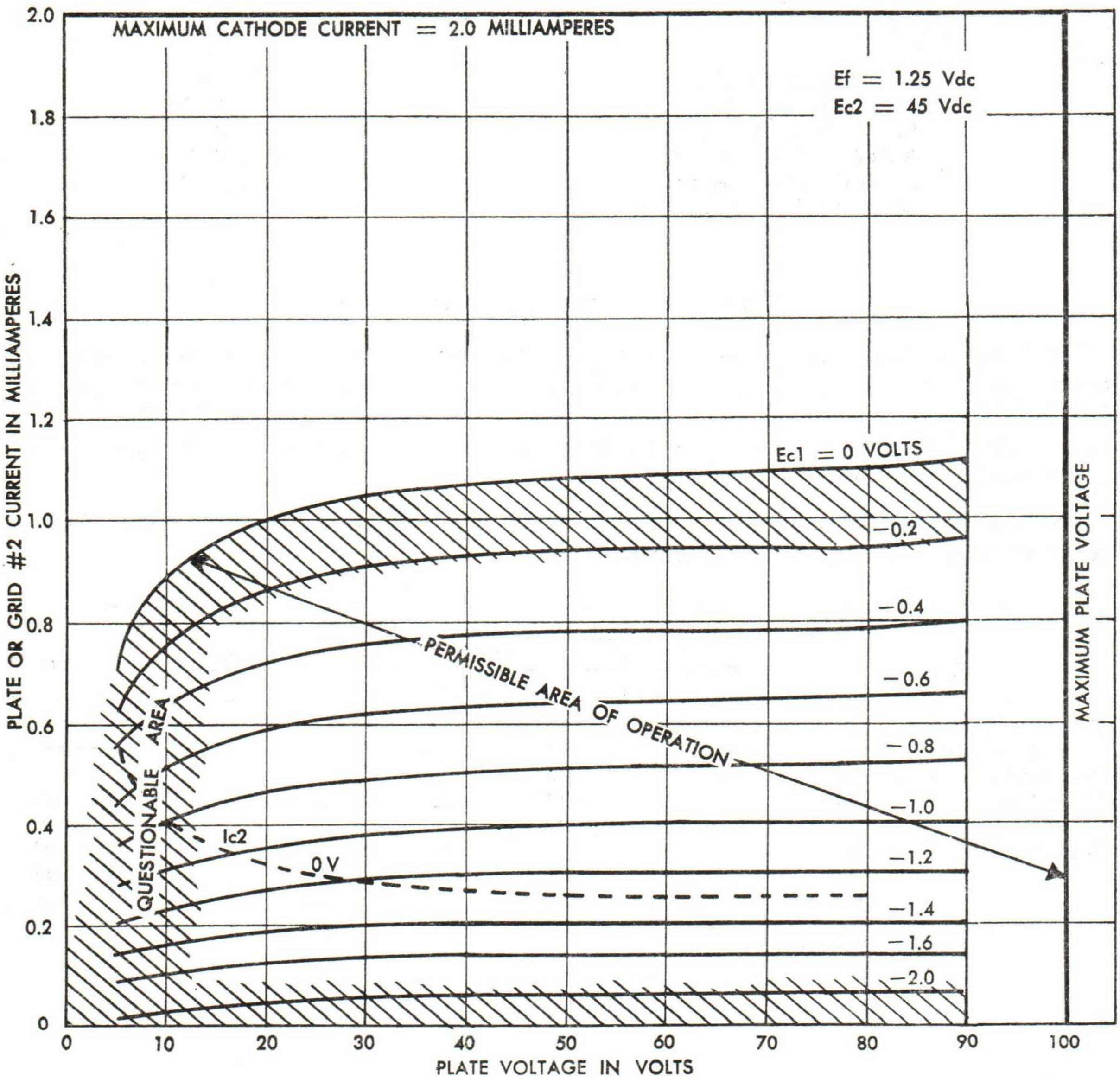


Figure 3-32. Typical Static Characteristics of Tube Type JAN-1AH4; Permissible Area of Operation.

The following table lists general considerations for the application of this type. The paragraph numbers refer to the applicable section or paragraph of this manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

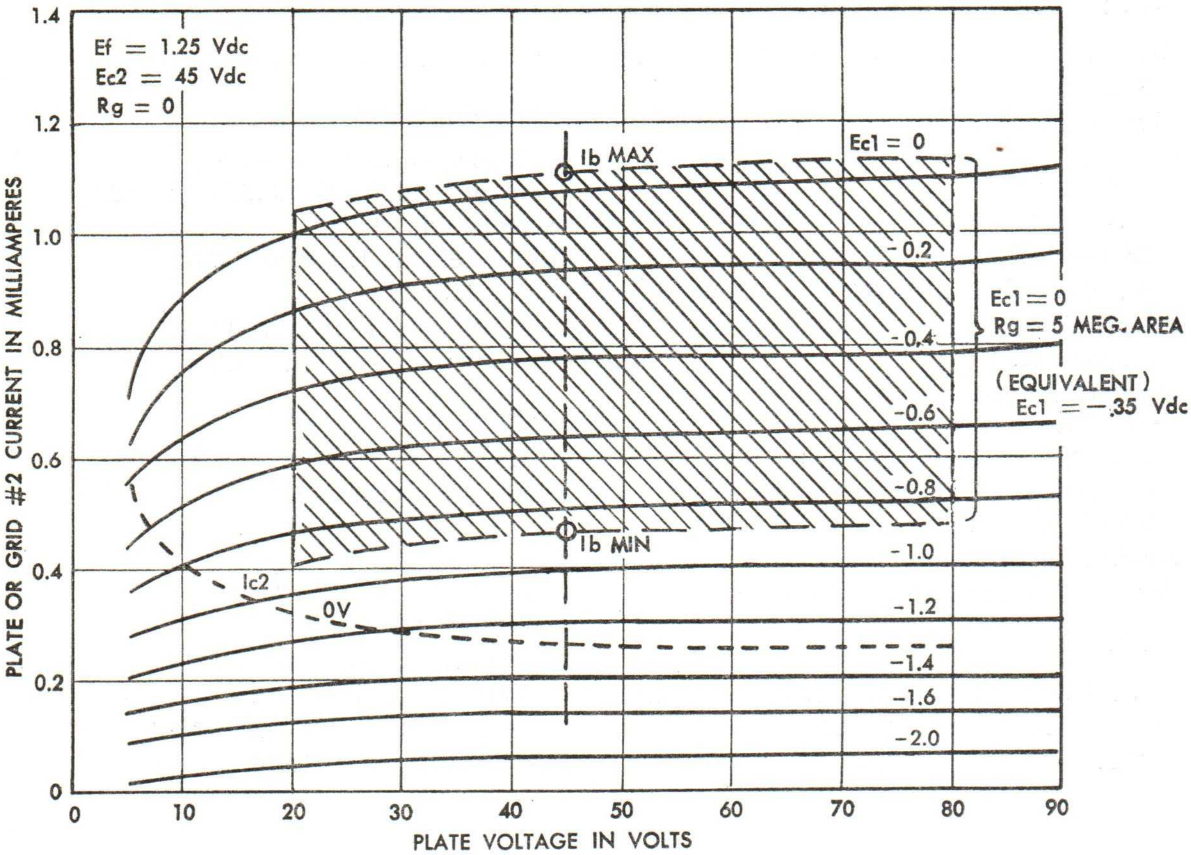


Figure 3-33. Limit Plate Characteristics of Tube Type JAN-1AH4; Variability of Ib.

VARIABILITY OF JAN–1AH4 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given in the applicable specification.

The limit chart on the preceding page presents the limit behavior of static plate characteristics for JAN–1AH4 as defined by MIL–E–1/316, dated 14 August, 1953.

DESIGN CENTER CHARACTERISTICS OF JAN-1AH4

These typical curves have been obtained from current data being published by the original RETMA registrant of the type.

The chart below presents the average transfer data for JAN-1AH4.

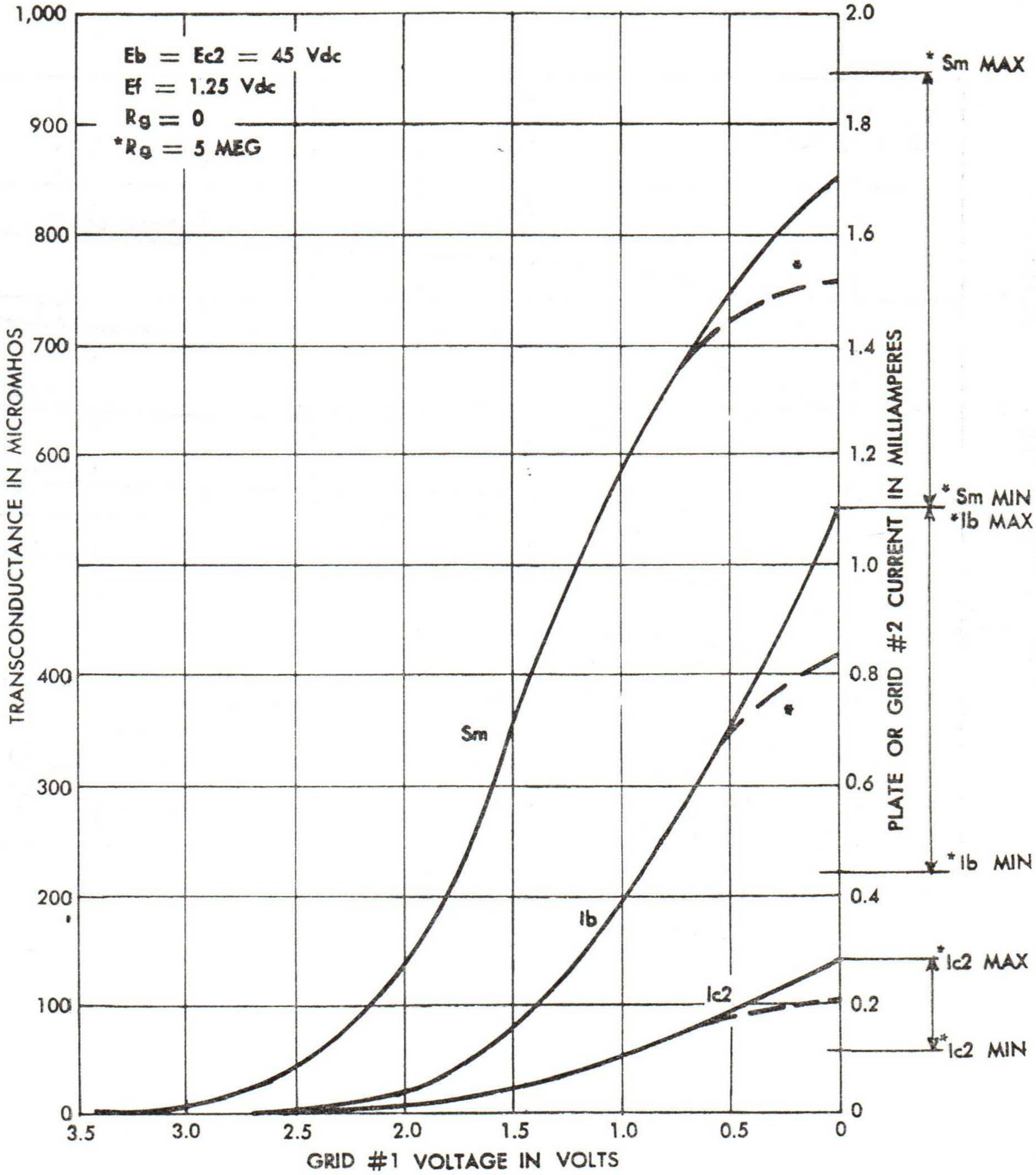


Figure 3-34. Typical Transfer Characteristics of JAN-1AH4.

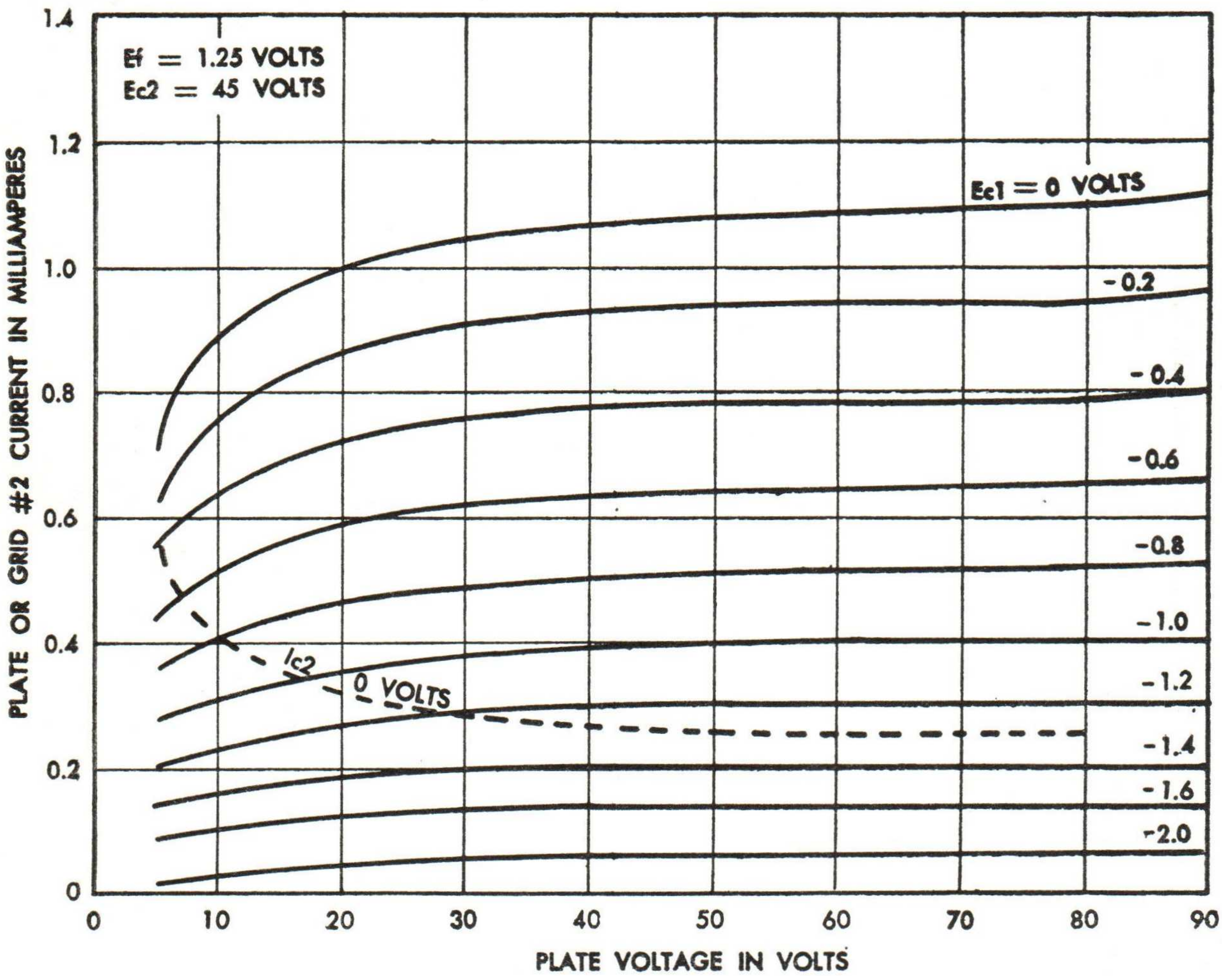


Figure 3-35. Typical Static Plate Characteristics of JAN-1AH4.

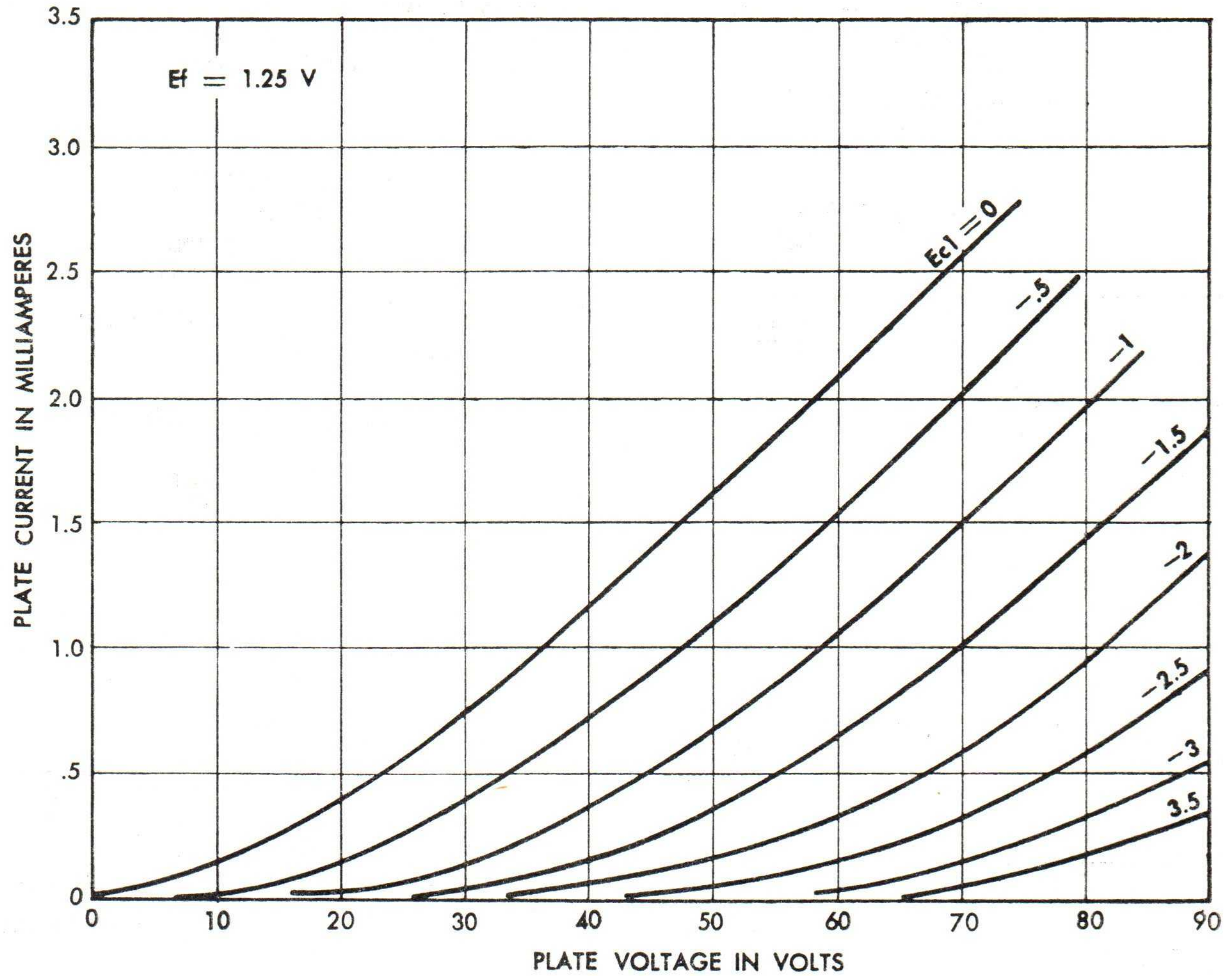


Figure3-36. Typical Triode Connected Characteristics of JAN-1AH4.

SECTION
TUBE TYPE JAN–1B3GT

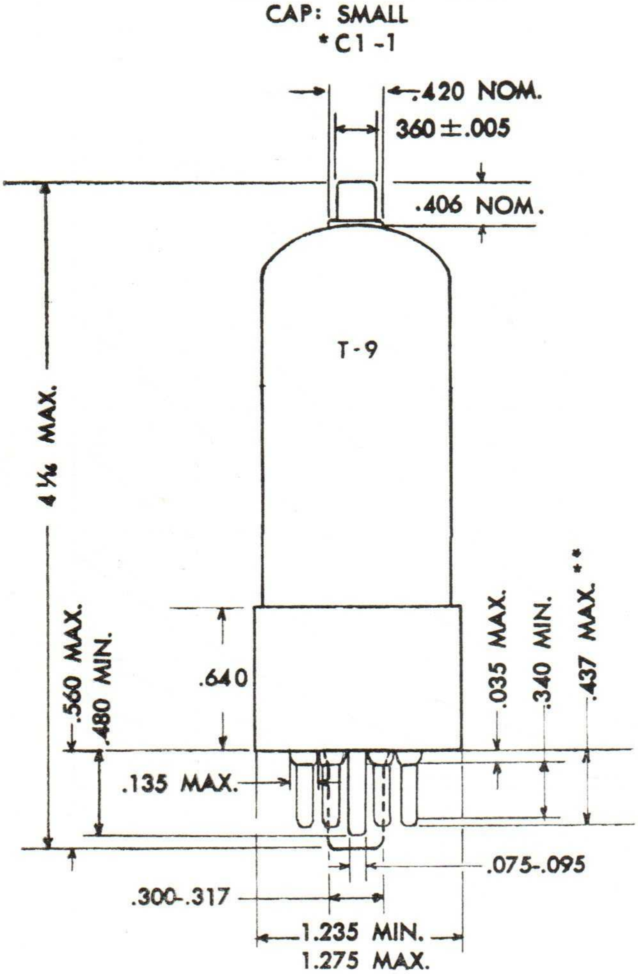
DECRIPTION.

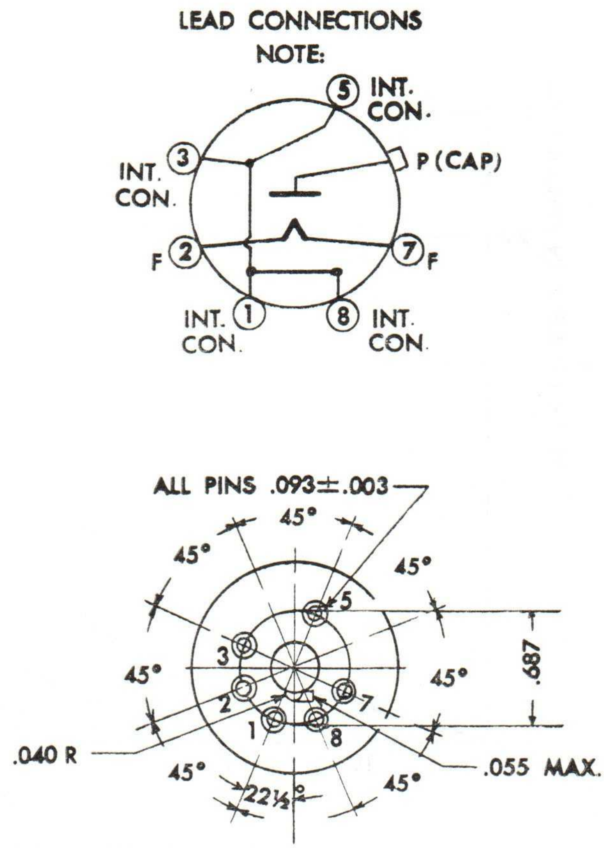
The JAN–1B3GT [1] is a 6 pin, octal base, half-wave, high vacuum rectifier suitable in applications where the dc load current does not exceed 2.2 milliamperes.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	1.25 Vac
Cathode	Coated Filament

MOUNTING. Not specified.





INTERMEDIATE SHORT SHELL OCTAL 6-PIN BASE
*B6-8

ALL DIMENSIONS IN INCHES

*REFERS TO JETEC PUBLICATION J0-G3-1, FEBRUARY 1949

**ON FINISHED TUBE, ADD 0.030 FOR SOLDER

NOTE: CONNECTING PINS 1, 3, 5 AND 8 TO PIN 7 EXTERNALLY IS PERMISSIBLE TO REDUCE CORONA DISCHARGE. OTHERWISE PINS 1, 3, 5 AND 8 MAY NOT BE USED.

Figure 3-37. Outline Drawing and Base Diagram of Tube Type JAN-1B3GT.

[1] The values and specification comments presented in this section are related to MIL-E-1/748B dated 23 December 1955.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 1.25 Vac ± 10%
Peak Inverse Plate Voltage .... 33 Kv
Peak Plate Current .... 18.7 mA
Steady State Peak Plate Current .... 2.2 mAdc
Minimum supply source impedance (at maximum voltage and current ratings) .... 105,000 ohms
*Frequency .... 300 KC
*Altitude Rating .... 10,000 ft

TESI CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 1.25 Vac
Peak Inverse Plate Voltage, epx .... 33 Kv
Minimum Frequency .... 75 Kc

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/748A dated 23 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Filament Current	If		180	200	...	...	mA
Operation (2)	Eo	R_L = 1000 Meg C_L = 400 uuf exp = 40 kv (test time not to exceed 1 minute)	17.5	...	...	...	kVdc
Emission	Is	Eb = 100 Vdc, Ef = 1.10 Vdc	5.0	15.0	3.0	...	mAdc
Capacitance	Cpf		1.0	2.0	...	...	uuf

Figure 3-38. *Rating Chart I* is based on maximum rated peak inverse voltage per plate (epx) of 33 kilovolts and maximum rated dc output current (Io) of 2.2 milliamperes. Point C corresponds to the simultaneous occurance of these two ratings, permissible under choke or capacitor-input filter conditions.

Figure 3-39. *Rating Chart II* for capacitor input filter applications, is based on maximum rated dc output current (Io) and maximum rated steady state peak plate current of 18.7 milliamperes. Rectification efficiency must not exceed 0.85 under conditions of maximum rated dc output current.

Figure 3-40. *Rating Chart III* for capacitor input filter is based on a maximum allowable surge current (i surge) of 150 milliamperes, as derived from the specification. Minimum permissible series resistance (Rs) is approximately 105, 000 ohms under conditions of maximum peak inverse voltage and current ratings.

OTHER CONSIDERATIONS:

CORONA DISCHARGE: Connecting pins 1, 3, 5, and 8 to pin 7 externally is permissible to reduce corona discharge, otherwise, pins 1, 3, 5 and 8 may not be used.

Heater Voltage: See paragraph 3.3.5.

Altitude: See paragraph 3.3.3.

APPLICATION OF JAN–1B3GT

Rating Charts I, II, and III represents areas of permissible operation within which any application of the JAN–1B3GT must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

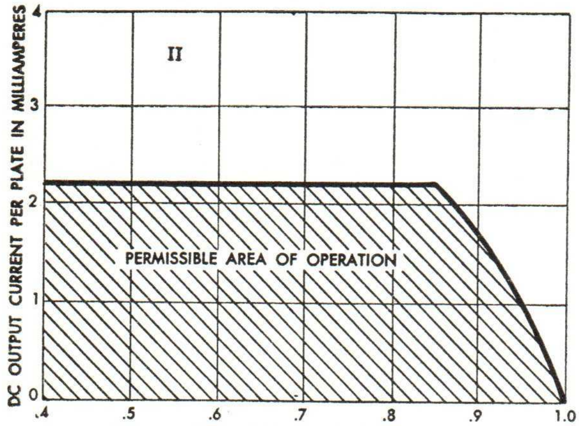


Fig. 3-38. Rating Chart I for JAN-1B3GT.

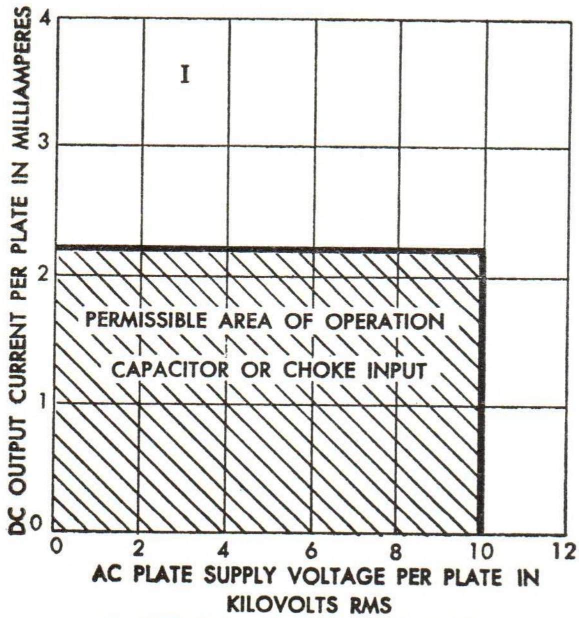


Fig. 3-39. Rating Chart II for JAN-1B3GT.

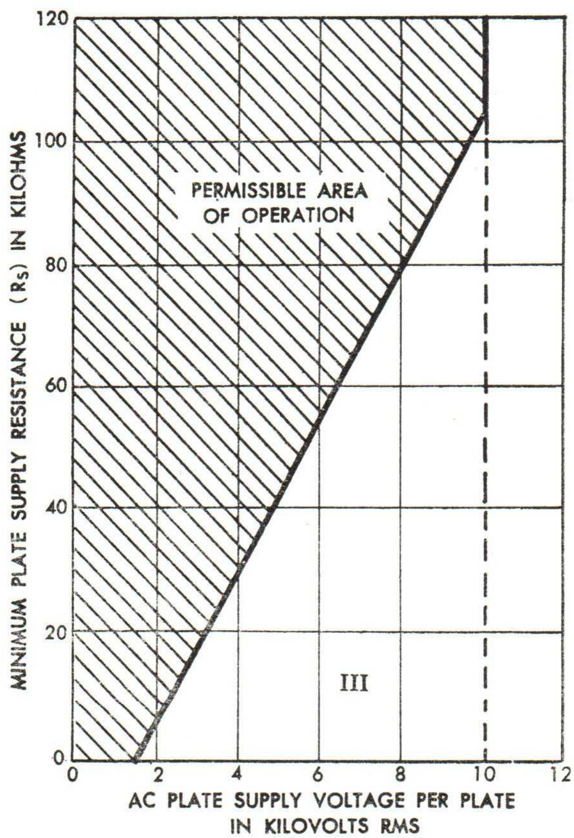


Fig. 3-40. Rating Chart III for JAN-1B3GT.

AVERAGE CHARACTERISTICS OF JAN-1B3GT

The chart below presents the Static Plate Characteristic of JAN-1B3GT, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes may be derived from the specification which provides minimum and maximum limits on emission, at Eb = 100 Vdc, of 5.0 and 15.0 m Adc respectively.

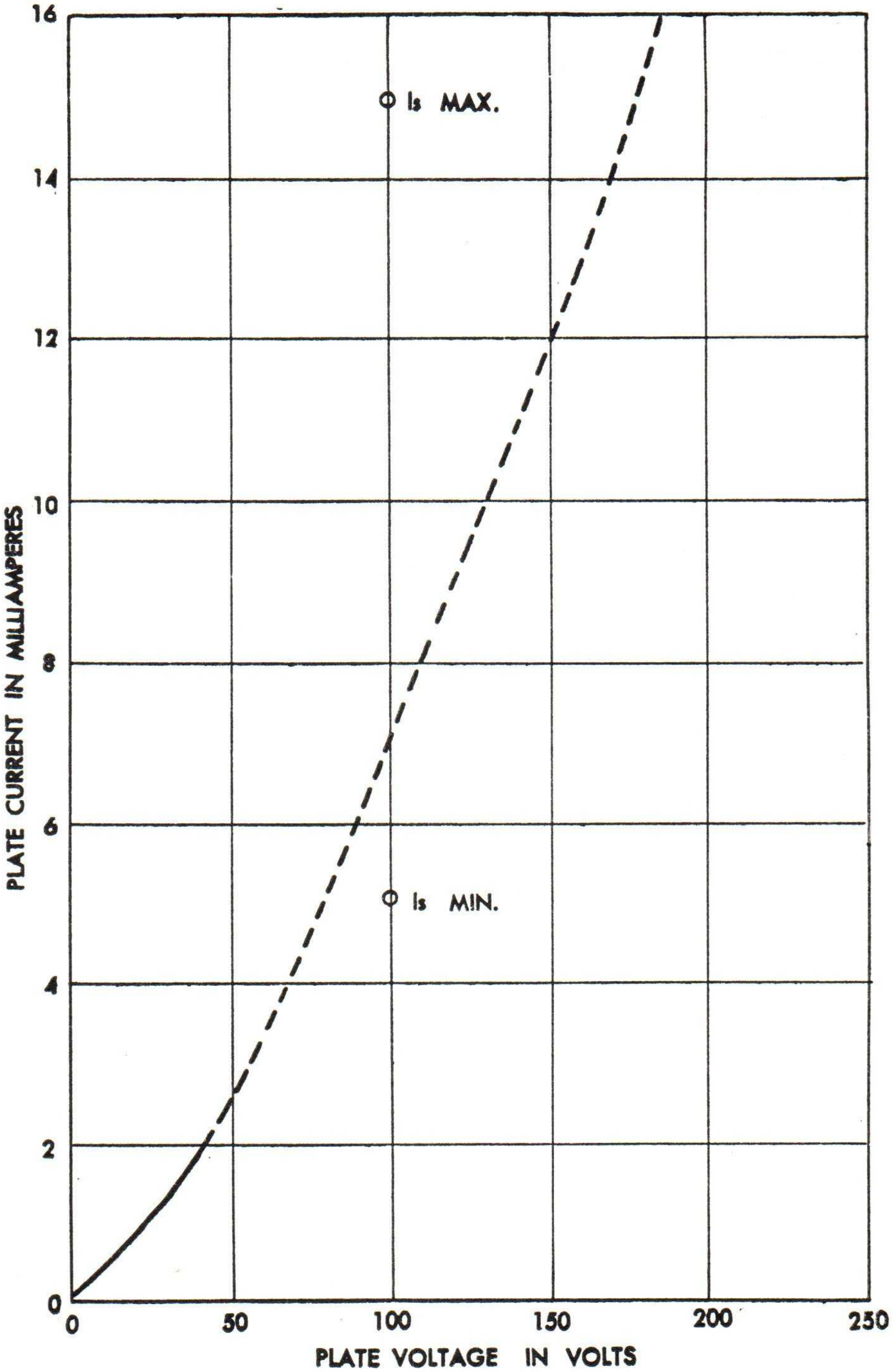


Figure 3-41. Typical Plate Characteristics of Tube Type JAN 1B3GT.

SECTION

TUBE TYPE JAN-1Z2

DESCRIPTION.

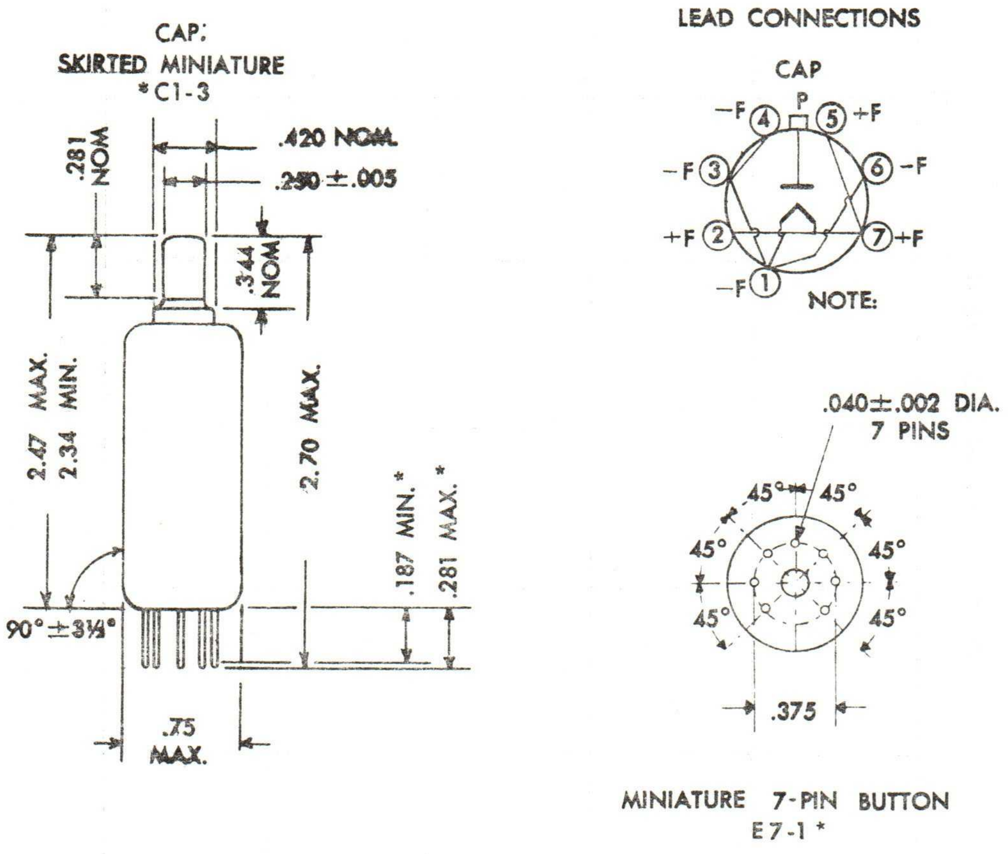
The JAN-1Z2[1] is a 7 pin button base, miniature, high vacuum rectifier (half wave).

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 1.25 V
Cathode .... Thoriated Tungsten

MOUNTING. Any type of mounting is adequate.

[1] The values and specification comments presented in this section are related to MIL-E-1/29 dated 5 February 1953.



*REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

ALL DIMENSIONS IN INCHES

NOTE:

PINS 1, 3, 4 AND 6 ARE CONNECTED TO AN INTERNAL SHIELD

Figure3-42. Outline Drawing and Base Diagram of JAN-1Z2.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 1.25 Vac 5%
Peak Inverse Plate Voltage .... 15 kv
Steady State Peak Plate Current, Ib ....8.5 mA
Output Current .... 1.5 mAdc
*Altitude Rating .... 10,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 1.25 Vac
Peak Inverse Plate Voltage, epx .... 15 kv
Load Resistance, RL .... 4.2 Meg
Load Capacitance, CL .... 0.01 uf
Output Current, Io .... 1.5 mAdc

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/29 dated 5 February 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Filament Current	If		245	285	...	...	mA
Emission	Is	Ef = 1.35 V Eb = 100 Vdc	9.5	...	8.5	...	mAdc

APPLICATION OF JAN–1Z2

Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN–1Z2 must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Figure 3-43. *Rating Chart I* is based on maximum rated peak inverse voltage (epx) of 15 kilovolts and maximum rated dc output current (Io) of 1.5 milliamperes. Point C is derived from life test conditions of maximum rated dc output current, peak inverse plate voltage, and steady state peak plate current.

Figure 3-44. *Rating Chart II* for capacitor input filter applications, is based on maximum rated dc output current (Io) and maximum rated steady state peak plate current of 8.5 milliamperes per plate. Rectification efficiency must not exceed 0.65 under conditions of maximum rated dc output current.

Figure 3-45. *Rating Chart III* for capacitor input filter is based on maximum surge current (i surge) of 25 milliamperes, as derived from specification minimum permissible source impedance of 300,000 ohms under conditions of maximum permissible supply voltage.

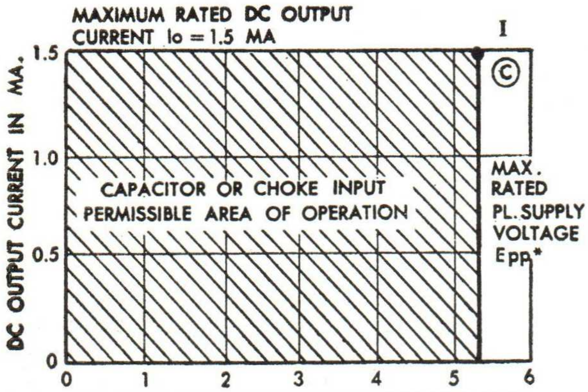


Figure 3-43. Rating Chart I for JAN-1Z2.

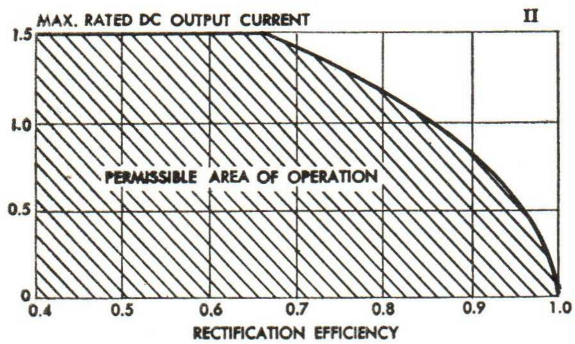


Figure 3-44. Rating Chart II for JAN-1Z2.

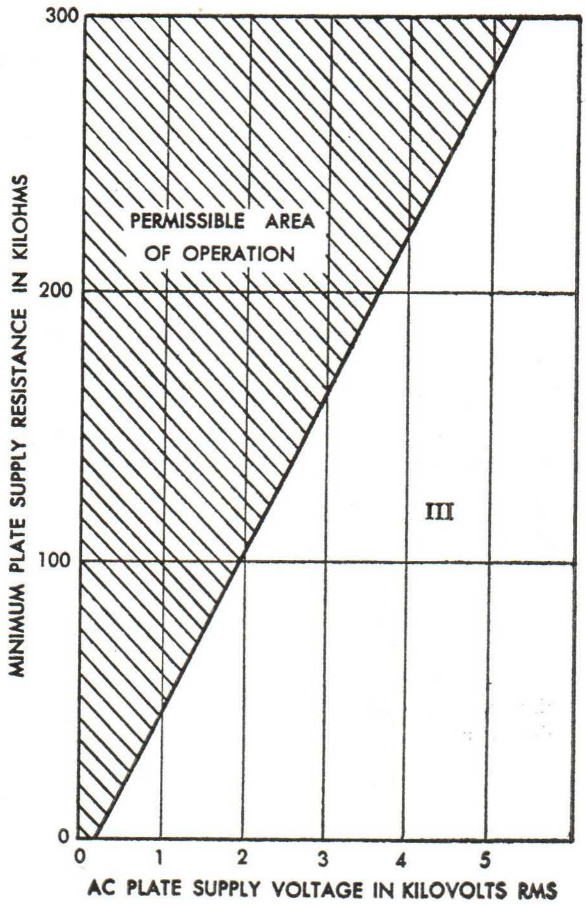


Figure 3-45. Rating Chart III for JAN-1Z2.

OTHER CONSIDERATIONS:

Heater Voltage: See paragraph 3.3.5.

Altitude: See paragraph 3.3.3.

AVERAGE CHARACTERISTICS OF JAN-1Z2

The chart below presents the Static Plate Characteristic of JAN-1Z2, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

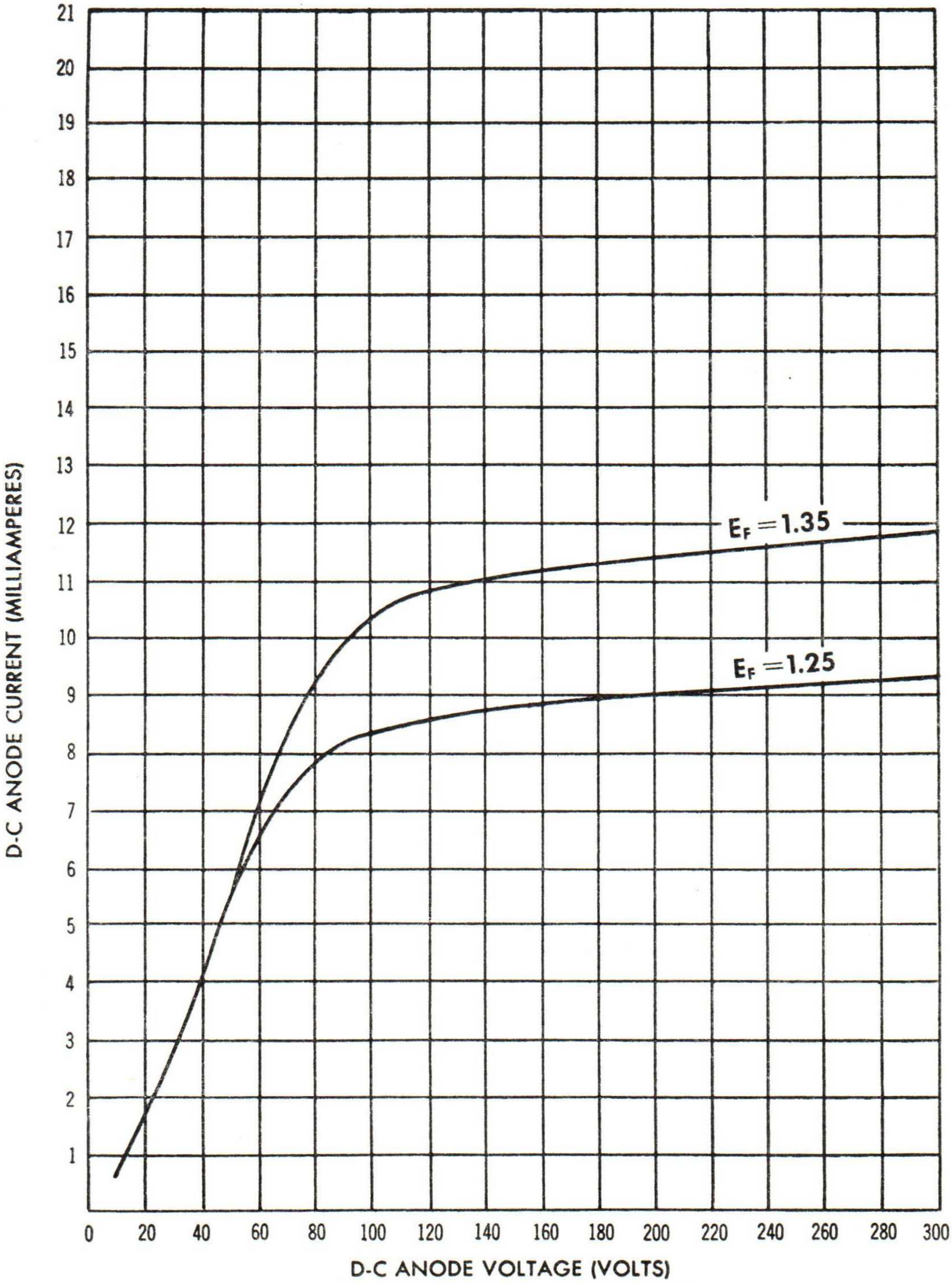


Figure 3-46. Typical Plate Characteristics for JAN-1Z2.

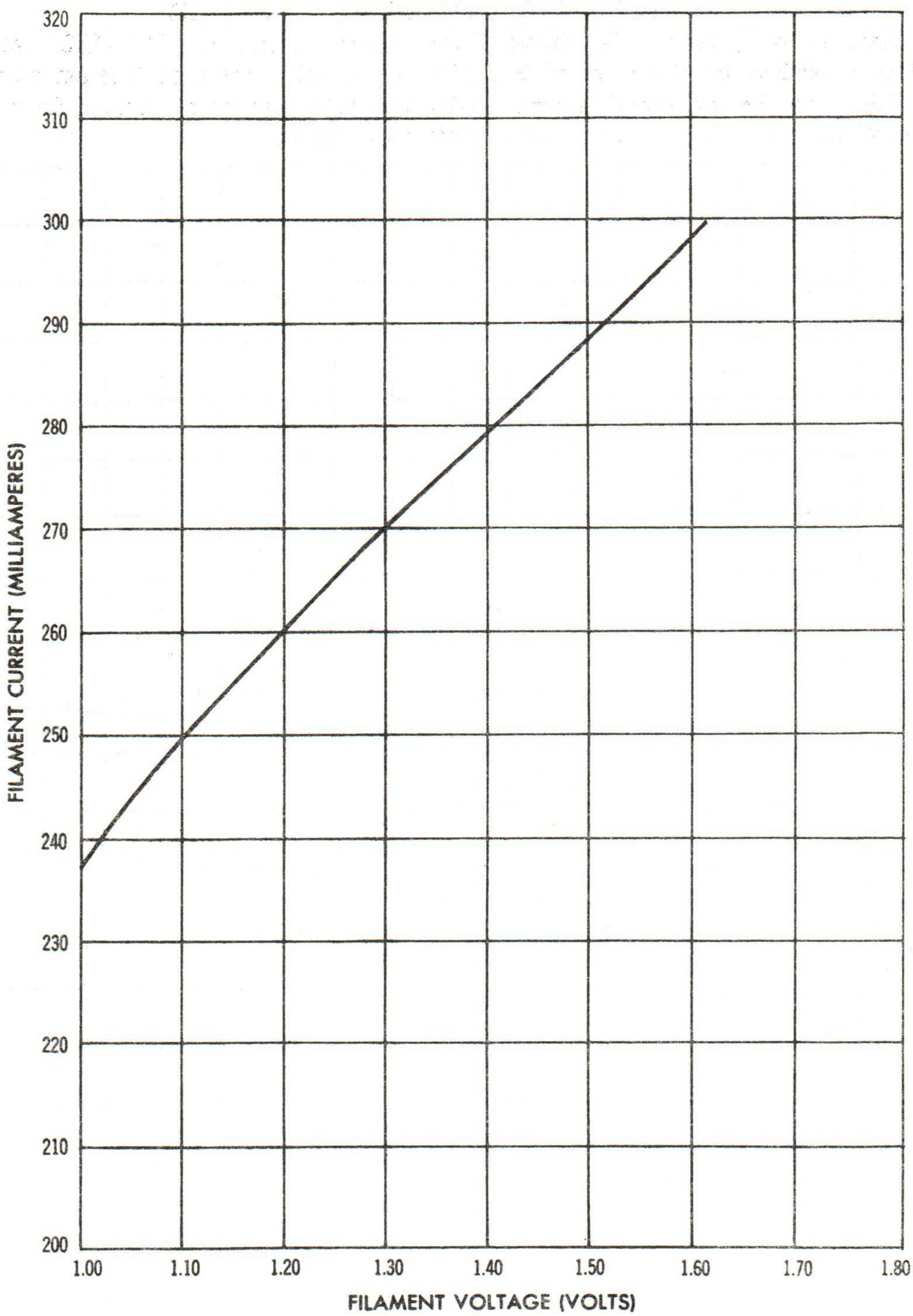


Figure 3-47. Typical Filament Characteristics for JAN-1Z2.

SECTION

TUBE TYPE JAN-2B22

DESCRIPTION.

The JAN-2B22 [1] is a 6 pin, octal base, U.H.F. diode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 Vac
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Maximum Frequency at which maximum ratings apply, F1,	1200 Mc
Heater Voltage	6.3 ± 5% Vac
**Peak Plate Voltage	100 v
Peak Inverse Plate Voltage	300 v
Heater-Cathode Voltage	100 v
**Steady State Peak Plate Current	1.0 a
Plate Current	20 mAdc
Output Voltage	150 Vdc
Cathode Conditioning Time, tk	60 Sec
*Seal Temperature	200° C
*Altitude Rating	10,000 ft

TEST CONDITIONS

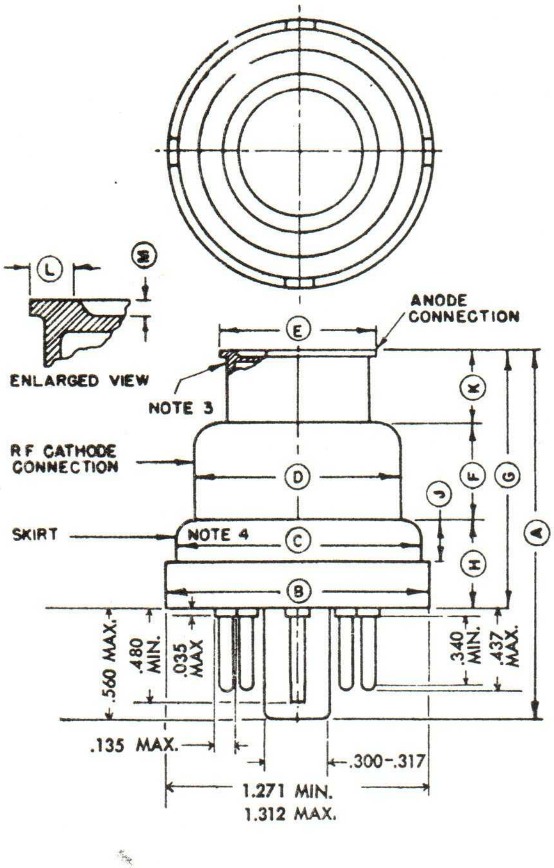
Test conditions are as follows:

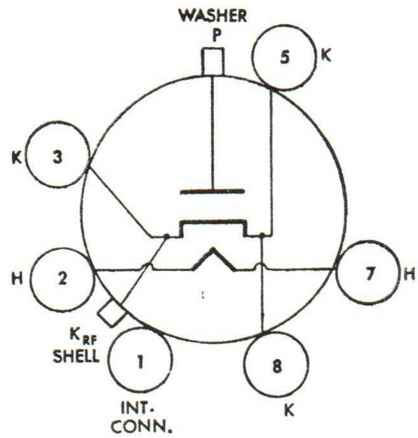
Heater Voltage, Ef	6.3 Vac
Plate Current	20 mAdc
Cathode Conditioning Time	300 Sec

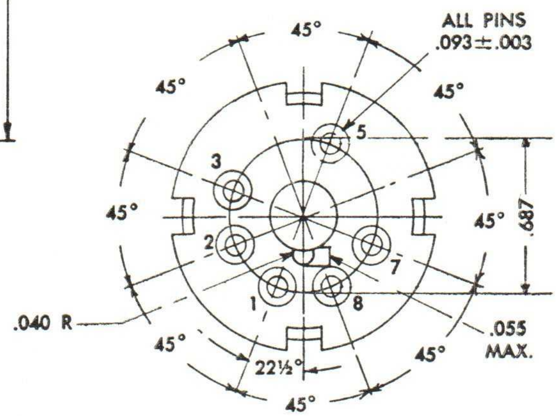
* No test at this rating exists in the specification.

** Tube shall not be operated more than 5 usec in a 100 usec interval.

[1] The values and specification comments presented in this section are related to MIL-E-1/736 dated 17 December 1954.







REF.	DIMENSION	
	MIN.	MAX.
**A		1 15/16
**B		1.312 DIA.
**C	1.216 DIA.	1.236 DIA.
*D	1.023 DIA.	1.039 DIA.
*E	.806 DIA.	.818 DIA.
*F	.475	.505
*G		1.350
**H	.395	.455
**J	.180	.210
*K	.360	.390
**L	1/16	
**M	.013	.027

**Note 1: Silver plate external surface of metal parts, except base pins, MIN .100 MS1.

*Note 2: Cathode RF connection & anode connection shall be concentric with respect to each other within 0.020.

Note 3: Glass shall not extend beyond edge of anode.

Note 4: Tolerance does not apply to point where skirt is crimped.

Note 5: Skirt shall not be used RF contact surface.

Figure 3-48. Outline Drawing and Base Diagram of Tube Type JAN-2B22.

APPLICATION

SIGNAL RECTIFIER SERVICE: In theapplication of the JAN-2B22 in UHF signal rectifier service, specification MIL-E-1/736 dated 17 December 1954 prescribes that the maximum ratings are applicable up to a maximum frequency of 1200 megacycles, though no performance tests are specified in the UHF region. It should be noted that the specification prescribes also that the JAN-2B22 shall not be operated more than 5 microsecons in a 100 microsecond interval, under conditions of maximum rated peak plate voltage or maximum rated peak plate current.

Permissible steady state peak plate voltage is limited to 100 volts, and peak plate cur-
When used in reference to pulses the maximumrent to 1.0 ampere, under these conditions.
rated peak plate current excludes the current spike. An additional restriction should be borne in mind by designers — a minimum cathode conditioning time (t_k) of 60 seconds must be allowed before the application of high voltage.

SUPPLY VOLTAGE RECTIFIER SERVICE: Not applicable.

OTHER CONSIDERATIONS:

HEATER VOLTAGE: See paragraph 3.4.3.

LOW ELECTRODE CURRENT: See paragraph 3.4.3.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits areprovided. Specification MIL-E-1/736 dated 17 December 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		700	800	...	...	mAdc
Tube Drop	Etd	Ib = 20 mAdc	3.0	9.0	...	10.0	Vdc
Pulse Emission Voltage	eb	Is = 0.90a; tp = 2us prr = 500	...	150	...	...	v
Capacitance	Cout	Ef = 0	1.9	2.4	...	...	uuf
Heater-Cathode Leakage	Ihk	Ehk = 100 Vdc	...	-20	...	...	uAdc
	Ihk	Ehk = -100 Vdc	...	-50	...	...	uAdc
Insulation of Electrodes	Rpsh		25	...	...	...	Meg

SECTION

TUBE TYPE JAN–2C40

DESCRIPTION.

The JAN–2C40[1] is a six pin octal base disc seal triode amplifier and oscillator with an indirectly heated cathode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V ac
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 5% V ac
Plate Voltage	500 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Plate Dissipation	6.5 W
Cathode Conditioning Time	60 sec. min.
Seal Temperature	200° C
Altitude Rating	10,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V ac
Plate Voltage, Eb	250 Vdc
Cathode Conditioning Time	300 sec.
Cathode Resistance, Rk	200 ohms
Cathode Bypass Capacitance	1,000 uf

[1] The values and specification comments presented in this section are related to MIL-E-1/737 dated 17 December 1954.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/737 dated 17 December 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		700	800	...	...	mA
Transconductance	Sm		4400	5700	...	...	umhos
Amplification Factor	Mu		27	44	...	...	...
Plate Current	Ib		13	22	...	...	mAdc
Grid Voltage	Ec	Ec/Ib = 10 uAdc	–10	–26	...	...	Vdc
Emission	Es	E_bE_c/I_k = 40 mAdc R_k = O	...	10	...	...	Vdc
Power Oscillation	Po	Eb = 250 Vdc max Ib = 25 mAdc max Rk = O; Rg = 10,000 F = 3370 Mc/sec nom	35	...	25	...	mW
Capacitance	Cgp:		1.15	1.40	...	...	uuf
	Cin:		1.90	2.35	...	...	uuf
	Cout:		...	0.03	...	...	uuf
	Cshk:		30	200	...	...	uuf
Grid Current	Ic		0	–1.0	...	...	uAdc
Heater-Cathode Leakage	Ihk	t = 180 sec, Ehk = + 100 Vdc	...	20	...	...	uAdc
	Ihk	Ehk = – 100 Vdc	...	–50	...	...	uAdc
Insulation of Electrodes	Rk – sh		25	...	...	...	Meg
	Rh – sh		25	...	...	...	Meg
	Rg – sh		25	...	...	...	Meg
	Rg – p		25	...	...	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

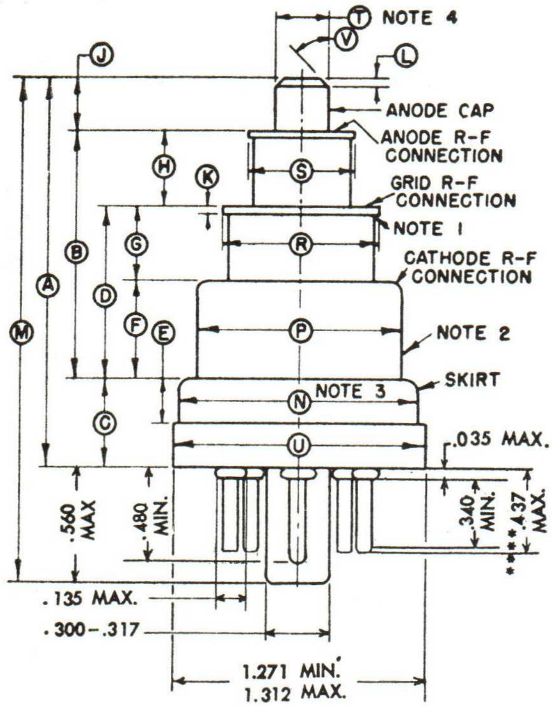
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature

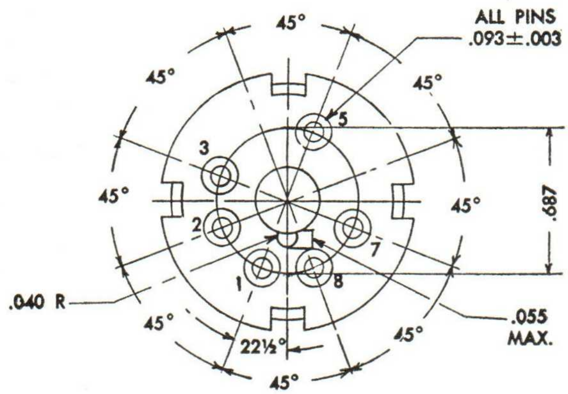
Bulb and Environmental, 3.1.4

Miscellaneous

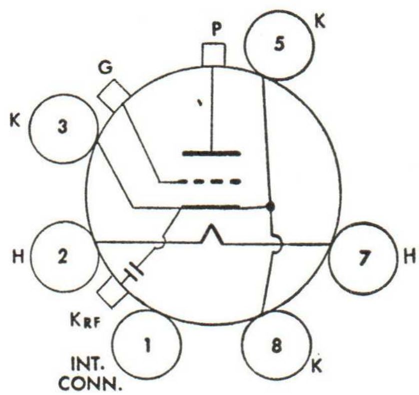
Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5



REF	DIMENSION MIN	MAX	NOM
*A		1.973	
*B	1.220	1.260	
C	.395	.455	
*D	.850	.880	
E	.180	.210	
*F	.475	.505	
*G	.360	.390	
H	.360	.390	
*J	.242	.258	
K	.030	.035	
L		3/64	
M		2 9/16	
N	1.216	1.236	
*P	1.023	1.039	
*R	.8085	.8155	
S	.557	.567	
*T	.248	.252	
U		1.312	
V			45°



LEAD CONNECTIONS



** SMALL WAFER OCTAL, 6-PIN BASE, ***B6-23

NOTES:
*1. GLASS SHALL CONFORM WITH REQUIREMENTS OF DETAIL A.
*2. CATHODE R-F CONNECTION SURFACE SHALL BE FREE FROM WELDING FLASH MATERIAL.
3. TOLERANCE DOES NOT APPLY AT POINTS WHERE SKIRT IS CRIMPED TO BASE.
4. A 3/64 MAX. RADIUS CHAMFER MAY BE USED INSTEAD OF BEVEL.
**5. EXTERNAL SURFACE OF METAL PARTS, EXCEPT PINS, SHALL BE SILVER PLATED 100 MS1 MIN.
*6. THE ANODE CAP GRID R-F CONNECTION AND THE CATHODE R-F CONNECTION SHALL BE CONCENTRIC WITH RESPECT TO EACH OTHER WITHIN 1/64.
7. TEST SHALL BE MADE ON TEN TUBES PER MONTH WHEN IN CONTINUOUS PRODUCTION, FAILURE OF MORE THAN ONE TUBE TO MEET THE TOLERANCE FOR ANY OF THESE DIMENSIONS, SHALL CAUSE THAT DIMENSION TO BECOME A DESIGN ON ALL LOTS IN PROCESS.

***REFERS TO JETEC PUBLICATION J0-G3-1, FEBRUARY 1949
****ON FINISHED TUBE, ADD 0.030 FOR SOLDER
ALL DIMENSIONS IN INCHES

Figure 3-49. Outline Drawing and Base Diagram of Tube Type JAN-2C40.

The chart below shows the permissible operating area for JAN-2C40 as defined by the ratings in MIL-E-1/737 dated 17 December 1954. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.5.

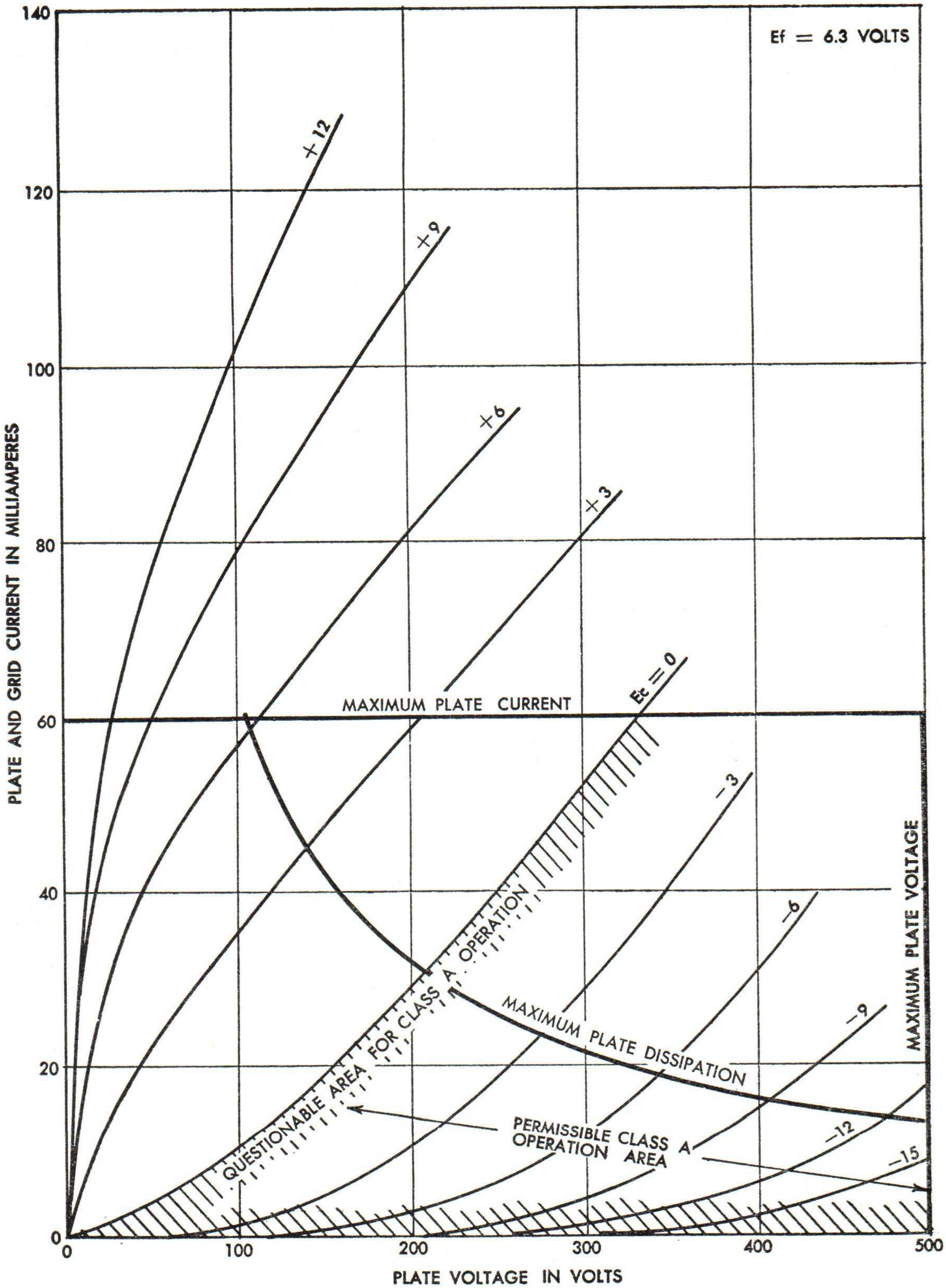


Figure 3-50. Permissible Operating Region of JAN-2C40.

VARIABILITY OF JAN-2C40 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-2C40 as defined by MIL-E-1/737 dated 17 December 1954.

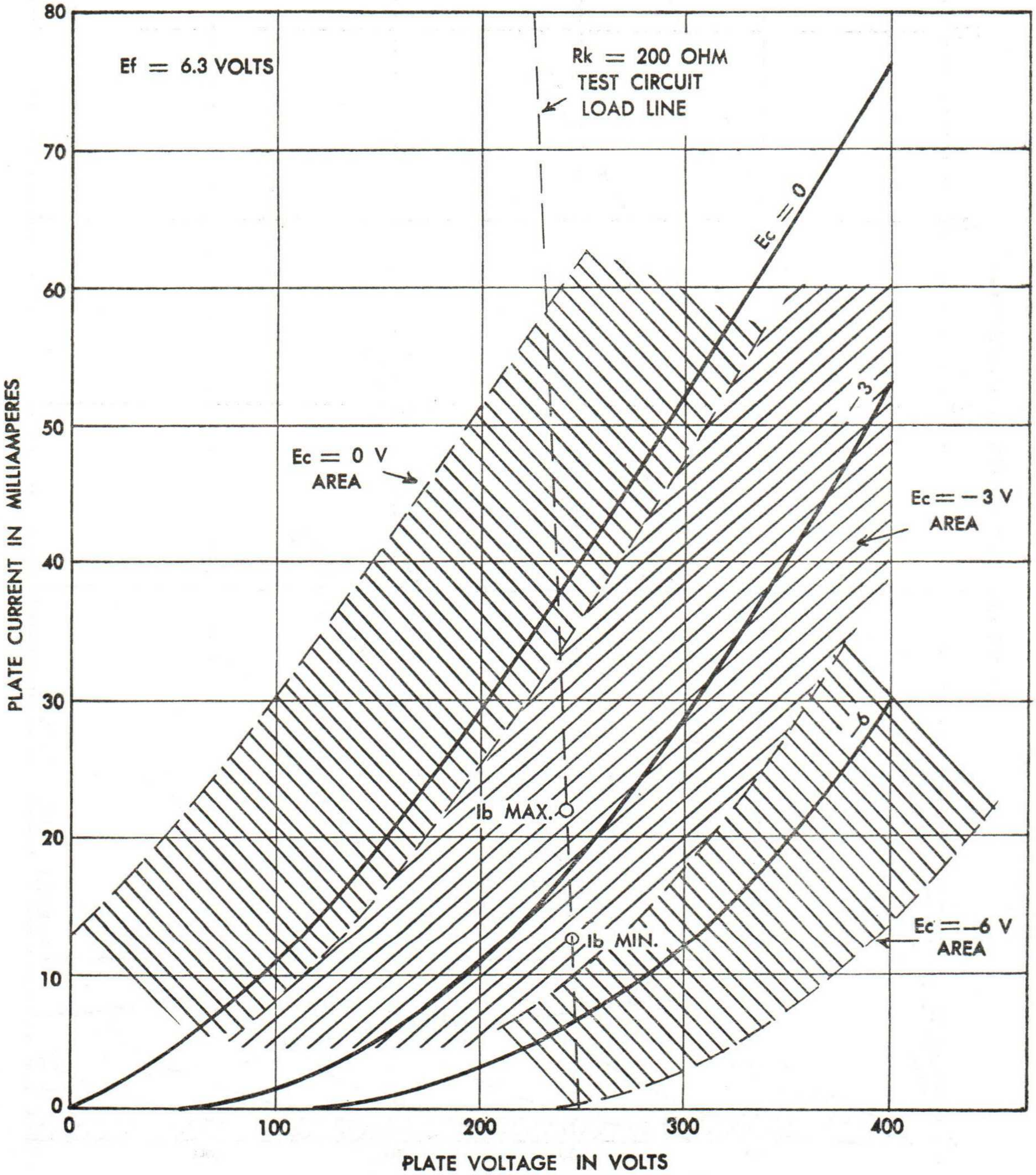


Figure 3-5. Limit Behavior of JAN-2C40; Static Plate Data.

The chart below presents the limit behavior of transfer data for JAN-2C40 as defined by MIL-E-1/737 dated 17 December 1954.

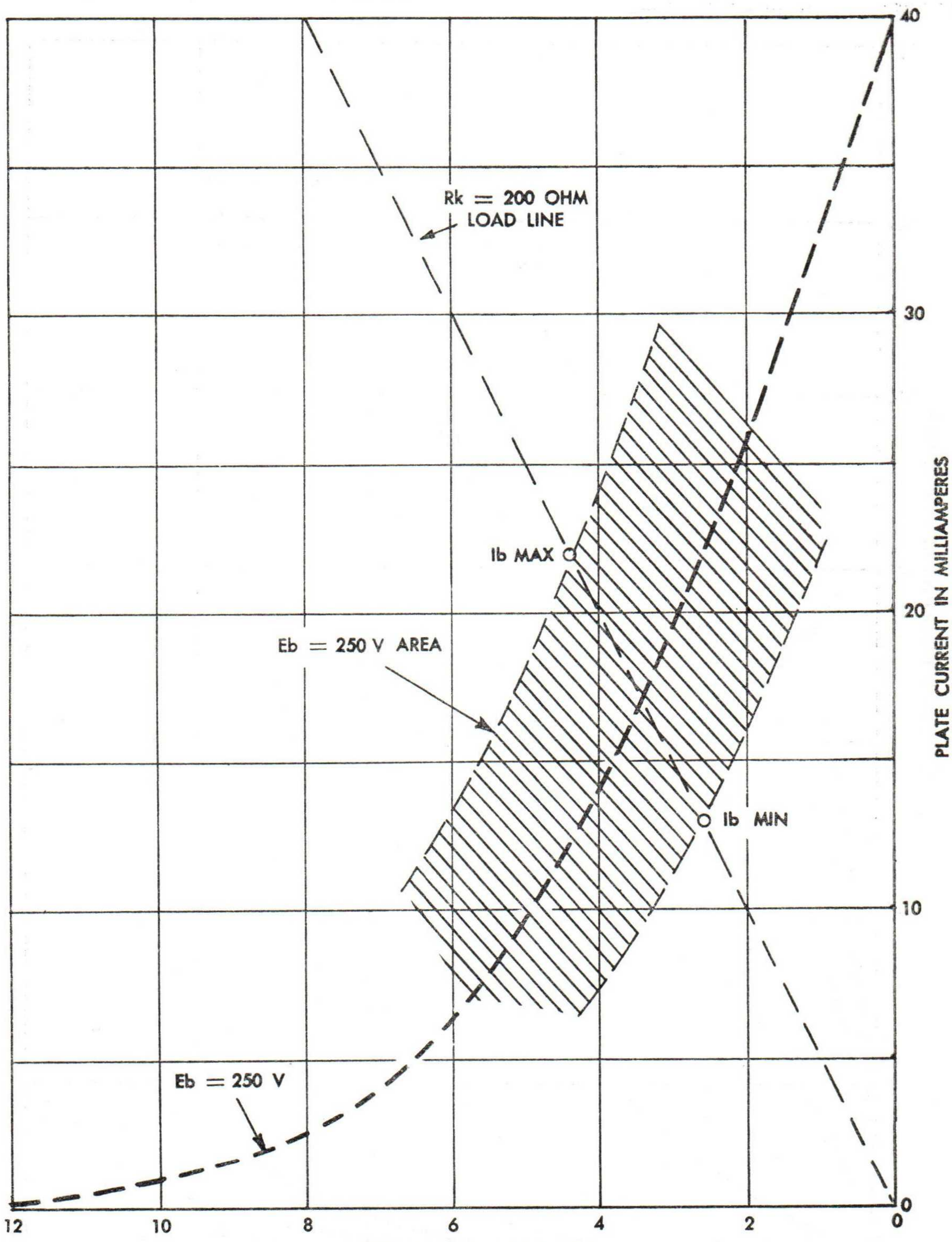


Figure 3-52. Limit Behavior of JAN-2C40; Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-2C40

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

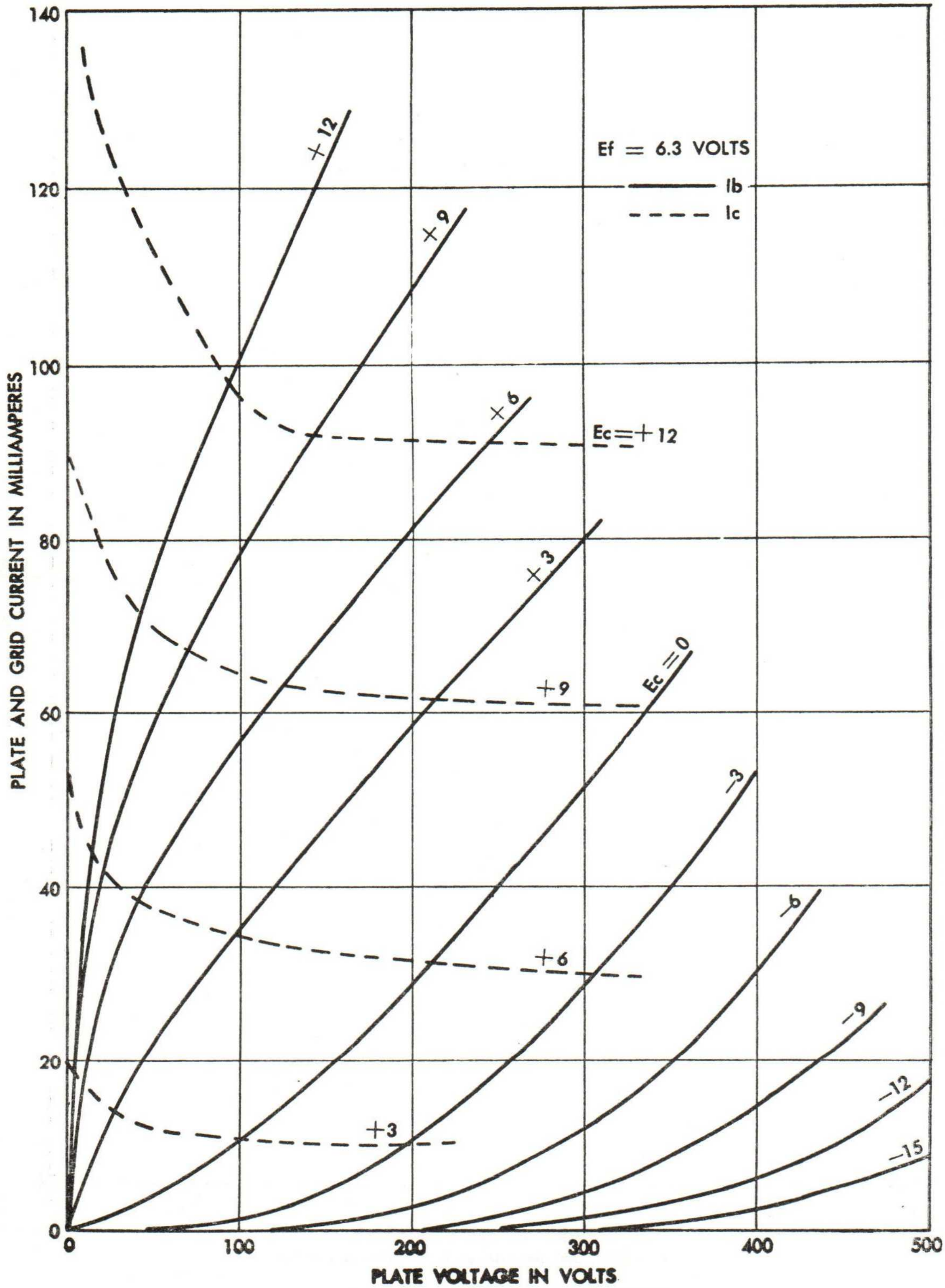


Figure 3-53. Static Plate Characteristics of JAN-2C40.

The figure below shows the typical behavior of the JAN-2C40 as an oscillator with the specified life test requirements superimposed.

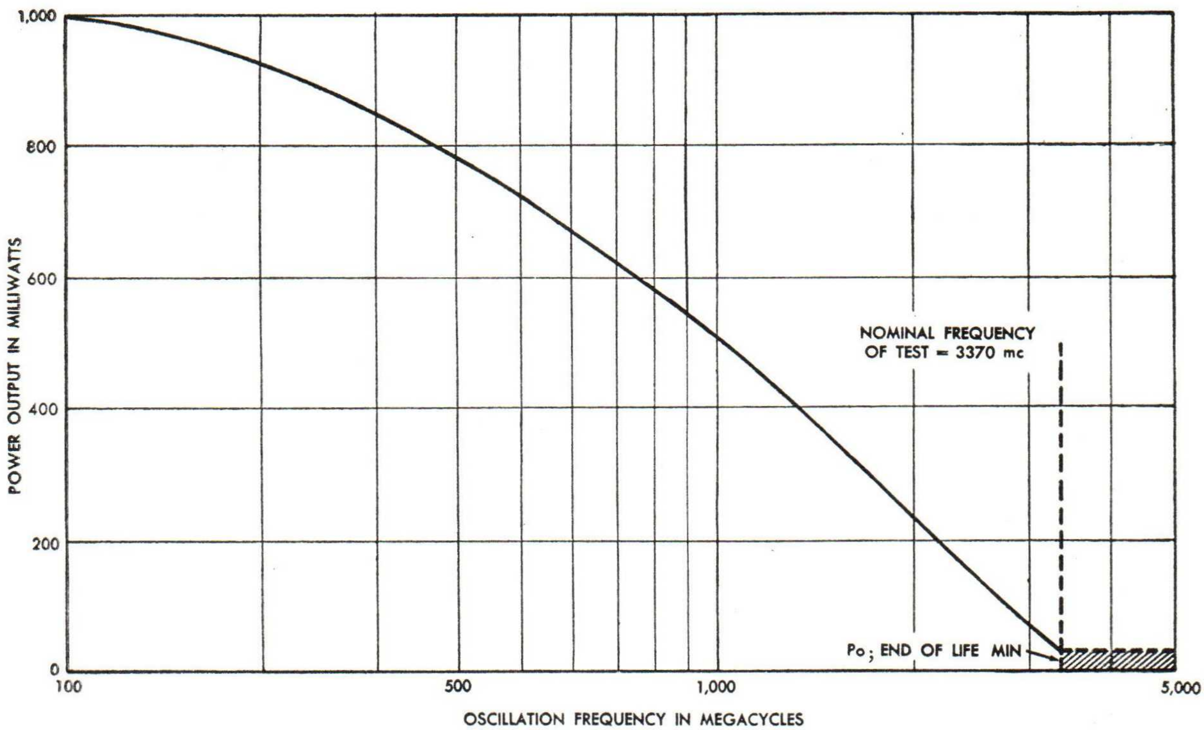


Figure 3-54. Typical Power Output of JAN-2C40 Versus Frequency of Oscillation.

SECTION

TUBE TYPE JAN-2E30

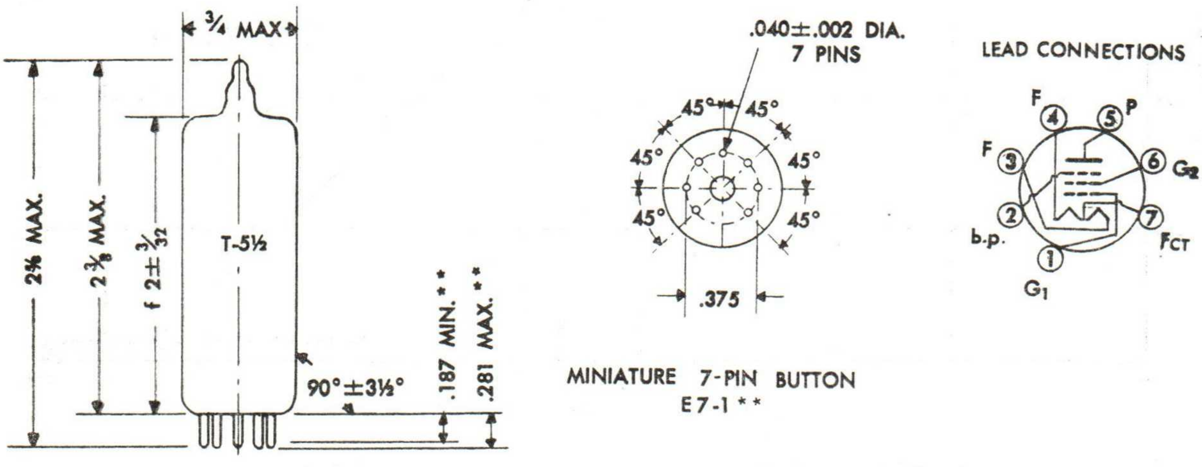
DESCRIPTION.

The JAN-2E30[1] is a 7 pin, button base, miniature instant heating beam pentode power amplifier.

ELECTRICAL. The electrical characteristics are as follows:

Filament Voltage, AC or DC .... Parallel 3.0 Series 6.0 V
Filament Current
Cathode .... Oxide Coated Filament

MOUNTING. Filament plane must be vertical.



7 PIN MINIATURE
6-5
5-3 *

* REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952

**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-55. Outline Drawing and Base Diagram of Tube Type JAN-2E30.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Filament Voltage .... Parallel 3.0 ± 10% Series 6.0 ± 10% V
Plate Voltage .... 250 Vdc
Reference MIL–E–1C Section 6.5.1.1. Plate Voltage
Control Grid Voltage, Maximum Negative Voltage ....—150 Vdc
Screen Grid Voltage .... 250 Vdc
Plate Dissipation .... 10 W
Screen Grid Dissipation .... 2.5 W
Altitude Rating .... 10,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/32 dated 5 February 1953.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Filament Voltage, Ef	6.0 Vac
Plate Voltage, Eb	250 Vdc
Control Grid Voltage, Ec1	—20 Vdc
Screen Grid Voltage, Ec2	250 Vdc

ACCEPTANCE TEST LIMITS

The following tables summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/32 dated 5 February 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Filament Current	If	Ef = 6V	585	715	...	...	mA
Transconductance	Sm		3500	5000	...	...	umhos
Grid Current	Ic1	Measuring time t = 120 Sec.	0	—5	...	...	uAdc
Screen Grid Current	IC2		...	5.5	...	...	mAdc
Plate Current	Ib		28	52	...	...	mAdc
Amplification Factor G1-G2	Mu	Tie screen to plate	6.6	8.6	...	...	
Class C Doubler	Pg	F = 160 mc eg = 70 v. Load and Rg1/Max Po at Ib = 50 mAdc	1.2	...	...	...	W
Primary Screen Emission	Isc2	Eb=0; Ec2=127 Vac; Ec1/Pg2 = 2.5 W; measuring time t = 120 sec	...	100	...	...	uAdc
Operation Output Load Current	Ip	Ebb = 250 Vdc Ecc1 = 0; RL = 750; Eg1 = 90 Vac; Rg1 = 35,000	90	...	...	...	mA
Operation Screen Current	Ic2	Ebb = 250 Vdc; Ecc1 = 0; RL = 750; Eg1 = 90 Vac; Rg1 = 35,000	...	20	...	20	mAdc
Activity	$\frac{\Delta Ip}{Ef}$	Ef = 5.4 Vdc	...	5	...	10	%
Capacitance (Unshielded)	Cgp	Ef = 0	...	0.2	...		uuf
	Cin	Ef = 0	8.2	10.2	...		uuf
	Cout	Ef = 0	6.3	8.3	...		uuf

Tests performed on this tube indicate that it is suitable for use in Class C circuitry as an oscillator, amplifier or doubler at frequencies up to 160 mc.

APPLICATION OF JAN 2E30

The chart below shows the permissible operating area for JAN 2E30 as defined by the ratings in MIL-E-1/32 dated 3 February 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

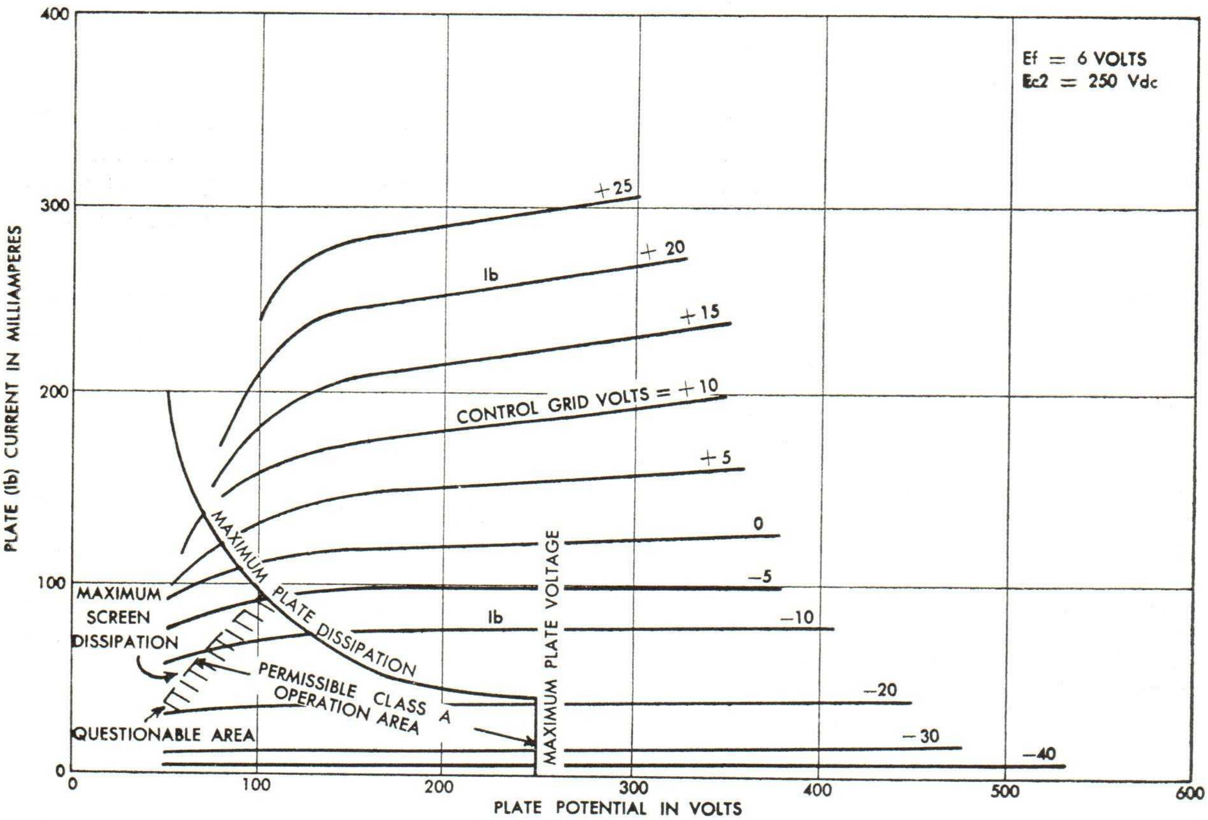


Figure 3-56. Typical Static Plate Characteristics of the Tube Type JAN-2E30; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraphs of this manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8

Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-2E30 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-2E30 as defined by MIL-E-1/32 dated 3 February 1953.

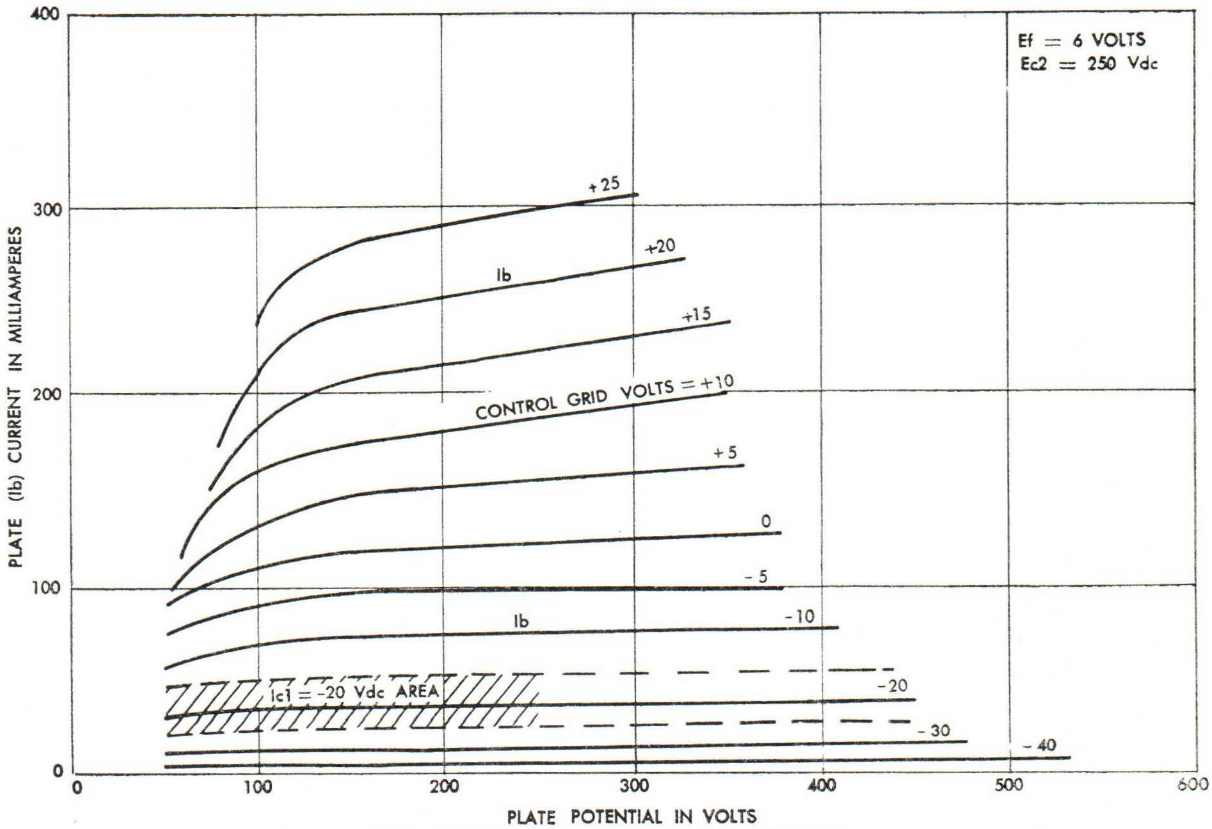


Figure 3-57. Limit Plate Characteristics of JAN-2E30.

The chart below presents the limit behavior of transfer data for JAN 2E30 as defined by MIL–E–1/32 dated 3 February 1953.

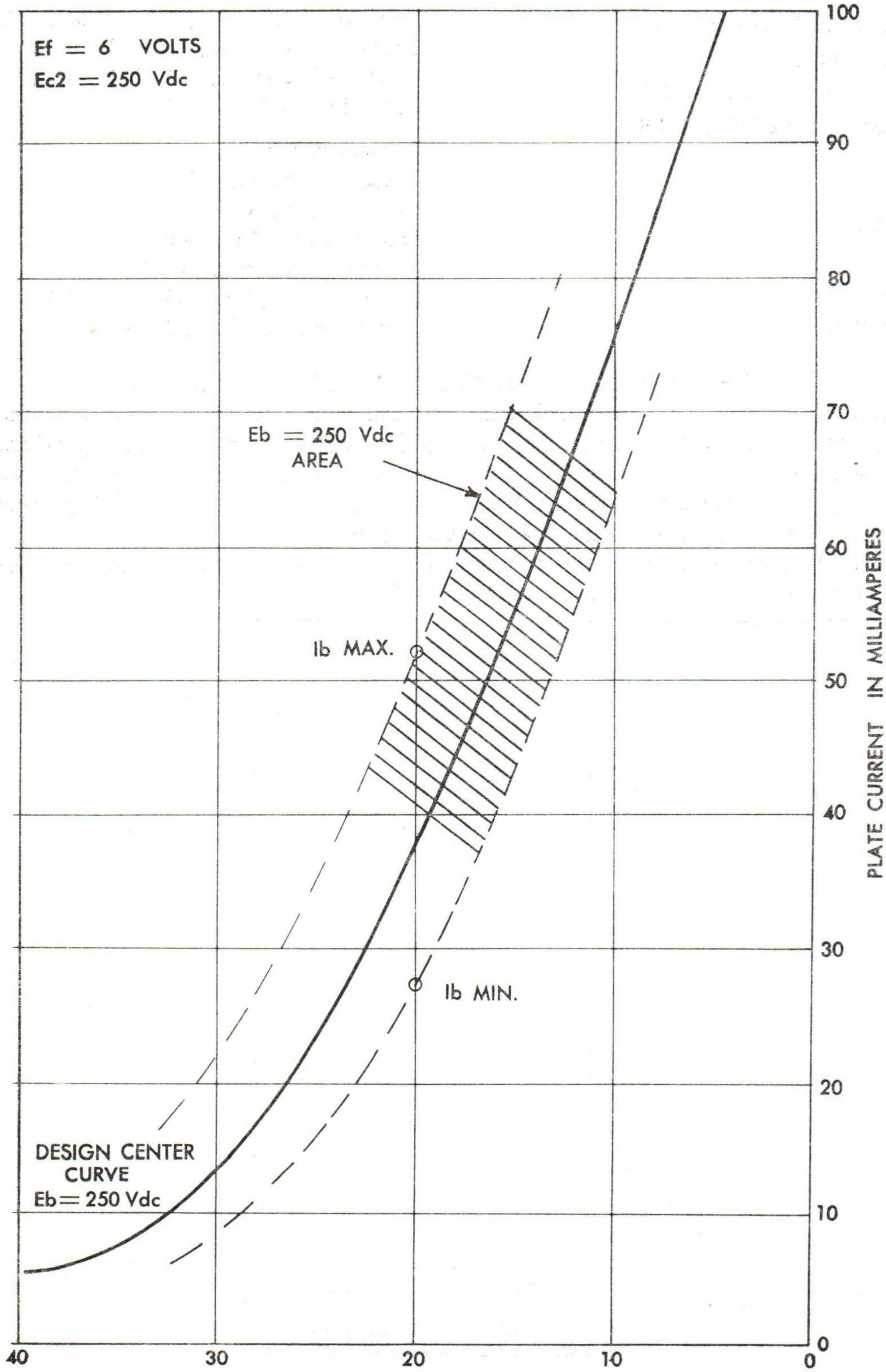


Figure 3-58. Limit Transfer Characteristics of Tube Type JAN 2E30.

DESIGN CENTER CHARACTERS OF JAN-2E30

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The charts below present the Static Plate Characteristics of JAN-2E30.

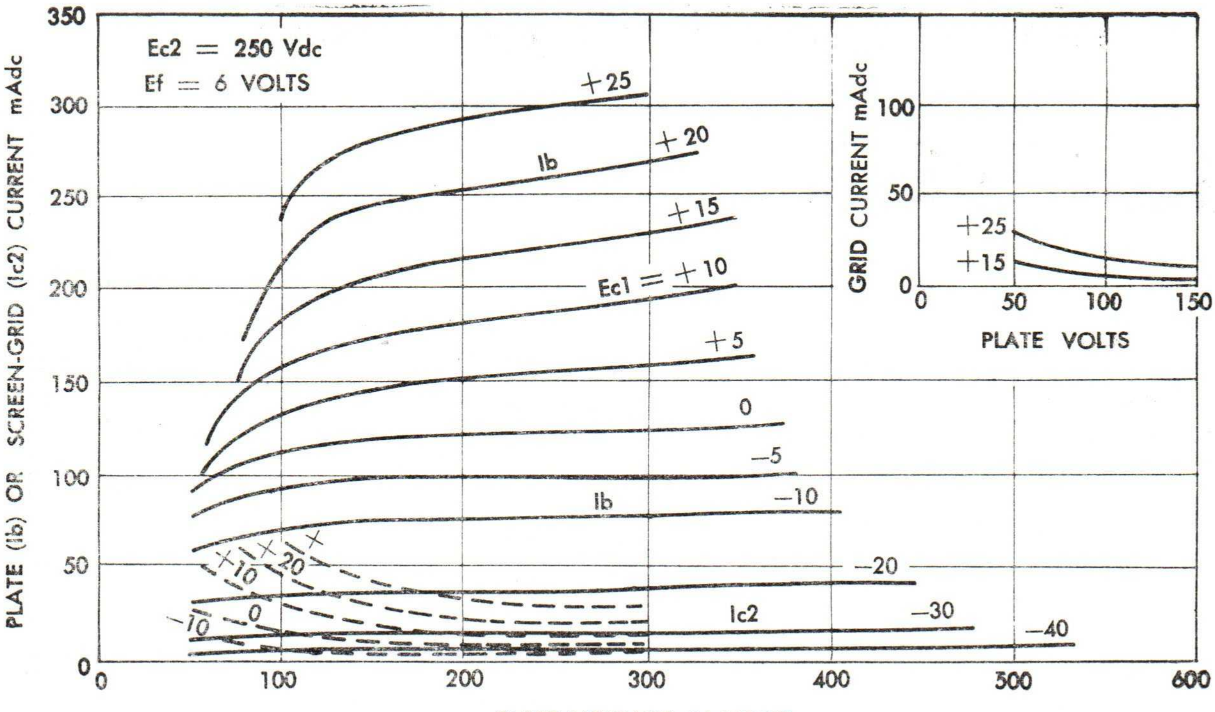


Figure 3-59. Typical Static Plate Characteristics of Tube Type JAN 2E30; Ec2 = 200.

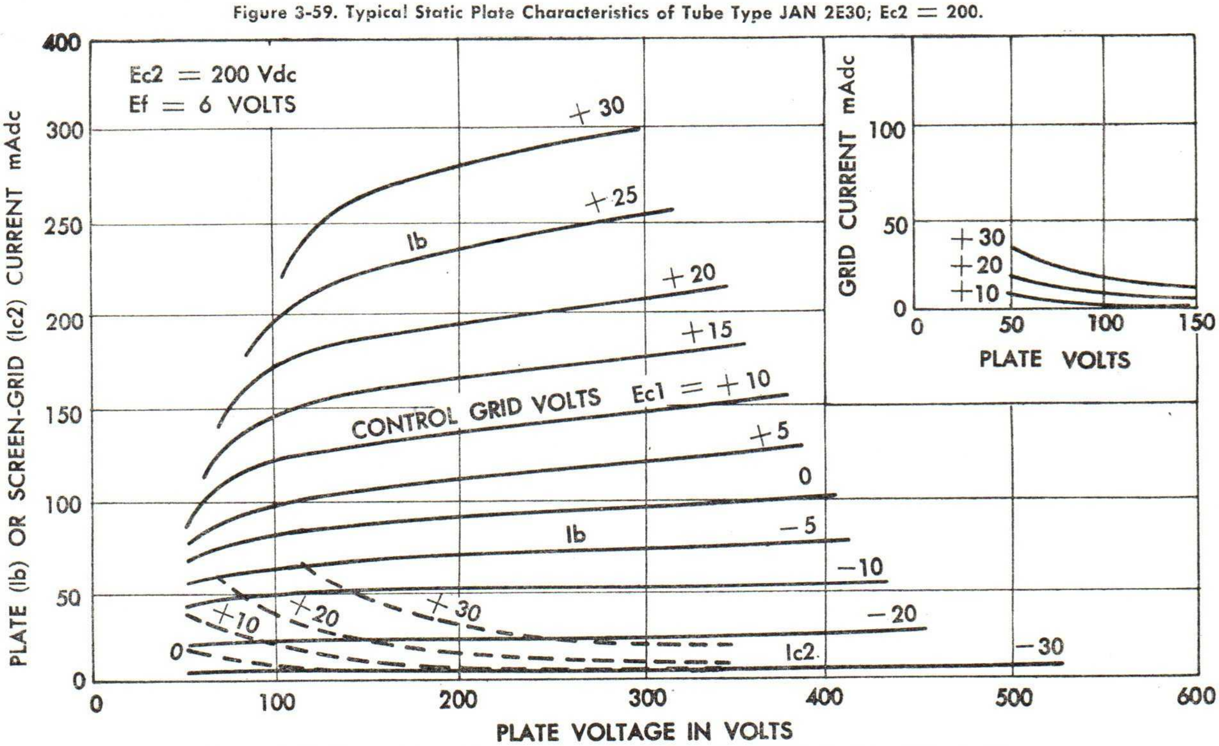


Figure 3-60. Typical Static Plate Characteristics of Tube Type JAN 2E30; Ec2 = 200.

DESIGN CENTER CHARACTERISTICS OF JAN 2E30

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The charts below present the Static Plate Characteristics of JAN-2E30.

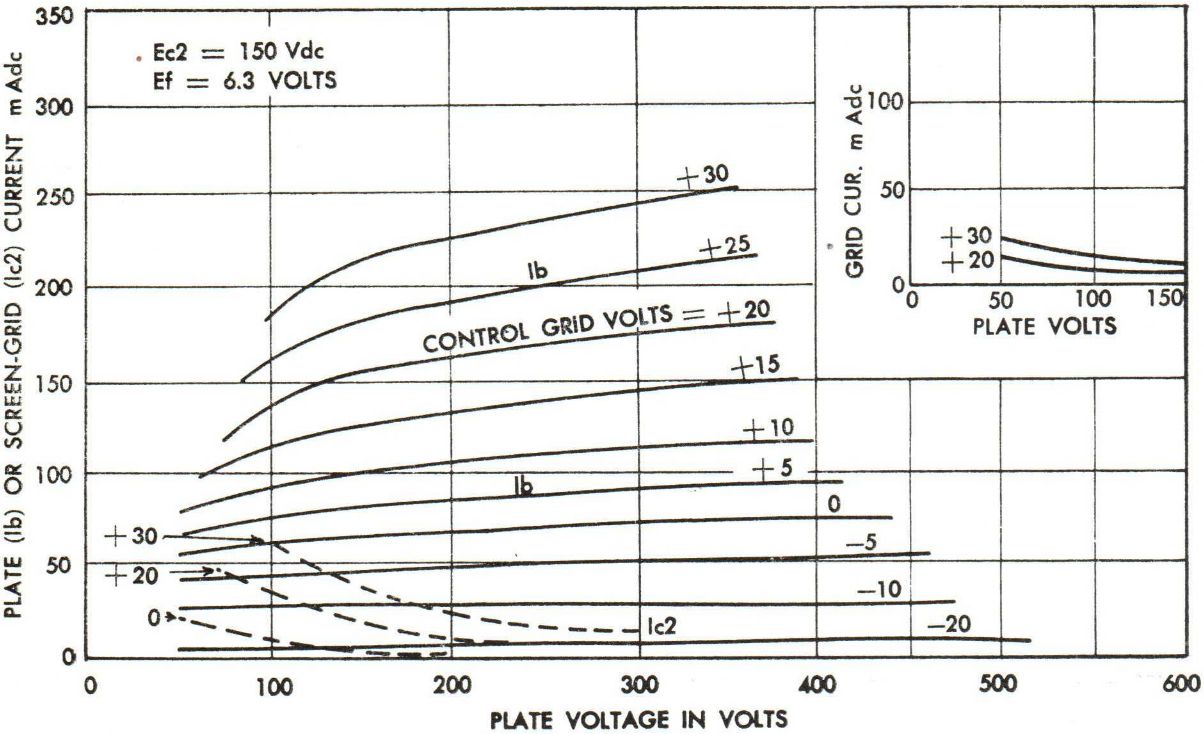


Figure 3-61. Typical Static Plate Characteristics of Tube Type JAN 2E30; Ec2 = 150.

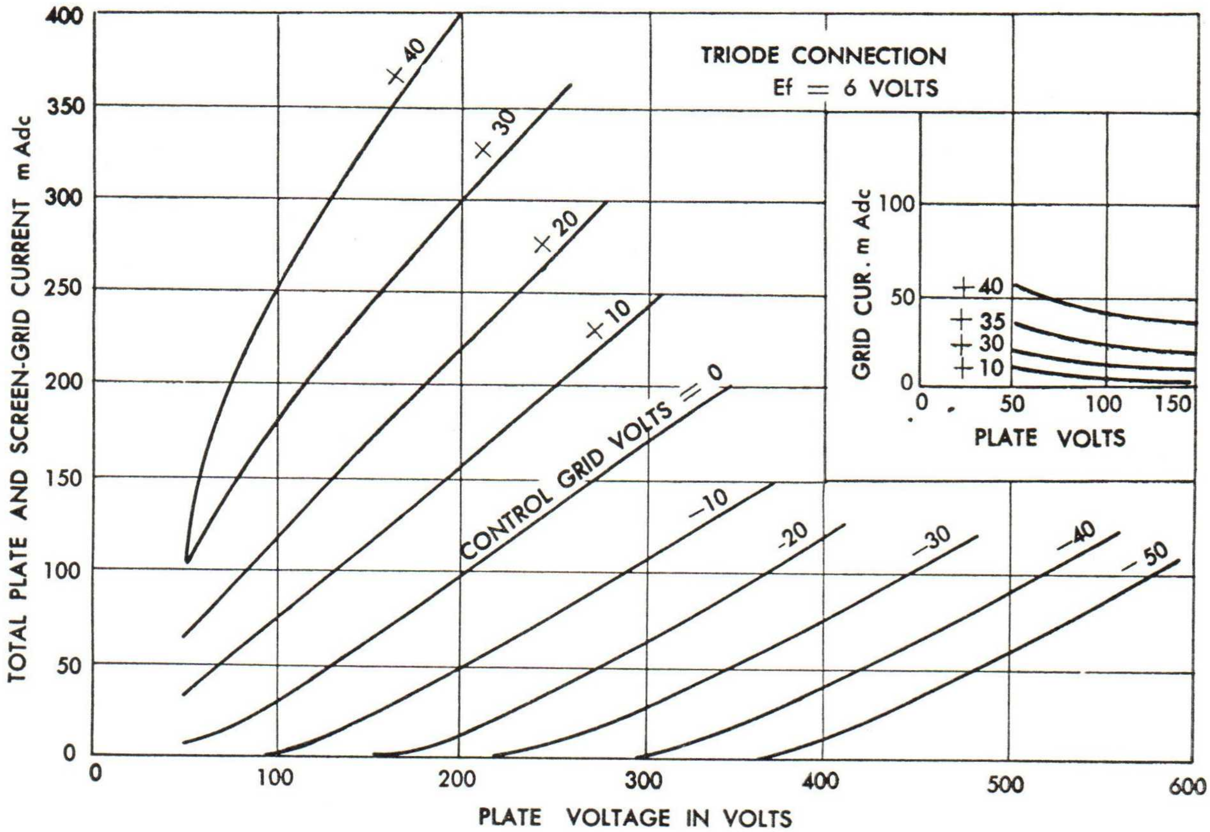


Figure 3-62. Typical Static Plate Characteristics of Tube Type JAN 2E30; Triode Connected.

SECTION

TUBE TYPE JAN–3A5

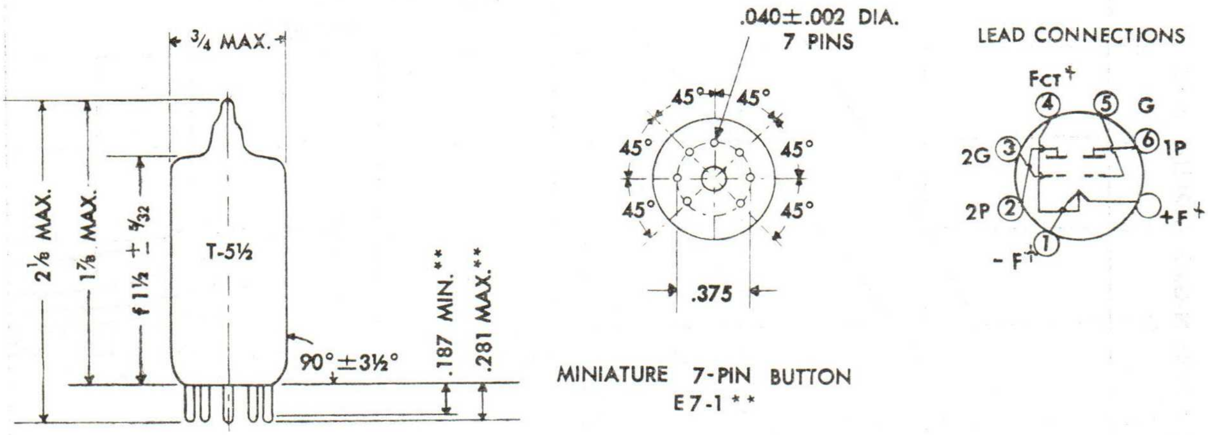
DESCRIPTION.

The JAN–3A5 [1] is a miniature, filamentary twin triode designed for use as a high-frequency amplifier or oscillator in portable, battery-operated equipment. Operation at a filament voltage of either 2.8 volts or 1.4 volts is permitted by the center-tapped filament.

ELECTRICAL. The electrical characteristics are as follows:

Filament Voltage	Series 2.8 Vdc Parallel 1.4 Vdc
Cathode	Coated Filament

MOUNTING. Any type of mounting is adequate.



7 PIN MINIATURE
6-2
5-2*

* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

† FOR PARALLEL FILAMENT OPERATION, PIN NUMBER 4 IS POSITIVE, PIN NUMBERS 1 AND 7 ARE NEGATIVE

ALL DIMENSIONS IN INCHES

Figure 3-63. Outline Drawing and Base Diagram of Tube Type JAN-3A5.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Filament Voltage	1.4 ± 15% or 2.8 ± 15% Vdc
Plate Voltage	150 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*	
Cathode Current (per Cathode)	14 mAdc
Plate Dissipation (per Plate)	1.0 W
Altitude Rating	10,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/33A dated 14 January 1954.

TEST CONDITIONS.

Test conditions are as follows:

- Filament Voltage, Ef .... 1.4 Vdc
- Plate Voltage, Eb .... 135 Vdc
- Grid Voltage, Ec .... –1.5 Vdc

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/33A dated 14 January 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Filament Current	If		200	240	...	...	mA
Transconductance	Sm		2080	3120	1690	...	umhos
Amplification Factor	Mu		13	17	...	...	...
Plate Current (1)	Ib		8.3	16.7	...	...	mAdc
Plate Current (2)	Ib	Ec = —10.5 Vdc Eb = 90 Vdc Test Each unit separately; unit not under test, Ec = —50 vdc	..	375	...	...	uAdc
Power Oscillation (1)	Po	F = 50 mc Push-pull Ib = 30 mAdc Ic = 6 mAdc Rg = 4000 ohms	1.4	...	...	...	W
Power Oscillation (2)	Po	Ef = 1.1	0.45	...	...	...	W
Capacitance	Cgp	Ef = 0	2.7	3.7	...	...	uuf
(Unshielded)	Cin	Ef = 0	0.70	1.10	...	...	uuf
	Cout	Ef = 0	0.70	1.30	...	...	uuf
Grid Current	Ic	Units tied together	0	—1.5	...	...	uAdc

APPLICATION OF JAN-3A5

The chart below shows the permissible operating area for JAN-3A5 as defined by the ratings in MIL-E-1/33A dated 14 JAN 1954. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2 through 3.1.6.

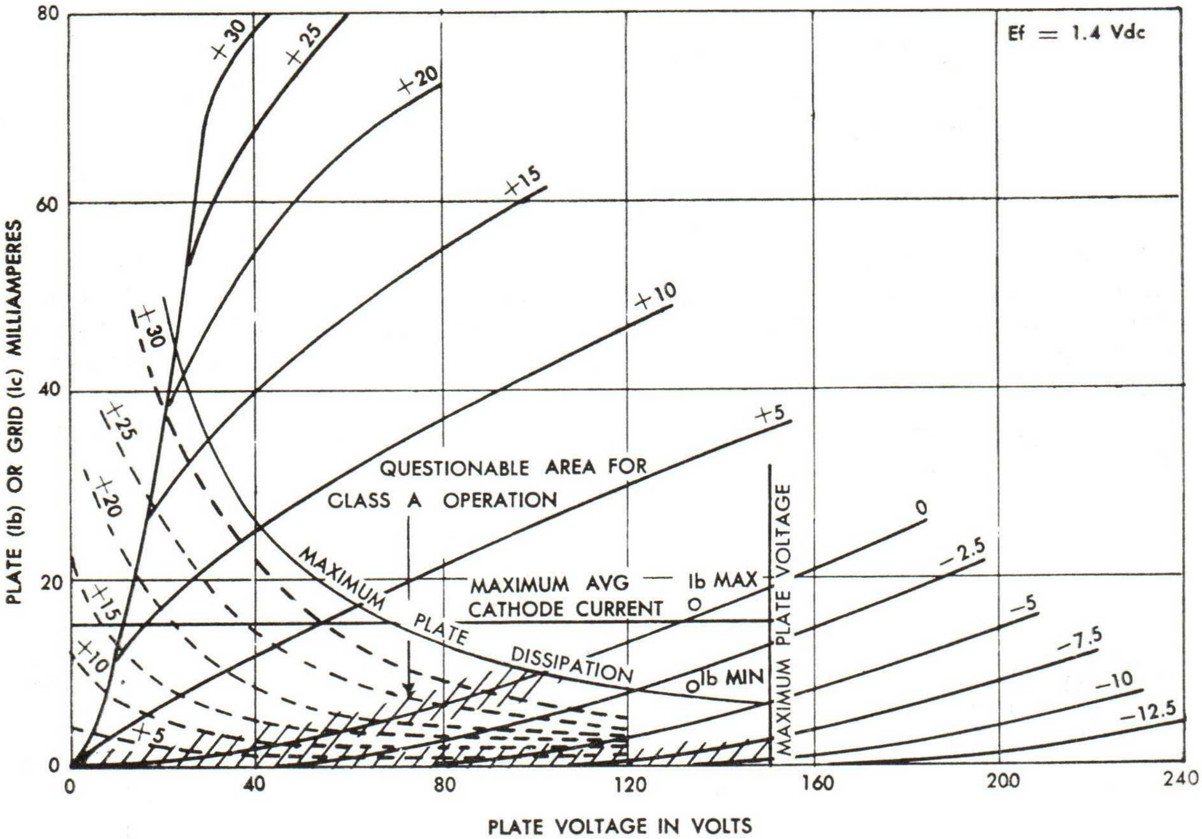


Figure 3-64. Typical Static Plate Characteristics of Tube Type JAN-3A5; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operationo, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermioonic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN-3A5 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-3A5 as defined by MIL-E-1/33A dated 14 January 1954.

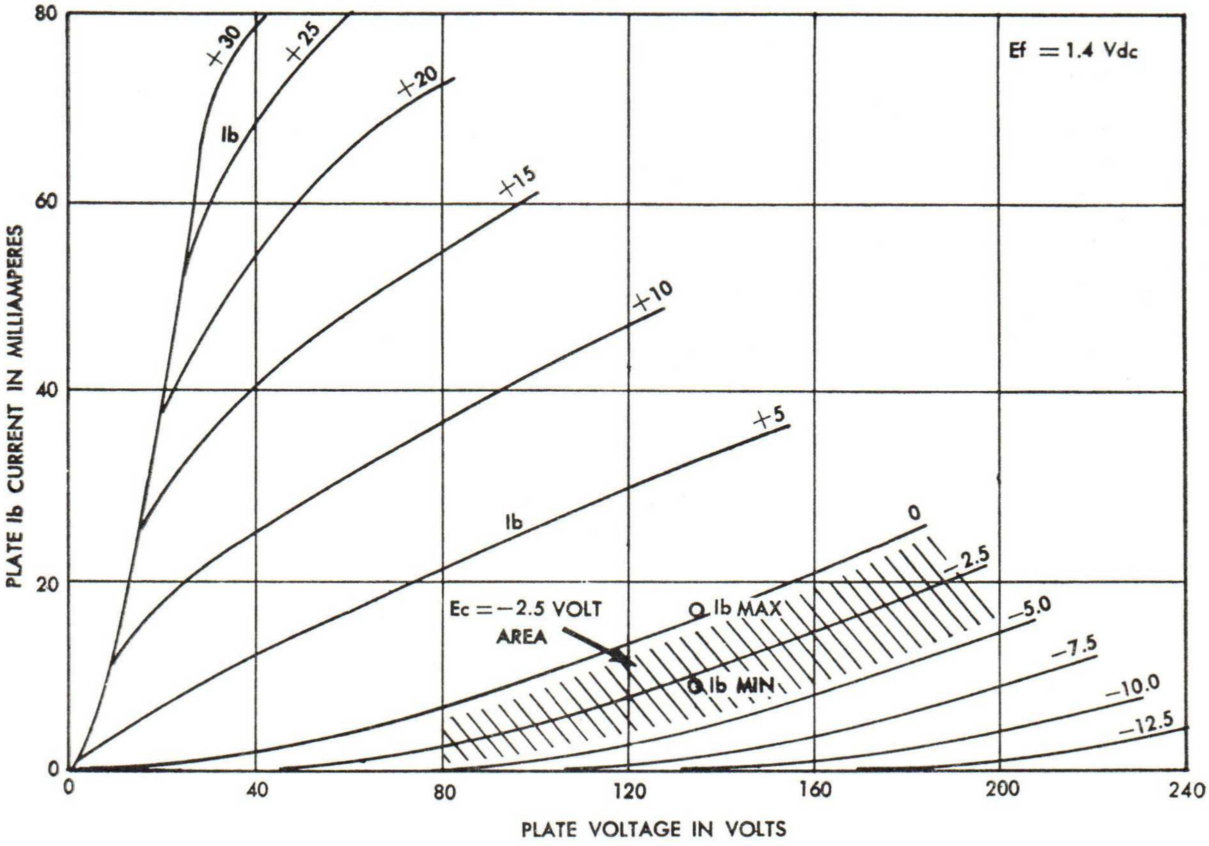


Figure 3-65. Limit Plate Characteristics of JAN-3A5.

DESIGN CENTER CHARACTERISTICS OF JAN–3A5

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristic of JAN–3A5.

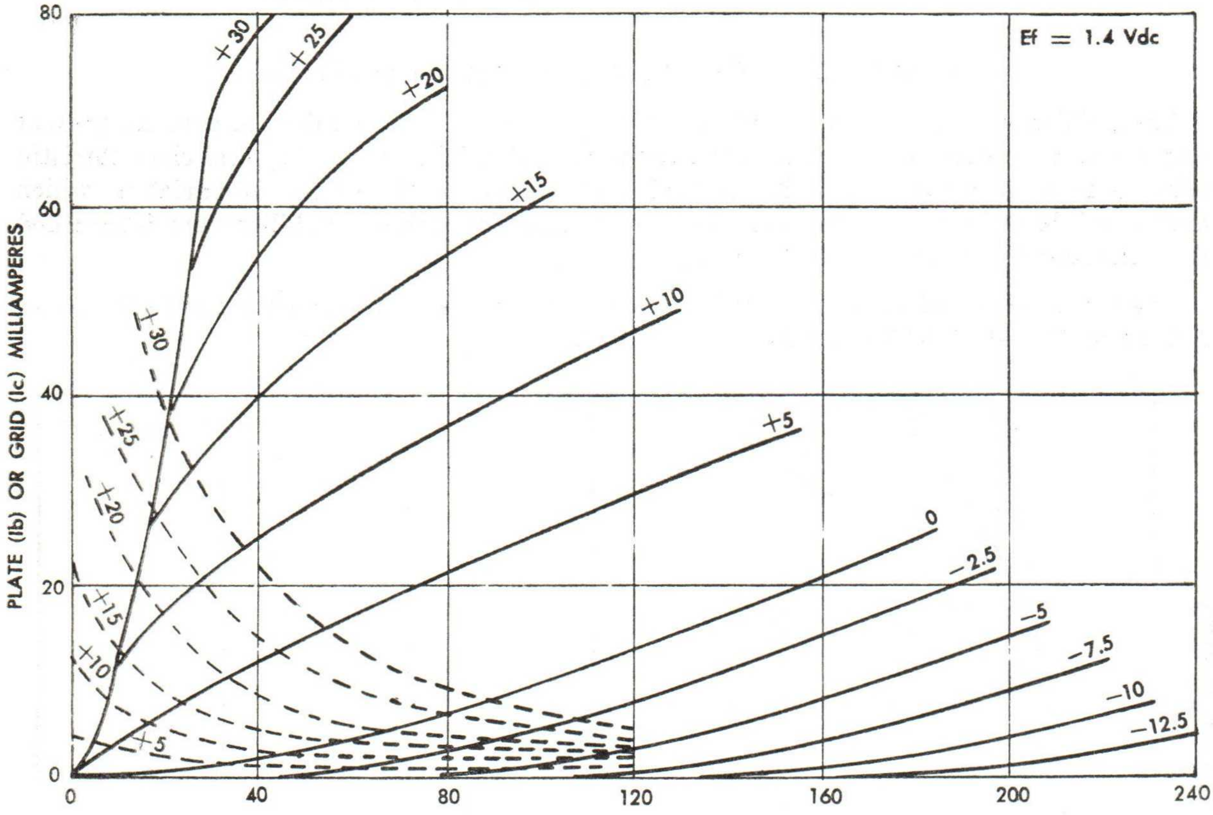


Figure 3-66. Typical static plate Characteristics of JAN-3A5.

SECTION

TUBE TYPE JAN-3B4

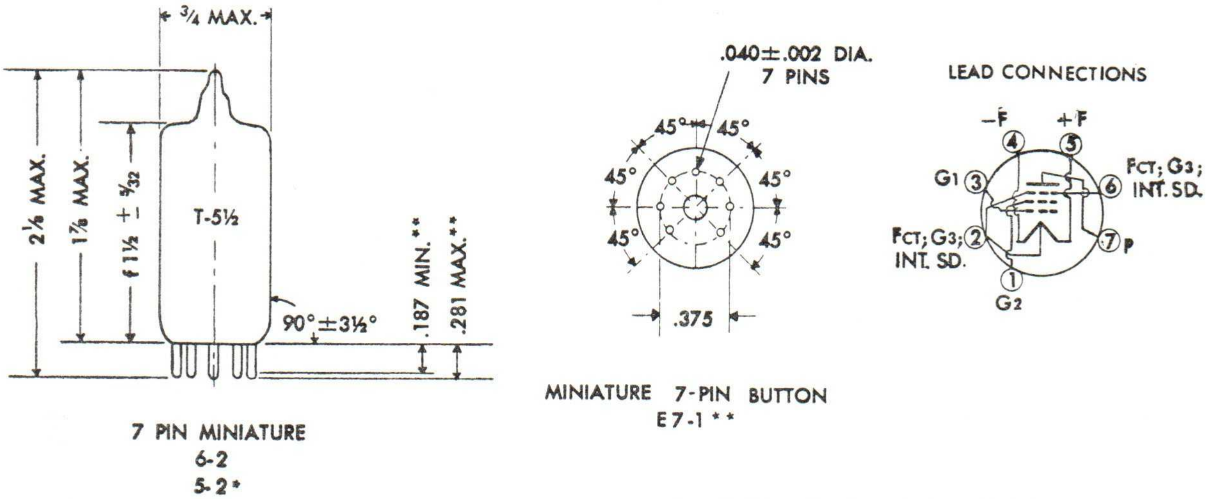
DESCRIPTION.

The Jan-3B4 [1] is a 7 pin, miniature, filamentary, power amplifier.

ELECTRICAL. The electrical characteristics are as follows:

	Parallel	Series
Filament Voltage	1.25 V	2.5 V
Cathode	Oxide Coated Filament	

MOUNTING. Any type of mounting is adequate.



* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-67. Outline Drawing and Base Diagram of Tube Type JAN-3B4.

RATINGS, ABSOLUTE SYSTEM.
The absolute system ratings are as follows:

	Parallel	Series
Filament Voltage, Maximum	1.438V	2.875V
*Filament Voltage, Minimum	1.062V	2.125V
Plate Voltage, Maximum		150 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*		
Control Grid Voltage, Minimum		—75 Vdc
*Control Grid Current		1.5 mAdc
*Plate Dissipation		3 W
*Screen Grid Dissipation		1.1 W
*Plate Current		25 mAdc

* No test of operation at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/34B dated 17 December 1954.

Screen Grid Voltage .... 135 Vdc
*Altitude Rating .... 10,000 ft
Frequency Rating .... 100 Mc

TEST CONDITIONS AND DESIGN CHARACTERISTICS.

Test conditions and design center characteristics are as follows:
Heater Voltage, Ef .... 2.5 Vac
Plate Voltage, Eb .... 200 Vdc
Control Grid Voltage, Ec1 .... —25 Vdc
Screen Grid Voltage, Ec2 .... 150 Vdc

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/34B dated 17 December 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Filament Current	If	Ef = 2.5V	150	180	...	...	mA
Grid Current	Ic1	Measuring time, t = 120 Sec.	0	—1.5	...	...	uAdc
Screen Grid Current	Ic2		...	2	...	...	mAdc
Plate Current	Ib		13	26	...	...	mAdc
Transconductance	Sm		1400	2300	...	...	umhos
Triode Amplification Factor	Mu	Eb=Ec2=150 Vdc	2.7	4.7			
Primary Screen Emission		Eb = 0; Ec2 = 127 Vdc; Ec1/Pg2 = 1W measuring time, t = 300 sec.	...	200			uAdc
Operation peak output voltage	ep	Ebh = 150 Vdc Ec1 = 0; Ec2 = 135 Vdc; R1 = 1000; Eg1 = 50 Vac; Rg1 = 55,000	100	...	85	...	v
Operation Screen Grid Current	Ic2	Ebb = 150 Vdc Ec1 = 0; Ec2 = 135 Vdc; R1=1000; Eg1 = 50 Vac Rg1 = 55,000	5.5	11	...	15	mAdc
Activity	$\frac{\Delta Ep}{Ef}$	Ef = 2.125 Vac	...	7.5	...	15	%
Class C Amplifier		F = 100 mc Eb = Ec2 = 90 Vdc Rg1 = 45,000 Excitation, eg = 35v peak; Max Po/Ib = 15 mAdc	0.5	...			W

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heatre-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-3B4 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The designer is directed to the specification of this type wherein the variation of tube properties are definedby a series of operation tests. The class A variability of this type is difficult to portray, inasmuch as most of the acceptance testing of this type utilize its properties as an oscillator or class C amplifier.

DESIGN CENTER CHARACTERISTICS OF JAN -3B4

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The charts below represent the typical static plate behavior of JAN-3B4.

APPLICATION OF THE JAN-3B4

The chart below shows the permissible operation area for JAN-3B4 as defined by the ratings in MIL-E-1/34B dated 17 December, 1954. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7 of this manual.

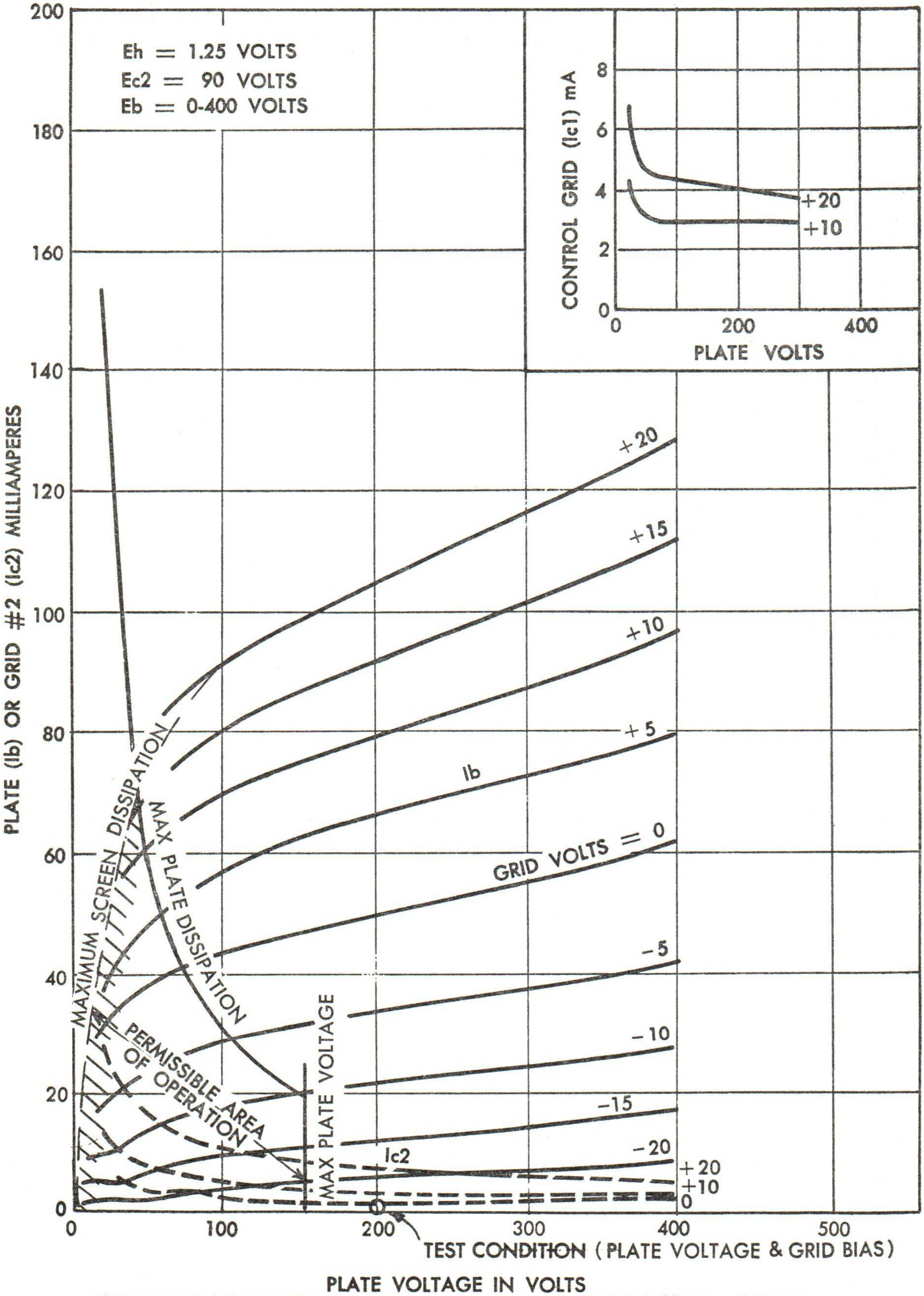


Figure 3-68. Typical Static Plate Characteristics of Tube Type JAN-3B4; Permissible Area of Operation.

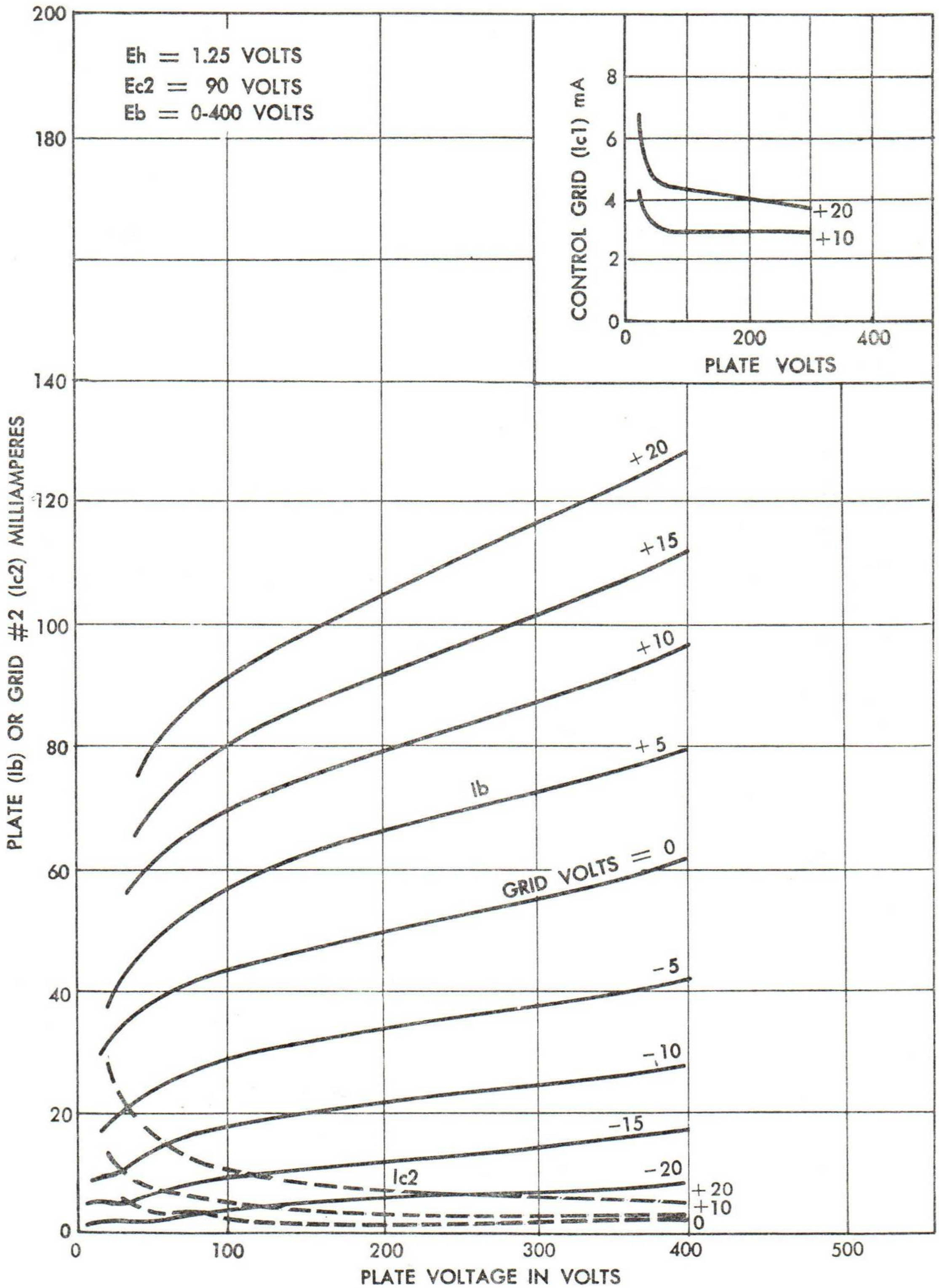


Figure 3-69. Typical Static Plate Characteristics of JAN-3B4; Ec2 = 90.

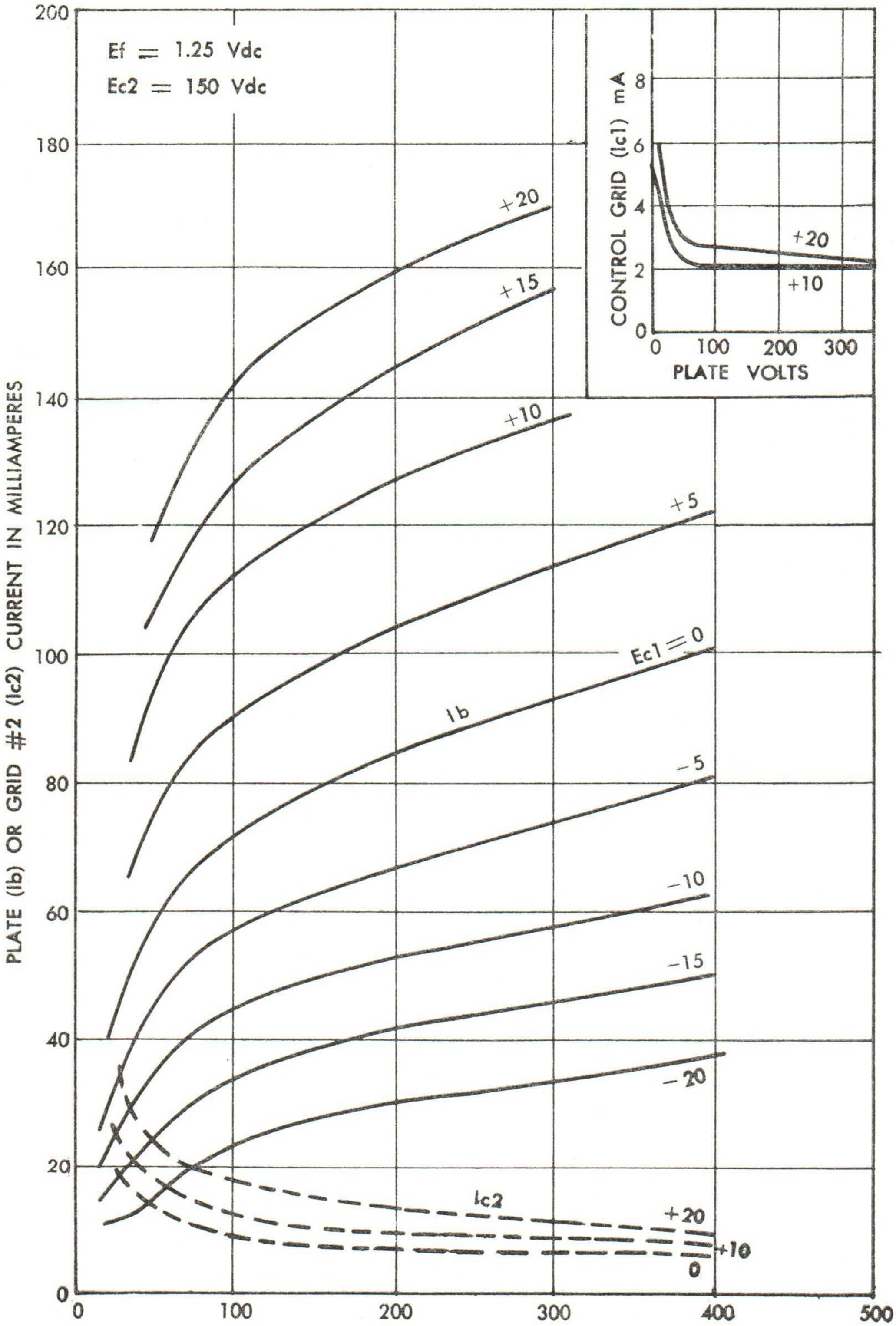


Figure 3-70. Typical Static Plate Characteristics of JAN-3B4; Ec2 = 150.

SECTION

TUBE TYPE JAN-3V4

DESCRIPTION.
The JAN-3V4 [1] is a 7 pin miniature, filamentary, power, amplifier.
ELECTRICAL. The electrical characteristics are as follows:

Filament Voltage	Parallel 1.4 Series 2.8
Filament Current	88-112 mAdc....44-56 mAdc
Cathode	Coated filament

MOUNTING. Any type of mounting is adequate.

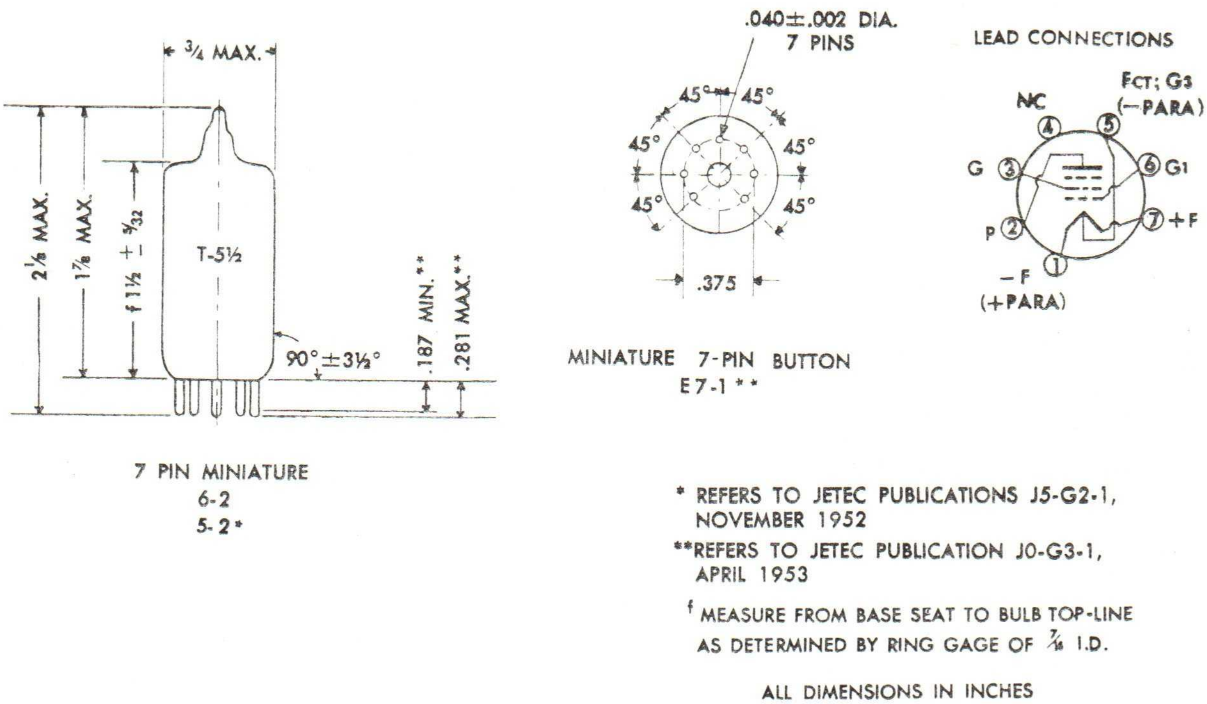


Figure 3-71. Outline Drawing and Base Diagram of Tube Type JAN-3V4.

RATINGS, ABSOLUTE SYSTEM
The absolute system ratings are as follows:

Filament Voltage	1.4 or 2.8 + 15%
Plate Voltage	100 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Screen Voltage	100 Vdc
Cathode Current	13 mAdc
Altitude Rating	10,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/343 dated 14 August 1953.

Test Conditions.

Test conditions are as follows:

Filament Voltage, Ef	1.4 Vdc
Plate Voltage, Eb	90 Vdc
Control Grid Voltage, Ec1	—4.5 Vdc
Screen Grid Voltage, Ec2	90 Vdc

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/343 dated 14 August 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Limits: Initial Max	Limits: Life test Min	Limits: Life test Max	Units
Filament Current	If		88	112	...	...	mA
Grid Current	Ic1		0	—1.0	...	...	uAdc
Plate Current	Ib		6.5	12.5	...	...	mAdc
Screen Current	Ic2		1.3	3.1	...	...	mAdc
Transconductance	Sm		1800	2500	...	...	umhos
Power Output (1)	Po	Esig = 3.2 Vac Rp = 0.01 Meg	210	...	135	...	mW
Power Output (2)	Po	Esig = 3.2 Vac Rp = 0.01 Meg Ef = 1.1 Vdc	140	...	...	...	mW
Capacitance (Unshielded)	Cg1-p	Ef = 0	...	0.40	...	...	uuf
	Cin	Ef = 0	3.8	7.3	...	...	uuf
	Cout	Ef = 0	2.2	5.4	...	...	uuf

APPLICATION OF JAN-3V4

The chart below shows the permissible operating area for JAN-3V4 as defined by the ratings in MIL-E-1/343 dated 14 August 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

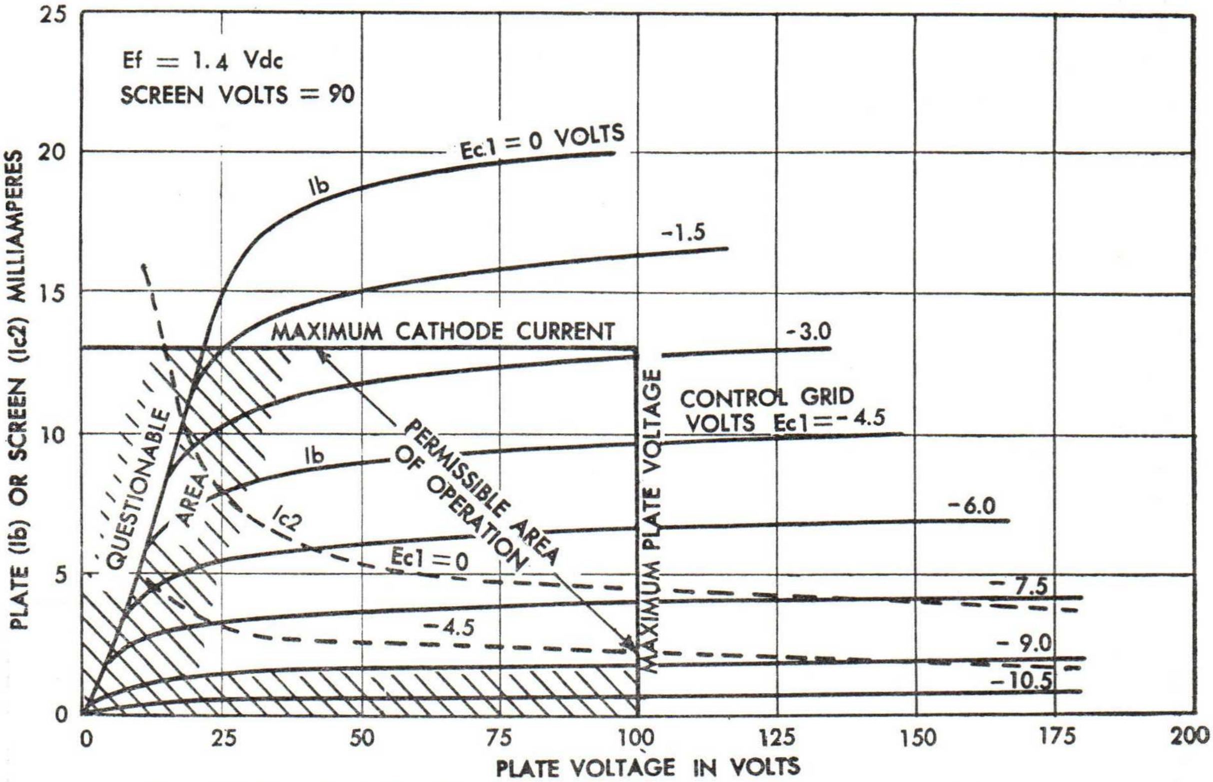


Figure 3-72. Typical Static Plate Characteristics of Tube Type JAN-3V4; Permissible Area of Operation.

The following table lists general considerations for the application of this type type. The numbers refer to applicable sections or paragraphs of this manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8

Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN–3V4 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN–3V4 as defined by MIL–E–1/343 dated 14 August 1953.

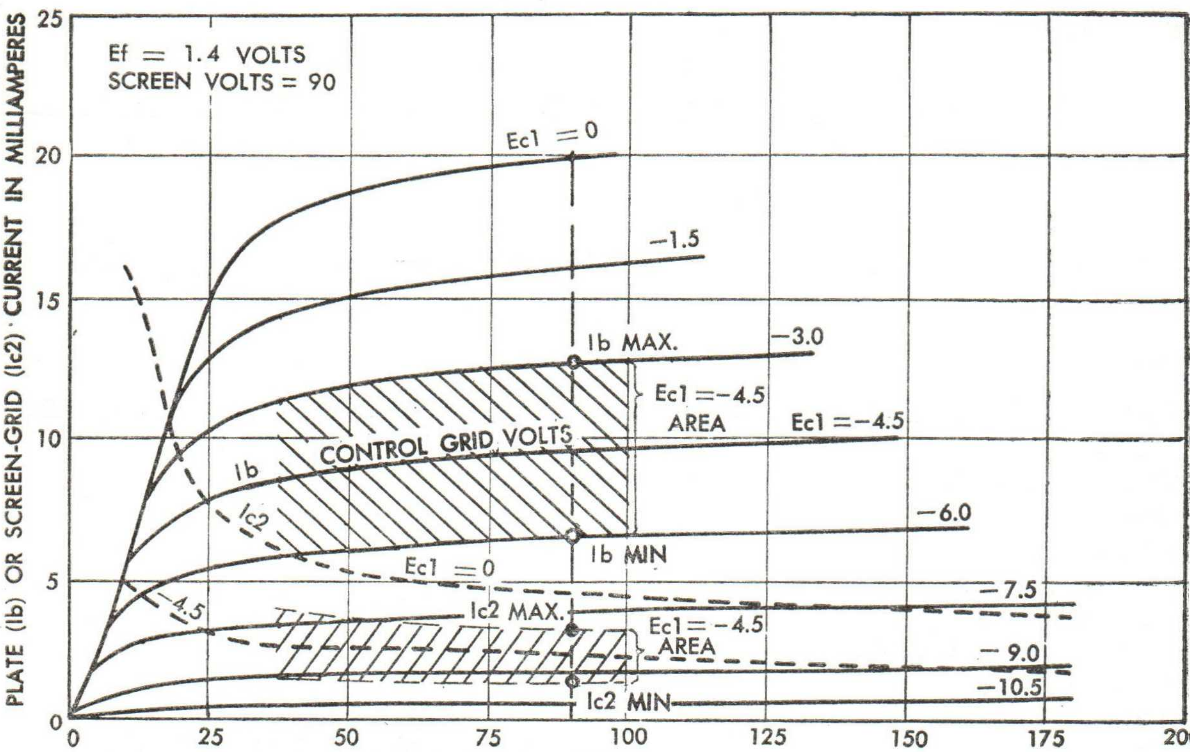


Figure 3-73. Limit Plate Characteristics of JAN-3V4.

DESIGN CENTER CHARACTERISTICS OF JAN-3V4

These typical curves have ben obtained from current data being published by the original RETMA registrant of this tube type.

The chart below represents the Static Plate Characteristics of JAN-3V4.

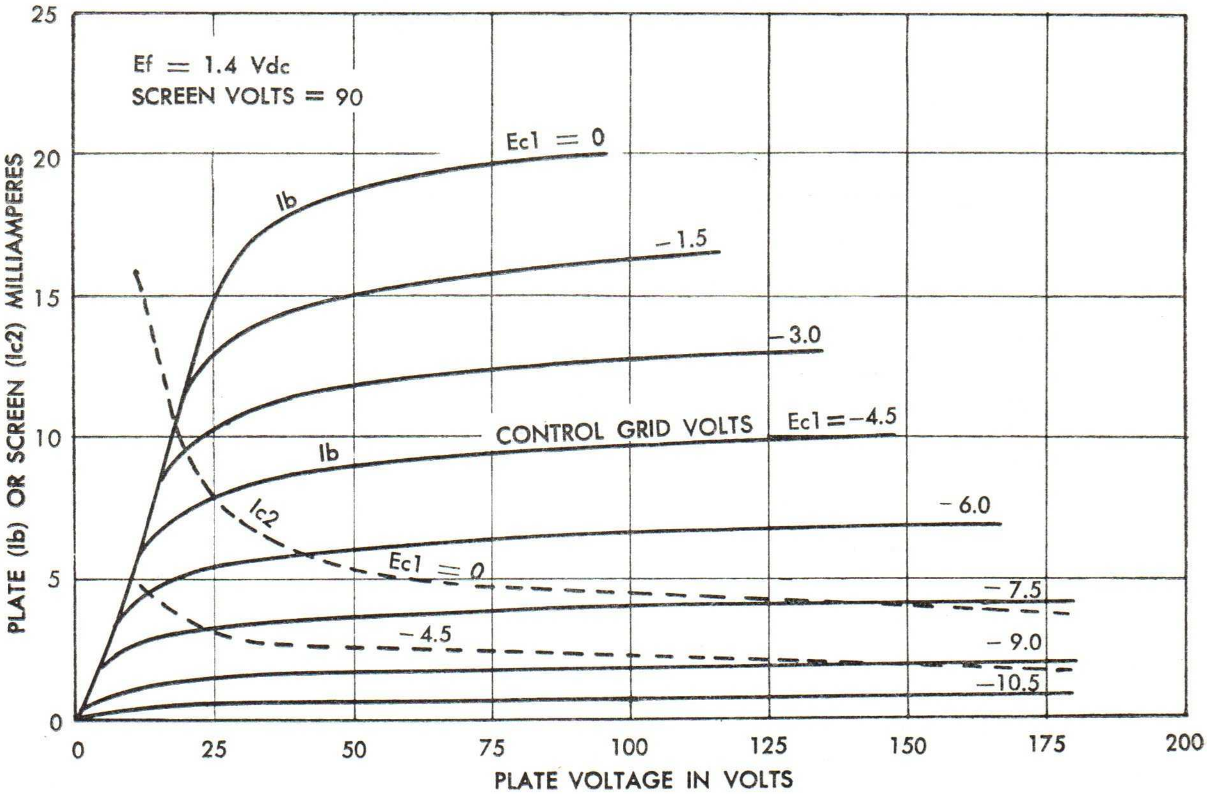


Figure 3-74. Typical Static Plate Characteristics for JAN-3V4.

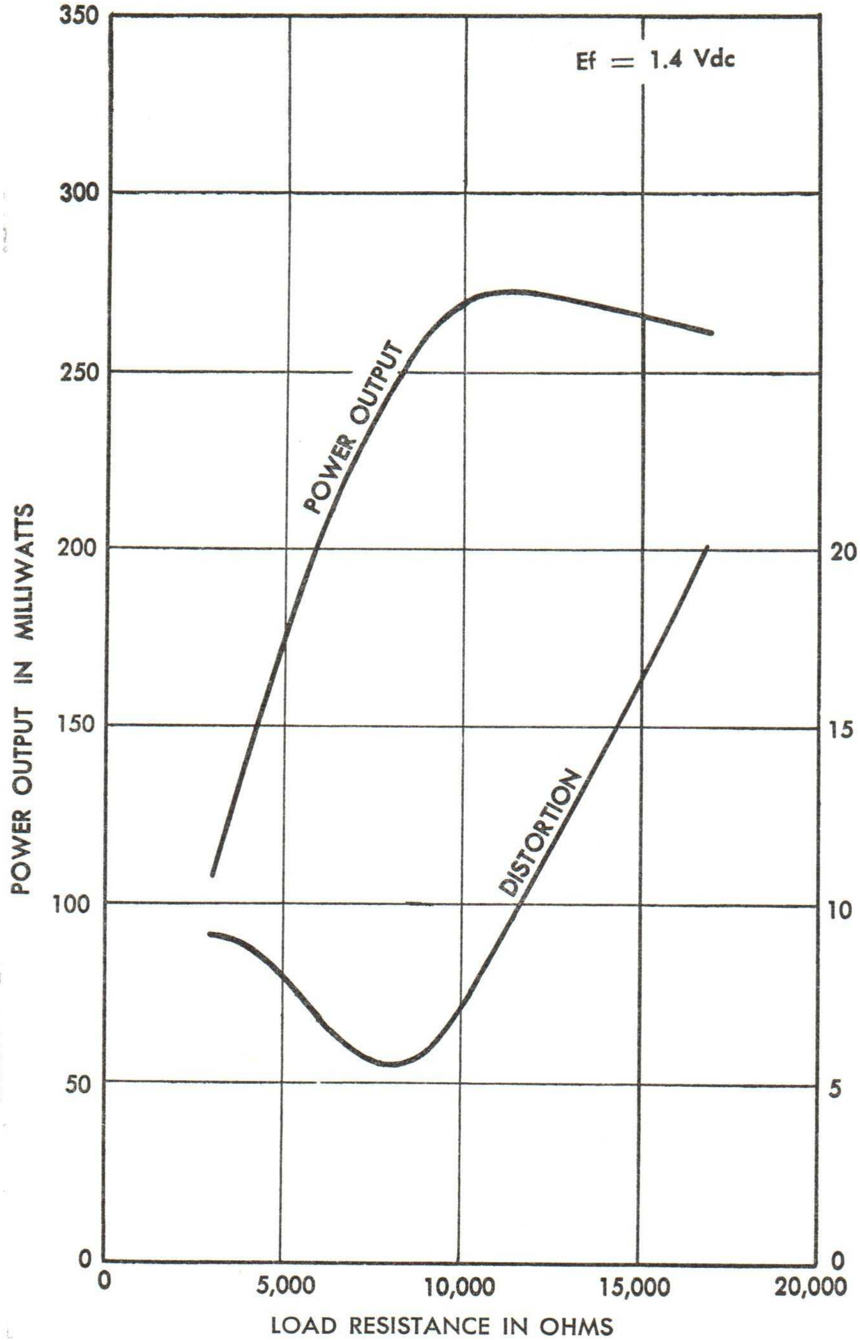


Figure 3-75. Typical Operating Characteristics of Tube Type JAN-3V4.

SECTION

TUBE TYPE JAN-5R4WGA

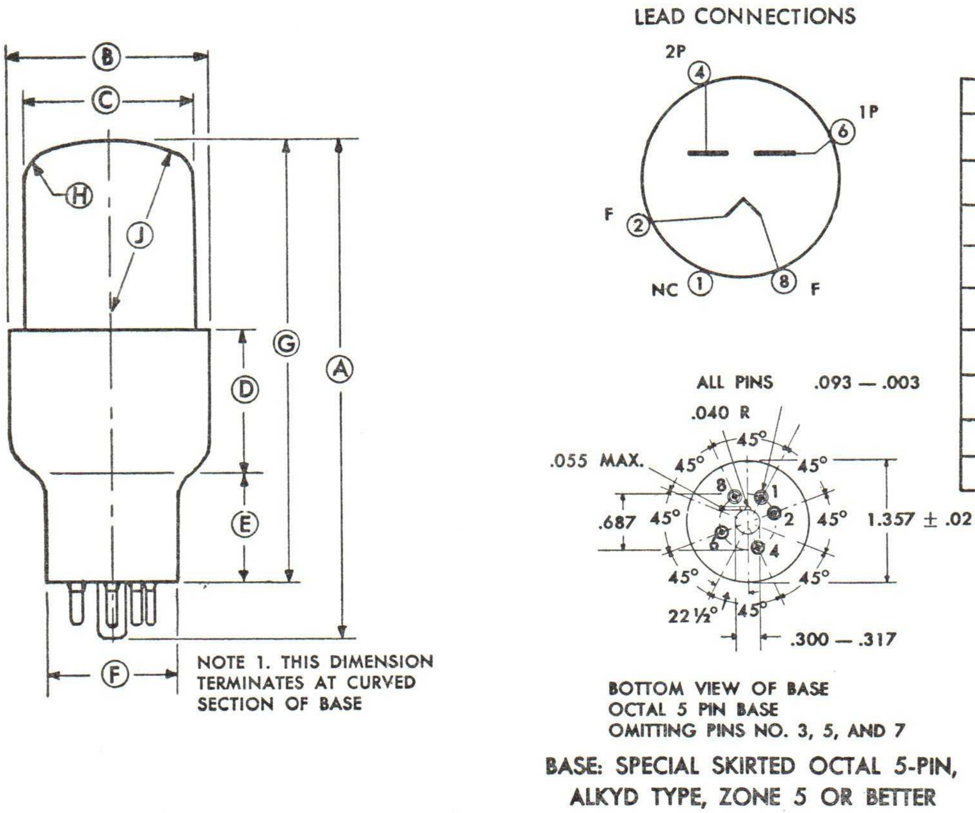
DESCRIPTION.

The JAN-5R4WGA [1] is a 5 pin, octal base, full-wave, high vacuum rectifier suitable in applications where the dc load current does not exceed 275 milliamperes.

ELECTRICAL: The electrical characteristics are as follows:

Heater Voltage .... 5.0 Vac
Cathode .... Coated Filament

MOUNTING. Vertical mounting or as specified.



REF	DIMENSION
A	5 5/16 MAX.
B	2 1/16 MAX.
C	1 3/4 ± 1/16
D	1 5/8 MAX.
E	7/8 MIN. SEE NOTE 1
F	1.337 MIN. 1.377 MAX.
G	4 3/4 MAX.
H	5/16 O.R. NOM.
J	2 O.R. NOM.

ALL DIMENSIONS IN INCHES

Figure 3-76. Outline Drawing and Base Diagram for JAN-5R4WGA.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 5 Vac 10%
*Peak Inverse Plate Voltage .... 3050 v
Steady State Peak Plate Current (per Plate) .... 700 mA
Output Current .... 275 mAdc
Cathode Conditioning Time .... 10 Sec
Altitude Rating (See Chart) .... 60,000 Ft

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/116A dated 4 March 1954.

TEST CONDITIONS

Test conditions are as follows:

Heater Voltage, Ef	5.0 Vac
Plate Supply Voltage (per Plate) Epp/p	850 Vac
Load Resistance, RL	3500 ohms
Load Capacitance, CL	4 uf
Plate Circuit Impedance (per Plate) Max Zp/p	200 ohms

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/116A dated 4 March 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		1.8	2.2	—	—	A
Operation (1)	Io	epx = 2800 v Full-wave Zp/p = 500 RL = 7000 ohms tk = 10	140	—	—	—	mAdc
Operation (2)	Io	Full-wave tk = 10	245	—	210	—	mAdc
Emission (Each plate separately)	Is	Eb = 75 Vdc	225	400	—	—	mAdc

APPLICATION OF THE JAN-5R4WGA

Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN-5R4WGA must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Rating Chart I is based on maximum rated peak inverse voltage per plate (epx) of 3050 volts and maximum rated dc output current per plate (Io/p) of 137.5 milliamperes. Point C corresponds to the simultaneous occurance of these two ratings, permissible only under choke-input filter conditions. Point E is derived from life test conditions of rated dc output current into capacitor input filter. The area CDE is restricted to choke input service only.

Rating Chart II for capacitor input filter applications, is based on maximum rated dc output current per plate (Io/p) and maximum rated steady state peak plate current (Ib) of 700 milliamperes per plate. Rectification efficiency must not exceed 0.54 under conditions of maximum rated dc output current.

Rating Chart III for capacitor input filter is based on maximum rated surge current (i surge) of 2.2 amperes per plate. Minimum permissible series resistance (Rs) is approximately 575 ohms per plate under conditions of maximum permissible supply voltage.

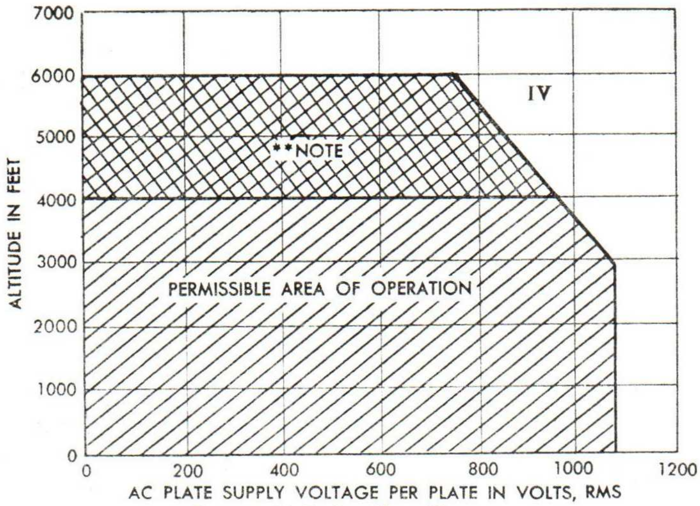


Figure 3-80. Rating Chart IV

* Note: No specification assurance of proper cathode operation exists if JAN-5R4WGA is operated in this region.

** Note: No specification test assurance exists for operation at altitudes greater than 40,000 feet.

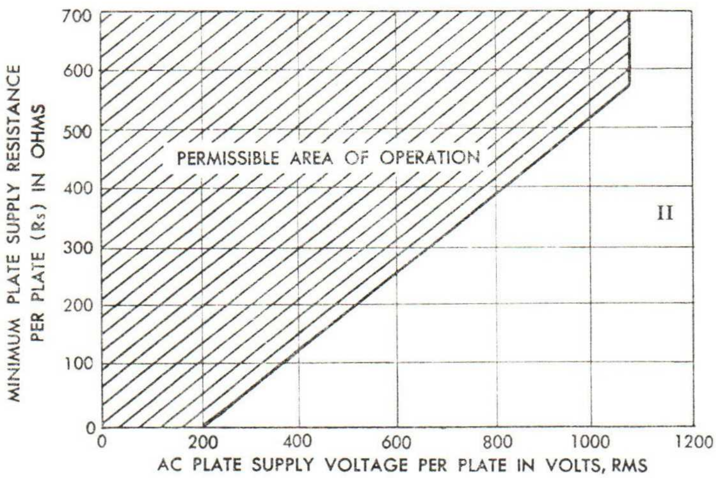


Figure 3-78. Rating Chart II

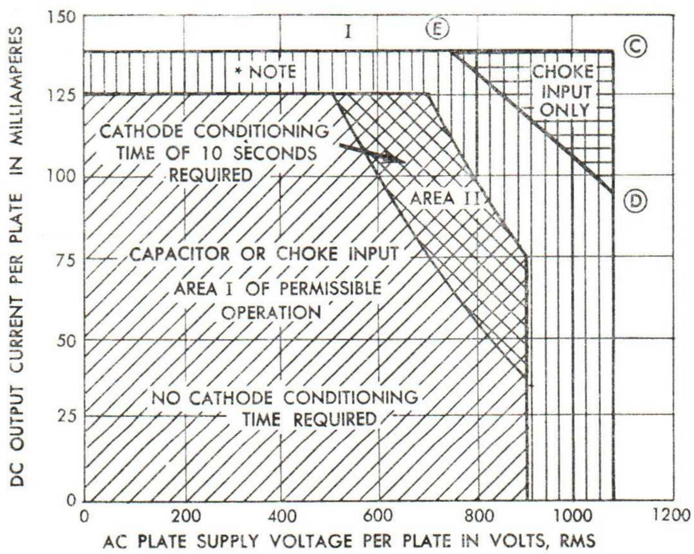


Figure 3-77. Rating Chart I

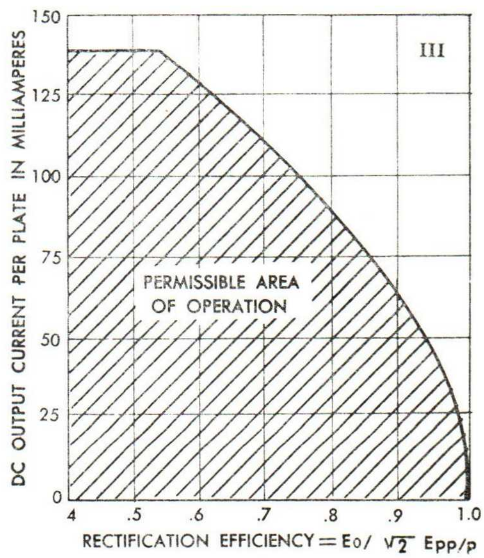


Figure 3-79. Rating Chart III

Rating Chart IV sets forth limiting conditions under high altitude operation, in terms of permissible peak-inverse plate voltage. Maximum peak inverse voltage rating of 3050 volts must be decreased at altitudes greater than 30,000 feet, as shown on the chart.

Rating Chart V is reproduced from the specification which describes this tube type. Operation in Area II requires a minimum of 10 seconds of filament pre-heating prior to the application of place voltage.

OTHER CONSIDERATIONS:

Heater Voltage: See paragraph 3.3.5.

TYPICAL CHARACTERISTICS OF JAN-5R4WGA

The chart below presents the static Plate Characteristics of JAN–5R4WGA, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limin on emission.

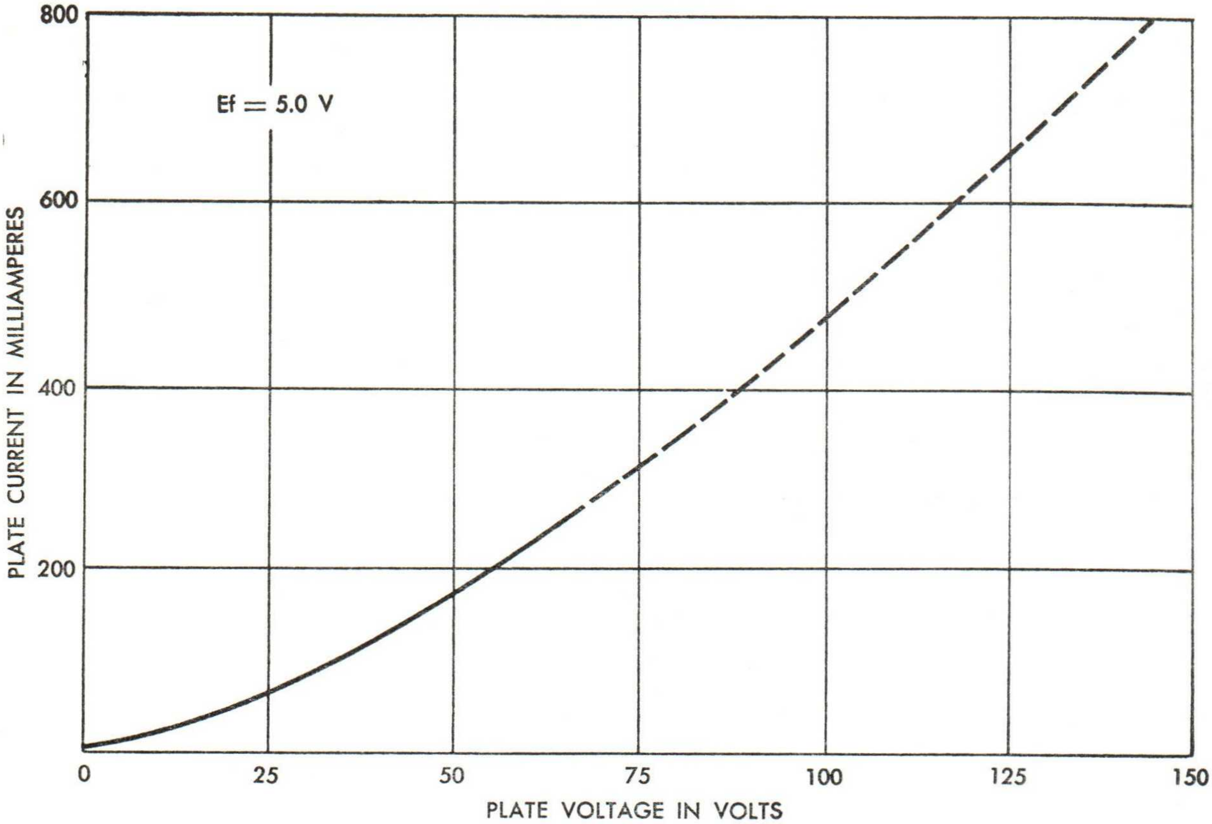


Figure 3-81. Typical Plate Characteristics for JAN-5R4WGA.

SECTION
TUBE TYPE JAN-5Y3WGTA

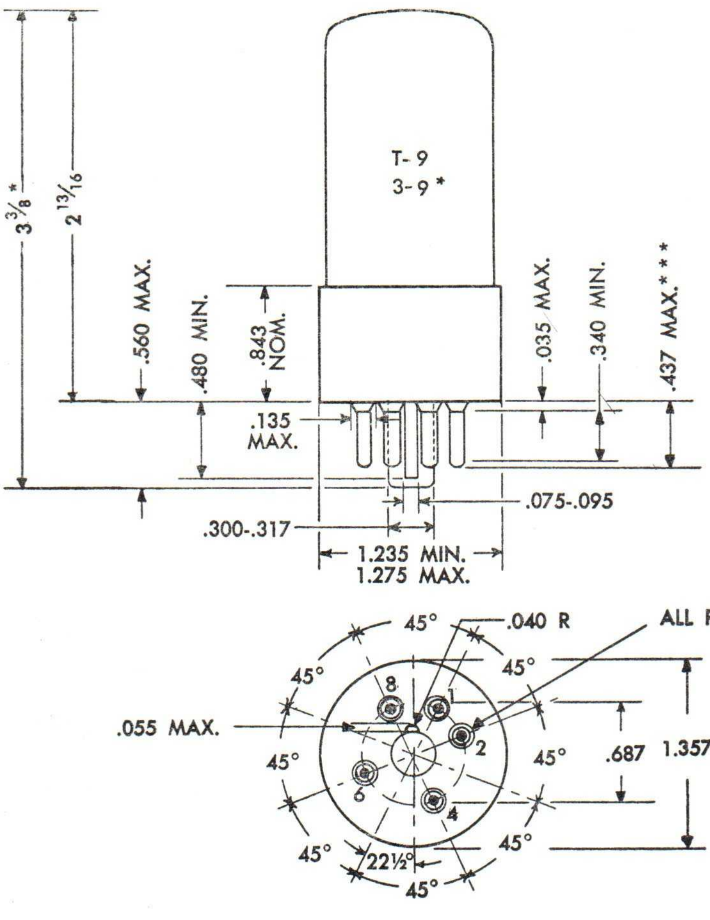
DESCRIPTION

The JAN-5Y3WGTA [1] is a 5 pin, octal base, full-wave, high vacuum rectifier suitable for operation where the average dc output current does not exceed 150 milliamperes.

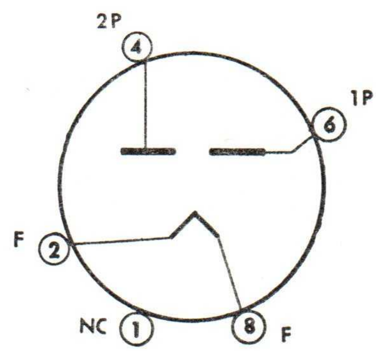
ELECTRICAL:

Heater Voltage .... 5.0 V
Cathode .... Coated Filament

MOUNTING: .... Any



BOTTOM VIEW OF BASE
"LOW-LOSS PHENOLIC"
INTERMEDIATE SHELL OCTAL 5-PIN BASE
OMITTING PINS NO. 3, 5, AND 7
B5-10 **



* REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952

**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

*** ON FINISHED TUBE ADD 0.030 FOR SOLDER

ALL DIMENSIONS IN INCHES

Figure 3-82. Outline Drawing and Base Diagram For Tube Type JAN-5Y3WGTA.

[1] The values and specification comments presented in this section are related to MIL-E-1/1021 dated 28 June 1956.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage	5.0 Vac ± 10%
Peak Inverse Plate Voltage (See Chart I)	1550 v
Steady State Peak Plate Current (Chart II)	415 mA
*Transient Peak Plate Current (Chart III)	2.0 A
Bulb Temperature	225°C
Altitude Rating (See Altitude vs. Current and Voltage Charts)	65,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	5.0 Vac
Plate Supply Voltage, Epp/p	400 Vac
Load Resistance (Unity Power Factor)	2750 ohms
Load Capacitance	4 uf

* No measurement test at this rating exists in the specification.

ACCEPTANCE TESTS LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/44A dated 14 January 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property			Measurement Conditions	Limits				Units
				Initial		Life test		
				Min	Max	Min	Max	
Filament Current		If		1.6	2.0	—	—	A
Operation		Io	See Note	125	—	110	—	mAdc
Emission	Section 1	Is	E2b = 0, E1b = 75 Vdc	120	—	—	—	mAdc
	Section 2	Is	E1b = 0, E2b = 75 Vdc	120	—	—	—	mAdc

Note. In a full wave circuit, adjust Zp/p such that a tube having Etd = 60 Vdc at 125 mAdc per plate gives Io = 140 mAdc.

APPLICATION OF THE JAN-5Y3WGTA

Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN-5Y3WGTA must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Figure 3-83. *Rating Chart I* is based on maximum rated peak inverse voltage per plate (epx) of 1550 volts and maximum rated dc output current per plate (Io/p) of 70 milliamperes. Point C corresponds to the simultaneous occurance of these two ratings, permissible only under choke-input filter conditions. Point E is derived from life test conditions of rated dc output current into capacitor input filter. The area DCE is restricted to choke-input service only.

Figure 3-84. *Rating Chart II* for capacitor input filter applications, is based on maximum rated dc output current per plate of 70 milliamperes and maximum rated steady state peak plate current of 415 milliamperes per plate. Rectification efficiency must not exceed 0.63 under conditions of maximum rated dc output current.

Figure 3-85. *Rating Chart III* for capacitor input filter is based on maximum rated surge current (i surge) of 2.0 amperes per plate. Minimum permissible series resistance (Rs) is approximately 350 ohms per plate under conditions of maximum permissible supply voltage.

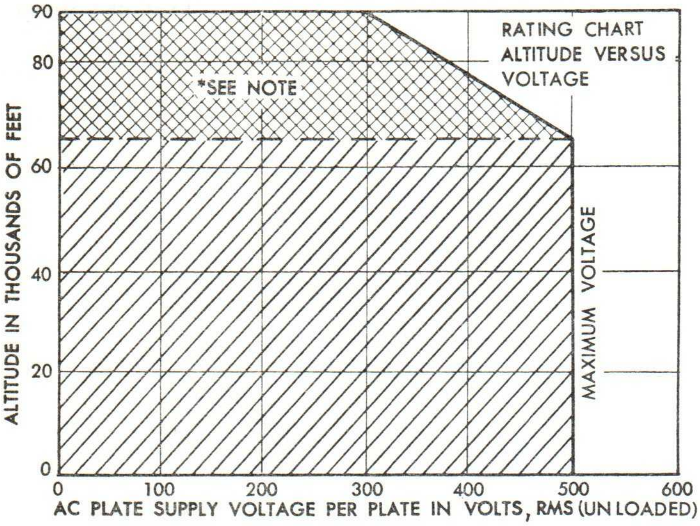
Figure 3-86. *Rating Chart Altitude vs. Voltage.* This chart represents manufacturers rating information and is concerned with the plate supply voltage derating recommended at altitudes greater than 65,000 ft. It should be noted that no specification assurance of performance is afforded at altitudes greater than the MIL-E-1 absolute maximum.

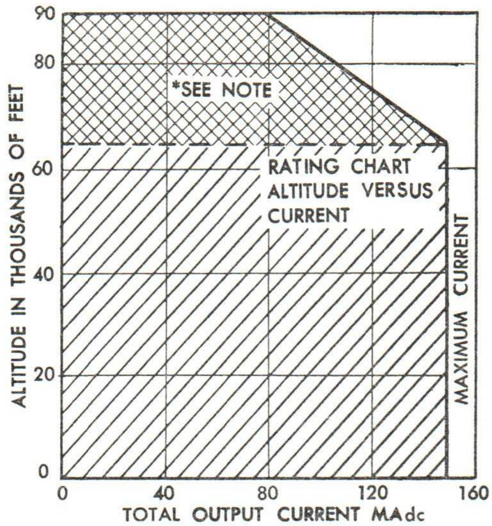
Figure 3-87. *Rating Chart Altitude vs. Current.* This chart represents manufacturers rating information and is concerned with the total output current derating recommended at altitudes greater than 65,000 ft. It should be noted that no specification assurance of performance is afforded at altitudes greater than the MIL-E-1 absolute maximum.

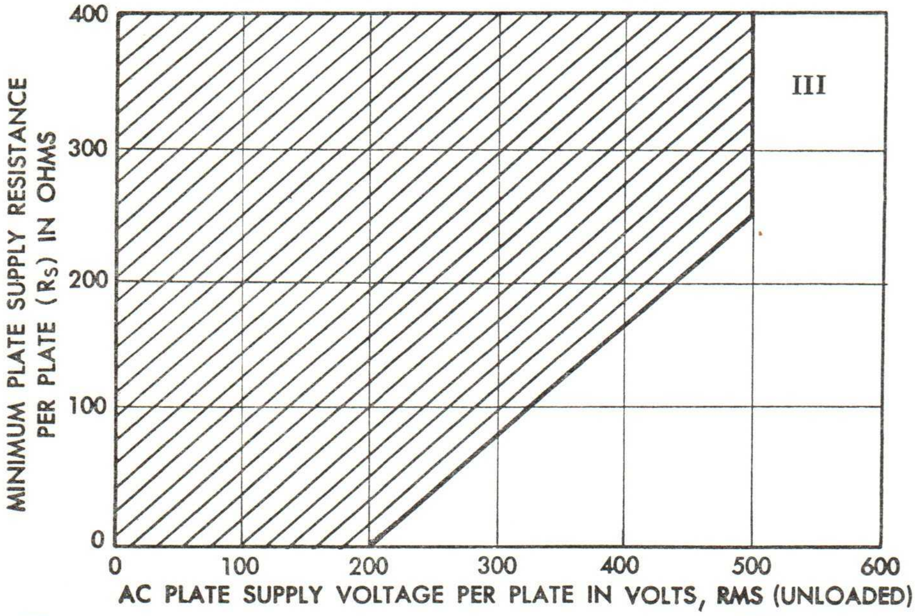
OTHER CONSIDERATIONS:

Heater Voltage. See paragraph 3.3.5.

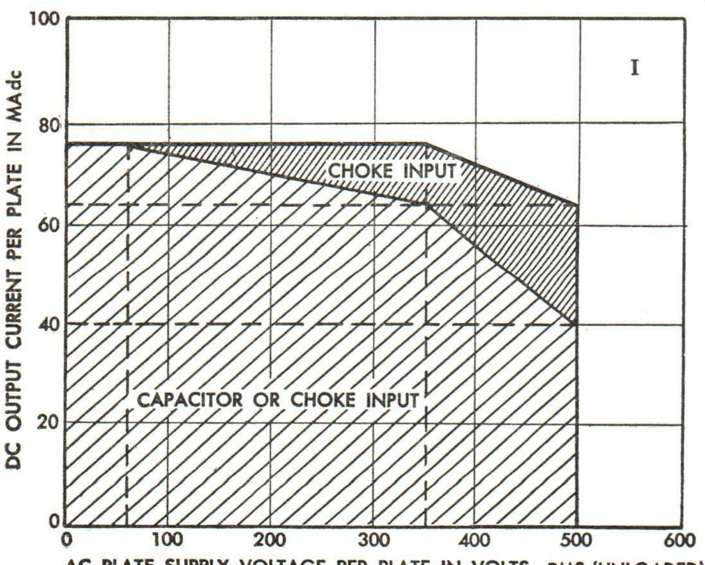
Altitude: See following chart, also paragraph 3.3.3.

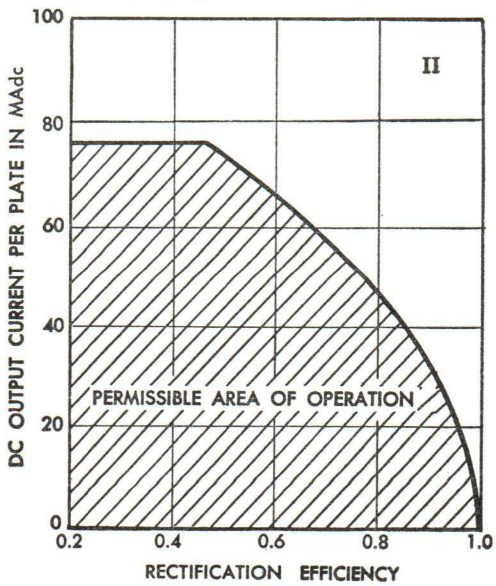






....NOTE: No specification assurance of performance exists in this region (at altitudes greater than the MIL-E-1 maximum of 65,000 ft).





TYPICAL CHARACTERISTICS OF JAN-5Y3WGTA

The chart below presents the Static Plate Characteristics of JAN-5Y3WGTA, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be completely derived from the specification which provides only limited information concerning emission.

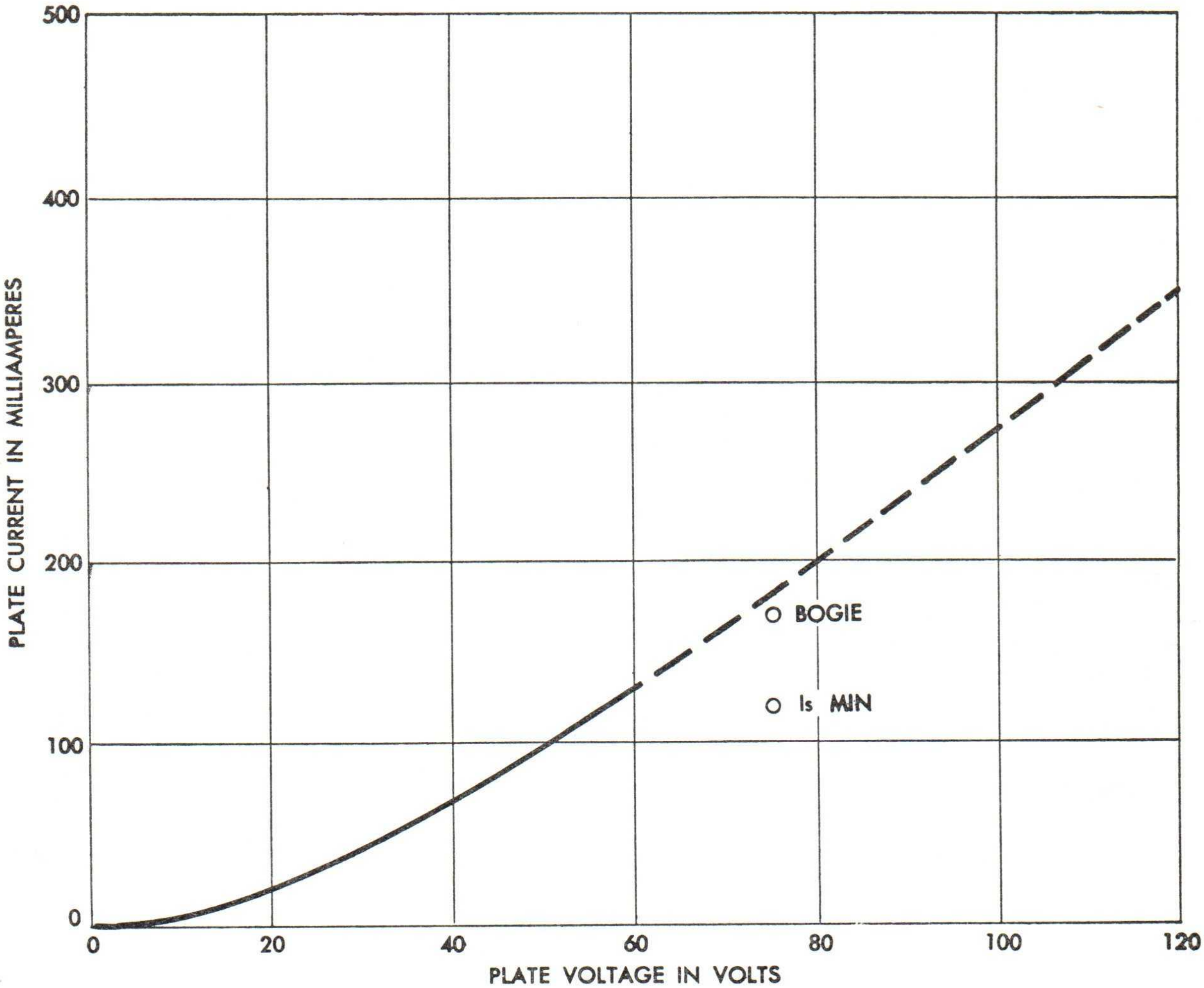


Figure 3-88. Typical Plate Characteristic of JAN-5Y3WGTA.

SECTION
TUBE TYPE JAN-6AG7Y

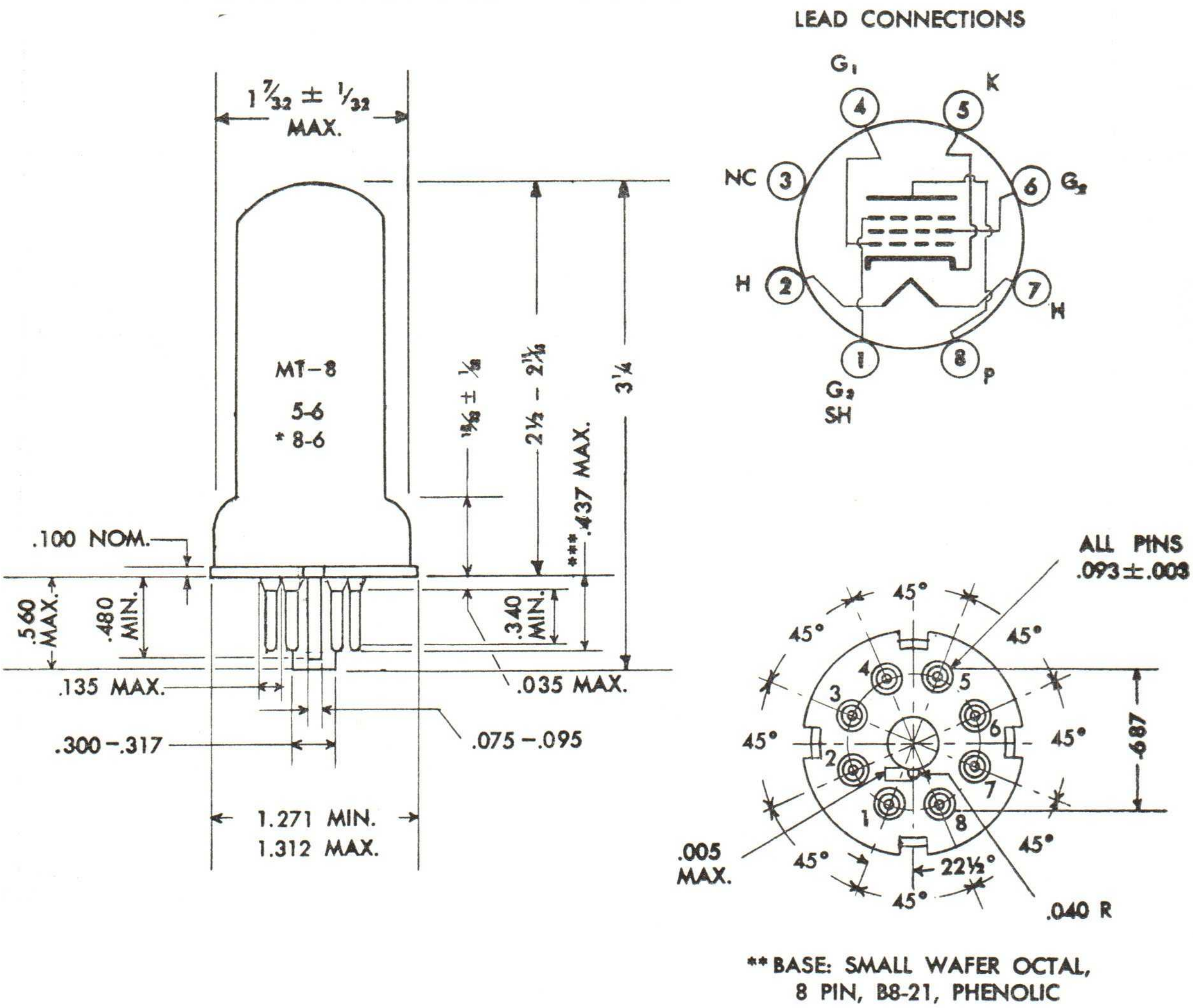
DESCRIPTION.

The JAN-6AG7Y [1] is a small wafer octal metal type power amplifier pentode.

ELECTRICAL. The electrical characteristics are as follows:

- Heater Voltage, AC or DC .... 6.3 V
- Heater Current .... 610 — 690 mA
- Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



ALL DIMENSIONS IN INCHES

*REFERS TO JETEC PUBLICATION J5-G2-1, NOVEMBER 1952

**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

***ON FINISHED TUBE, ADD 0.030 FOR SOLDER

Figure 3-89. Outline Drawing and Base Diagram of Tube Type JAN-6AG7Y.

[1] The values and specification comments presented in this section are related to MIL-E-1/45C dated 14 May 1956.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 10% V
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
*Screen Grid Voltage	330 Vdc
Suppressor Grid Voltage Maximum	0 Vdc
*Cathode Current Maximum	95 mAdc
Plate Dissipation	9.0 W
*Screen Grid Dissipation	1.5 W
Altitude Rating	10,000 ft
Heater Cathode Voltage	100 V

TEST CONDITIONS AND CHARACTERISTICS

Test conditions and characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	300 Vdc
Control Grid Voltage, Ec1	—3 Vdc
Screen Grid Voltage, Ec2	150 Vdc
Suppressor Grid Voltage, Ec3	0 Vdc

ACCEPTANCE TESTS LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/45C dated 14 May 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		610	690	—	—	mA
Transconductance (1)	Sm		9200	14200	—	—	umhos
Plate Current (1)	Ib		20	40	—	—	mAdc
Plate Current (2)	Ib	Eb = 150 Vdc; Ec1 = —20 Vdc	—	100	—	—	uAdc
Emission	Is	Eb = Ec1 = Ec2 = 20 Vdc	180	—	—	—	mAdc
Screen Grid Current	Ic2		4.0	9.0	—	—	mAdc
Power Output	Po	Esig = 2.1 Vac; Rp = 10,000 Ohms Rg series = 300 ohms	2.4	—	1.6	—	W
Capacitance	Cglp	Ef = 0	—	0.060	—	—	uuf
(Without shield)	Cin	Ef = 0	11.5	14.5	—	—	uuf
	Cout	Ef = 0	6.5	8.5	—	—	uuf
Grid Current	Ic		0	—2.0	—	—	uAdc
Heater-Cathode Leakage	Ihk	Ehk = + 100	0	40	—	—	uAdc
	Ihk	Ehk = — 100	0	—40	—	—	uAdc

* No test at this rating exists in the specification.

APPLICATION OF JAN-6AG7Y

The chart below shows the permissible operating area for JAN-6AG7Y as defined by the ratings in MIL-E-1/45C dated 14 May 1956. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7 of this Manual.

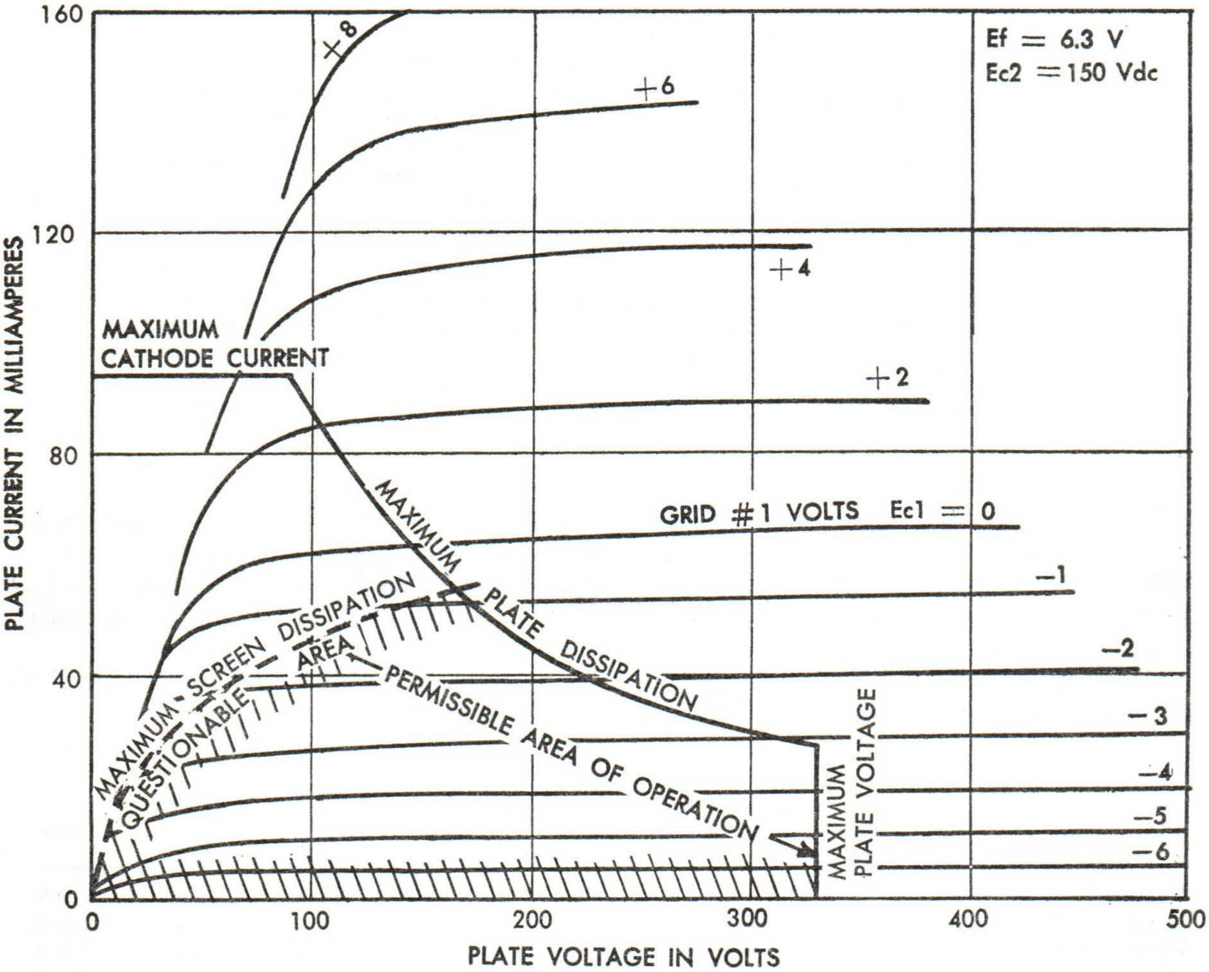


Figure 3-90. Typical Static Plate Characteristics of JAN-6AG7Y; Permissible Area of Operation.

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraphs of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Temperature
Bulb and Environmental, 3.2.3
Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8
Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7
Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9
Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-6AG7Y CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate charactertistics for JAN-6AG7Y as defined by MIL-E-1/45C, dated 14 May, 1956.

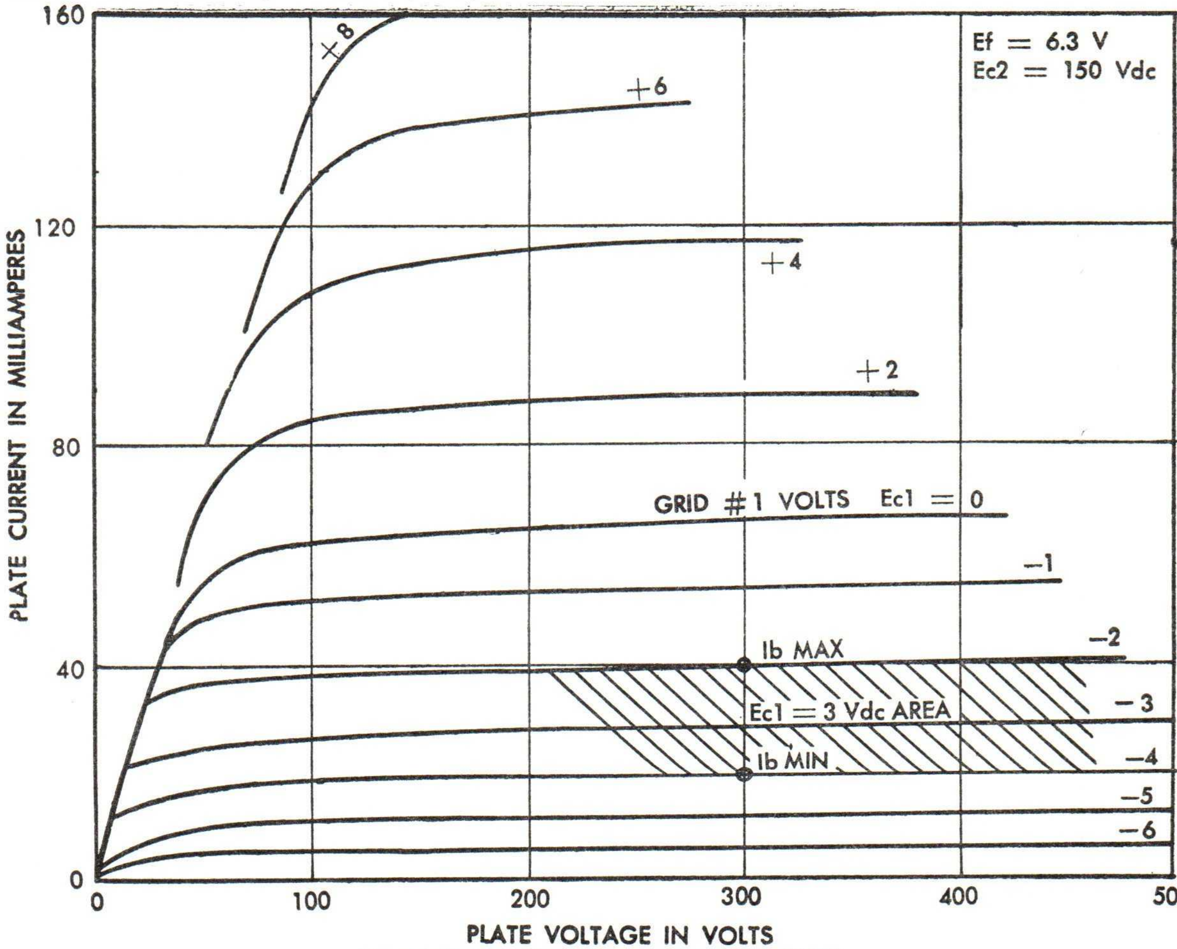


Figure 3-91. Limit Plate Characteristics of JAN-6AG7Y.

The next chart presents the limit behavior of transfer data for JAN-6AG7Y as defined by the specification also.

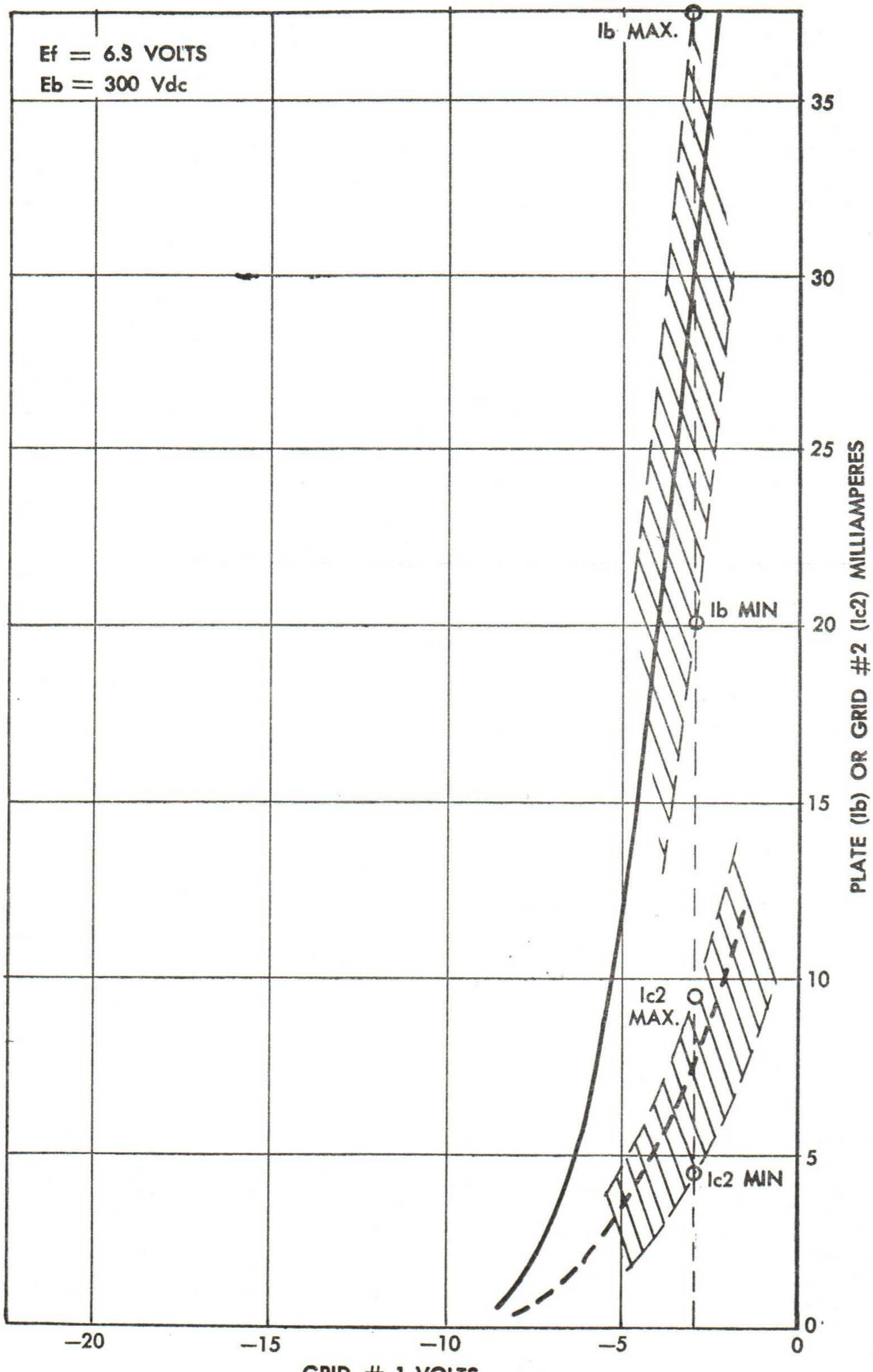


Figure 3-92. Limit Transfer Characteristics of JAN-6AG7Y.

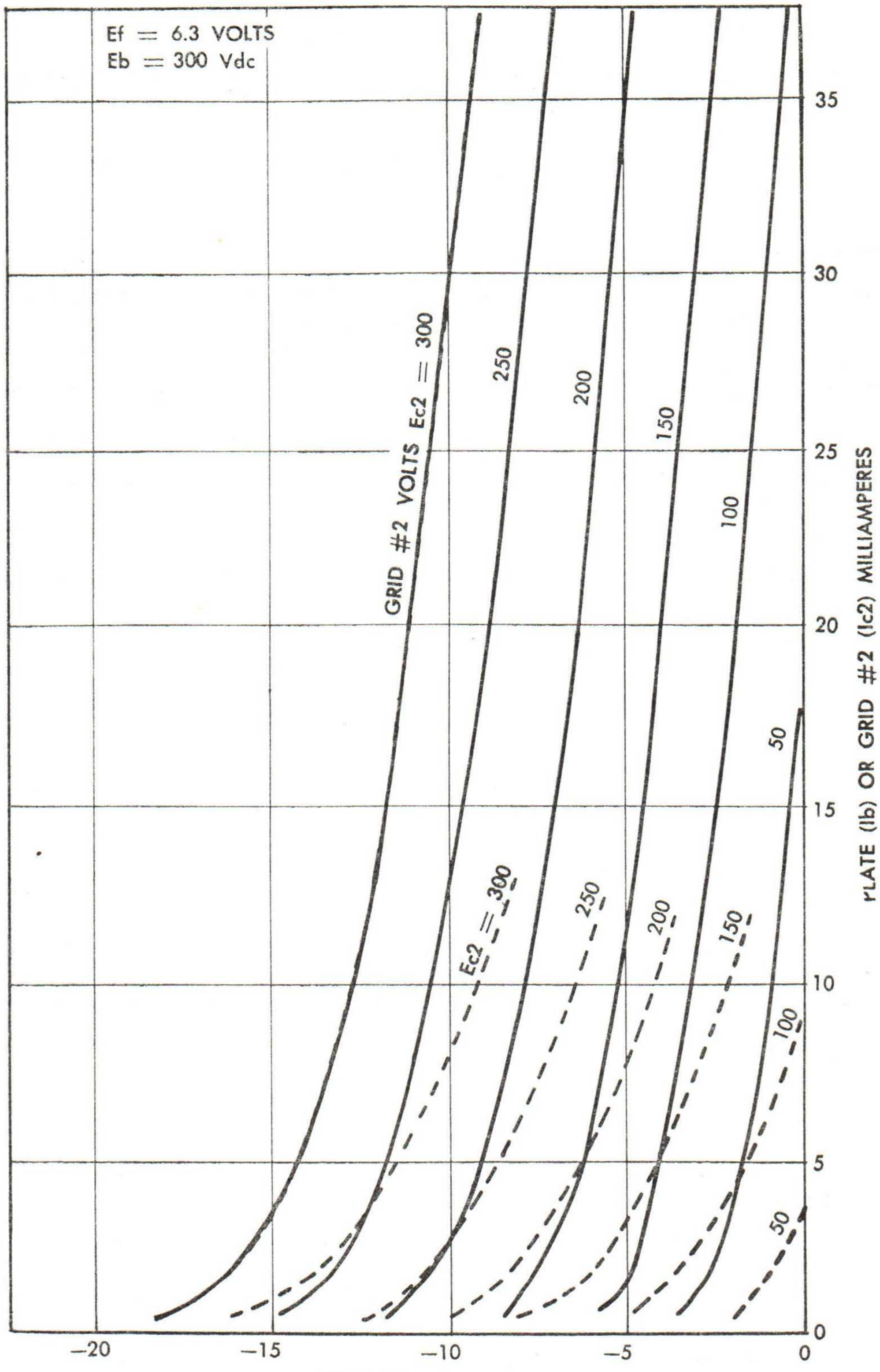


Figure 3-93. Typical Transfer Characteristics of JAN-6AG7Y.

DESIGN CENTER CHARACTERISTICS OF JAN-6AG7Y

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

Figure 3-94 represents the typical static plate behavior of JAN-6AG7Y.

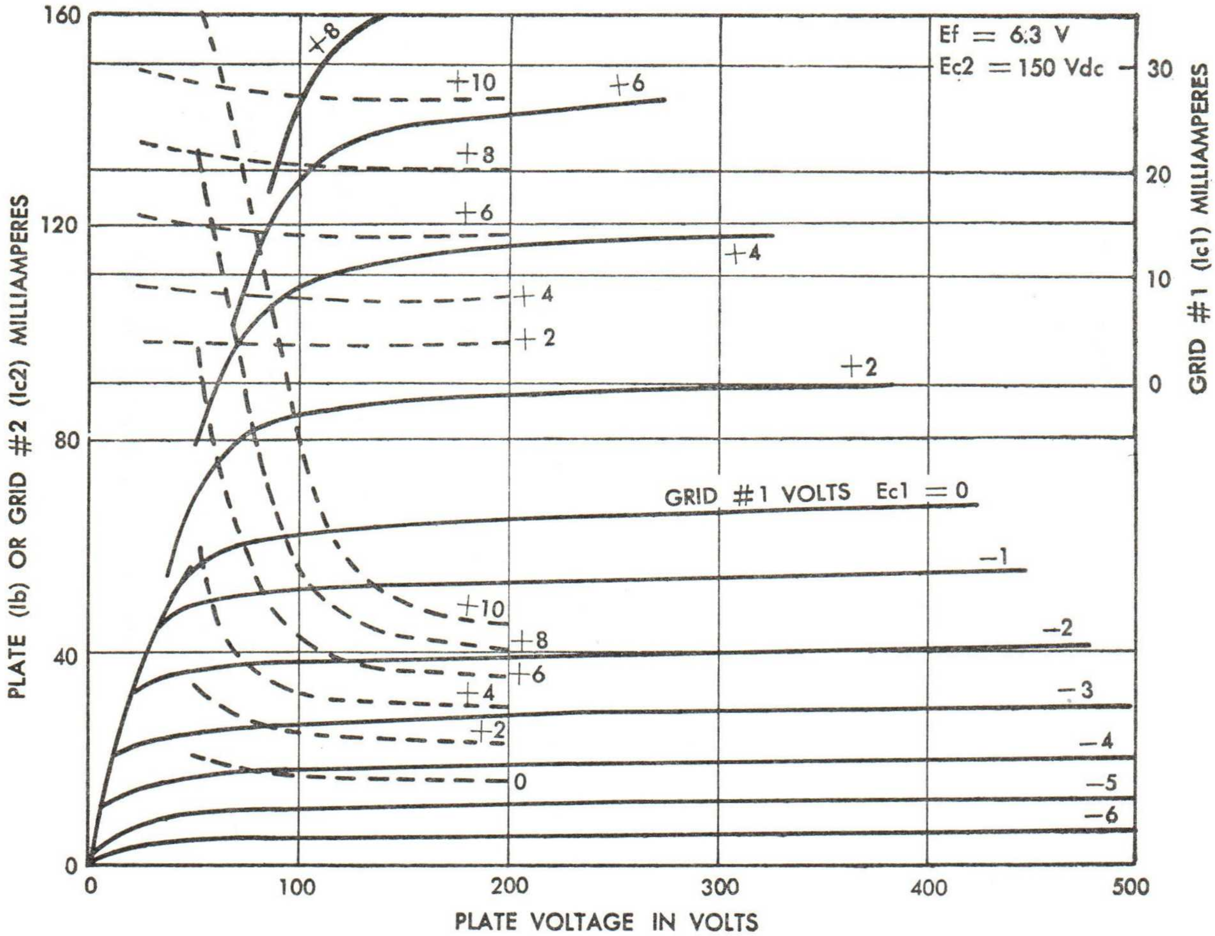


Figure 3-94. Typical Static Plate Characteristics of JAN-6AG7Y.

Figure 3–93 represents the typical transfer behavior of the tube type with parametric variability of screen grid voltage.

Figure 3–96 represents typical static plate behavior at a fixed screen grid voltage of 300 Vdc.

Figure 3–97 represents the parametric behavior of the zero bias line with varying screen voltage as static plate data.

Figure 3–95 represents the typical transfer behavior of the characteristic Sm, parametric in screen grid voltage, Ec2.

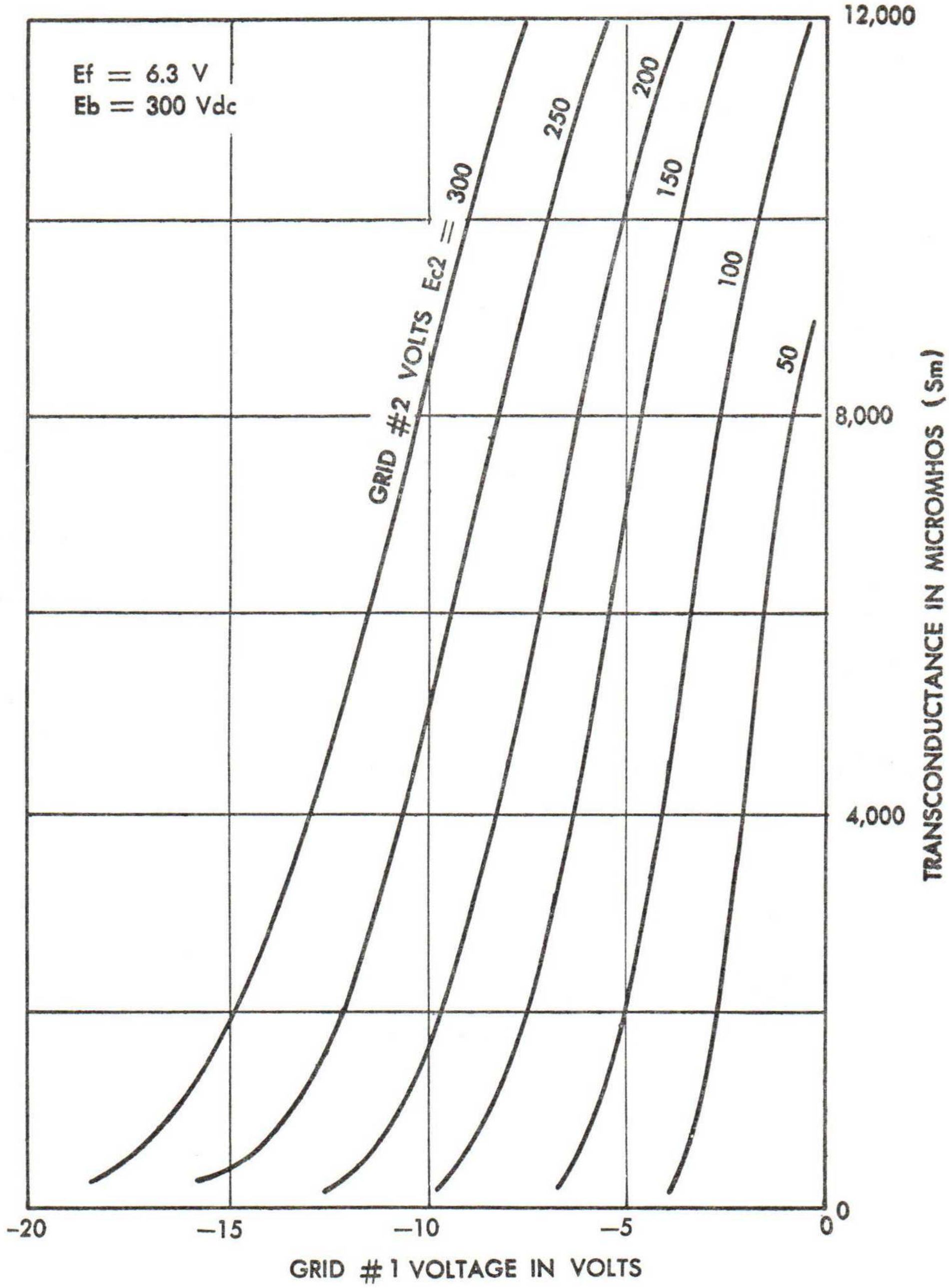


Figure 3-95. Typical Transfer Characteristics of JAN-6AG7Y; Variability of Sm, Parametric in Ec2.

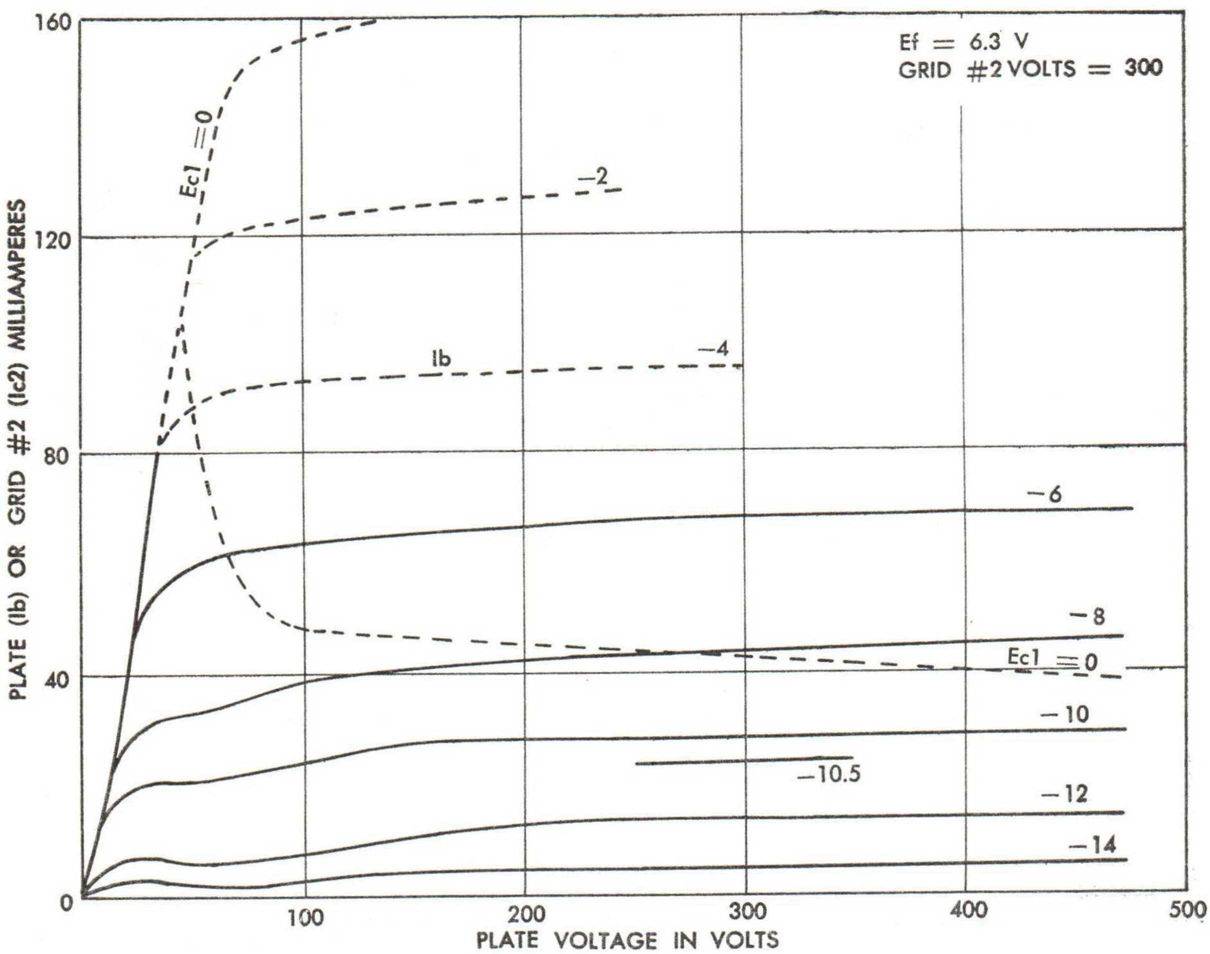


Figure 3-96. Typical Plate Characteristics of JAN-6AG7Y; Ec2 = 300 Vdc.

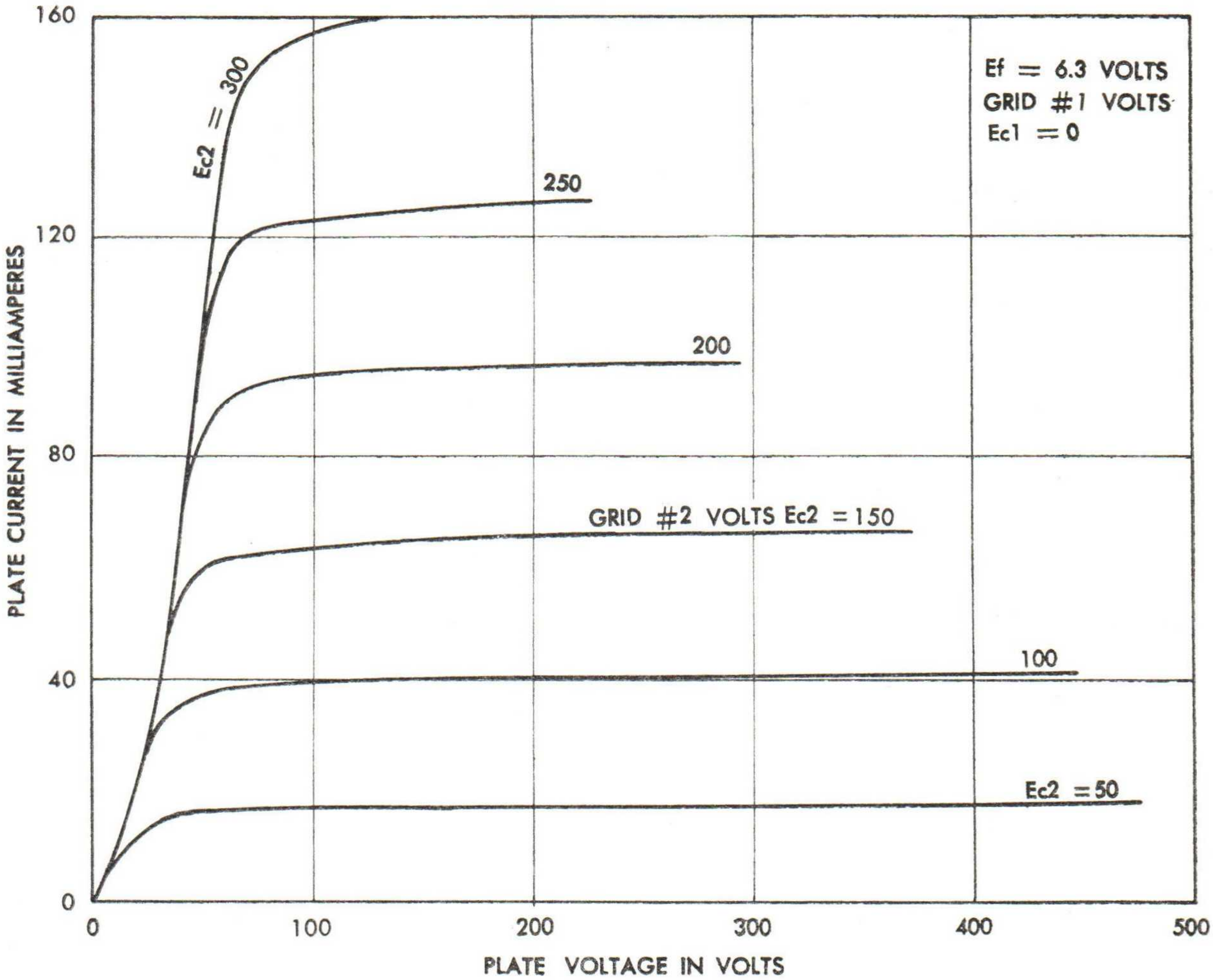


Figure 3-97. Typical Plate Characteristics of JAN-6AG7Y; Parametric Ec2.

SECTION
TUBE TYPE JAN-6AH6

DESCRIPTION.

The JAN-6AH6 [1] is a 7 pin, miniature, RF sharp cutoff pentode with a separate suppressor connection, having a transconductance in the range of 6000 and 11000 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage, AC or DC	6.3 V
Heater Current	425-475 mA
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

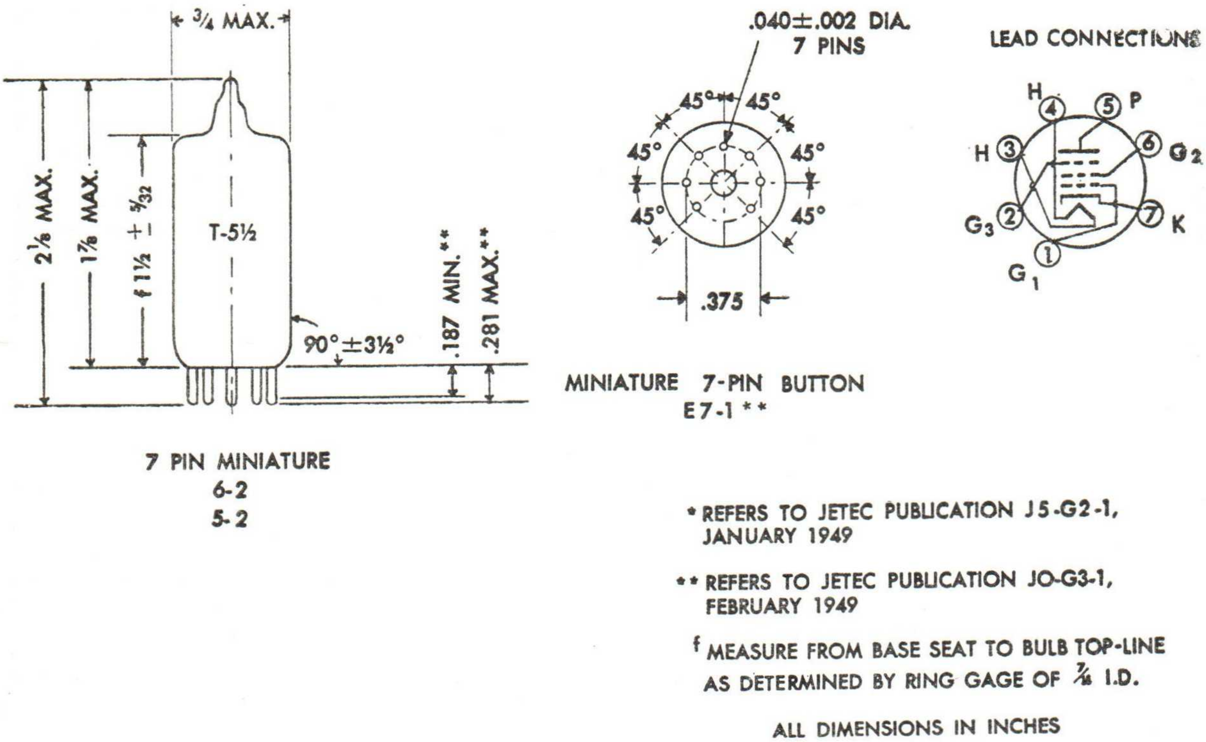


Figure 3-98. Outline Drawing and Base Diagram of Tube Type JAN-6AH6.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 10%
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Screen Grid Voltage	165 Vdc
Plate Dissipation	3.3 W
*Screen Grid Dissipation	0.45 W
Heater Cathode Voltage	100 V
Altitude Rating	10,000 ft

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/46 dated 5 February 1953.

TEST CONDITIONS AND CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	300 Vdc
Control Grid Voltage, Ec1	0 Vdc
Screen Grid Voltage, Ec2	150 Vdc
Suppressor Grid Voltage, Ec3	0 Vdc
Cathode Resistor, Rk	160 ohms

ACCEPTANCE TESTS LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/46 dated 5 February 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		425	475	—	—	mA
Transconductance(1)	Sm	Ck = 1000 uf	6000	11000	5300	—	umhos
Plate Current(1)	Ib		7.0	12.5	—	—	mAdc
Plate Current(2)	Ib	Ec1 = —10 Vdc	0.0	30.0	—	—	uAdc
Emission	Is	Eb = Ec1 = Ec2 = Ec3 = 10 Vdc; Rk = 0	40	—	—	—	mAdc
Screen Grid Current	Ic2		1.5	3.8	—	—	mAdc
Capacitance	Cgp	Ef = 0	—	0.020	—	—	uuf
(Shielded as	Cin	Ef = 0	8.0	12.0	—	—	uuf
specified	Cout	Ef = 0	2.5	4.7	—	—	uuf
Grid Current	Ic1		0	—3.0	—	—	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	0	20	—	—	uAdc
	Ihk	Ehk = —100 Vdc	0	—20	—	—	uAdc
Insulation of Electrodes	Rg — all	Eg-all = —300 Vdc	10	—	—	—	Meg
	Rp — all	Ep-all = —500 Vdc	10	—	—	—	Meg

APPLICATION OF JAN-6AH6

The chart below shows the permissible operating area for JAN-6AH6 as defined by the ratings in MIL-E-1/46 dated 5 Feb 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

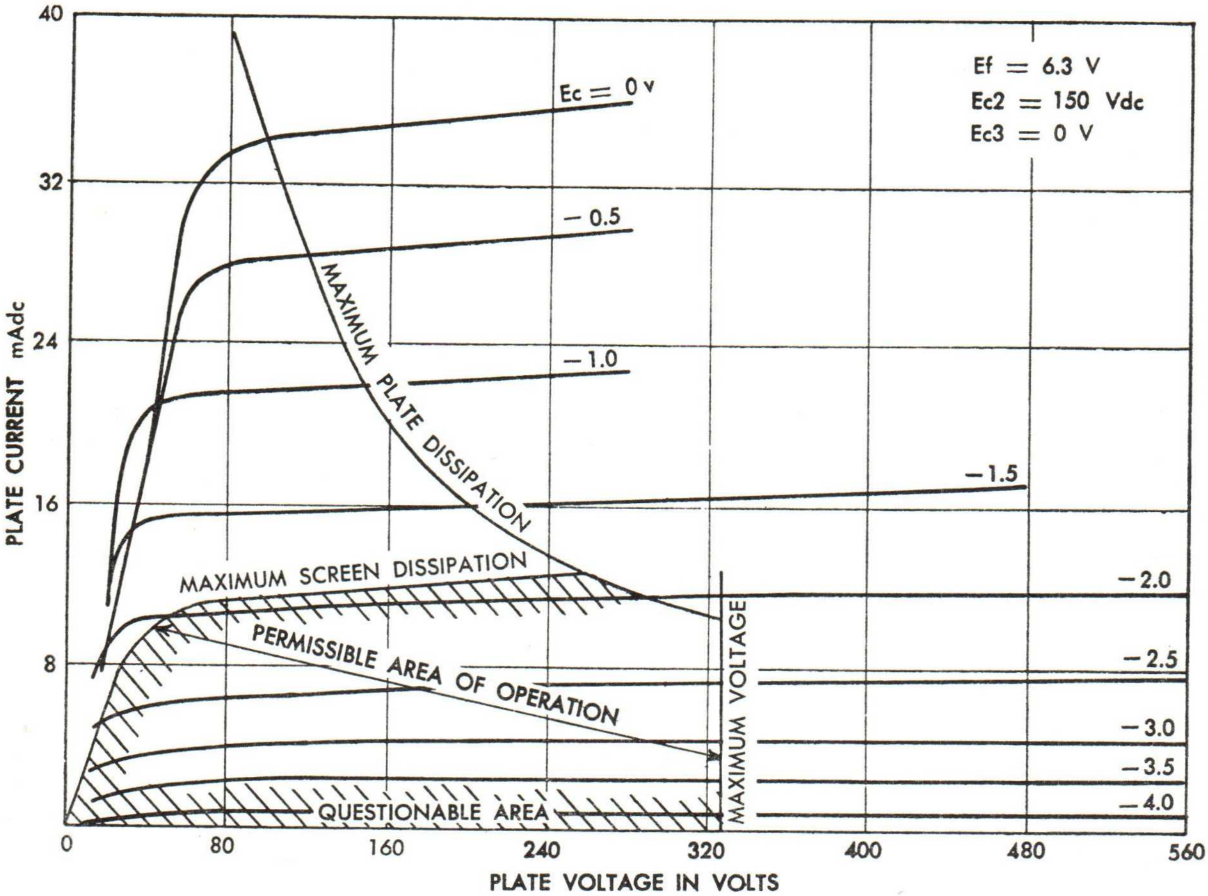


Figure 3-99. Typical Static Plate Characteristics of JAN-6AH6; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature
Bulb and Environmental, 3.2.3

Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3

Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-6AH6 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6AH6 as defined by MIL-E-1/46 dated 5 Feb 1953.

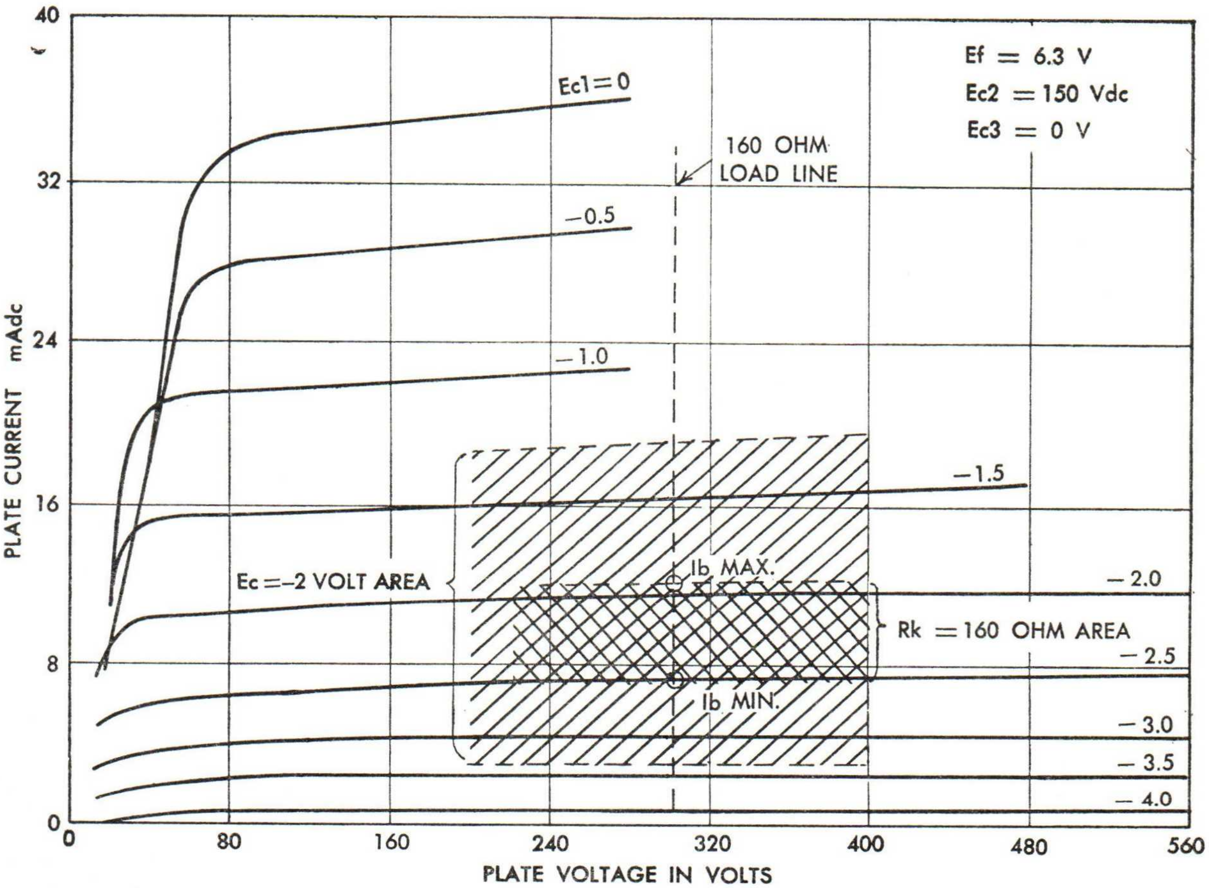


Figure 3-100. Limit Plate Characteristics of JAN-6AH6.

The chart below presents the limit behavior of transfer data for JAN–6AH6 as defined by MIL–E–1/46 dated 5 Feb 1953.

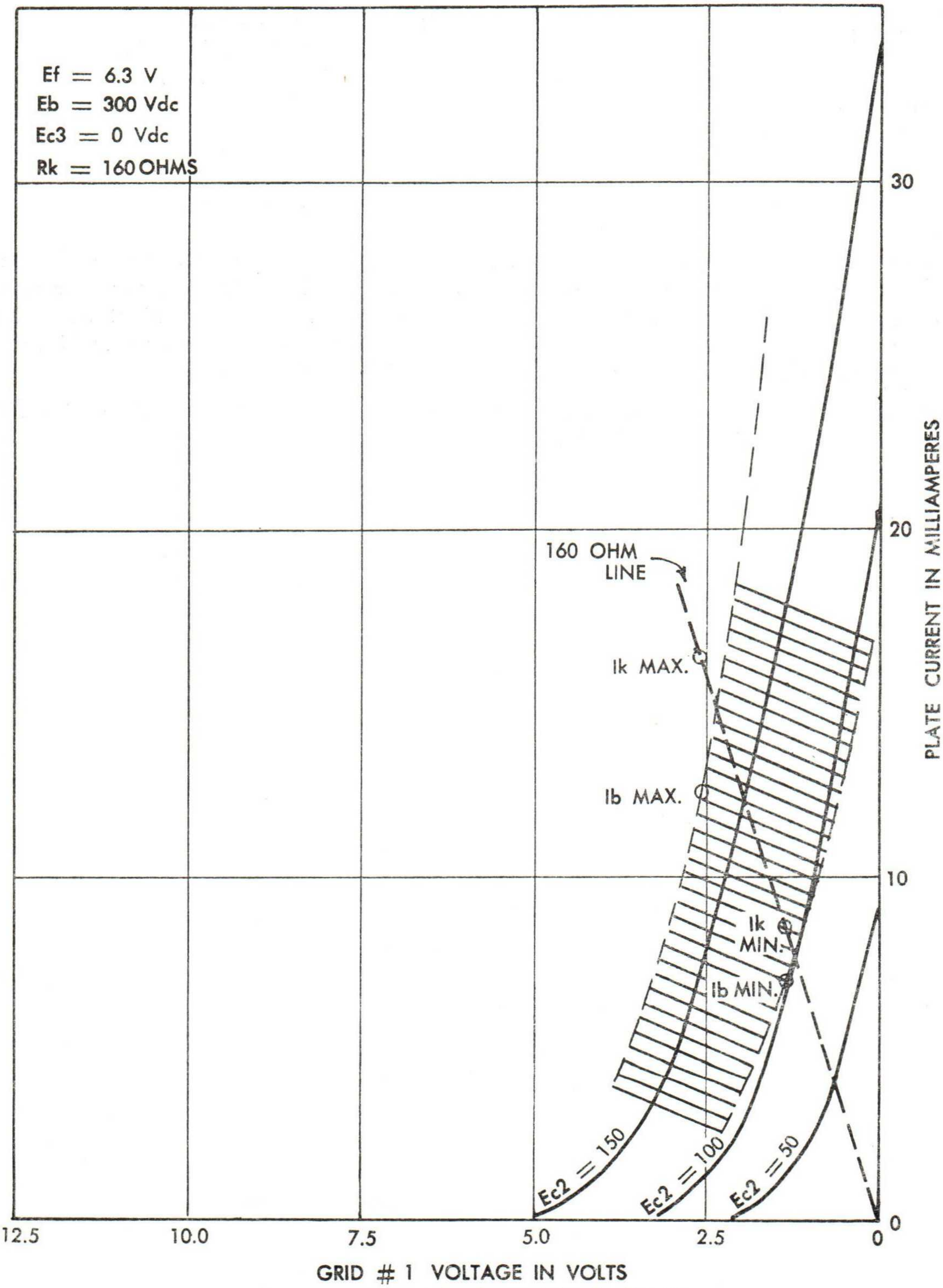


Figure 3-101. Limit Transfer Characteristics of JAN-6AH6.

DESIGN CENTER CHARACTERISTICS OF JAN-6AH6

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-6AH6.

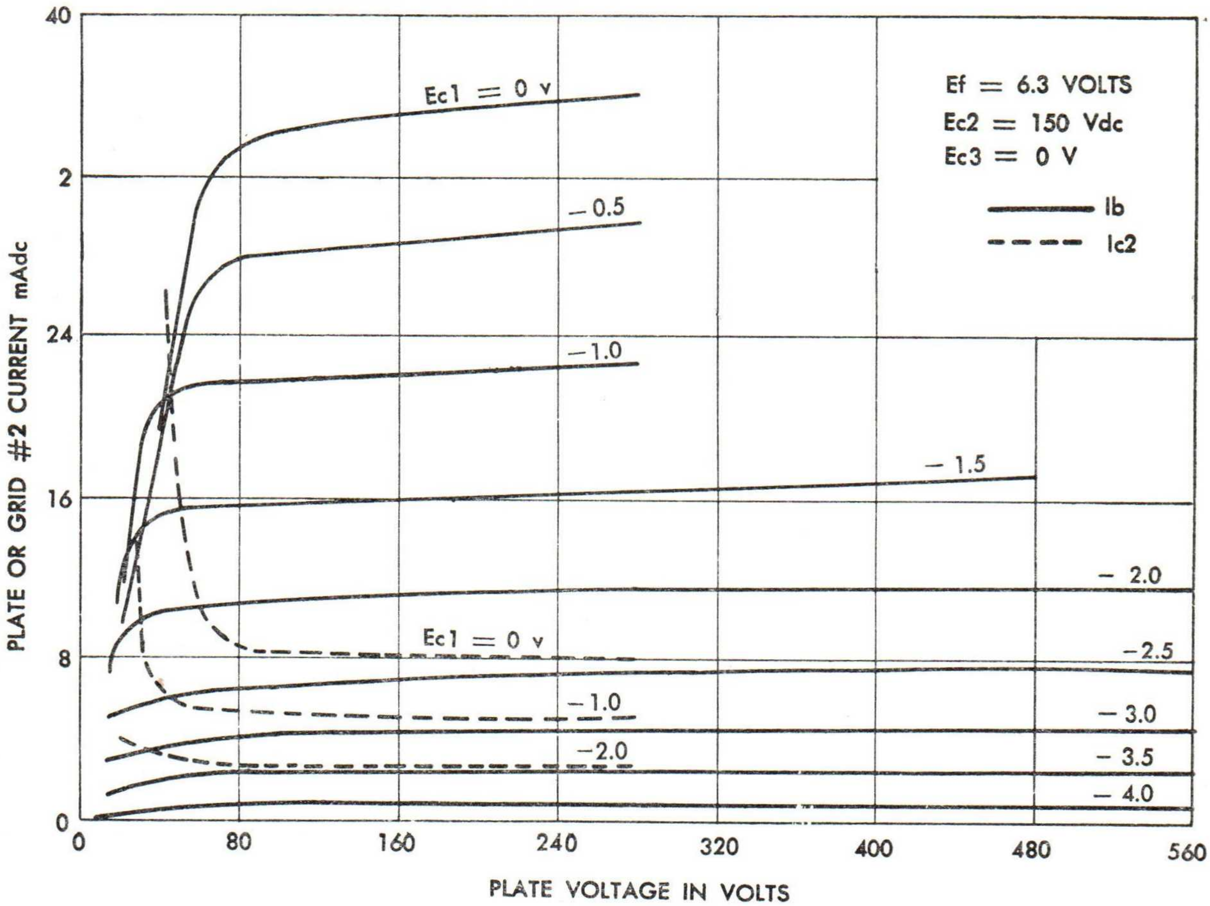


Figure 3-102. Typical Static Plate Characteristics of JAN-6AH6.

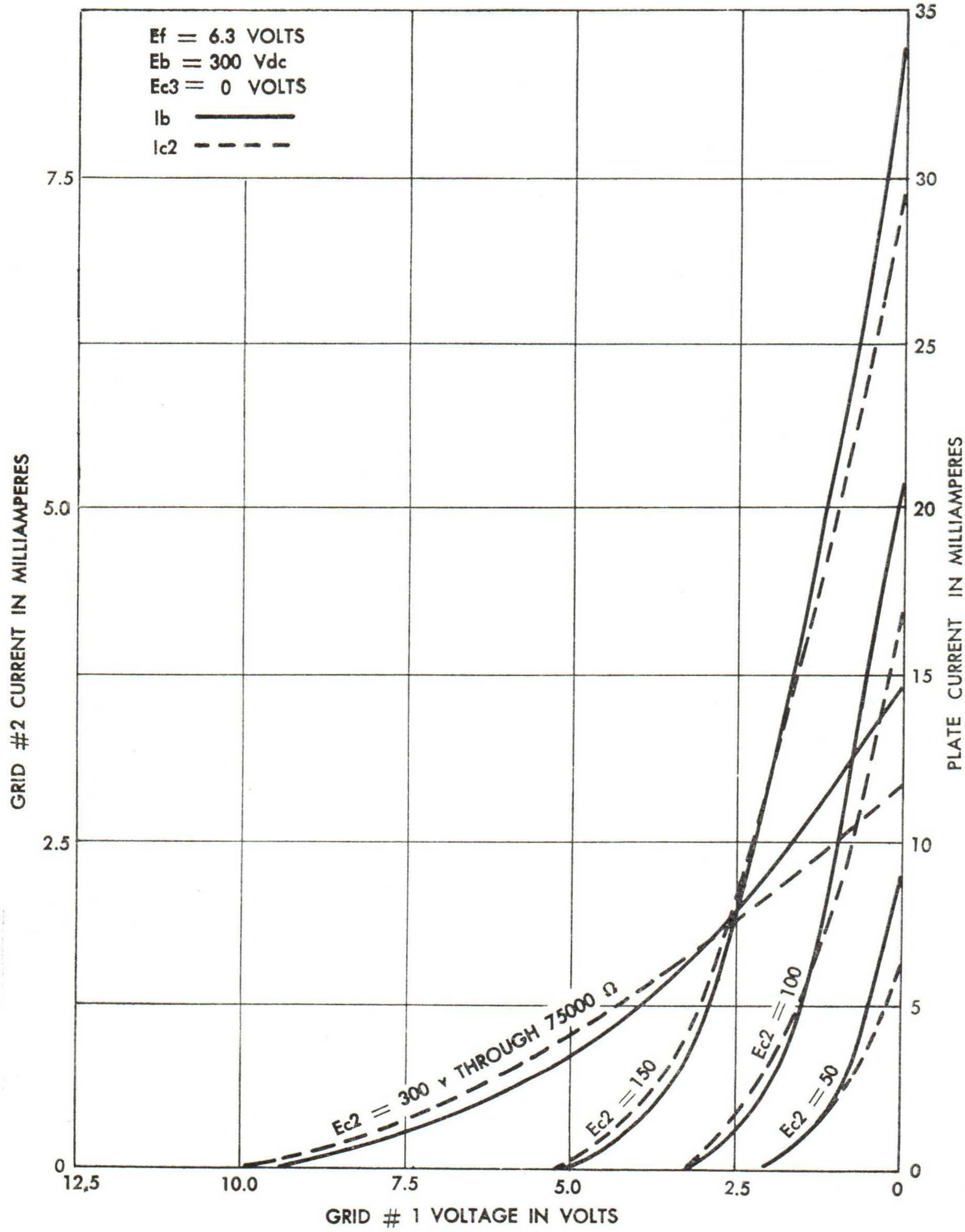


Figure 3-103. Typical Transfer Characteristics of JAN-6AH6.

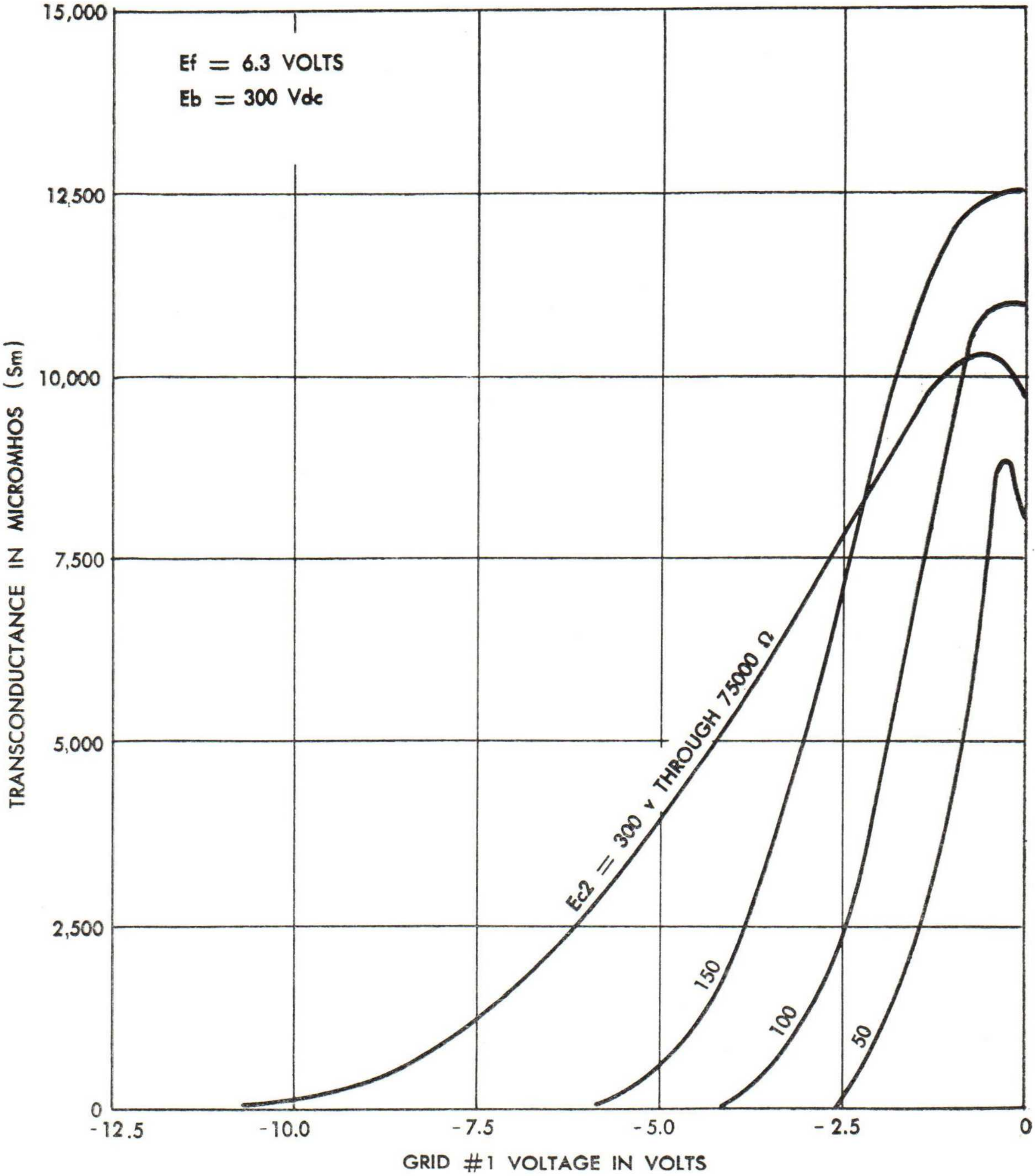


Figure 3-104. Typical Transfer Characteristics of JAN-6AH6; Variability of Sm.

SECTION
TUBE TYPE JAN–6AU6WA

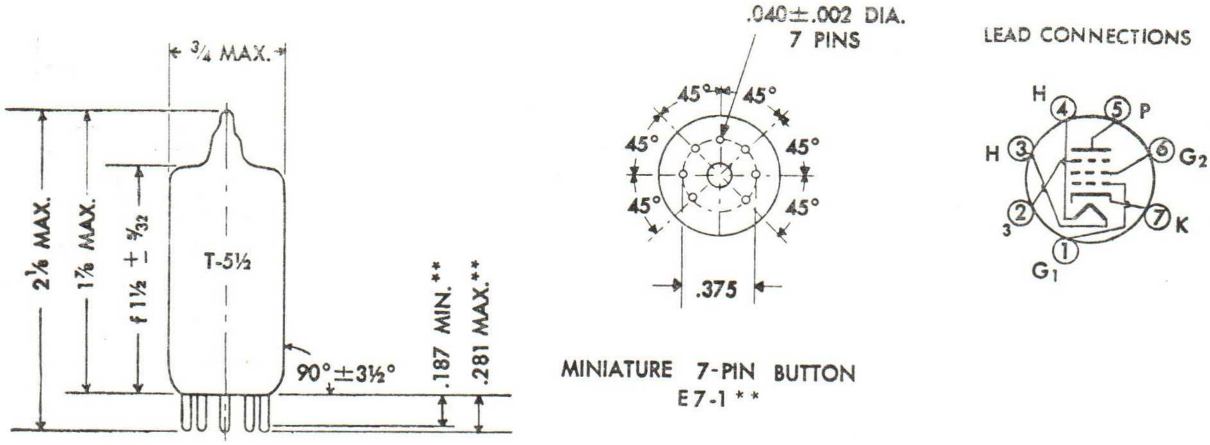
DESCRIPTION.

The JAN–6AU6WA [1] is a seven pin, miniature, sharp cutoff pentode having a design center transconductance of 5200 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	300 mA
*Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



7 PIN MINIATURE
6-2
5-2*

* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-105. Outline Drawing and Base Diagram of Tube Type Jan-6AU6WA.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 10% V
Plate Voltage	330 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage, Maximum	0 Vdc
Screen Grid Voltage	165 Vdc
Suppressor Grid Voltage	0 Vdc
Plate Dissipation	3.3 W
Screen Grid Dissipation	0.7 W
Heater-Cathode Voltage	± 100 V
Bulb Temperature	165°C
Altitude	10,000 ft

* Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/1 dated 13 January 1953.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows.

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	250 Vdc
Screen Grid Voltage, Ec2	150 Vdc
Suppressor Grid	Tied to Negative Terminal of Cathode Resistor
Cathode Resistor, Rk	68 ohms
Heater Current, If	300 mA
Plate Current, Ib	10.6 mA
Transconductance, Sm	5200 umhos
Screen Grid Current	4.3 mADc
Input Capacitance	6.0 uuf
Output Capacitance	4.9 uuf

ACCEPTANCE TESTS LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/1 dated 13 January 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		275	325	275	325	mA
Transconductance (1)	Sm		4150	6250	3600	6250	umhos
Transconductance (2)	Sm	Ef = 5.5 V	3900	—	—	—	umhos
Plate Current (1)	Ib		8.0	13.5	—	—	mAdc
Plate Current (2)	Ib	Ec1 = —9 Vdc Rp = 0.1 Meg Rk = 0; Ck = 0	—	35	—	—	uAdc
Screen Grid Current	Ic2		2.6	6.0	—	—	mAdc
Capacitance	Cg1p	Ef = 0	—	.0035	—	—	uuf
(No shield)	Cin	Ef = 0	4.8	7.2	—	—	uuf
	Cout	Ef = 0	3.9	5.9	—	—	uuf
Grid Current	Ic	Ec1 = —1 Vdc Rg1 = 0.25 Meg	—	—1.0	—	—1.0	uAdc
Grid Emission	Isc1	Ef = 7.5 V; Ec1 = —10 Vdc; Rg1 = .25 Meg Rk = 0; Ck = 0	—	—2.0	—	—	uAdc
Heater Cathode Leakage	Ihk	Ehk = + 100 Vdc	—	10	—	10	uAdc
	Ihk	Ehk = — 100 Vdc	—	—10	—	—10	uAdc
Insulation of Electrodes		Ef = 6.3 V					
	Rg — all	Eg1 — all = —100 Vdc	100	—	50	—	Meg
	Rp — all	Ep — all = —300 Vdc	100	—	50	—	Meg

APPLICATION OF JAN-6AU6WA

The chart below shows the permissible operating area for JAN-6AU6WA as defined by the ratings in MIL-E-1/1 dated 13 January 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

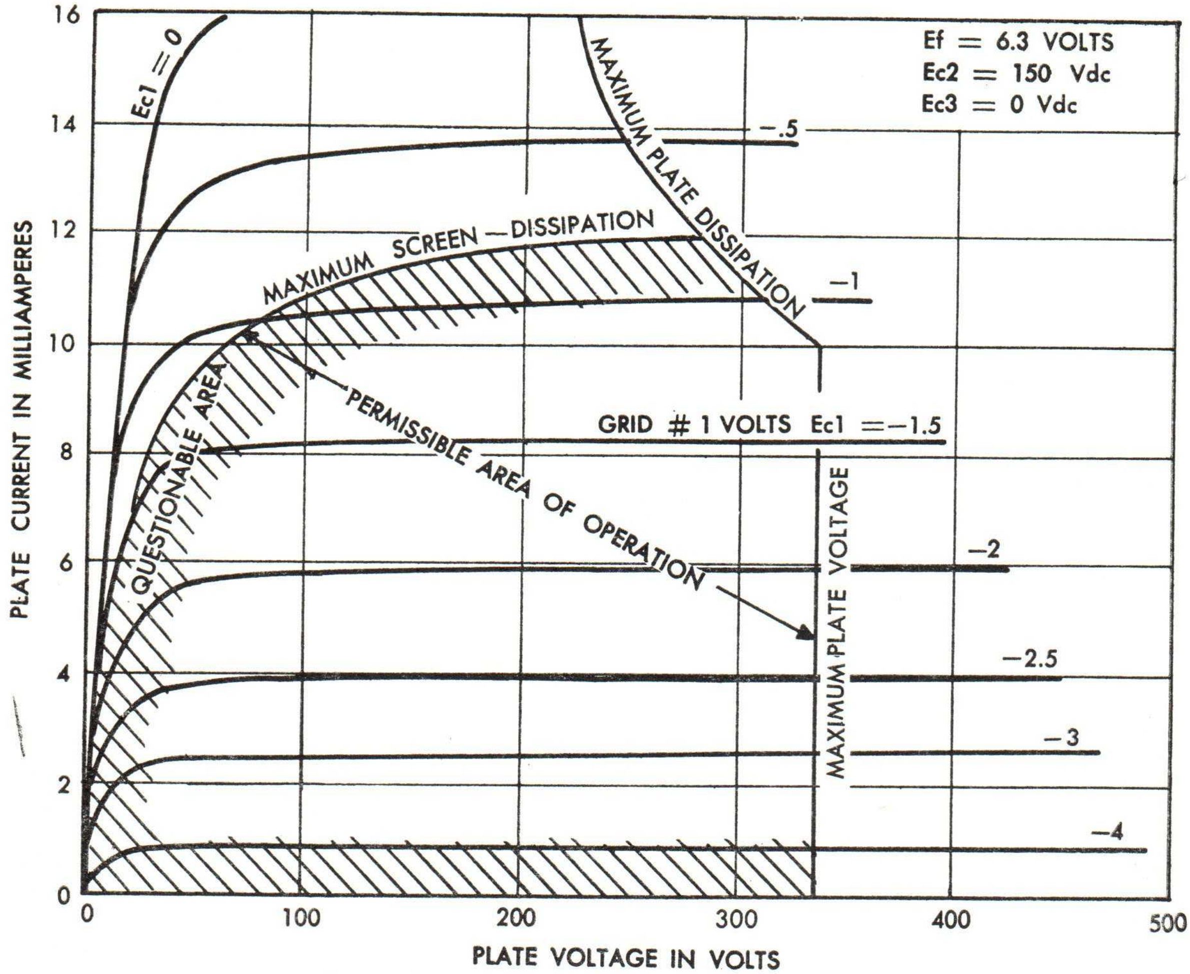


Figure 3-106. Typical Static Plate Characteristics of JAN-6AU6WA; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature
Bulb and Environmental, 3.2.3

Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7
Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-6AU6WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6AU6WA as defined by MIL-E-1/1 dated 13 January 1953.

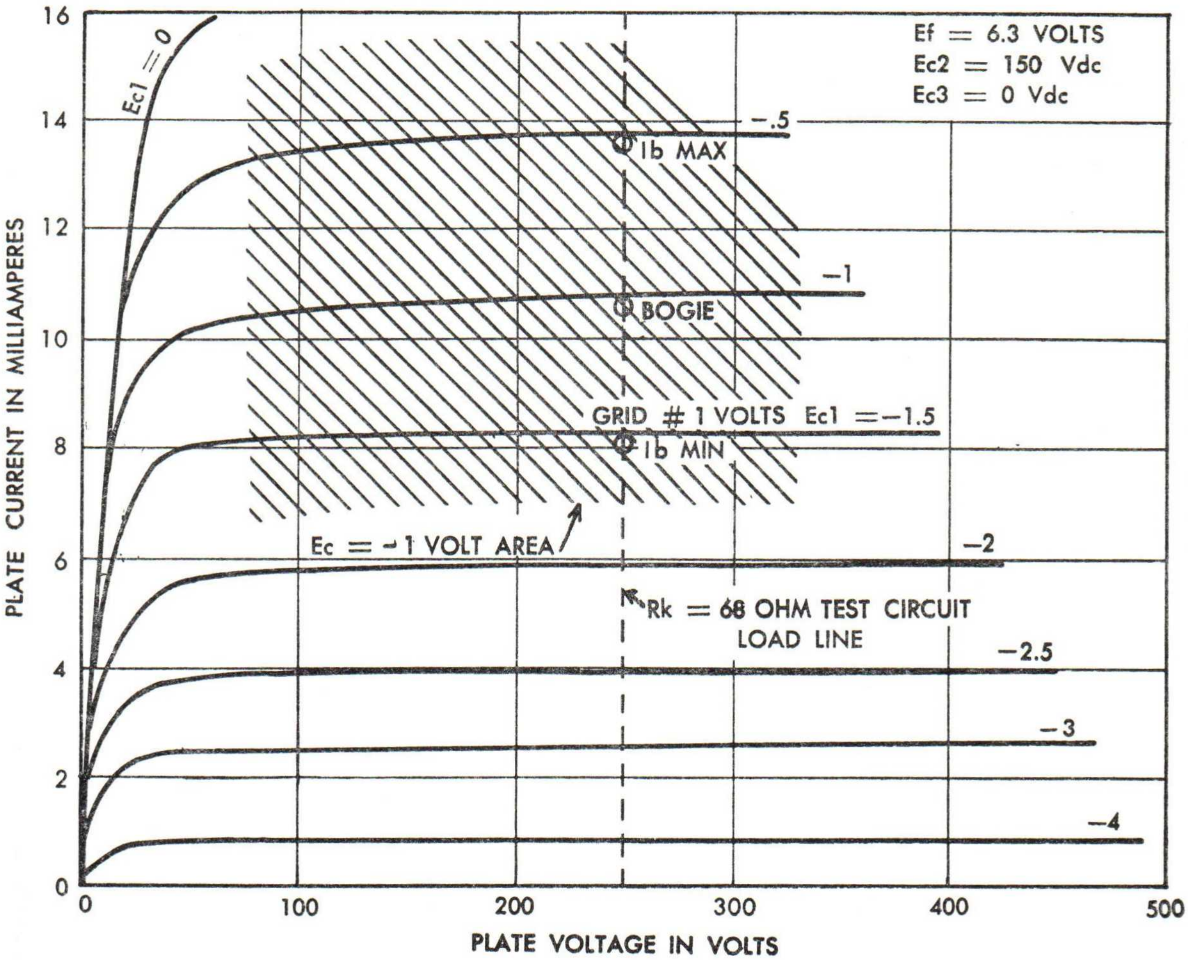


Figure 3-107. Limit Plate Characteristics of JAN-6AU6WA.

Figures 3-108 and 3-109. Presents the limit behavior of transfer data for JAN-6AU6WA as defined by MIL-E-1/1 dated 13 Jan. 1953.

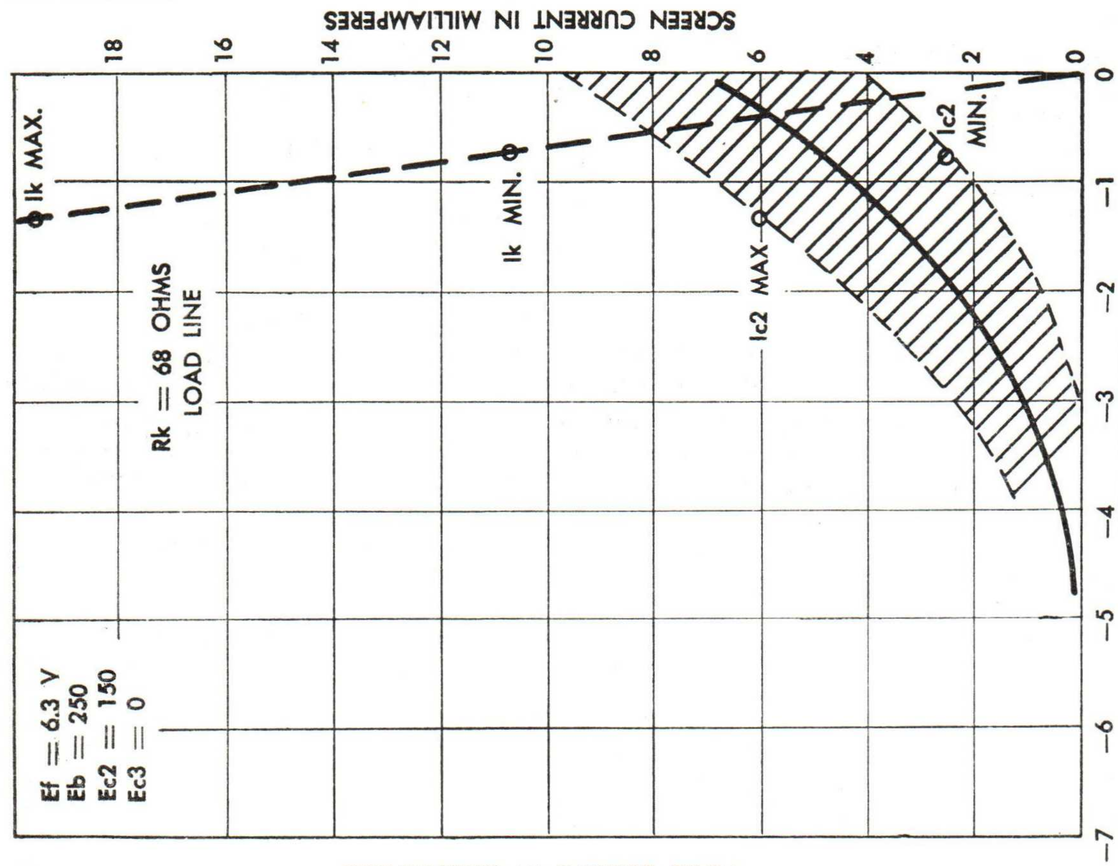


Figure 3-109. Limit Transfer Characteristics of JAN-6AU6WA; Variability of Ic2.

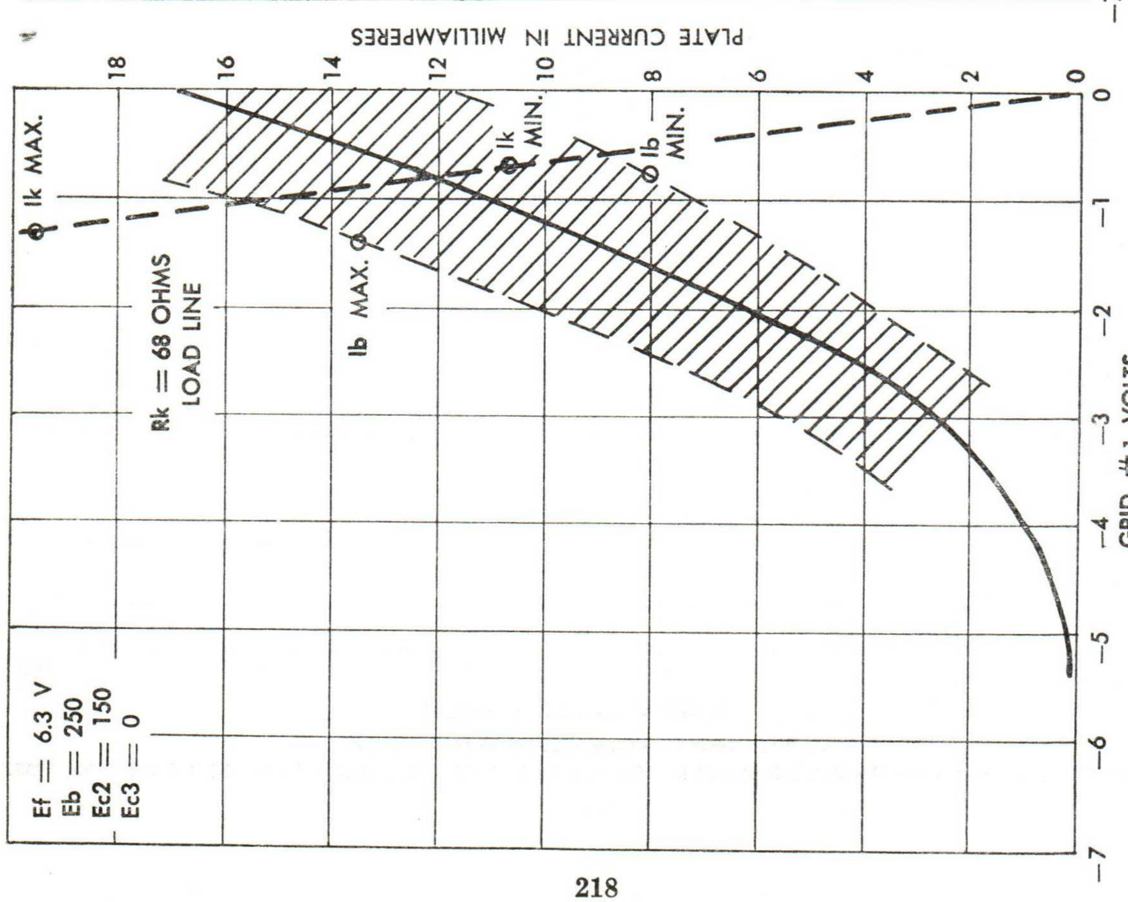


Figure 3-108. Limit Transfer Characteristics of JAN-6AU6WA; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-6AU6WA

The typical curves portrayed as Figures 3-110 through 3-114, have been obtained from current data being published by the original RETMA registrant of this type.

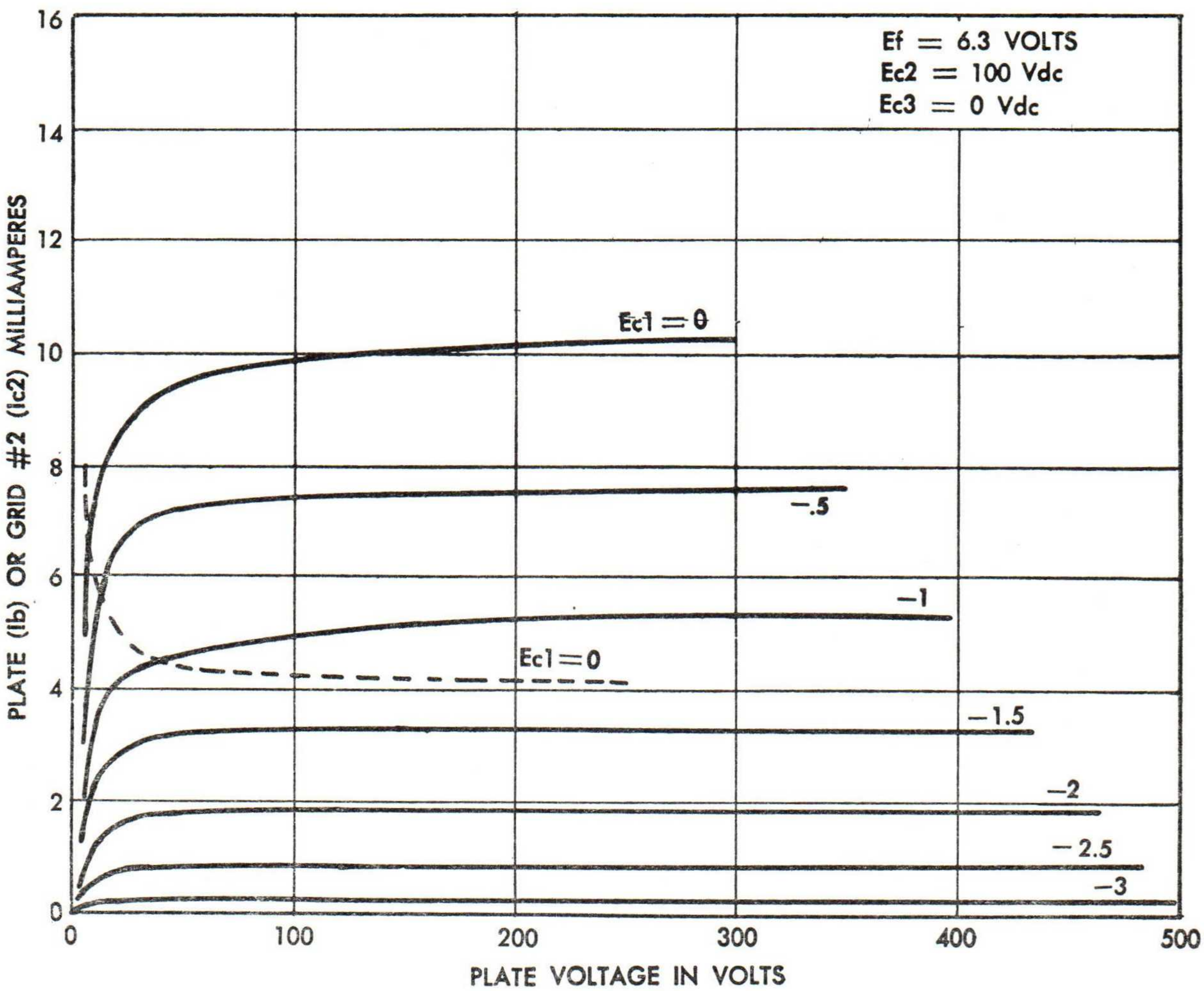


Figure 3-110. Typical Plate Characteristics of JAN 6AU6WA. Ec2 = 100 Vdc

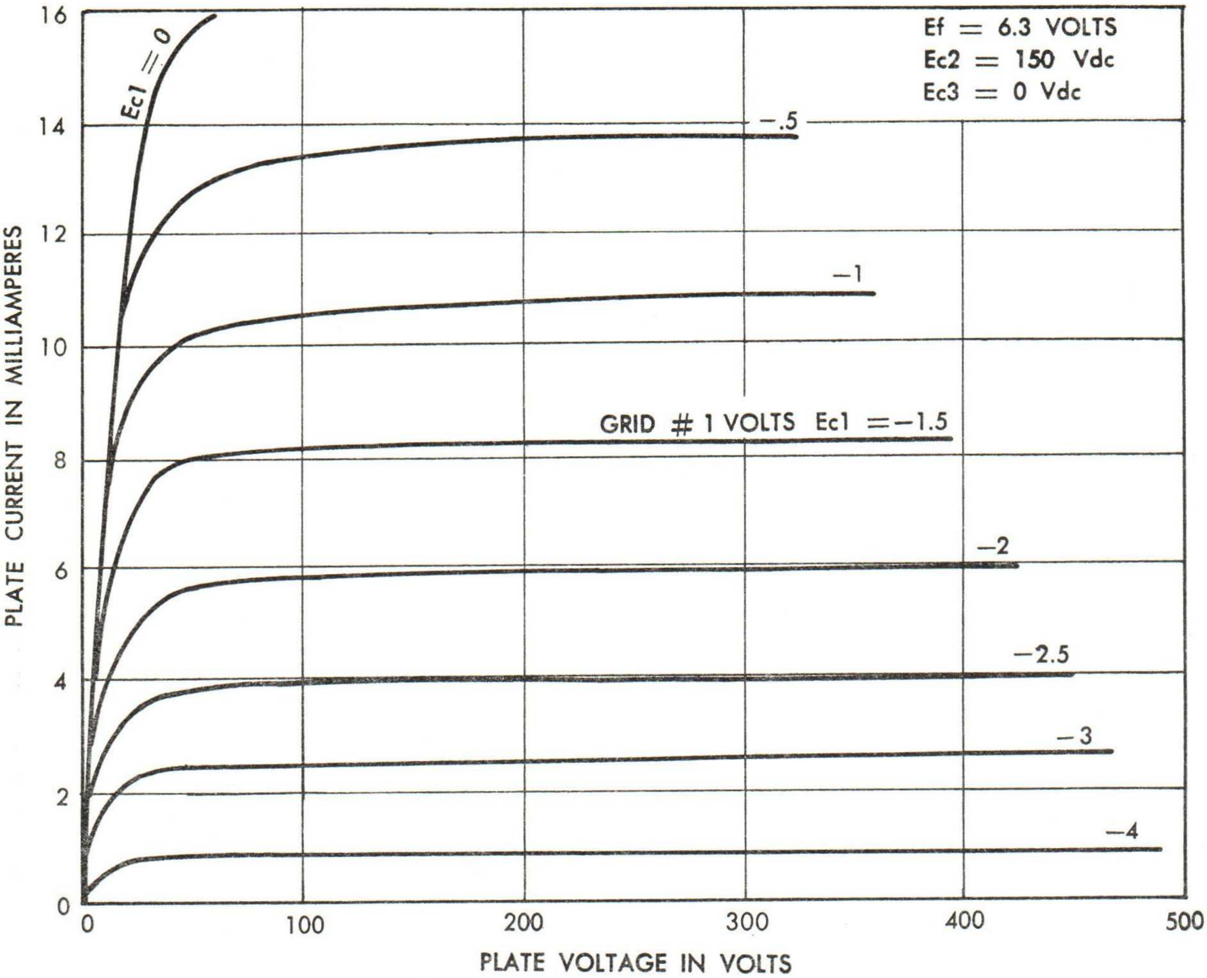


Figure 3-111. Typical Plate Characteristics of JAN-6AU6WA. Ec2 = 150 Vdc

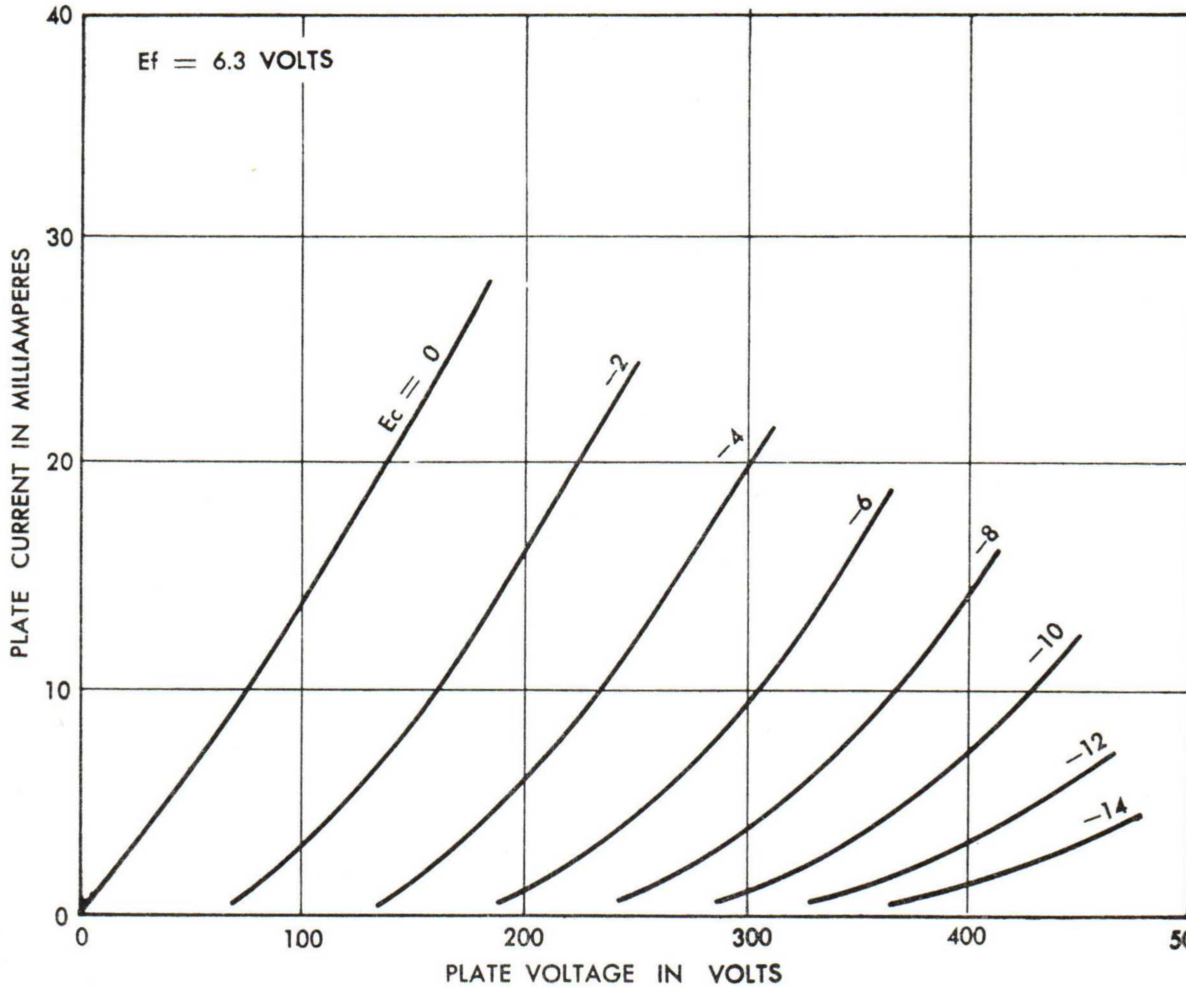


Figure 3-112. Typical Plate Characteristics of JAN 6AU6WA; Triode Connected.

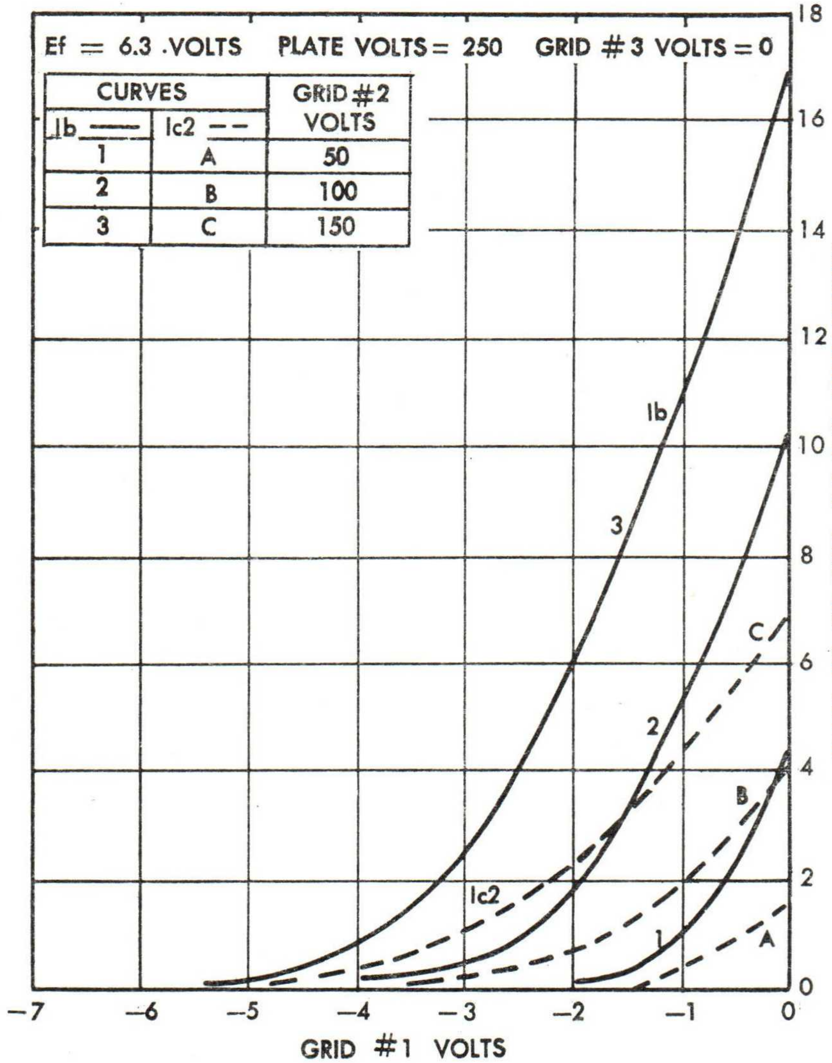


Figure 3-113. Typical Transfer Characteristics of JAN 6AU6WA.

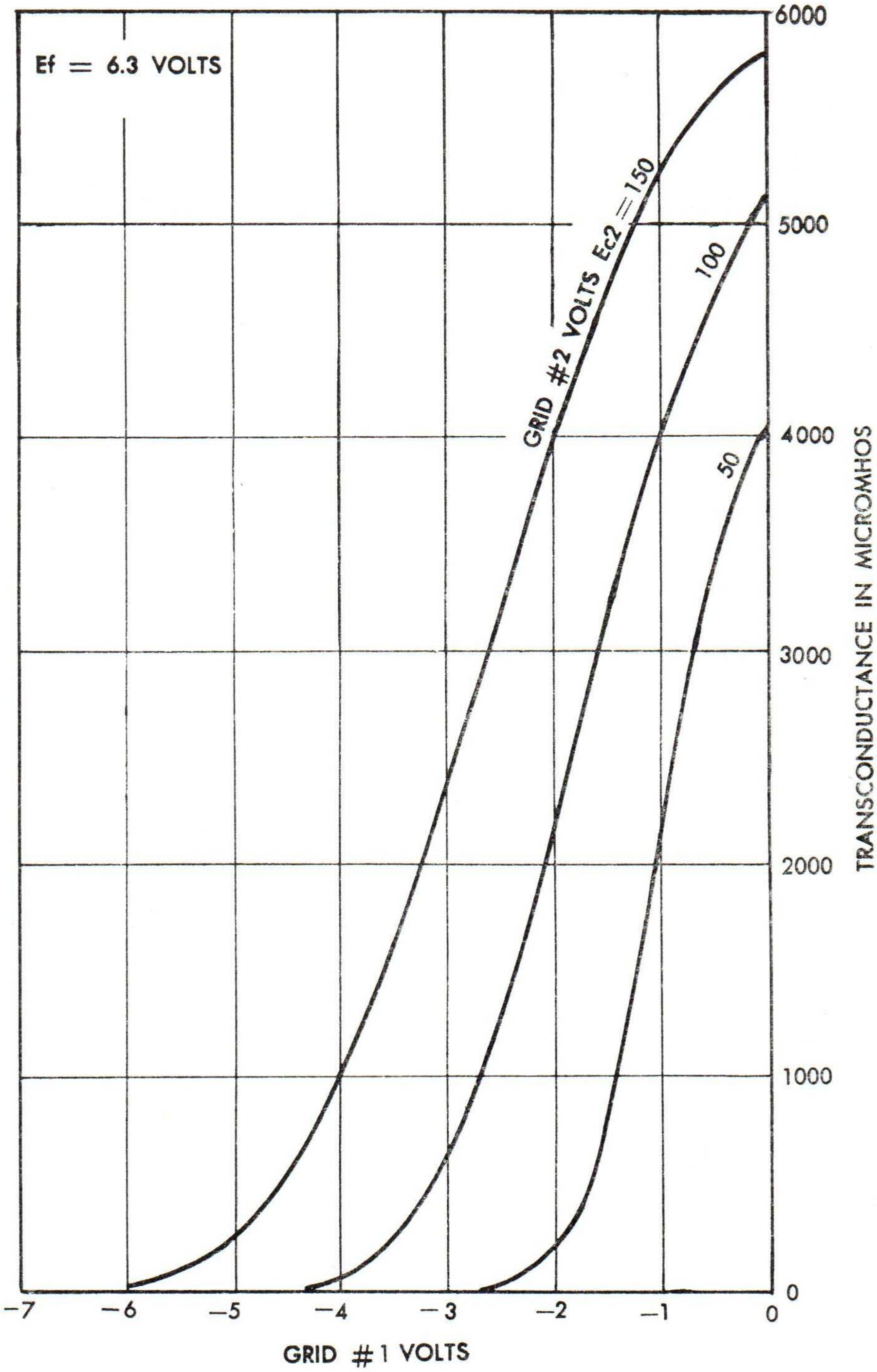


Figure 3-114. Typical Transfer Characteristics of JAN 6AU6WA; Variability of Sm.

SECTION
TUBE TYPE 6BG6G

DESCRIPTION.

The JAN-6BG6G[1] is an 8 pin octal base, double ended, glass envelope beam power pentode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage, AC or DC .... 6.3 V
Heater Current .... 0.81 to 0.99 A
Cathode .... Coated Unipotential

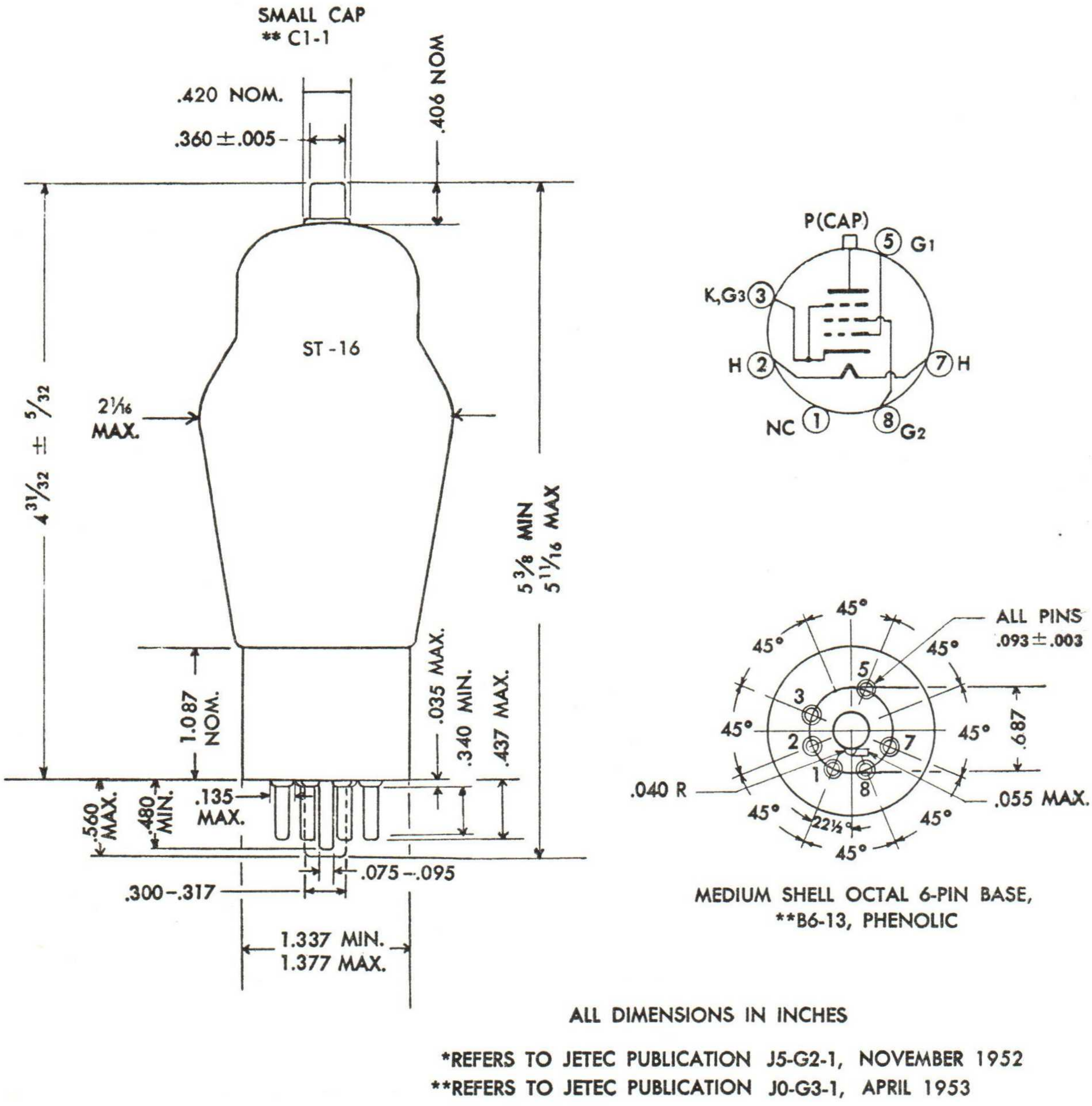


Figure 3-115. Outline Drawing and Base Diagram of Tube Type JAN-6BG6G.

[1] The values and specification comments presented in this section are related to MIL-E-1/53A dated 5 February 1953.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3V ± 10%
Plate Voltage .... 550 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
*Peak Forward anode Voltage, epy .... 6600 v
Duration of pulse not to exceed 10 u sec.
Duty Cycle not to exceed 0.15
Screen Grid Voltage .... 385 Vdc
Control Grid Voltage .... —50 Vdc
*Peak Inverse Control Grid Voltage, egx .... —300 v
Duration of pulse not to exceed 10 u sec
Duty cycle not to exceed 0.15
**Plate Current .... 110 mAdc
*Screen Grid Dissipation .... 3.5 W
Plate Dissipation .... 25 W
Heater Cathode Voltage .... 135 V
*Control Grid Series Resistance .... 0.47 Meg
*Altitude Rating .... 10,000 ft

TEST CONDITIONS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 600 Vdc
Control Grid Voltage, Ec1 .... —30 Vdc
Screen Grid Voltage, Ec2 .... 300 Vdc

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurements limits are provided. Specification MIL-E-1/153A dated 14 January 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		810	990	...	...	mA
Plate Current (1)	Ib		24	55	...	...	mAdc
Plate Current (2)	Ib	Ec1 = —100 Vdc	...	0.5	...	...	mAdc
Emission	Is	Eb = Ec1 = Ec2 = 50 Vdc	300	...	225	...	mAdc
Grid Current	Ic2		...	4	...	...	mAdc
Capacitance	Cgp	Ef = 0	...	0.65	...	...	uuf
(No shield)	Cin	Ef = 0	10.1	13.9	...	...	uuf
	Cout	Ef = 0	4.9	8.1	...	...	uuf
Grid Current	Ic1	Test duration, t = 120 Sec.	0	—4	...	...	uAdc
Heater-Cathode Leakage	Ihk	Ehk = + 100 Vdc	0	100	...	...	uAdc
	Ihk	Ehk = — 100 Vdc	0	—100	...	...	uAdc

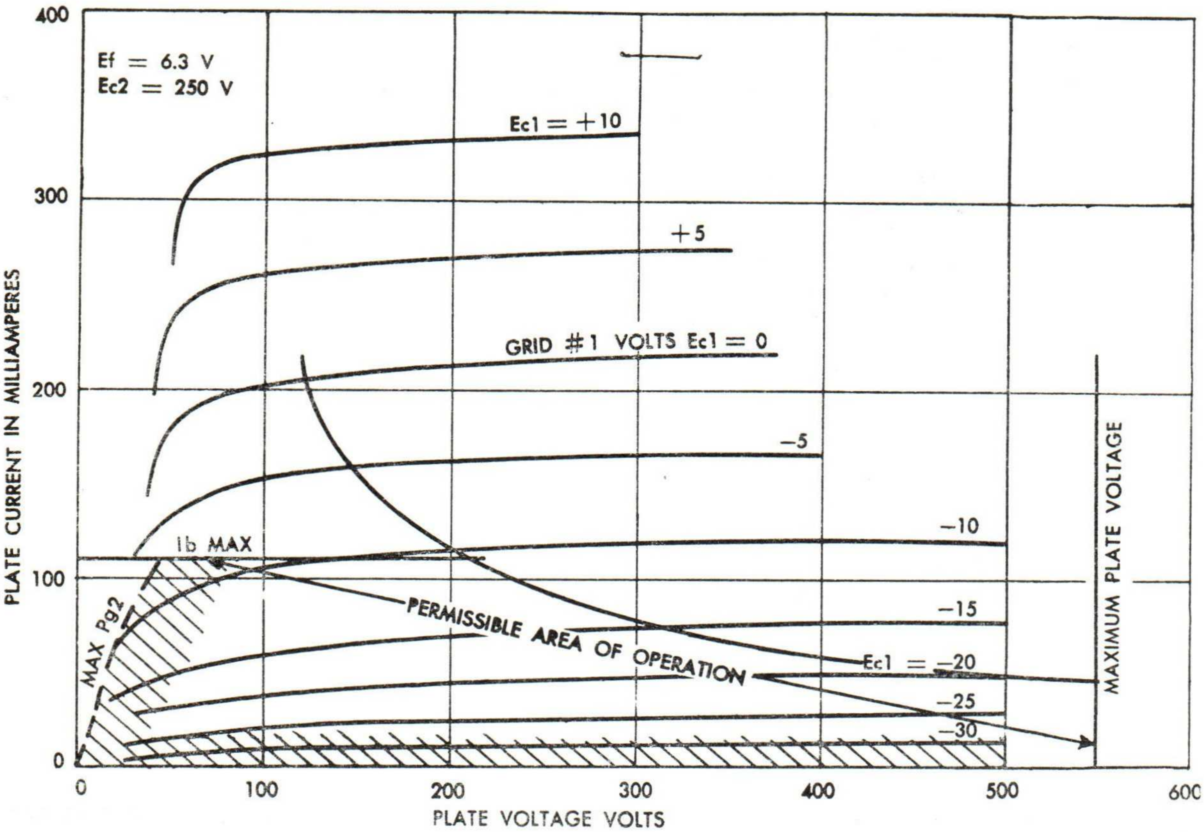


Figure 3-116. Typical Static Plate Characteristics of JAN-6BG6G; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

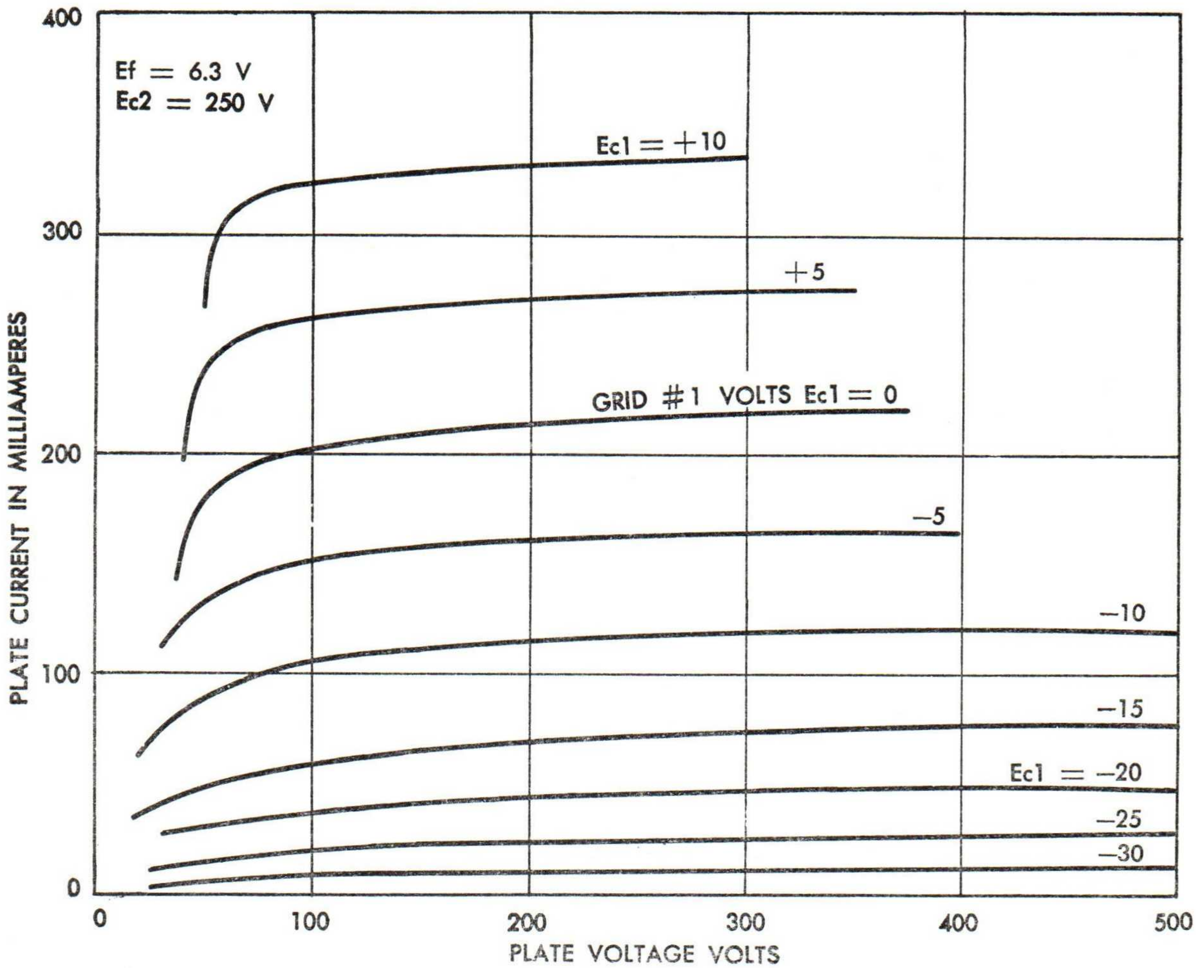


Figure 3-117. Typical Plate Characteristics of JAN 6BG6G; Variability of Ib.

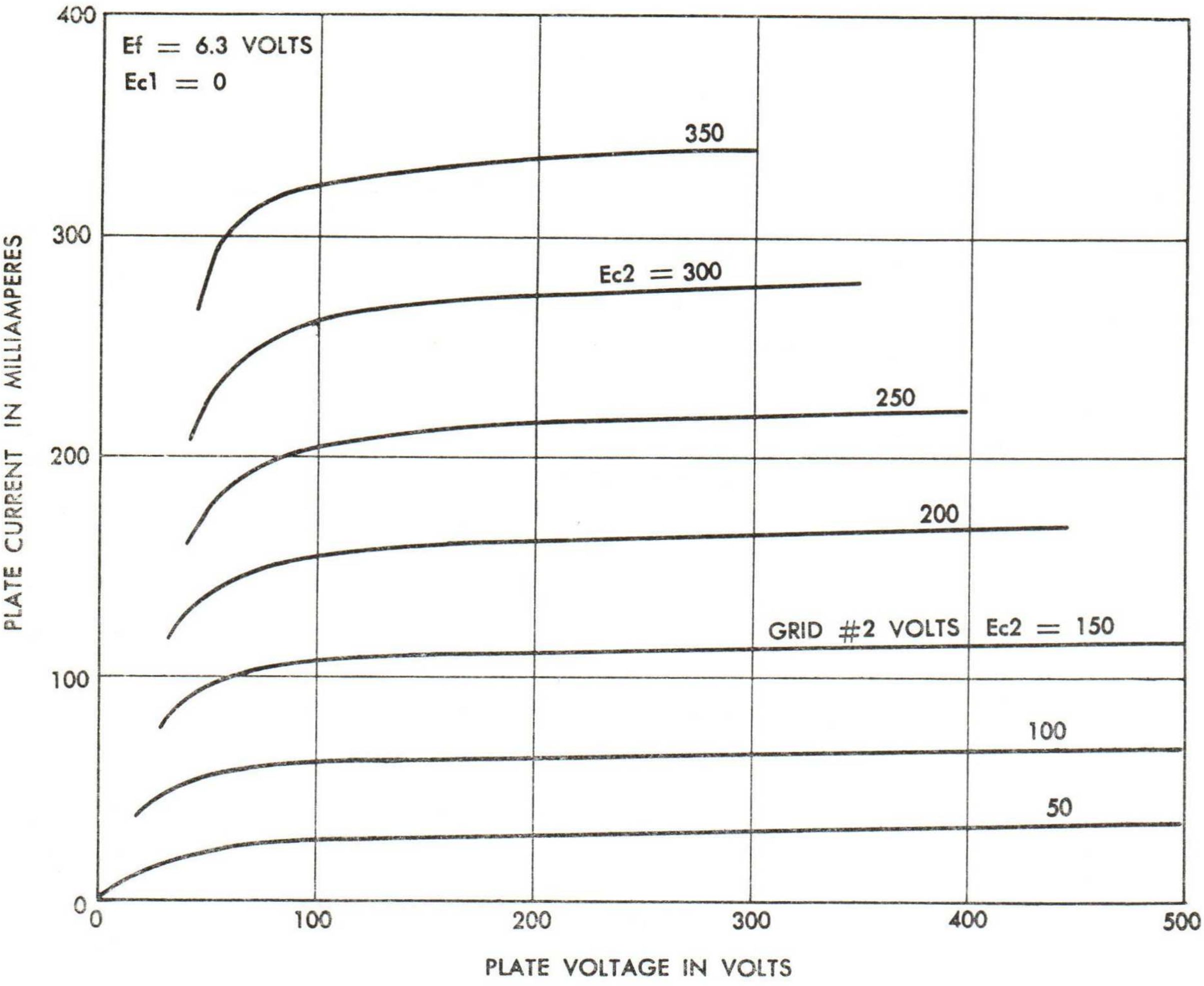


Figure 3-118. Typical Screen Characteristics of JAN 6BG6G.

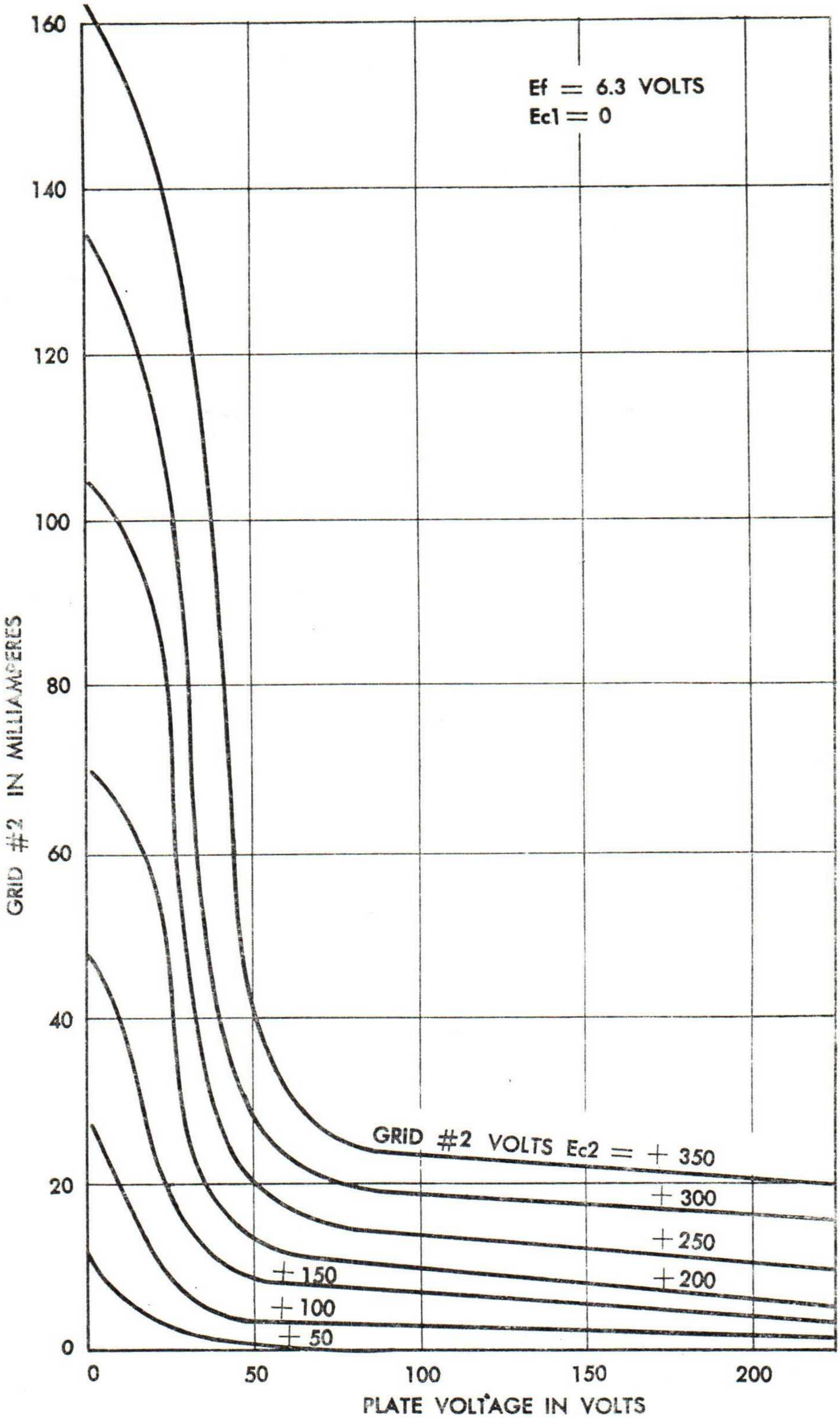


Figure 3-119. Typical Plate Characteristics of JAN-6BG6G; Variability of Ic2.

SECTION
TUBE TYPE JAN–6C4W

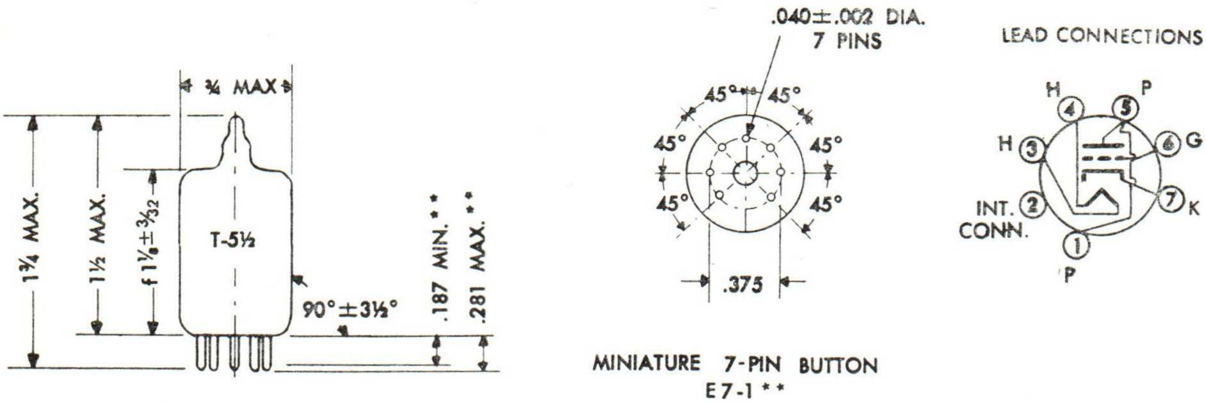
DESCRIPTION.

The Jan–6C4W [1] is a seven pin miniature triode with a mu in the Range 15.5 to 18.5 with a transconductance ranging from 1750 to 4400 depending upon choice of operating point.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



7 PIN MINIATURE
6-1
5-1*

MINIATURE 7-PIN BUTTON
E7-1 **

* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-120. Outline Drawing and Base Diagram of Tube Type JAN-6C4W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 10% V
Plate Voltage .... 330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Heater-Cathode Voltage .... 100 V
Plate Dissipation .... 3.8 W
*Altitude Rating .... 10,000 ft

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/55B dated 14 January 1954.

TEST CONDITIONS.

Test conditions are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Grid Voltage, Ec .... —8.5 Vdc

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/55B dated 14 January 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		138	162	...	...	mA
Transconductance (1)	Sm		1750	2650	1430	...	umhos
Amplification Factor	Mu		15.5	18.5	...	...	
Plate Current (1)	Ib		6.5	14.5	...	...	mAdc
Plate Current (2)	Ib	Ec = —30 Vdc	...	50	...	...	uAdc
Emission	Is	Eb = Ec = 15 Vdc	30	...	...	...	mAdc
Power Output	Po	Eb = 300 Vdc Rg = 8500 F = 150 Mc	1.8	...	...	...	W
Capacitance	Cgp	Ef = O	1.35	2.25	...	...	uuf
(Without shield)	Cin	Ef = O	1.2	2.2	...	...	uuf
	Cout	Ef = O	0.8	1.4	...	...	uuf
Grid Current	Ic		0	—1.5	...	—2.0	uAdc
Heater-Cathode Leakage	Ihk	Ehk = + 100 Vdc	0	20	...	...	uAdc
	Ihk	Ehk = — 100 Vdc	0	—20	...	...	uAdc

The following Table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:

High, 3.1.5

Low, 3.1.5

AC Operation, 1.3.3, 3.1.5

28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

APPLICATION OF JAN-6C4W

Figure 3-121 below shows the permissible operating area for JAN-6C4W as defined by the ratings in MIL-E-1/55B dated 14 January 1954. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.6.

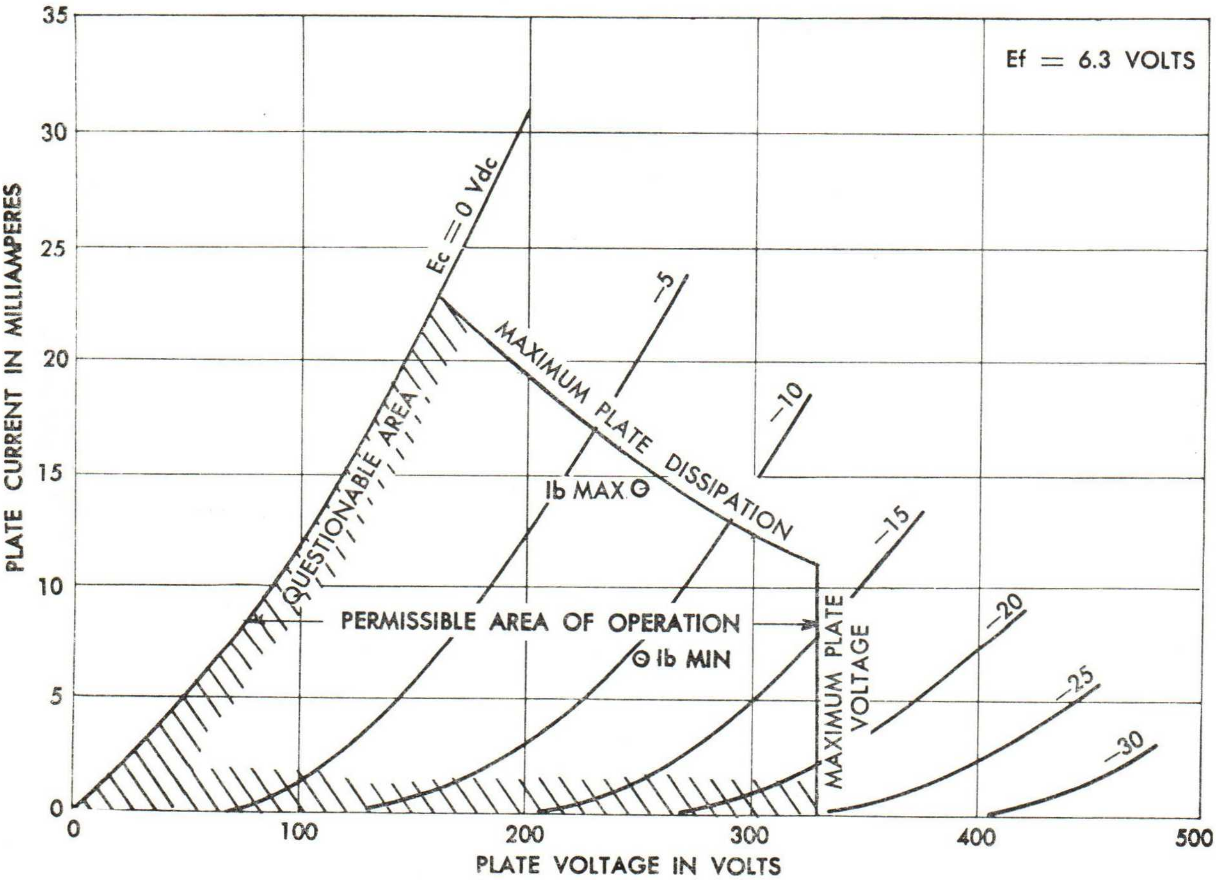


Figure 3-121. Typical Plate Characteristics of JAN 6C4W; Permissible Area of Operation.

VARIABILITY OF JAN-6C4W CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The charts below present the limit behavior of static and transfer plate characteristics for JAN-6C4W as defined by MIL-E-1/55B dated 14 January 1954.

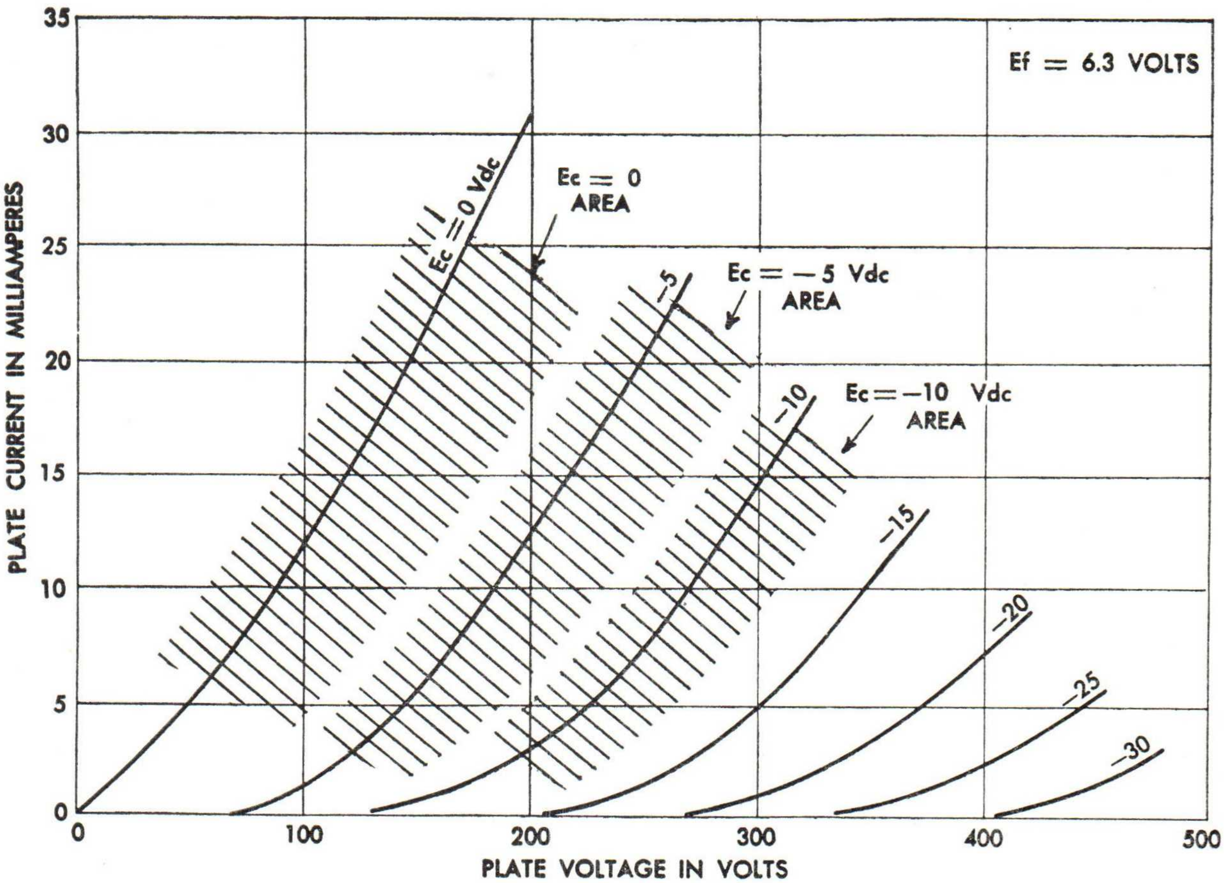


Figure 3-122 Limit Plate Characteristics of JAN 6C4W.

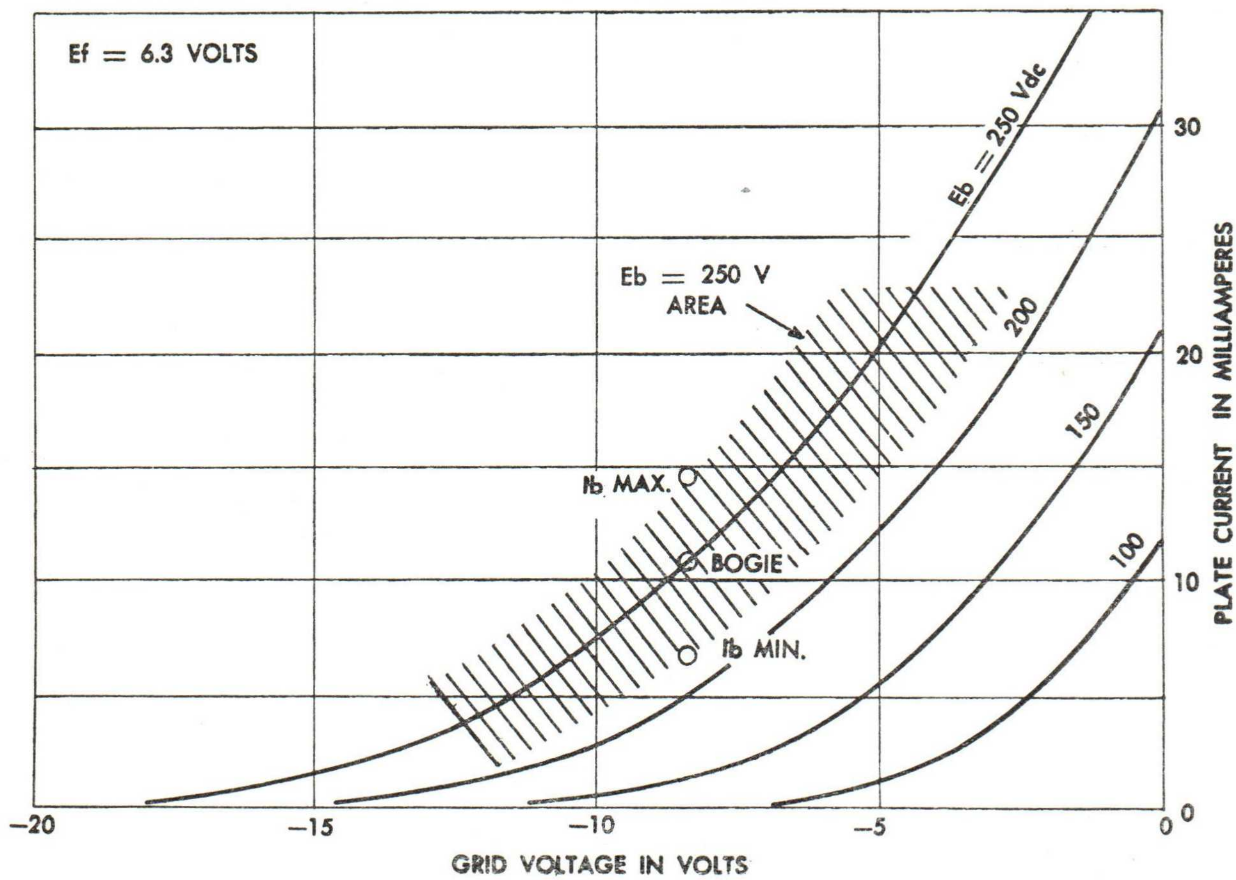


Figure 3-123. Limit Transfer Characteristics of JAN 6C4W.

DESIGN CENTER CHARACTERISTICS OF JAN-6C4W

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The charts below present the average Static and transfer Plate Characteristics of JAN-6C4W.

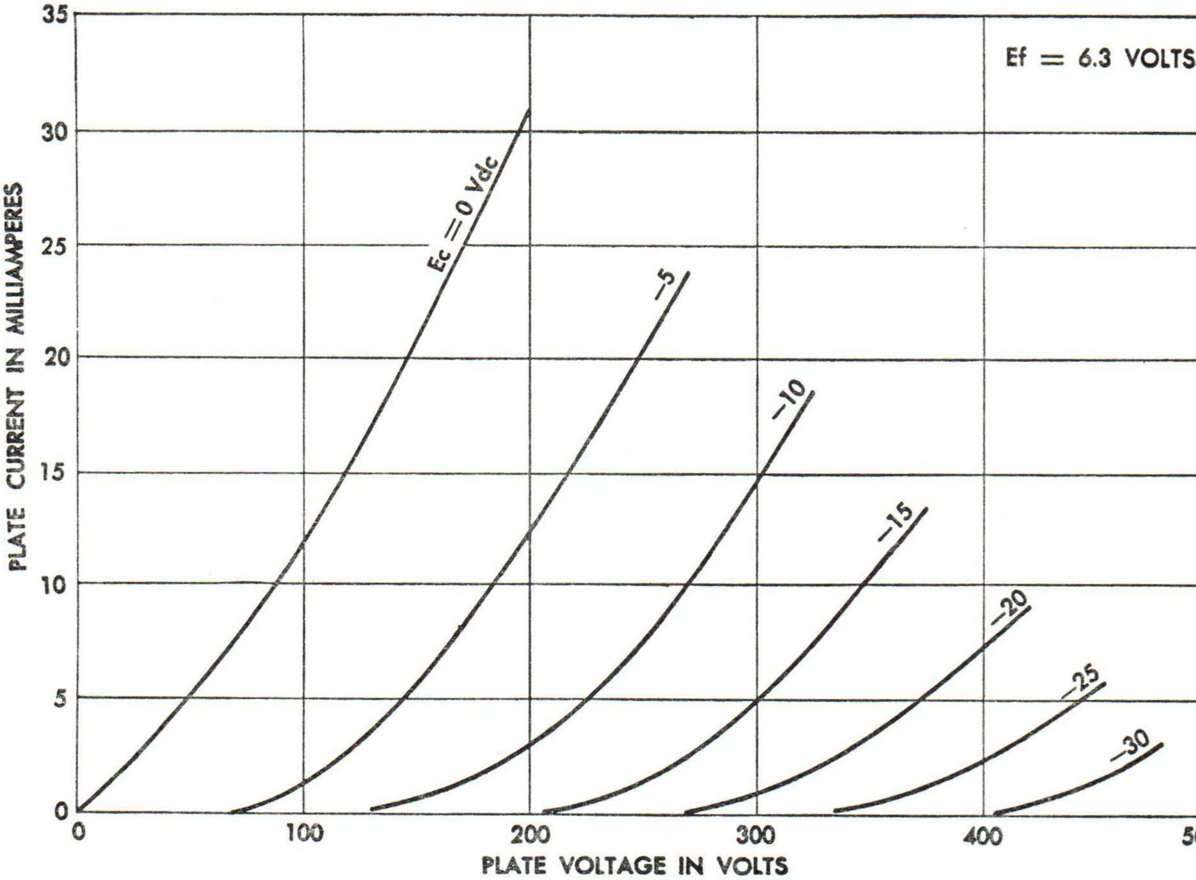


Figure 3-124. Typical Plate Characteristics of JAN 6C4W.

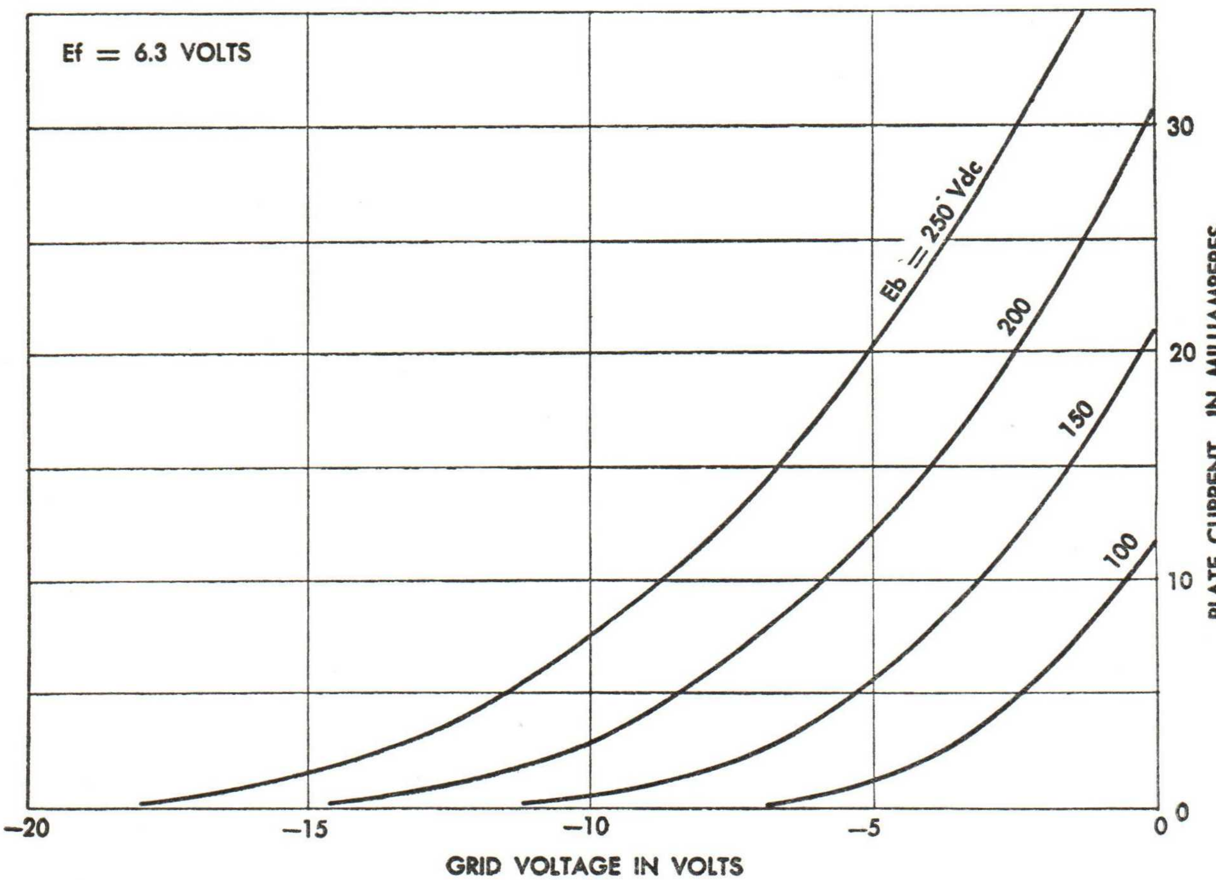


Figure 3-125. Typical Transfer Characteristics of JAN 6C4W.

SECTION
TUBE TYPE JAN-6L6WGB

DESCRIPTION.

The JAN 6L6WGB [1] is a 7 pin octal base, glass envelope, beam power-pentode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage, AC or DC .... 6.3 V
Heater Current .... 840 to 960 mA
**Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.

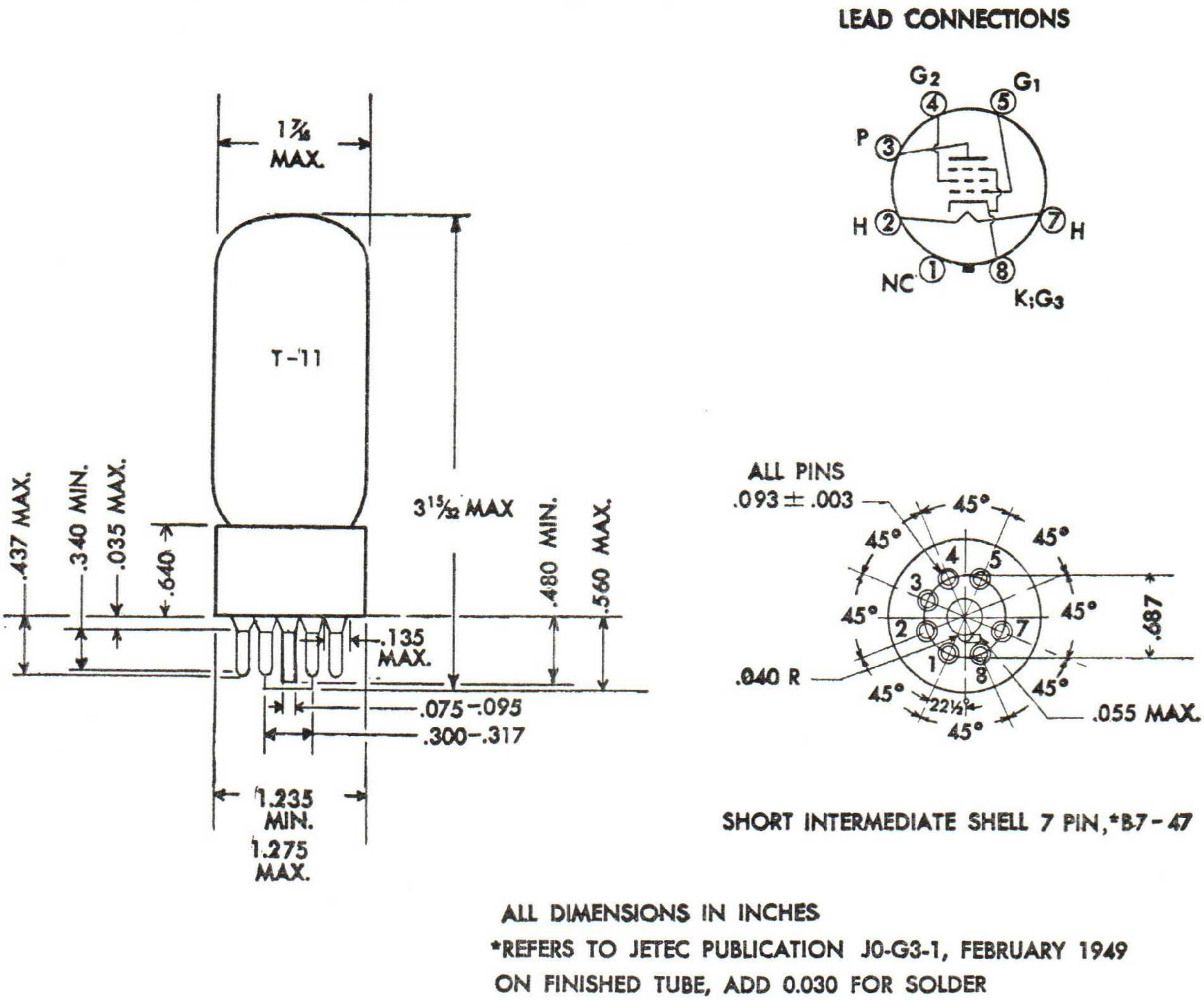


Figure 3-126. Outline Drawing and Base Diagram of Tube Type JAN-6L6WGB.

RATINGS, ABSOLUTE SYSTEM

The absolute systems ratings are as follows:

Heater Voltage .... 6.3 ± 10% V
Plate Voltage .... 400 Vdc

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/197 dated 20 May 1953.

Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*

Screen Grid Voltage .... 300 Vdc
Plate Dissipation .... 26 W
*Screen Grid Dissipation .... 3.5 W
Altitude .... 10,000 ft

TEST CONDITIONS

Test conditions are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Control Grid Voltage, Ec1 .... —14 Vdc
Screen Grid Voltage, Ec2 .... 250 Vdc

* No test at this rating exists in the specification.

ACCEPTANCE TESTS LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/197 dated 20 May 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		840	960	...	...	mA
Transconductance	Sm		5200	6800	4500	...	umhos
Plate Current	Ib	Eb = 400 Vdc; Ec2 = 300 Vdc; Ec1 = —22 Vdc.	50	80	...	...	mAdc
Emission	Is	Eb = Ec1 = Ec2 = 50 Vdc	275	...	...	...	mAdc
Screen Grid Current	Ic2	Eb = 400 Vdc; Ec2 = 300 Vdc; Ec1 = —22 Vdc	0	5.0	...	...	mAdc
Power Output	Po	Esig = 9.8 Vac; Rp = 2500 ohms	5.4	...	4.0	...	W
Grid Current	Ic1	Eb = 400 Vdc; Ec2 = 300 Vdc; Ec1 = —19 Vdc.	0	—3.0	...	...	uAdc
Heater-Cathode Leakage	Ihk	Ehk = ± 100 Vdc	0	75	...	...	uAdc
	Ihk	Ehk = — 100 Vdc					

APPLICATION OF JAN-6L6WGB

Figure 3-127 below shows the permissible operating area for JAN-6L6WGB as defined by the ratings in MIL-E-1/197 dated 20 May 1953. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

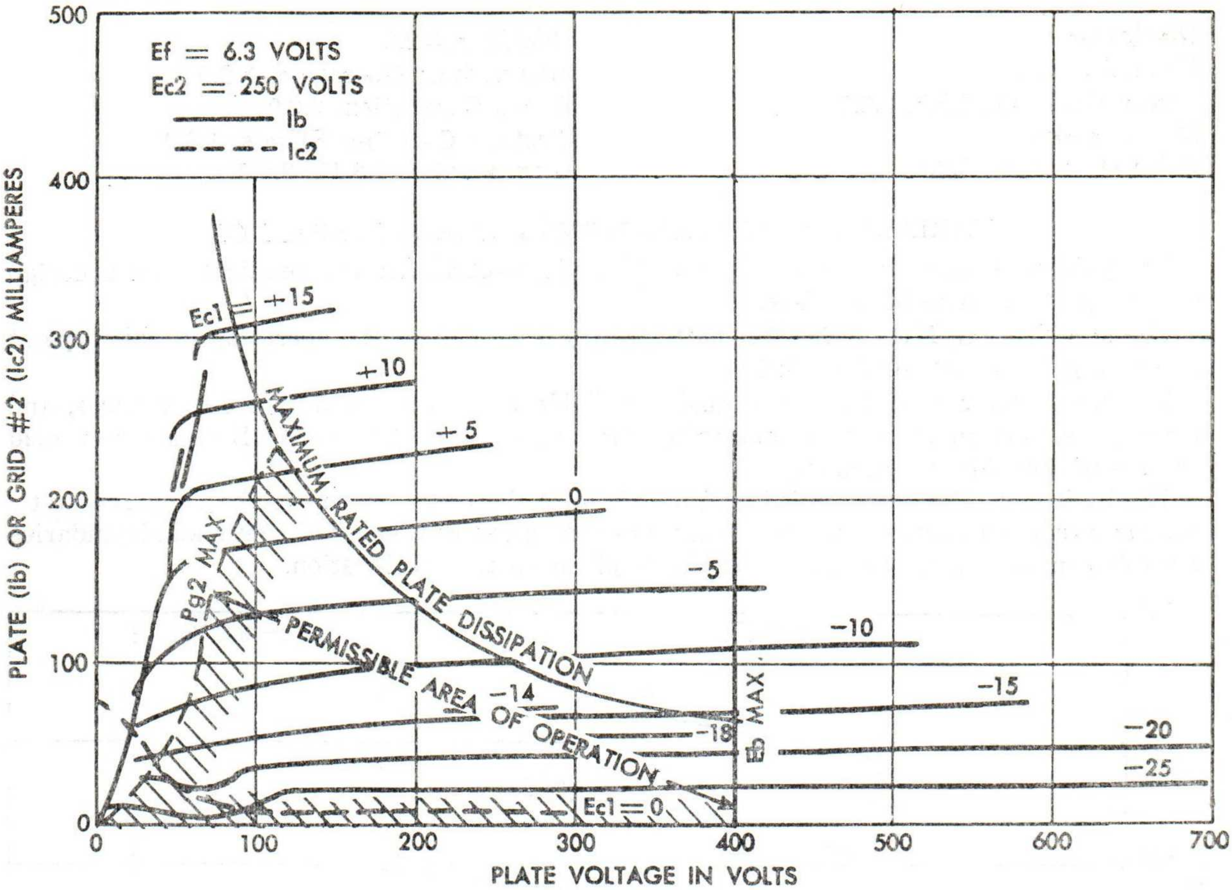


Figure 3-127. Typical Plate Characteristics of JAN 6L6WGB; Permissible Area of Operation $E_{c2} = 250$.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9

Screen Grid Series, 3.2.2, 3.2.9

Cathode Interface, 1.3.10, 3.2.9

Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8

Screen Grid, 3.2.2

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.2.8

Control Grid Emission, 1.3.3

Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7
Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-6L6WGB CHARACTERISTICS

The published data that describe and define JAN-6L6WGB are predicated on a design center screen voltage of 250 Vdc.

The specification, MIL-E-1/197, dated 20 May 1953 defines the operation of this type at a screen grid voltage of 300 Vdc.

The manufacturer of this type made available a quantity of design center tubes, and from these, certain inferences concerning the behavior of JAN-6L6WGB at a screen grid voltage of 300 Vdc were made.

The limit curves, Figures 3-128 and 3-129 were therefore drawn on the averaged static plate and transfer curves prepared from these design center tubes. The limits and boundaries were determined from the acceptance limits given on the specification.

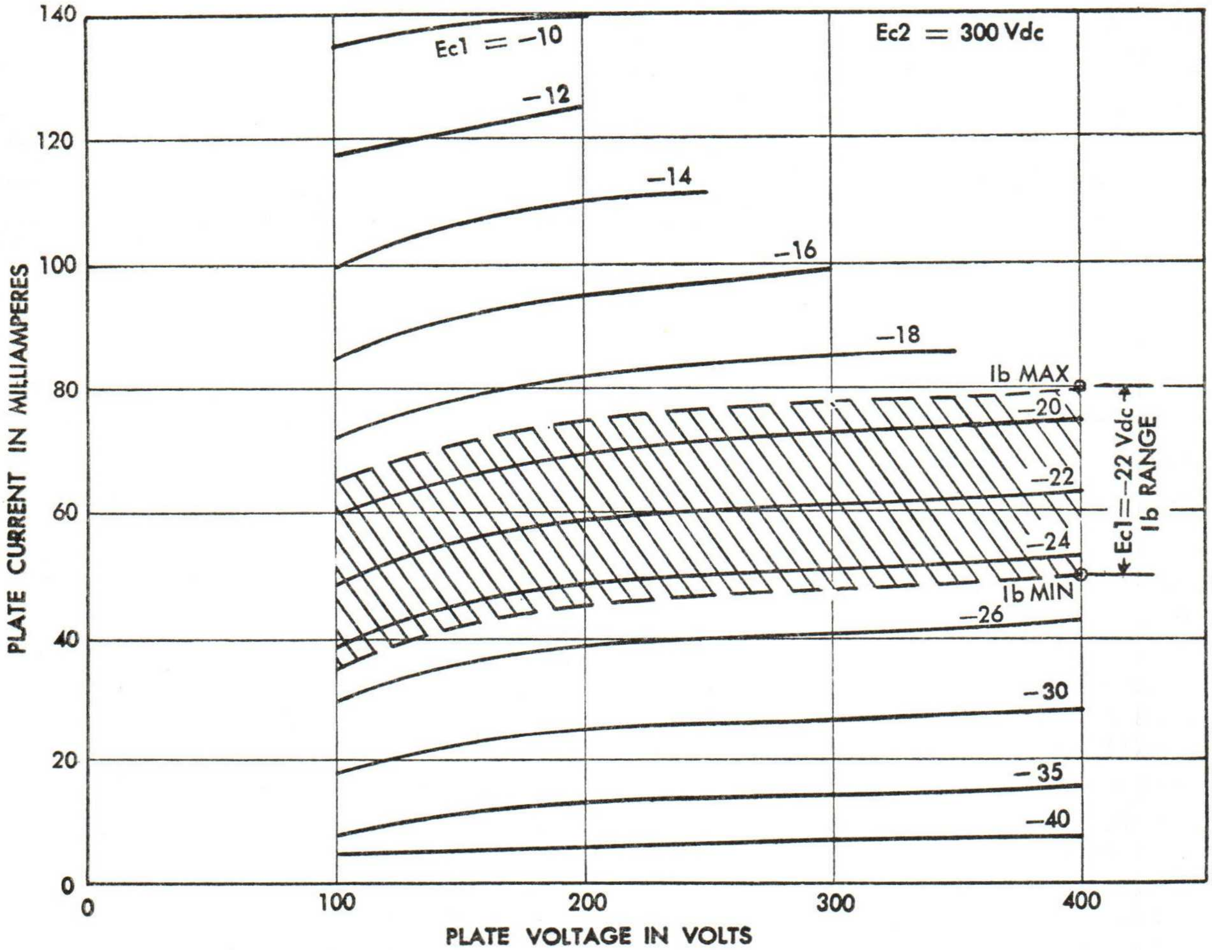


Figure 3-128. Limit Plate Characteristics of JAN 6L6WGB; Ec2 = 300.

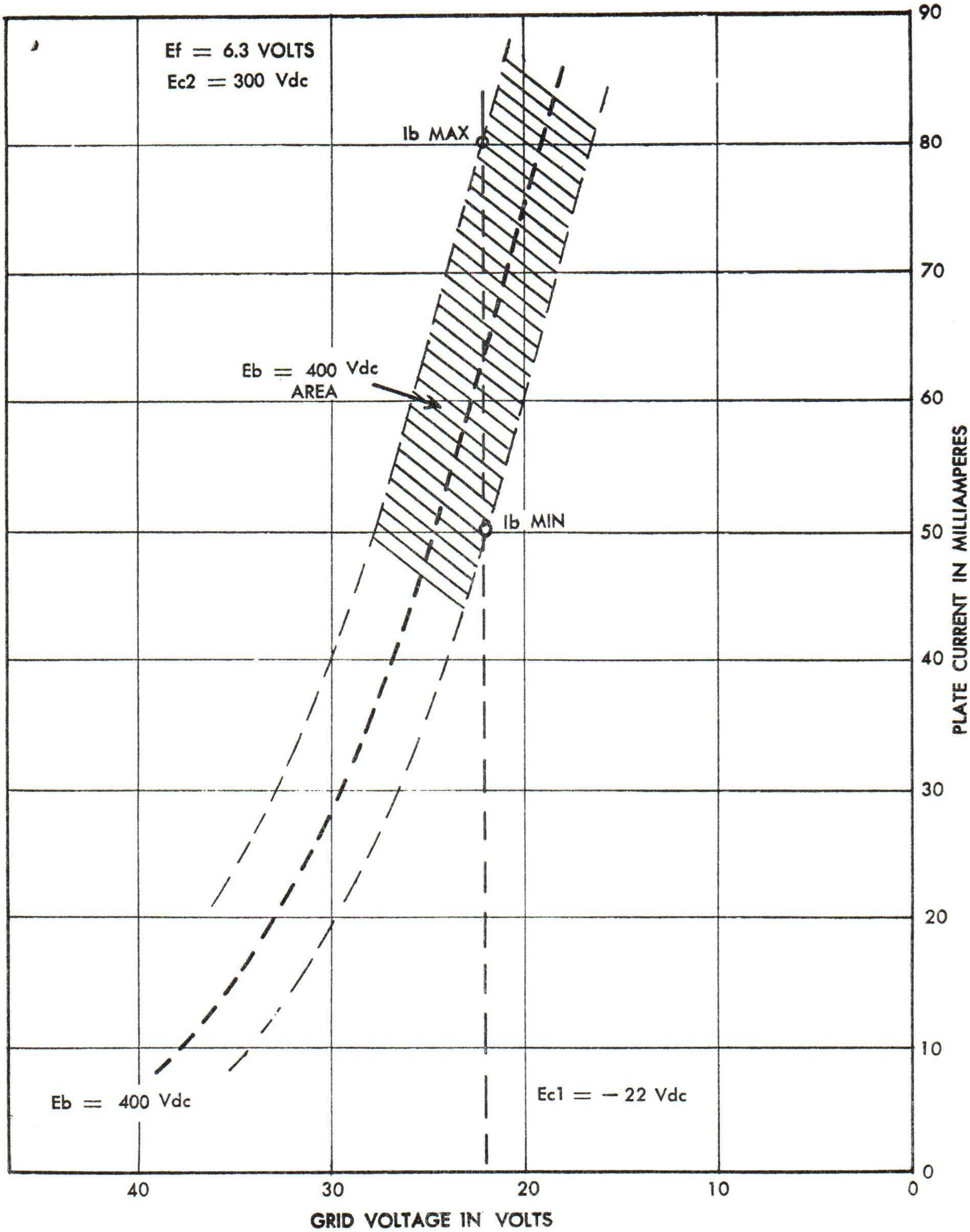


Figure 3-129. Limit Transfer Characteristics of JAN 6L6WGB; Ec2 = 300.

DESIGN CENTER CHARACTERISTICS OF JAN-6L6WGB

Figures 3-130, 3-131, and 3-132 are typical curves that have been obtained from current data being published by the original RETMA registrant of this type.

Analysis of a quantity of near design center tubes has resulted in a set of averaged static plate characteristics for JAN-6L6WGB at the MIL-E-1 test voltages. From this data, an average static plate plot has been prepared for Figure 3-127 and the permissible operating region has been portrayed thereon in Figure 3-129.

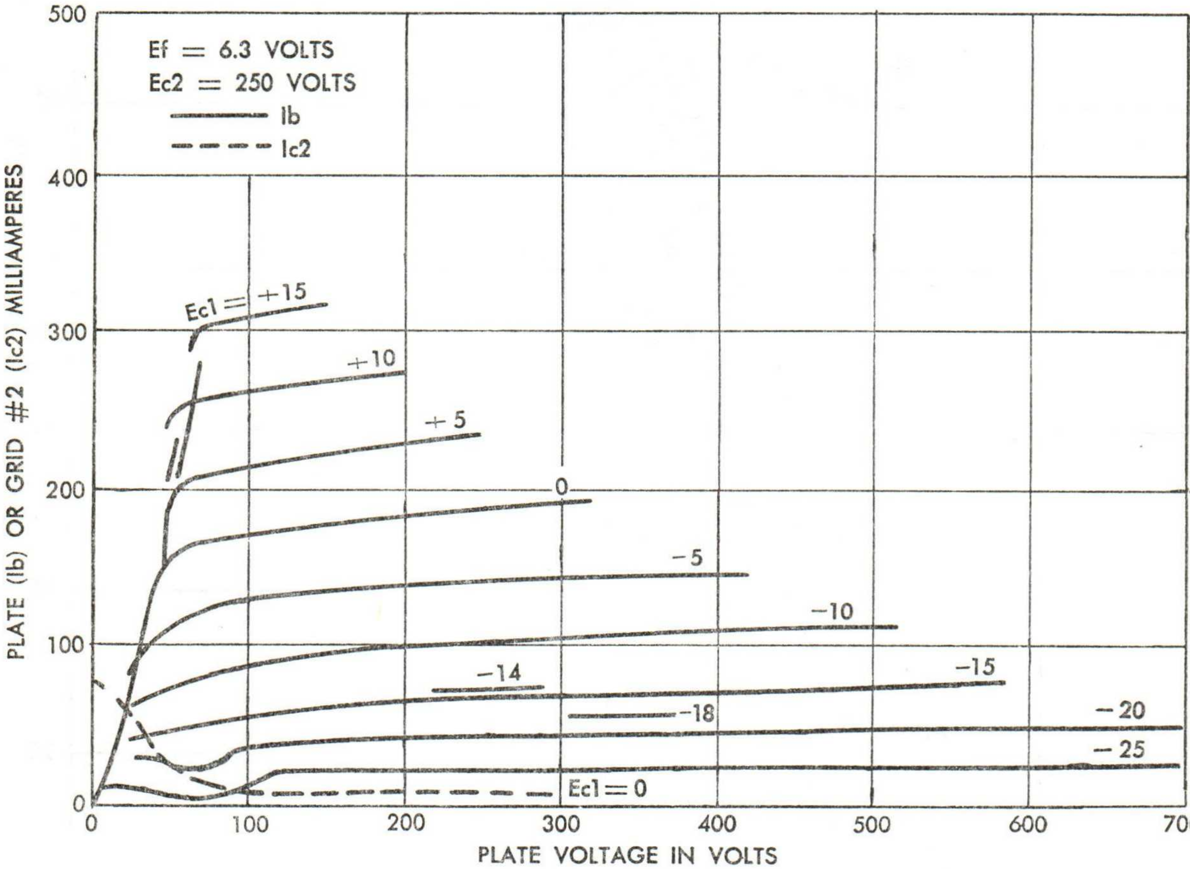


Figure 3-130. Typical Plate Characteristics of JAN 6L6WGB; Ec2 = 250.

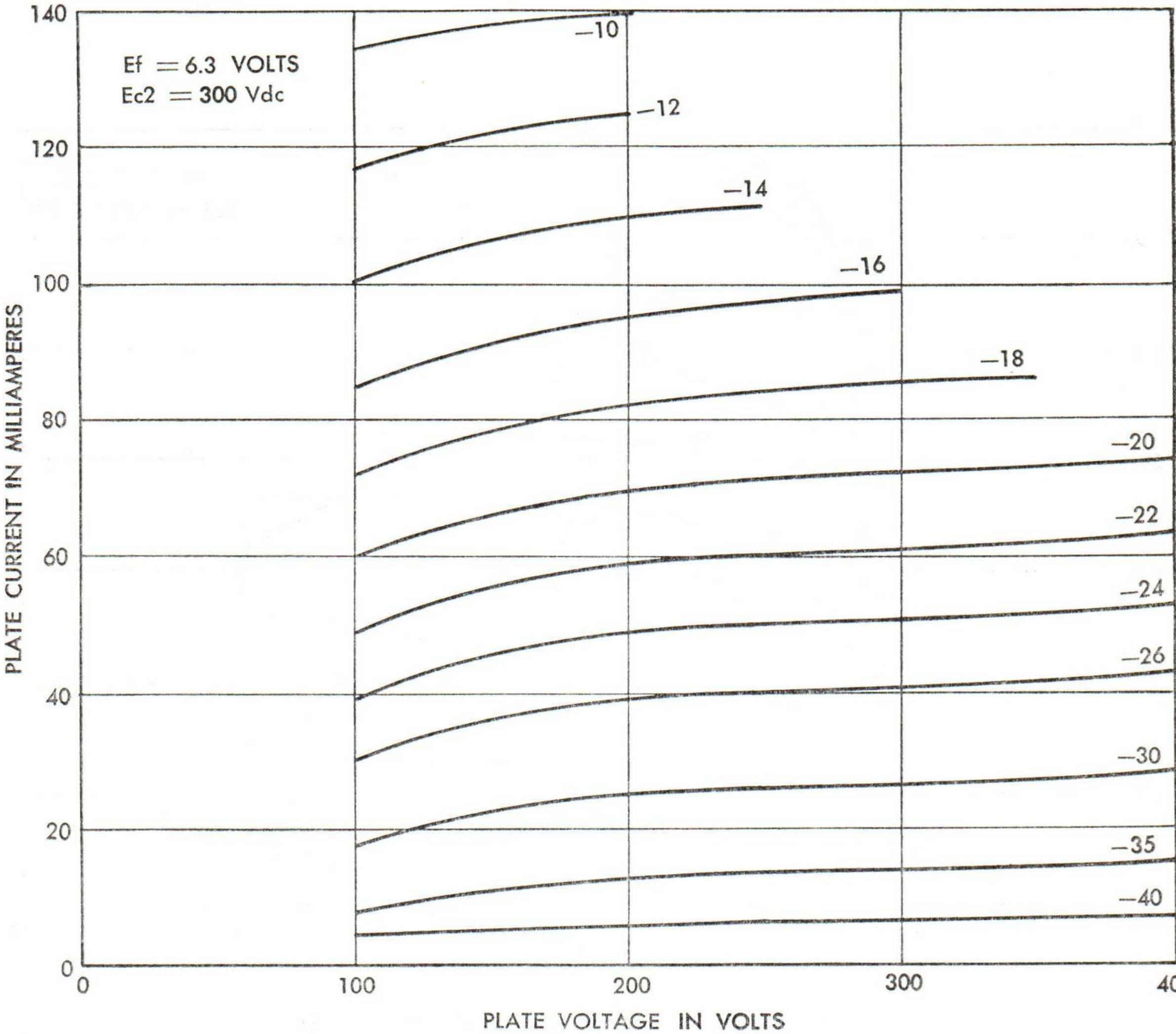


Figure 3-131. Typical Plate Characteristics of JAN 6L6WGB; Ec2 = 300.

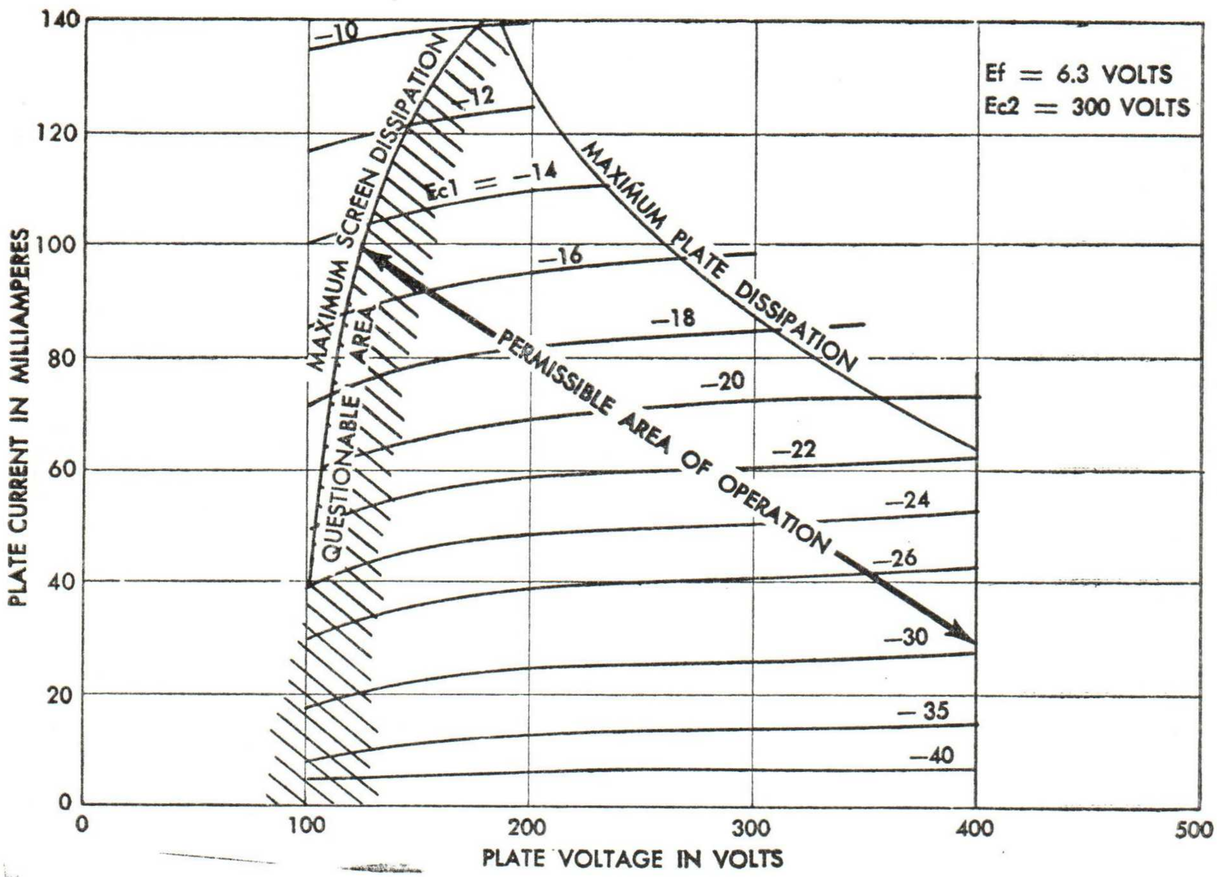


Figure 3-132. Permissible Operating Region of Jan 6L6WGB; Ec2 = 300.

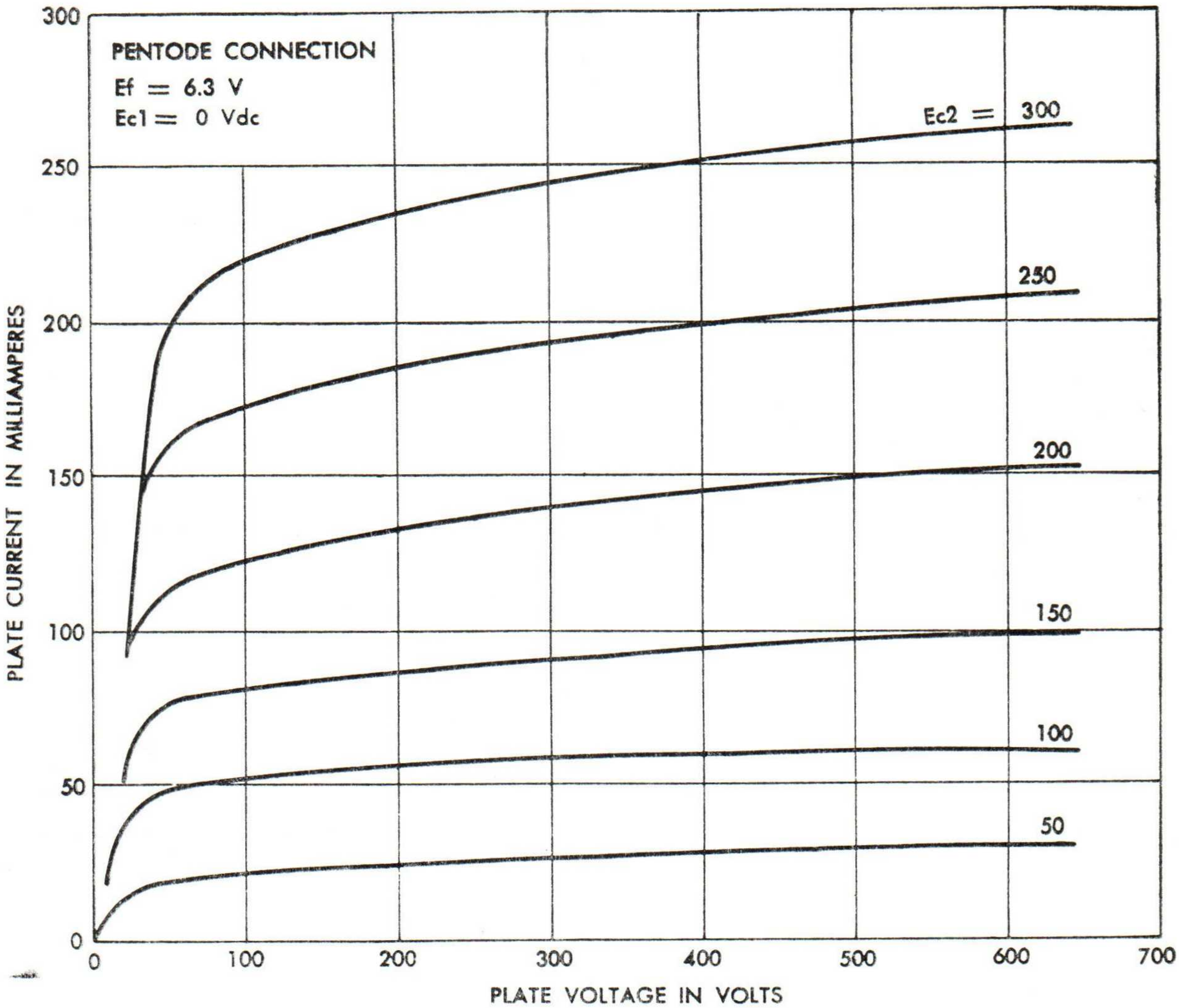


Figure 3-133. Typical Plate Characteristics of JAN 6L6WGB; Variability of Ec2.

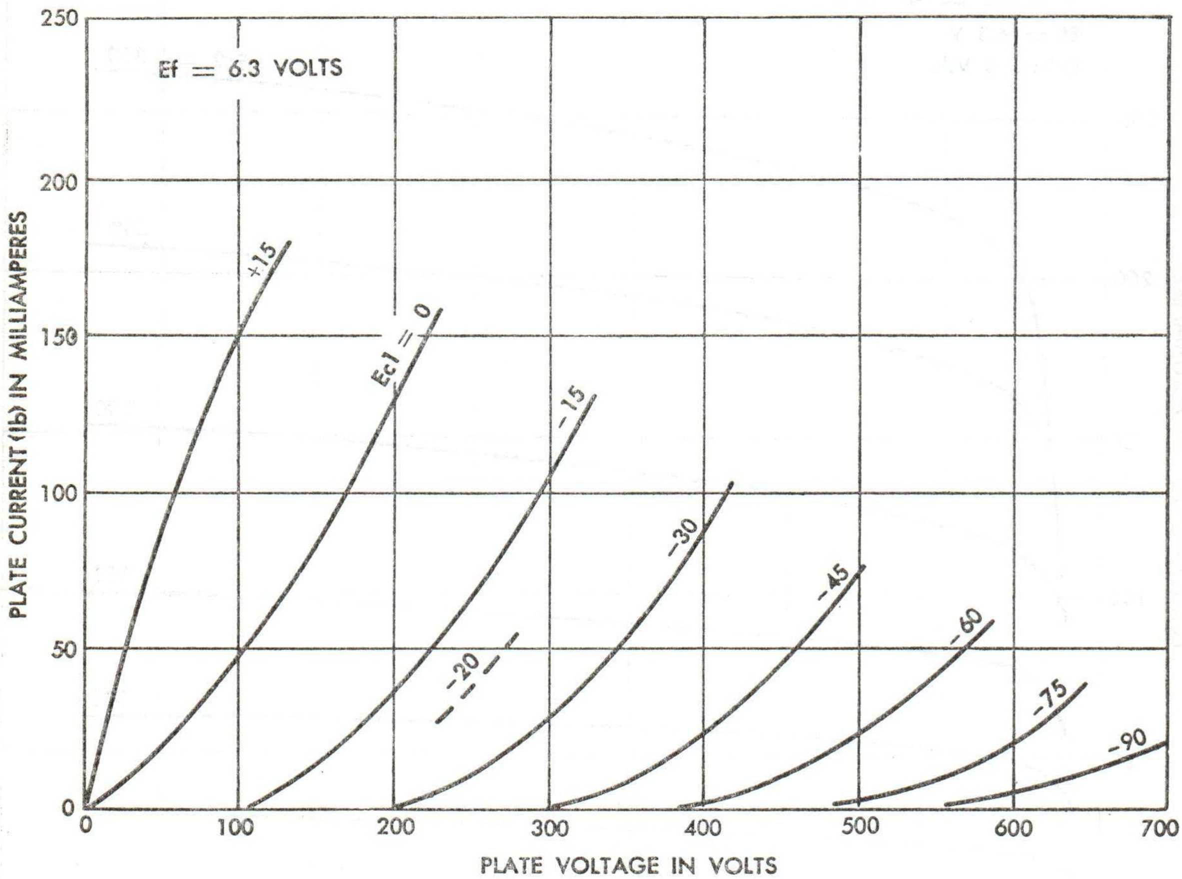


Figure 3-134. Typical Plate Characteristics of JAN 6L6WGB; Triode Connected.

SECTION
TUBE TYPE JAN-6X4W

DESCRIPTION.

The JAN-6X4W [1] is a miniature, heater-cathode type twin diode suitable for full wave rectifier operation where the average DC current is not in excess of 75 milliamperes.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

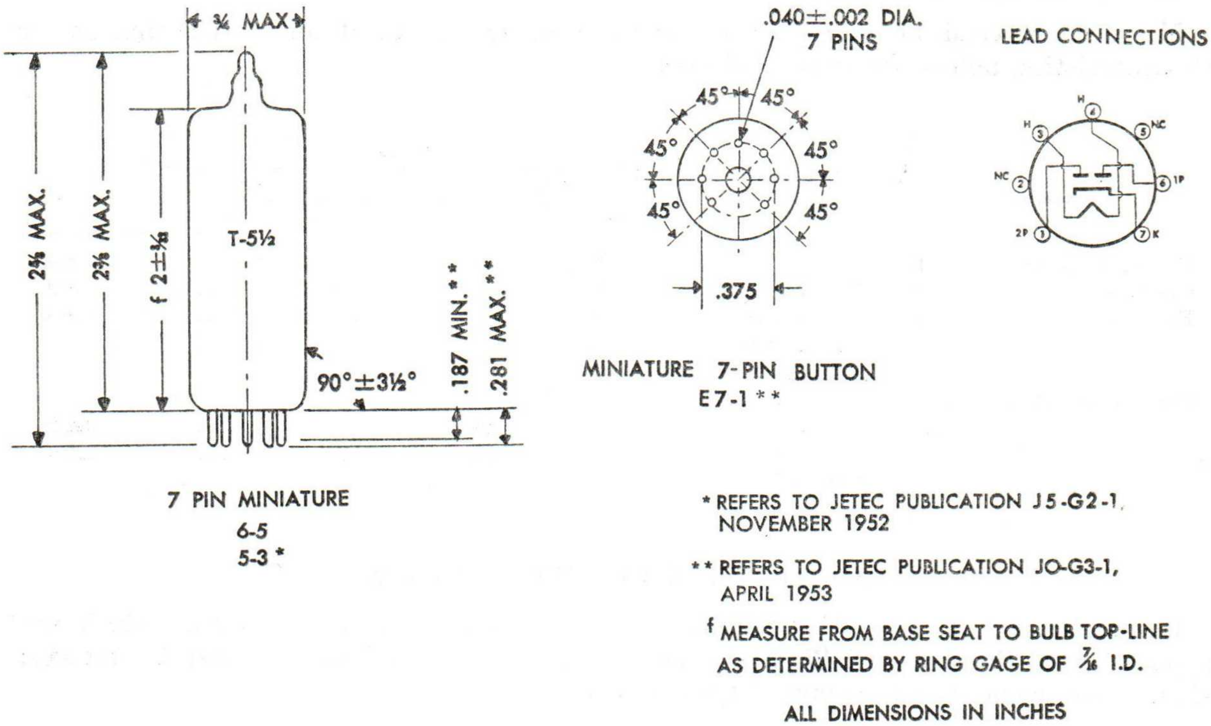


Figure 3-135. Outline Drawing and Base Diagram of Tube Type JAN-6X4W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 10%
Peak Inverse Plate Voltage	1375 v
Steady State Peak Plate Current (each plate)	230 ma
DC output current, both plates	75 mAdc
*Transient Peak Plate Current, each plate	750 ma
Heater-Cathode Voltage	450 v
*Altitude Rating	10,000 ft

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/64A dated 20 May 1953.

TEST CONDITIONS AND CHARACTERISTICS

Test conditions and characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Secondary Voltage to Plate, Epp .... 400 Vac
Load Resistance (RL) (unity power factor) .... 5700 ohms
Load Capacitor (CL) .... 8 uf

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/64A dated 20 May 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		540	660	...	...	mA
Operation	Io	(Fullwave)	70	...	60	...	mA
Emission	Is	Eb = 50 Vdc (opposite plate grounded)	140	...	...	...	mA
Heater-Cathode Leakage							
	Ihk	Ehk = Eo	0	150	...	...	uAdc
	Ihk	Ehk = 220 VRMS +100 Vdc	...	±150	...	...	uAdc

APPLICATION OF THE JAN-6X4W

Rating Chart I, II, and III represent areas of permissible operation within which any application of the JAN-6X4W must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

RATING CHART I is based on maximum rated peak inverse voltage per plate (epx) of 1375 volts and maximum rated dc output current per plate (Io/p) of 37.5 milliamperes. Point C corresponds to the simultaneous occurance of these two ratings, permissible only under choke-input filter conditions. Point E is derived from life test conditions of rated dc output current into capacitor input filter. The area CDE is restricted to choke input service only.

RATING CHART II for capacitor input filter applications, is based on maximum rated dc output current per plate (Io/p) and maximum rated steady state peak plate current of 230 milliamperes per plate. Rectification efficiency must not exceed 0.69 under conditions of maximum rated dc output current.

RATING CHART III for capacitor input filter is based on maximum rated surge current (i surge) of 750 milliamperes per plate. Minimum permissible series resistance (Rs) is approximately 750 ohms per plate under conditions of maximum permissible supply voltage.

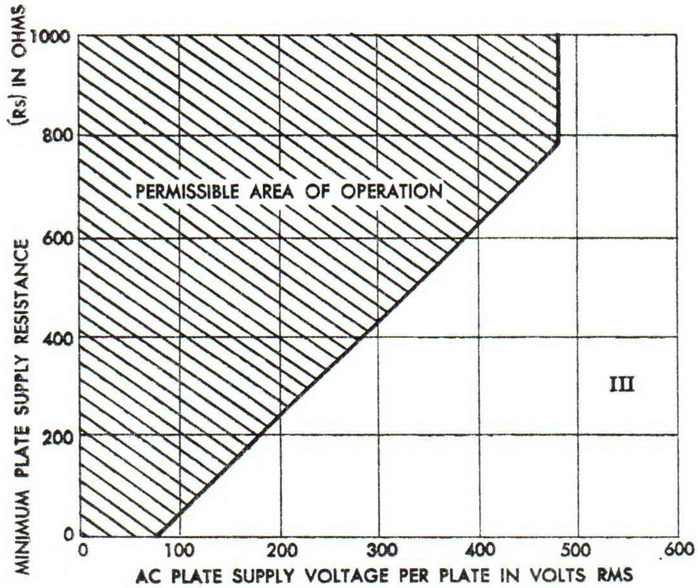


Figure 3-138. Rating Chart III for JAN-6X4W.

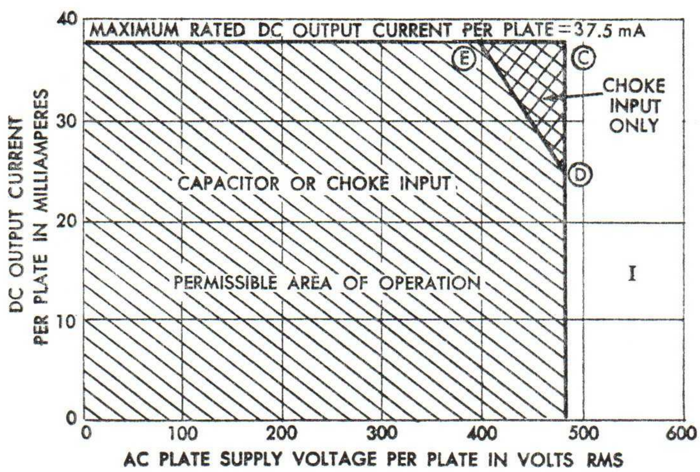


Figure 3-136. Rating Chart I for JAN-6X4W.

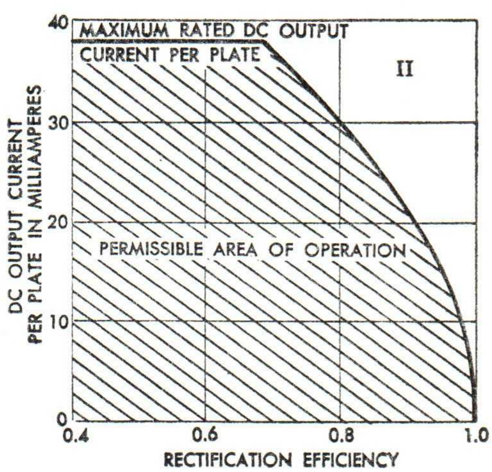


Figure 3-137. Rating Chart II for JAN-6X4W.

OTHER CONSIDERATIONS.
HEATER VOLTAGE: See paragraph 3.3.5
ALTITUDE: See paragraph 3.3.3

TYPICAL CHARACTERISTICS OF JAN-6X4W

The chart below presents the Static Plate Characteristics of JAN-6X4W reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

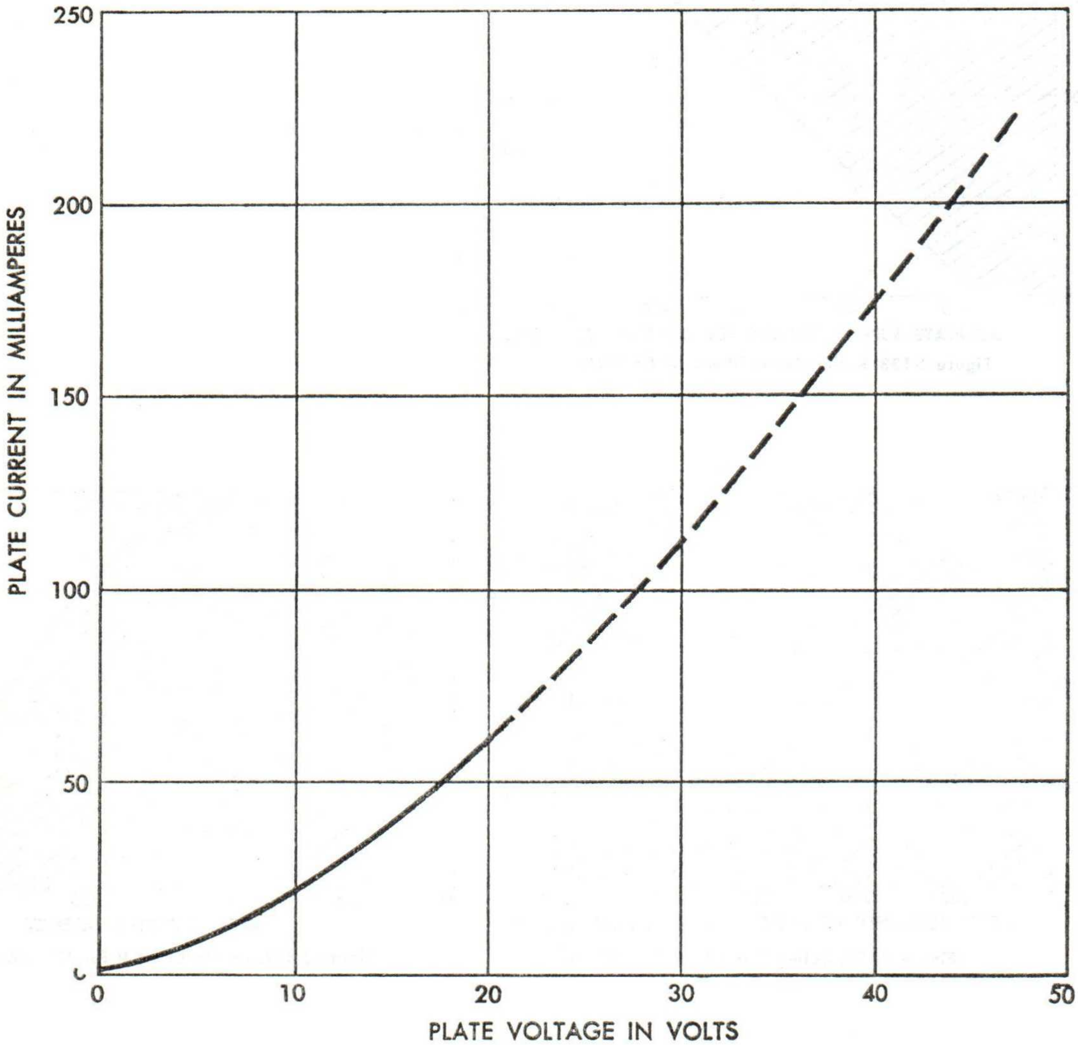


Figure 3-139. Typical Plate Characteristic of JAN-6X4W.

SECTION
TUBE TYPE JAN-12AT7WA

DESCRIPTION.

The JAN-12AT7WA[1] is a 9 pin miniature high transconductance (5500 micromhos) twin triode. This tube was originally designed for use as a grounded-grid RF amplifier or as a mixer in commercial T.V. circuitry. Its center tapped heater permits operation from either 6.3 or 12.6 V.

ELECTRICAL. The electrical characteristics are as follows:

	Series	Parallel
Heater Voltage (A-C or D-C)	12.6	6.3 V
Heater Current, Design Center	150	——
Cathodes	Coated Unipotential	

MOUNTING. Any type of mounting is adequate.

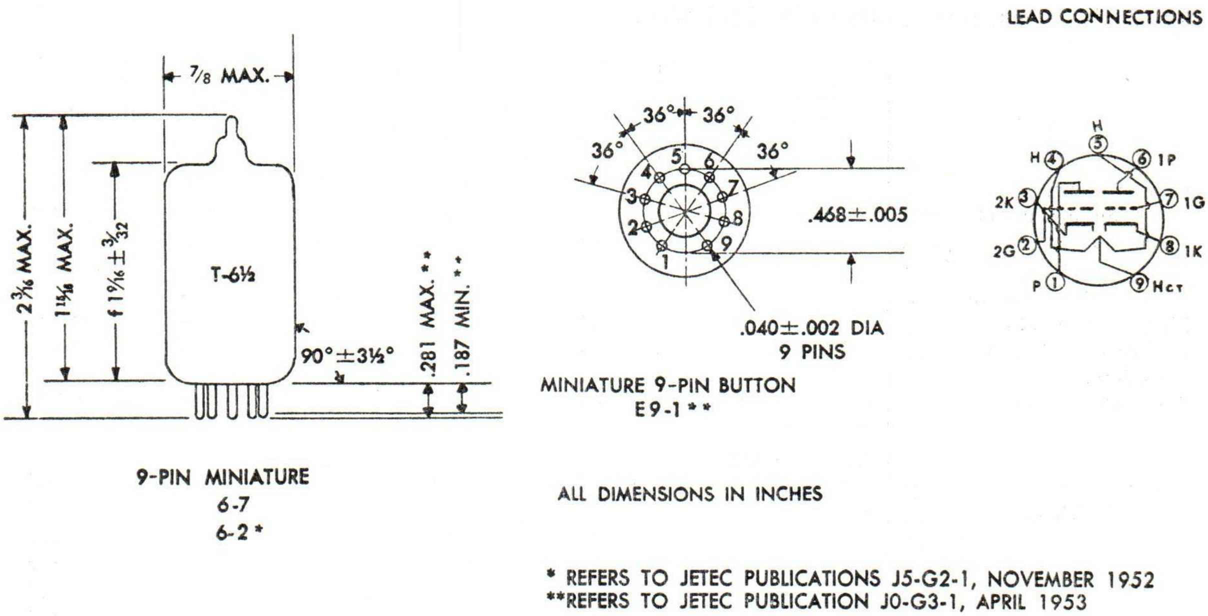


Figure 3-140. Outline Drawing and Base Diagram of Tube Type JAN-12AT7WA.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 10% or 12.6 ± 10% V
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
*Control Grid Voltage, Minimum	—55 Vdc
Plate Dissipation (per Plate)	2.8 W
Heater-Cathode Voltage	± 100 V
*Bulb Temperature	200°C
Altitude Rating	10,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/3A dated 23 August 1955.

* No test at this rating exists in the specification.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	12.6 V
Plate Voltage, Eb	250 Vdc
Cathode Resistance, Rk (per cathode)	200 ohms
Heater Current, If	150 mA
Plate Current, Ib	10 mA
Transconductance, Sm	5500 umhos

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/3A dated 23 August 1955 would be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as statedunder Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		138	162	138	162	mA
Transconductance (1)	Sm		4500	6500	3800	6500	umhos
Change in average	Δ Sm t		—	—	—	20	%
Amplification Factor	Mu		50	70	—	—	
Plate Current (1)	Ib		7.0	14.0	—	—	mAdc
Difference between sections	Ib		—	3.2	—	—	mAdc
Plate Current (2)	Ib	Ec1 = —20 Vdc Rp = 0.1 Meg Rk = 0; Ck = 0	—	100	—	—	uAdc
Capacitance (Unshielded)	Cgp	Ef = 0	1.30	1.90	—	—	uuf
	Cin	Ef = 0	2.00	3.00	—	—	uuf
	Cout-1	Ef = 0	0.20	0.70	—	—	uuf
	Cout-2	Ef = 0	0.16	0.60	—	—	uuf
	Cpp	Ef = 0	0.15	0.33	—	—	uuf
	Chk	Ef = 0	2.10	3.50	—	—	uuf
Grid Current	Ic	Rg = 0.5 Meg	—	—0.7	—	—0.7	uAdc
Heater-Cathode Leakage	Ihk	Ehk = 100 Vdc	—	10	—	10	uAdc
	Ihk	Ehk = —100 Vdc Units ties together	—	—10	—	—10	uAdc
Insulation of Electrodes	Rg-all	Eg-all = —100 Vdc	100	—	50	—	Meg
	Rp-all	Ep-all = —300 Vdc Ef = 12.6 V	100	—	50	—	Meg
Interface Resistance	R	500 hours life at Ef — 6.9 and test at Ef = 5.7, Eb = 135 Vdc, Ec/Ib = 2.0 mAdc	—	—	—	50	ohms

APPLICATION OF JAN-12AT7WA

The chart below shows the permissible operating area for JAN-12AT74A as defined by the ratings in MIL-E-1/3A dated 23 August 1955. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.6.

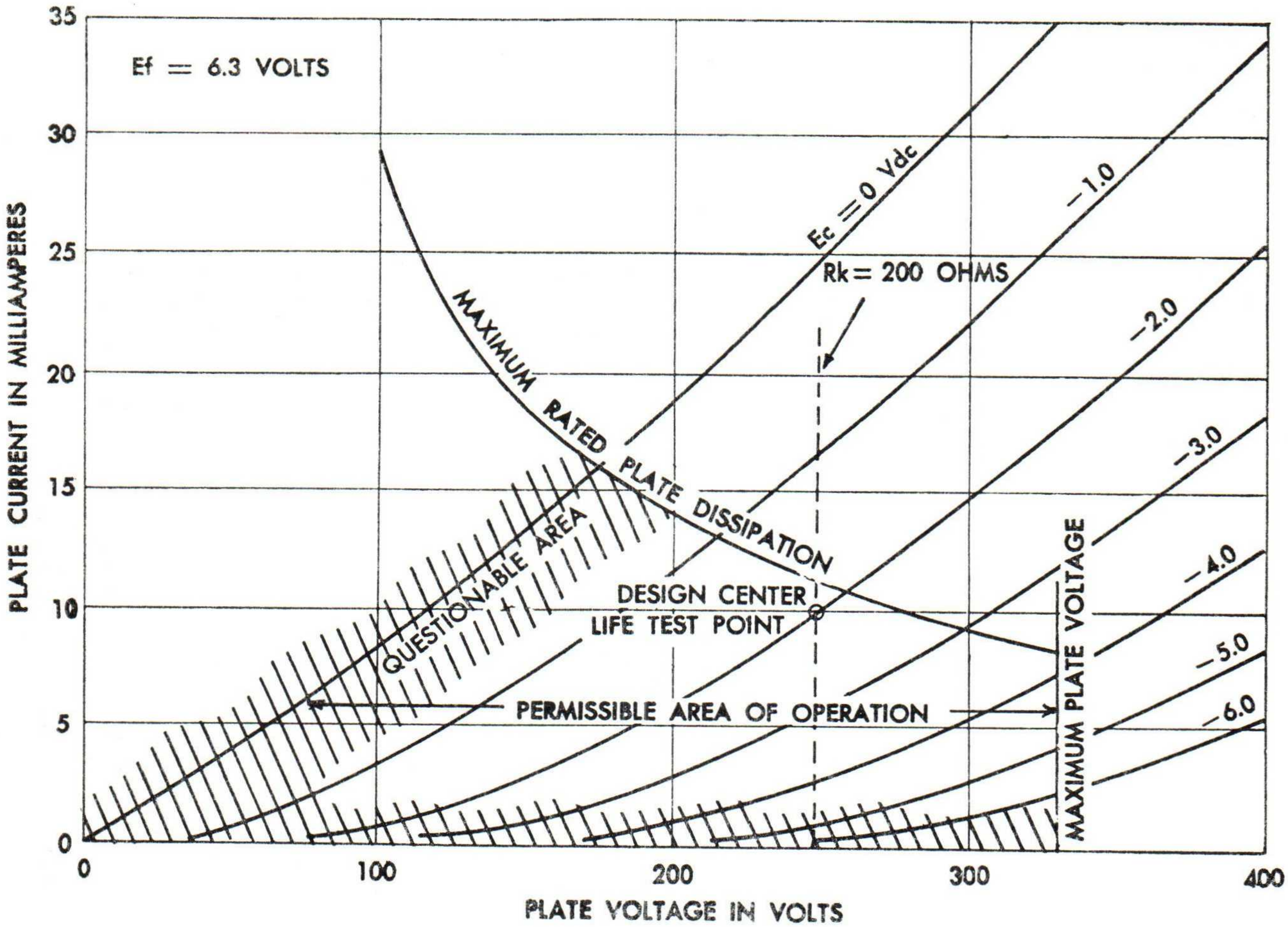


Figure 3-141. Typical Plate Characteristics of JAN-12AT7WA; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation
Plate, 2.1, 3.1.4
Current
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8
Temperature
Bulb and Environmental, 3.1.4
Miscellaneous
Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN-12AT7WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-12AT7WA as defined by MIL-E-1/3A dated 23 August 1955.

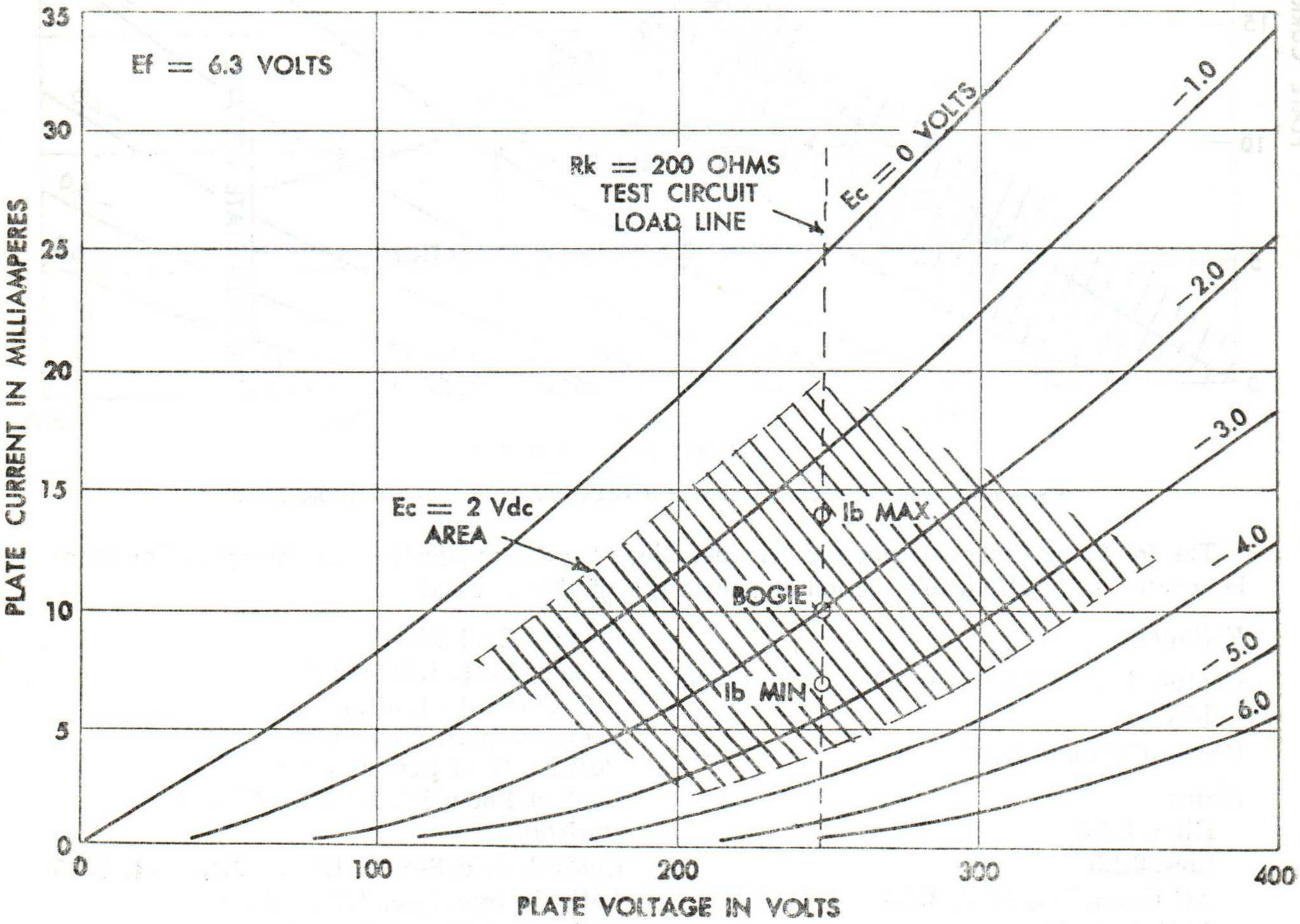


Figure 3-142. Limit Plate Characteristics of JAN-12AT7WA.

The chart below presents the limit behavior of transfer data for JAN-12AT7WA as defined by MIL-E-1/3A dated 23 August 1955.

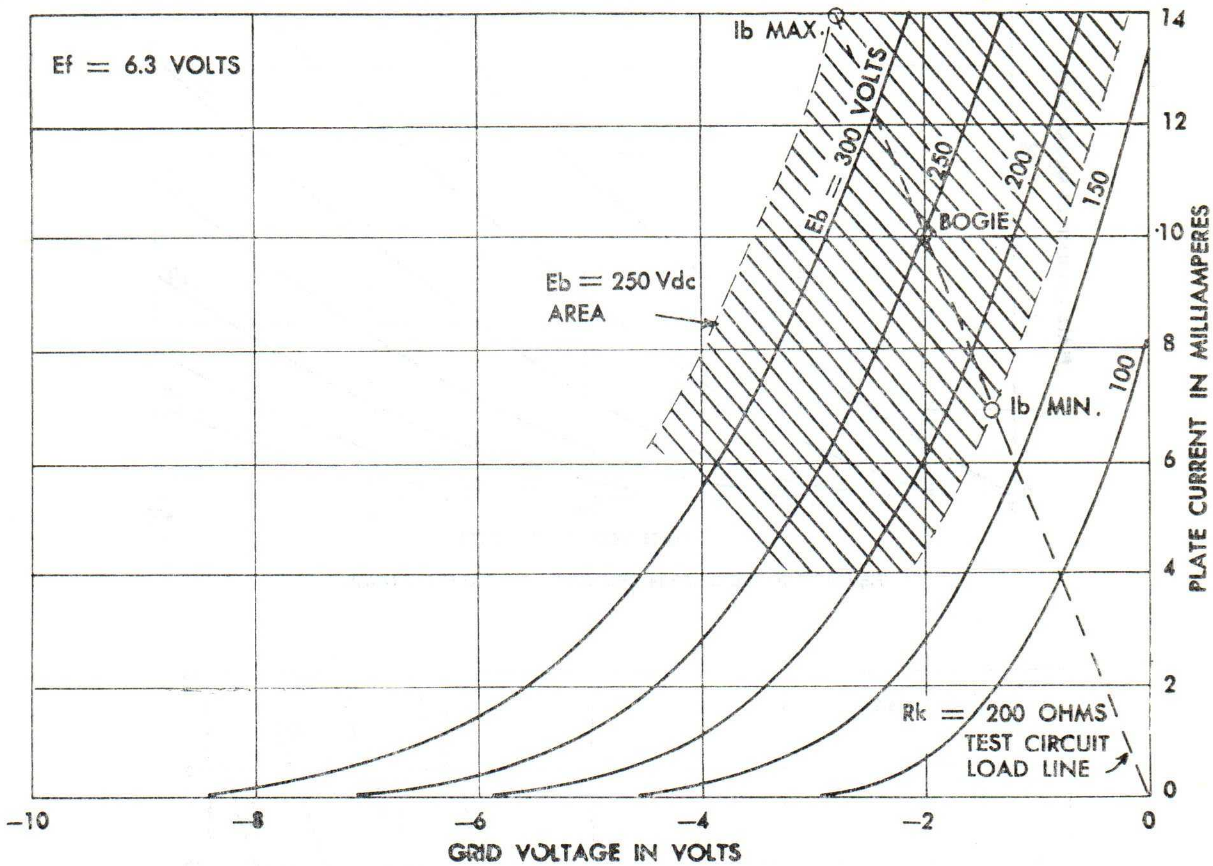


Figure 3-143. Limit Transfer Characteristics of Tube Type JAN-12AT7WA.

DESIGN CENTER CHARACTERISTICS OF JAN-12AT7WA

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

Figure 3-144 below presents the typical Static Plate Characteristics of JAN-12AT7WA.

Figure 3-145 represents typical transfer characteristics of this type.

Figure 3-146 afords a typical picture of the behavior of this tube in the positive grid region, although no MIL-E-1 testing is performed there.

Figure 3-147 is a plot of the typical behavior of the characteristics Mu, Sm, and rp as functions of plate current Ib.

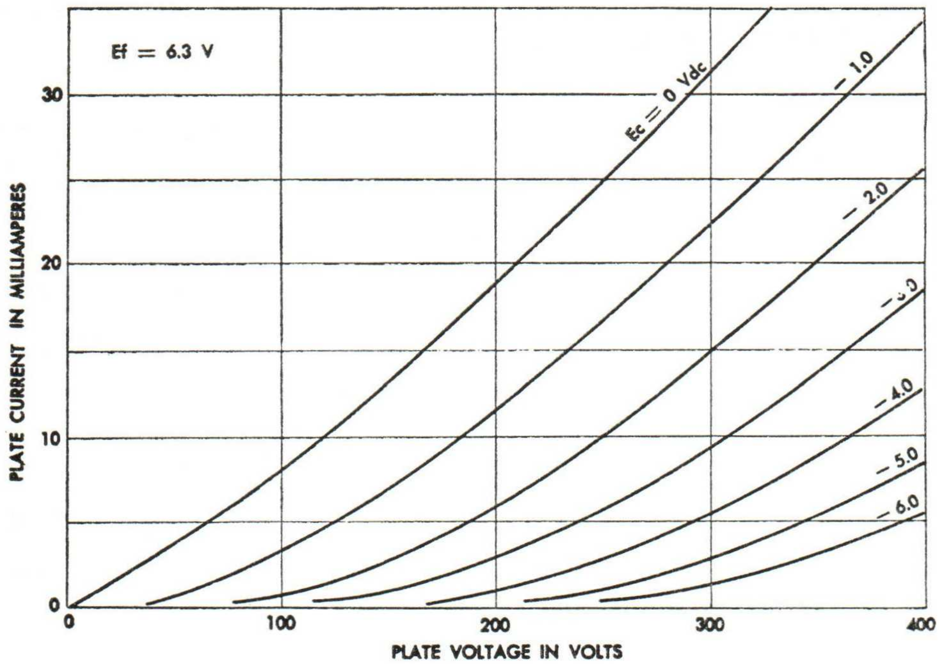


Figure 3-144. Typical Plate Characteristics of JAN-12AT7WA.

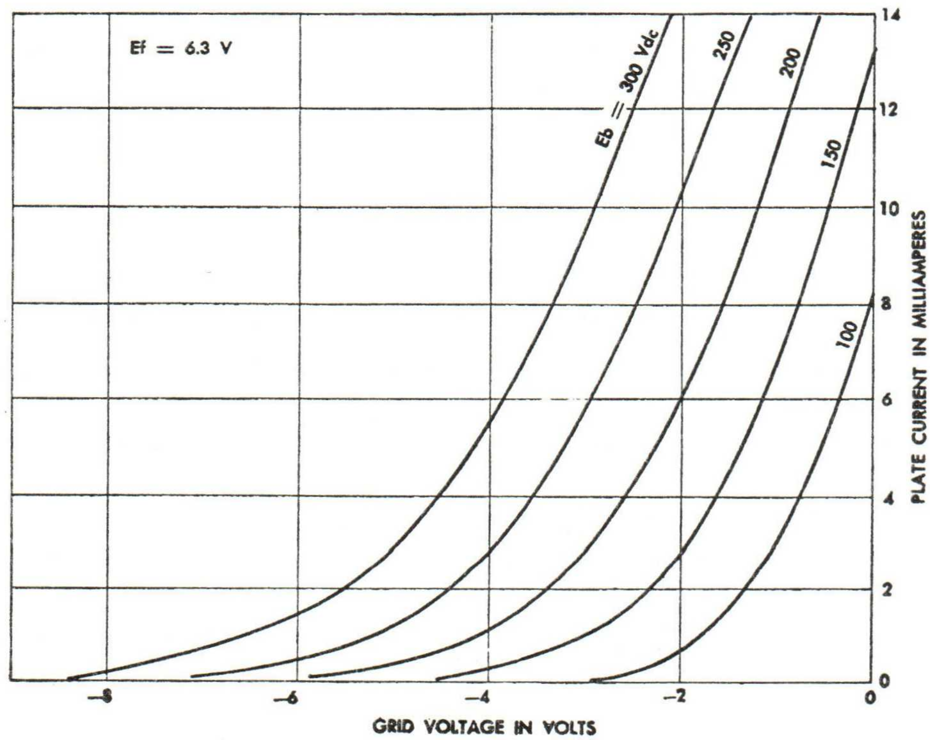


Figure 3-145. Typical Transfer Characteristics of JAN-12AT7WA.

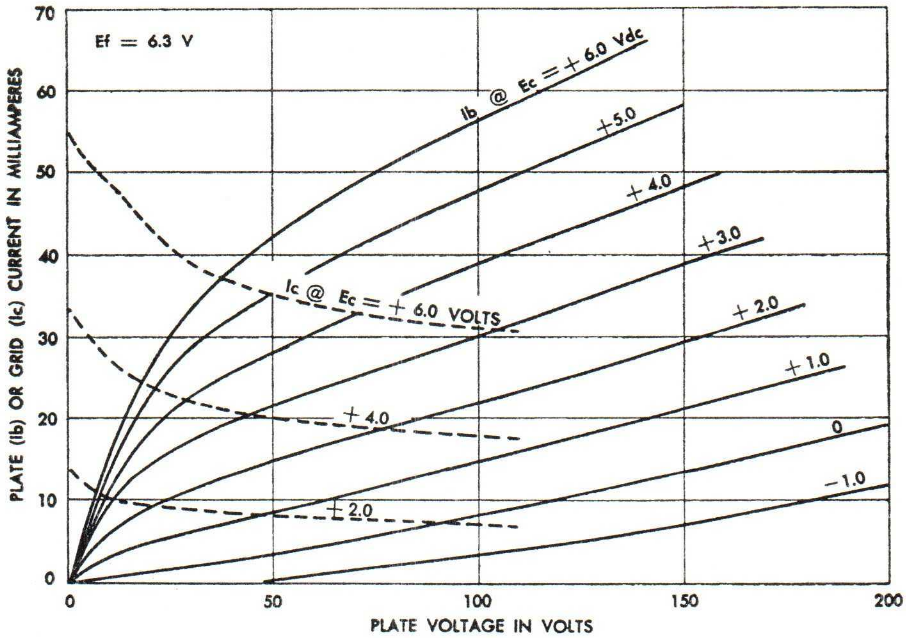


Figure 3-146. Typical Plate and Grid Characteristics of JAN-12AT7WA.

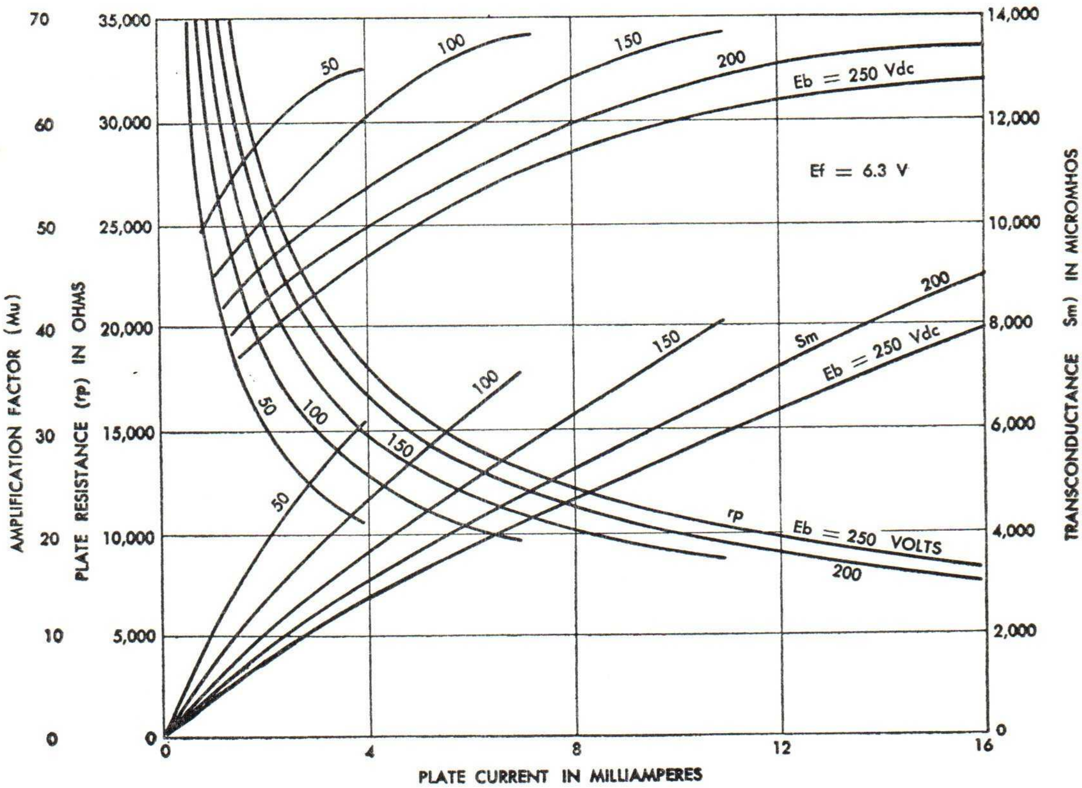


Figure 3-147. Typical Sm, Mu, rp behavior of JAN-12AT7WA.

SECTION TUBE TYPE JAN-5636

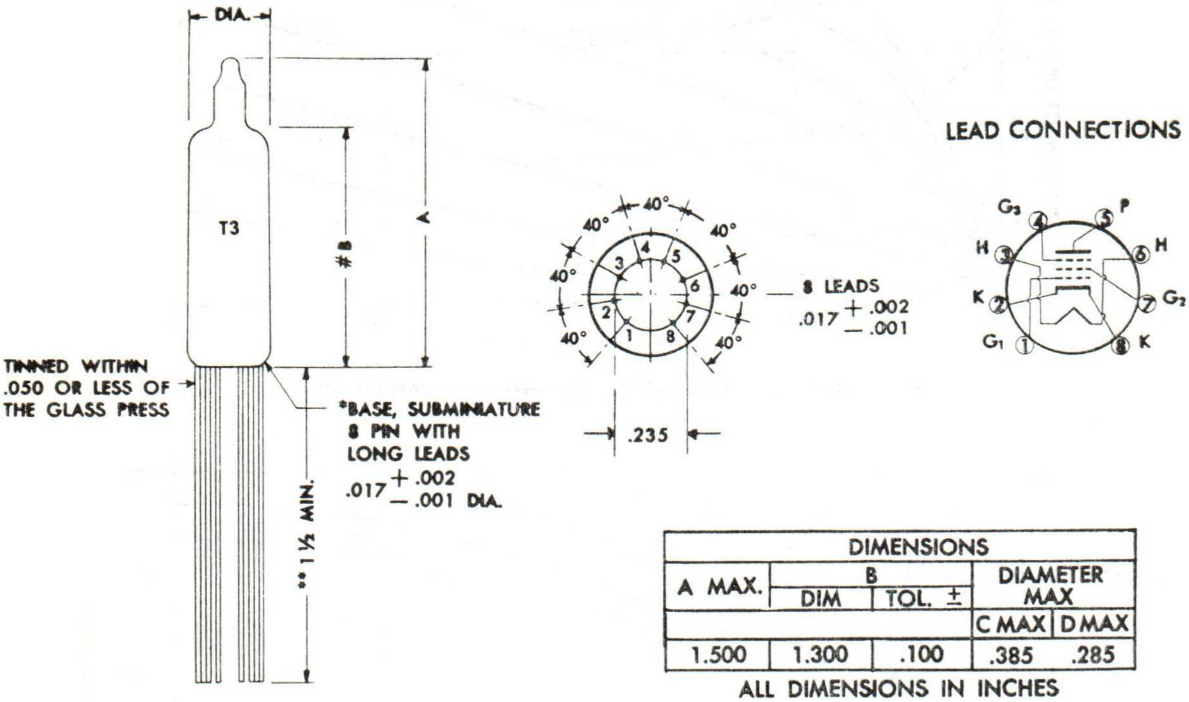
DESCRIPTION.

The JAN-5636 [1] is an 8-lead, button base, subminiature, dual control pentode having a design center transconductance of 3200 micromhos. The JAN-5636 is similar in plate characteristics to JAN-5784WA and JAN-5725/6AS6W.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 150 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS				
A MAX.	B		DIAMETER MAX	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-148. Outline Drawing and Base Diagram of Tube Type JAN-5636.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± .3 V
Plate Voltage .... 165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
First Control Grid Voltage, Maximum .... 0 Vdc
First Control Grid Voltage, Minimum .... —55 Vdc
*Screen Grid Voltage .... 155 Vdc
Suppressor Grid Voltage .... 30 Vdc
Heather-Cathode Voltage .... 200 v
Control Grid Series Resistance .... 1.1 Meg

[1] The values and specification comments presented in this section are related to MIL-E-1/168C dated 23 June 1955.

**Cathode Current, Maximum .... 16.0 mAdc
*Screen Grid Current .... 7.0 mAdc
Plate Dissipation .... 0.55 W
*Screen Grid Dissipation .... 0.45 W
Bulb Temperature .... +220°C
Altitude Rating .... 60,000 ft

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows.

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 100 Vdc
Screen Grid Voltage, Ec2 .... 100 Vdc
Suppressor Grid Voltage, Ec3 .... 0 Vdc
Cathode Resistance, Rk .... 150 ohms
Heater Current, If .... 150 mA
Plate Current, Ib .... 5.3 mAdc
Transconductance, Sm .... 3200 umhos

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/168C dated 23 June 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		140	160	138	164	mA
Transconductance (1)	Sm		2700	4000	—	—	umhos
Change in individual	$\Delta\frac{Sm}{t}$		—	—	—	20	%
Plate Current (1)	Ib		3.7	6.9	—	—	mAdc
Plate Current (3)	Ib	Ec3 = —8.0 Vdc	—	100	—	—	uAdc
Screen Grid Current	Ic2		2.8	5.4	—	—	mAdc
Capacitance	Cg1-p	Ef = 0	—	0.020	—	—	uuf
	Cg3-p	Ef = 0	—	1.10	—	—	uuf
(Shielded as specified)							
	Cg1-g3	Ef = 0	—	0.15	—	—	uuf
	Cg1-all	Ef = 0	3.5	4.5	—	—	uuf
	Cg3-all	Ef = 0	3.5	4.5	—	—	uuf
	Cp-all	Ef = 0	2.9	3.9	—	—	uuf
Control Grid Current	Ic1	Rg1 = 1.0 Meg	0	—0.3	0	—0.9	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	—	5.0	—	10.0	uAdc
	Ihk	Ehk = —100 Vdc	—	—5.0	—	—10.0	uAdc
Insulation of Electrodes	R(g1-all)	Eg1-all = —100 Vdc	100	—	50	—	Meg
	R(p-all)	Ep-all = —300 Vdc	100	—	50	—	Meg

APPLICATION

The chart below shows the permissible operating area for JAN-5636 as defined in the ratings of MIL-E-1/168C, dated 23 June 1955. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

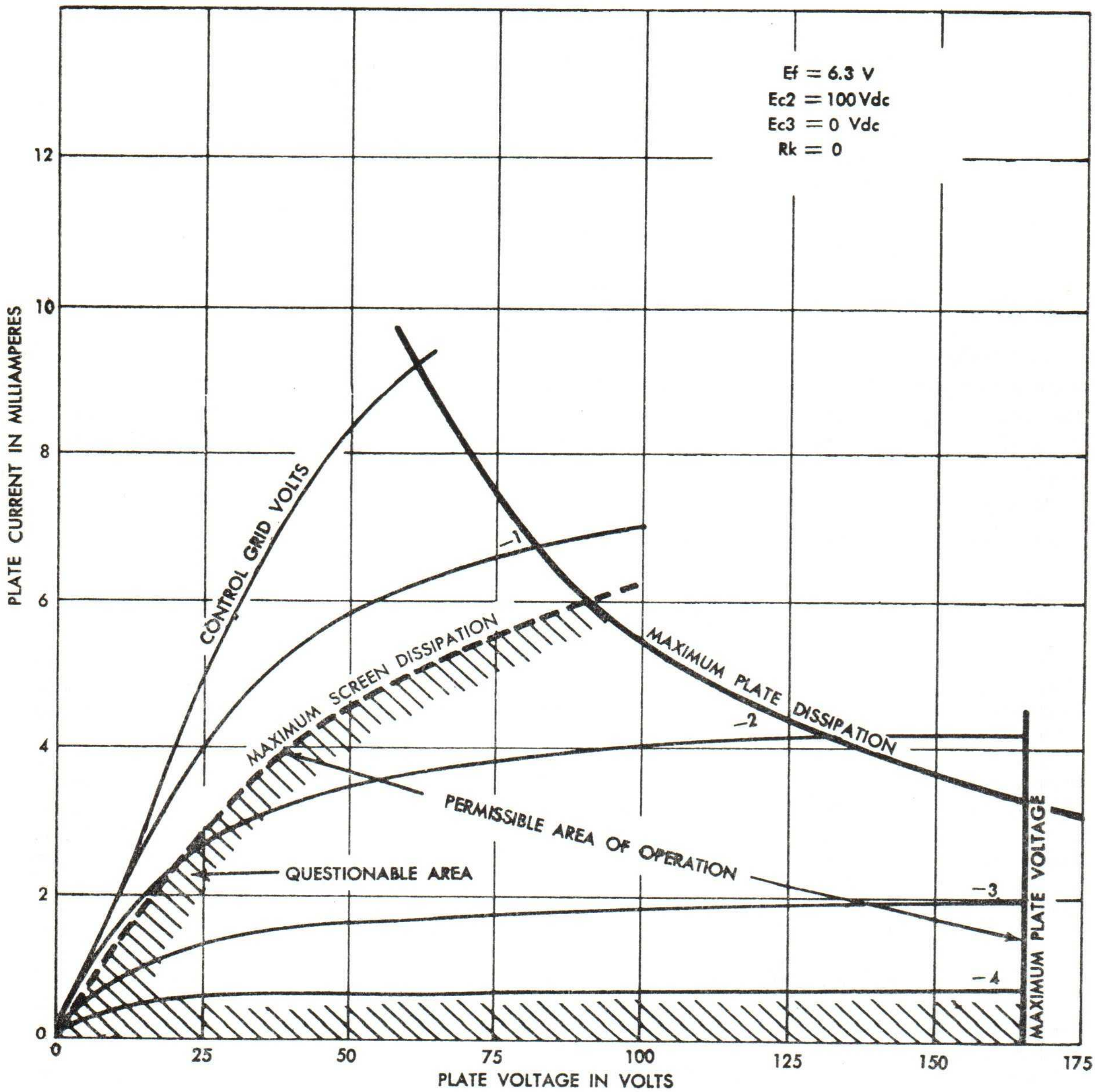


Figure 3-149. Typical Plate Characteristics of Tube Type JAN-5636; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.5.8

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.5.2, 3.5.6
- 28 Volt, 3.5.8
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.5.8

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.5.7
- Cathode, 2.1.1, 3.5.8
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.5.8

Contact Potential, 1.3.1, 3.5.7, 3.5.8

Temperature

Bulb and Environmental, 3.5.3

Current

Cathode, 1.3.10, 3.5.5, 3.5.8

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.5.7

Screen Grid, 3.5.2

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.5.7

Control Grid Emission, 1.3.3

Cathode, Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.5.3

Screen Grid, 2.1, 3.5.2, 3.5.6

Resistance

Control Grid Series,1.3.2, 1.3.3, 1.3.4, 3.5.8

Screen Grid Series, 3.5.2, 3.2.9

Cathode Interface, 1.3.10, 3.5.8

Cathode, 1.3.7, 2.1.1, 3.5.8

Miscellaneous

Pulse Operation, 3.5.8

Shielding, 3.5.3

Intermittent Operation, 3.5.8

Triode Connection, 3.5.8

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-5636 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5636 as defined by MIL-E-1/168C dated 23 June 1955.

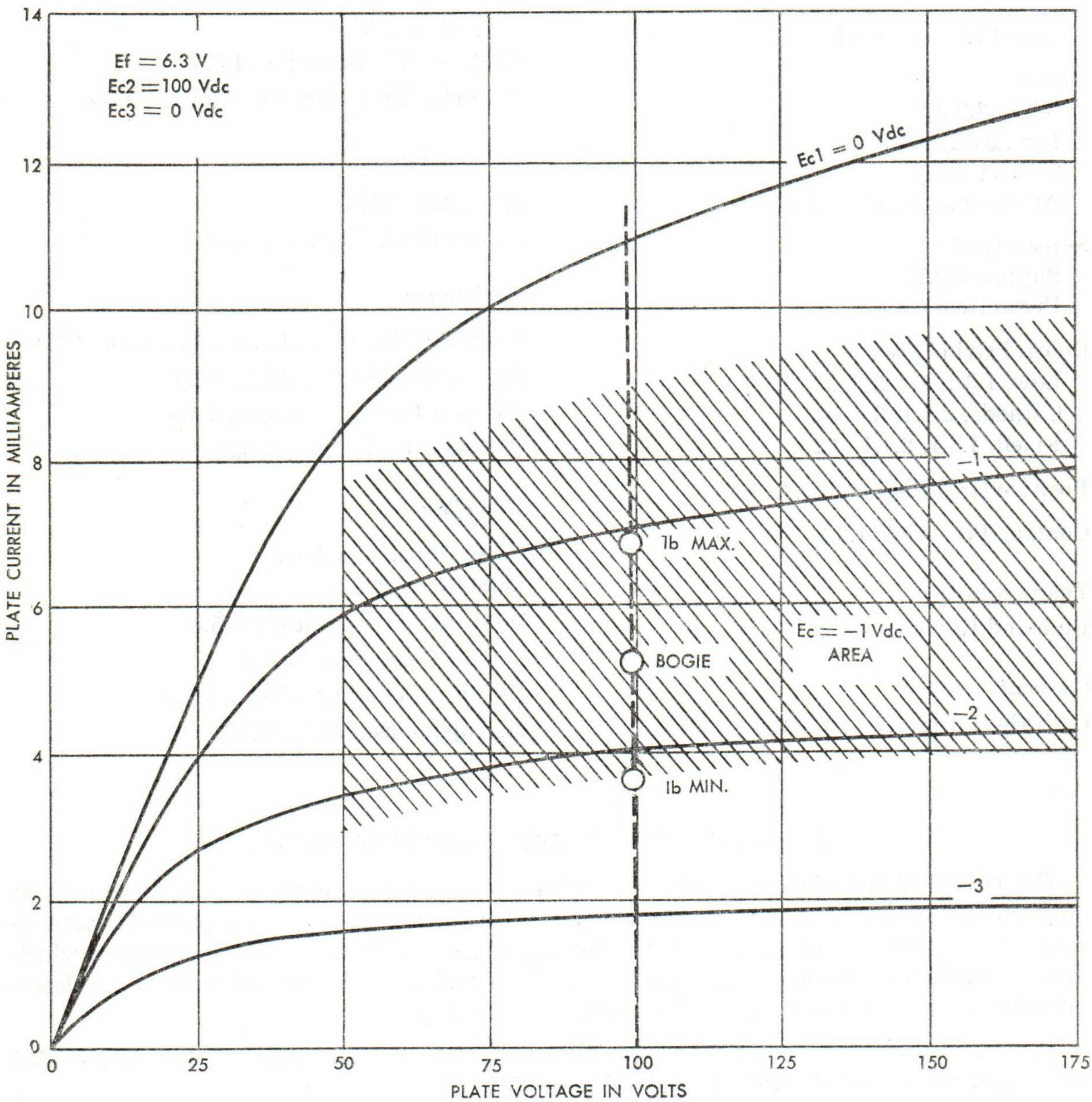


Figure 3-150. Limit Behavior of Jan-5636 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of transfer data for JAN-5636 as defined by MIL-E-1/168C dated 23 June 1955.

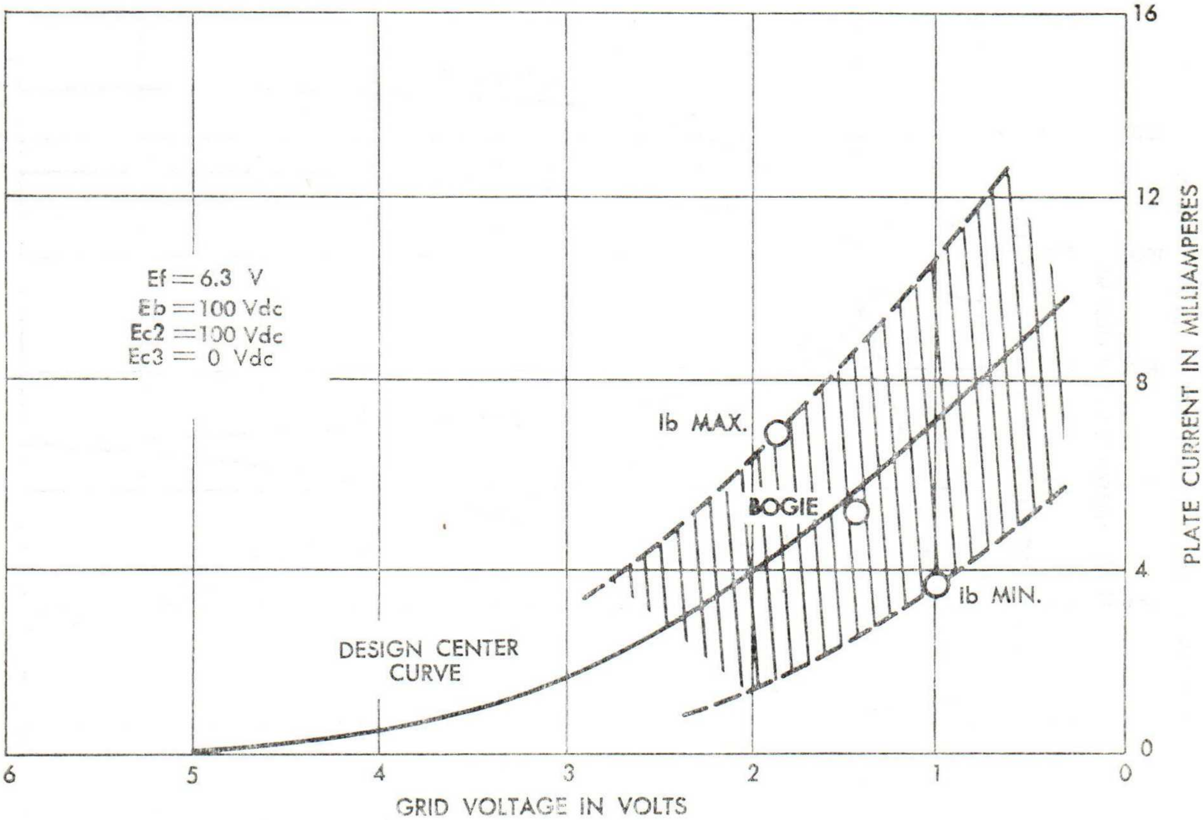


Figure 3-151. Limit Behavior of JAN-5636; Grid #1 Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-5636

These typical curves have been obtainedfrom data published by the original RETMA registrant of this type.

The chart below presents the typical conversion characteristics of JAN-5636.

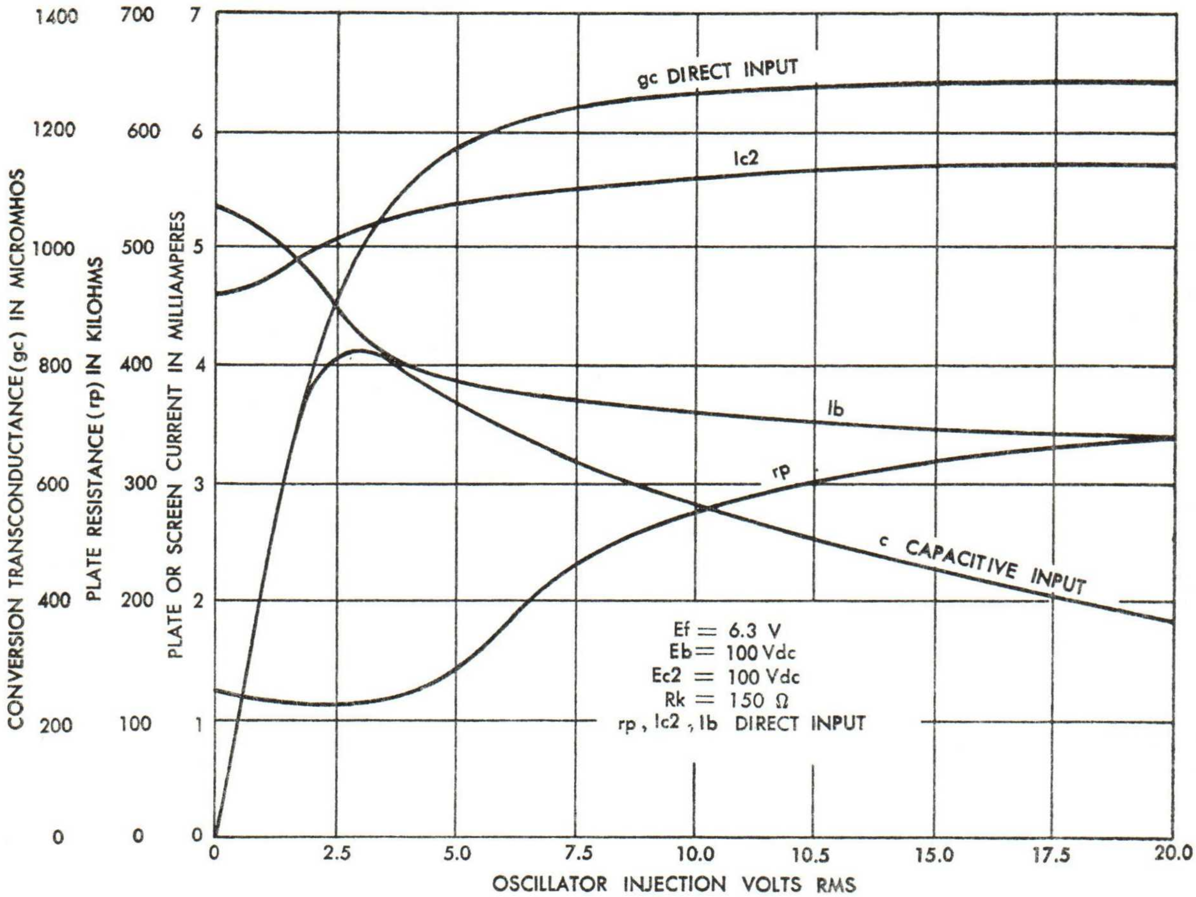


Figure 3-152. Typical Conversion Characteristics vs. Oscillator Injection Voltage of JAN-5636.

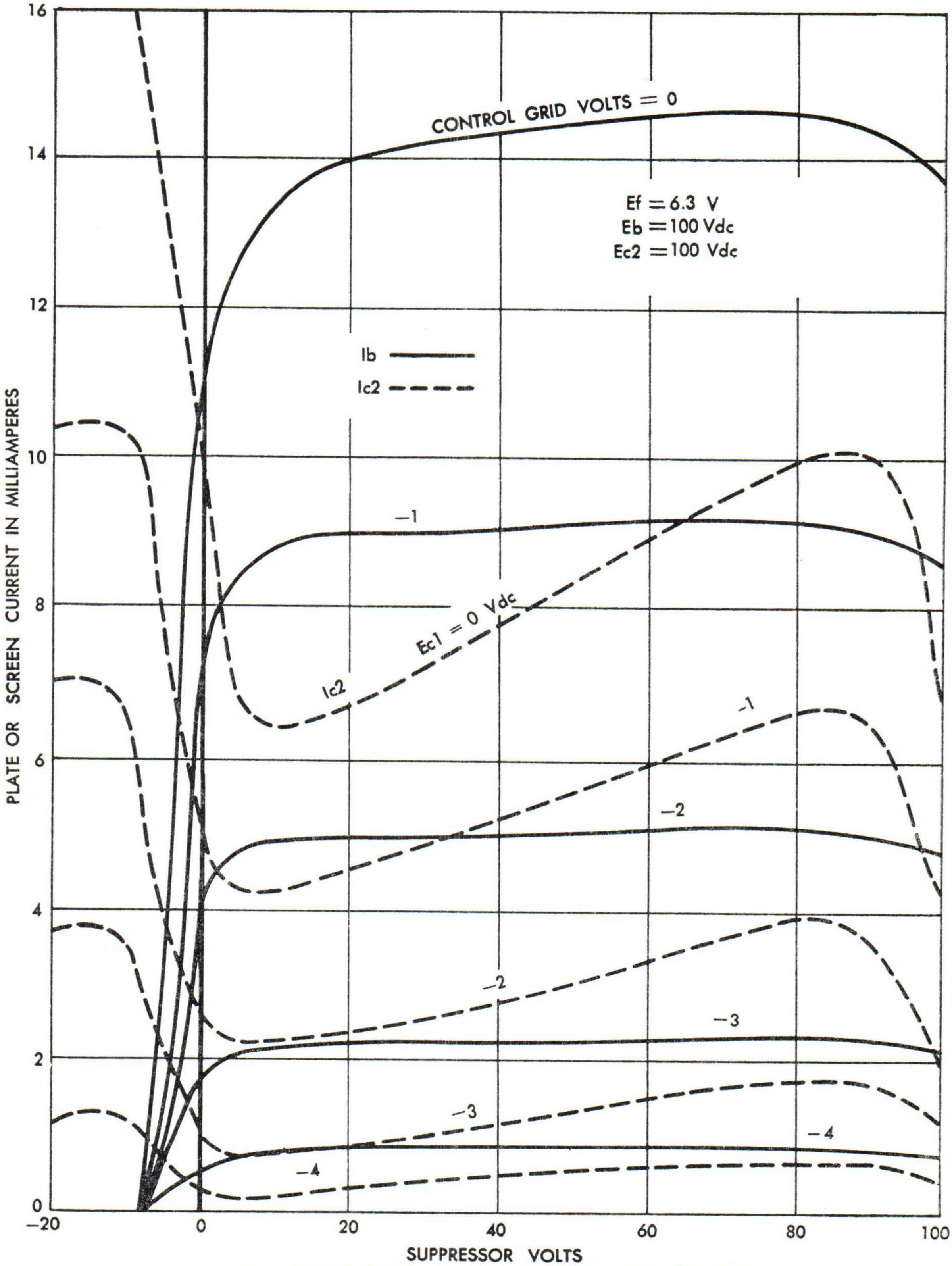


Figure 3-153. Typical Plate-Suppressor Grid Characteristics of Jan-5636.

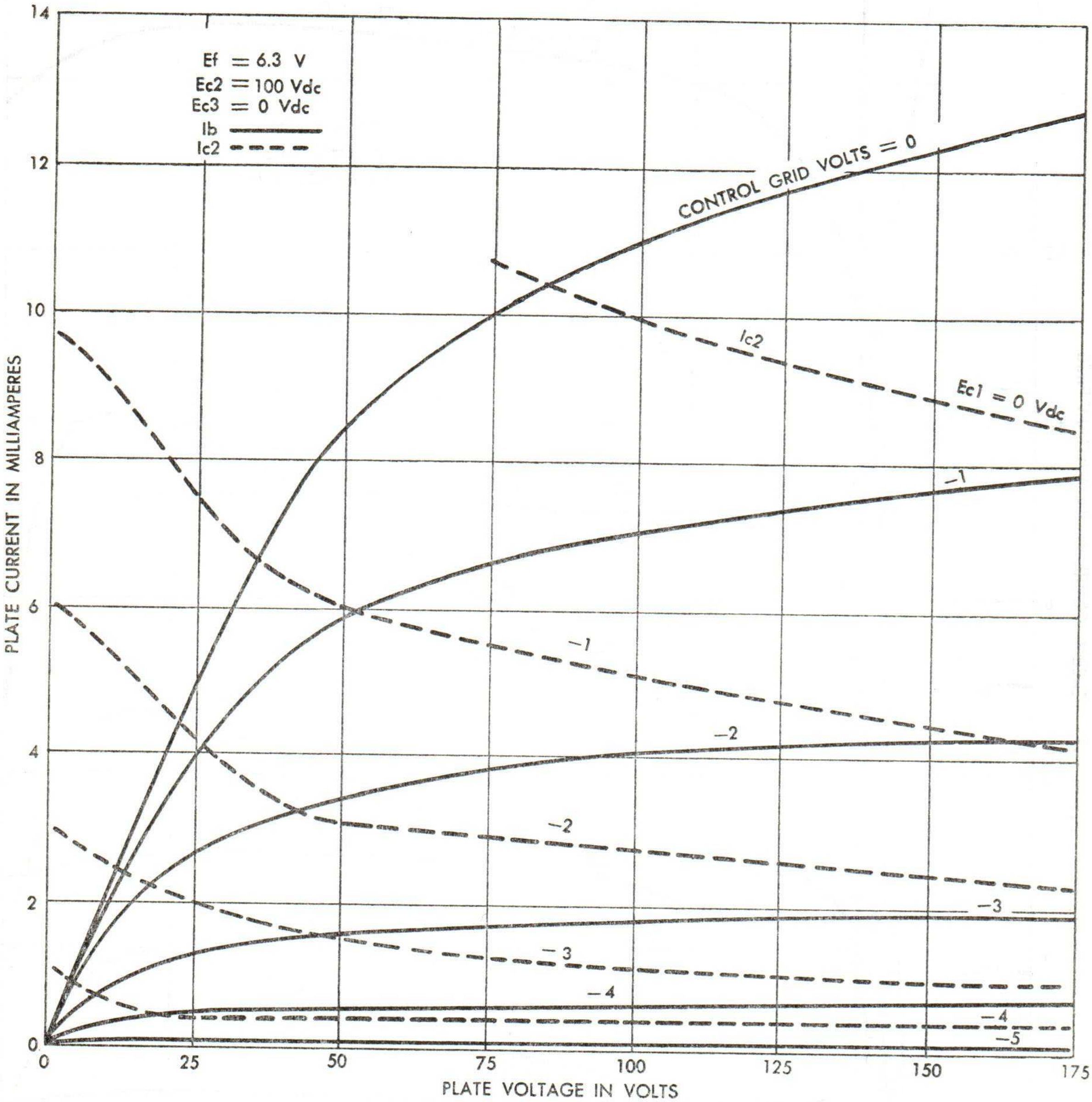


Figure 3-154. Typical Plate Characteristics of JAN-5636.

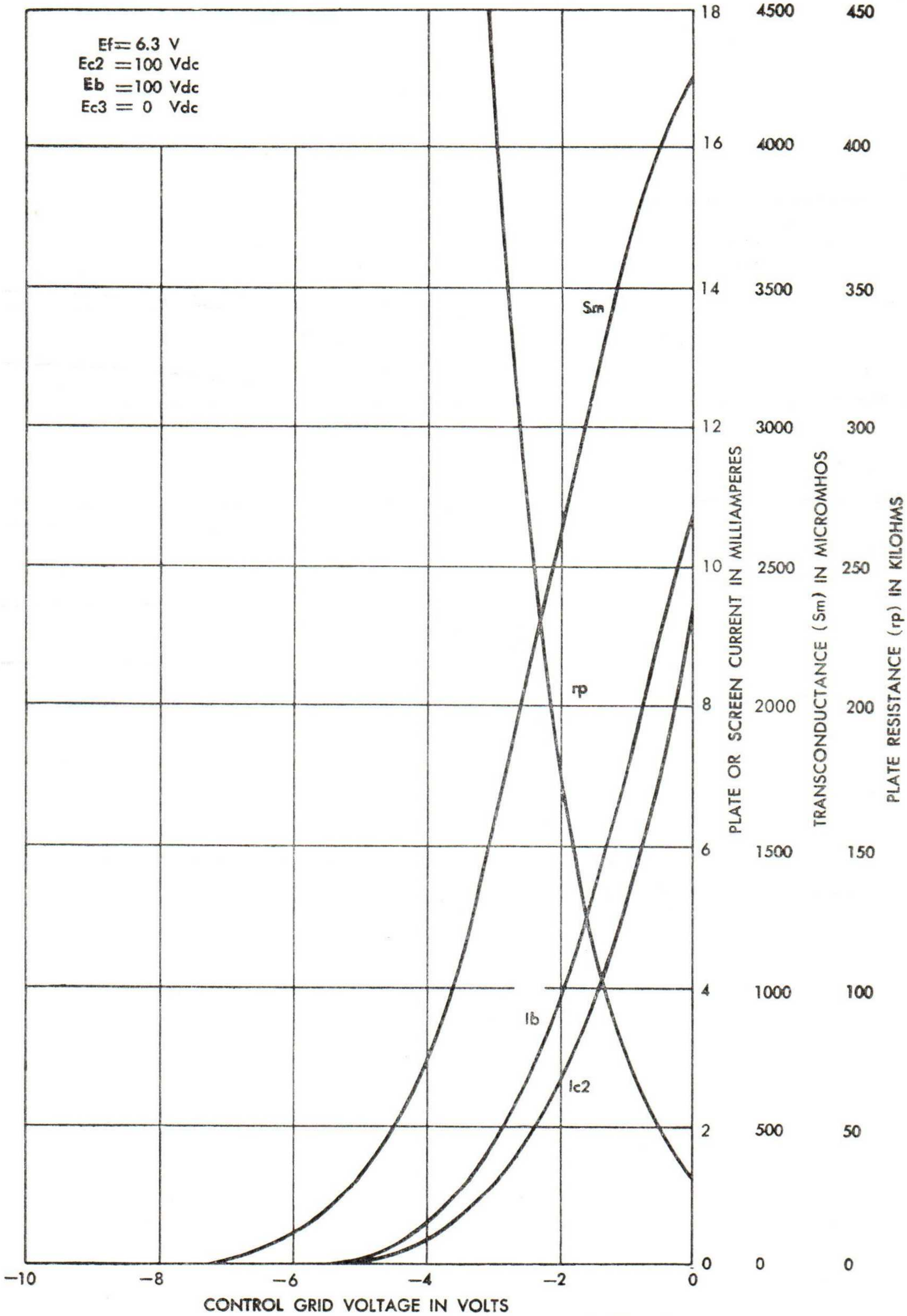


Figure 3-155. Typical Transfer Characteristics of JAN-5636.

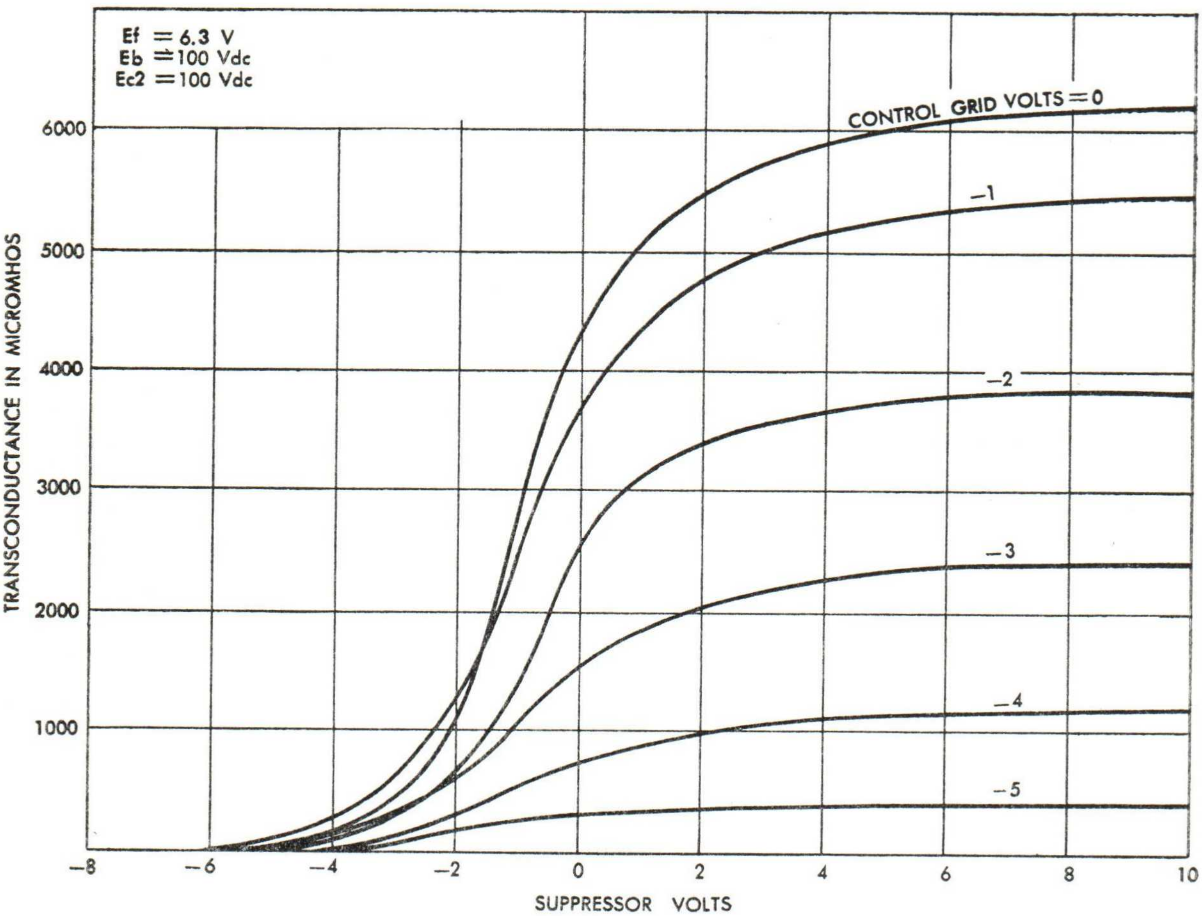


Figure 3-156. Typical Transconductance Characteristics of JAN-5636; Grid #1 to Plate.

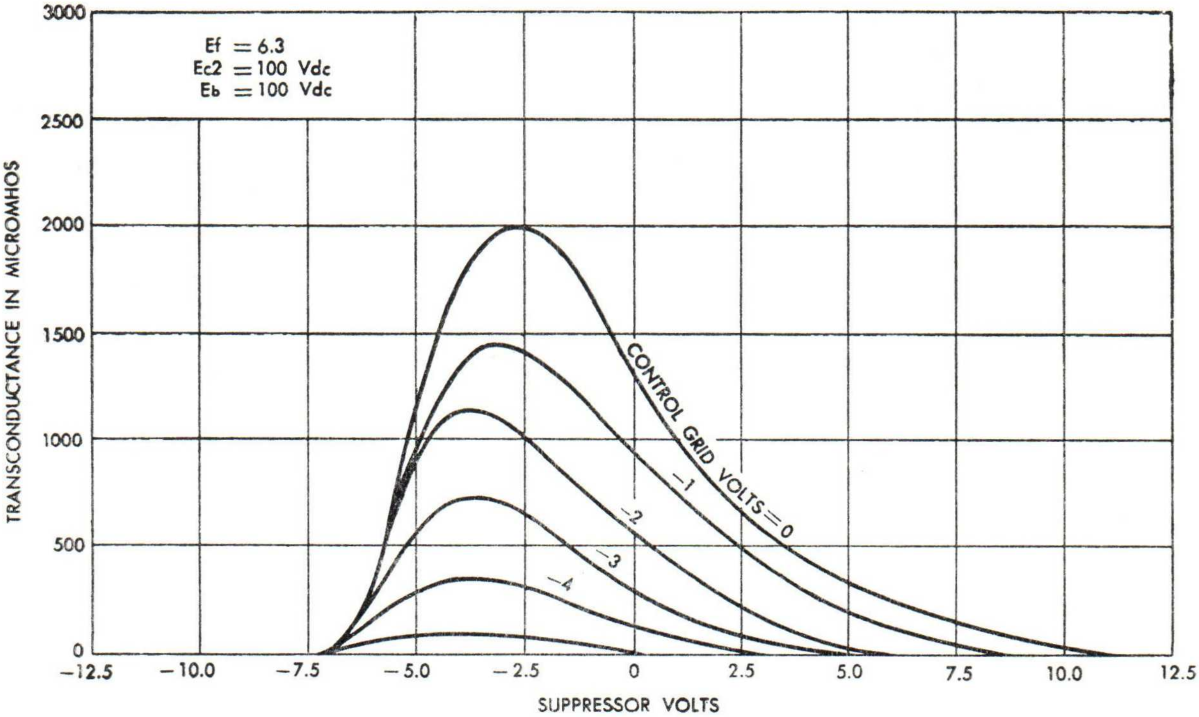


Figure 3-157. Typical Transconductance Characteristics of JAN-5636; Grid #3 to Plate.

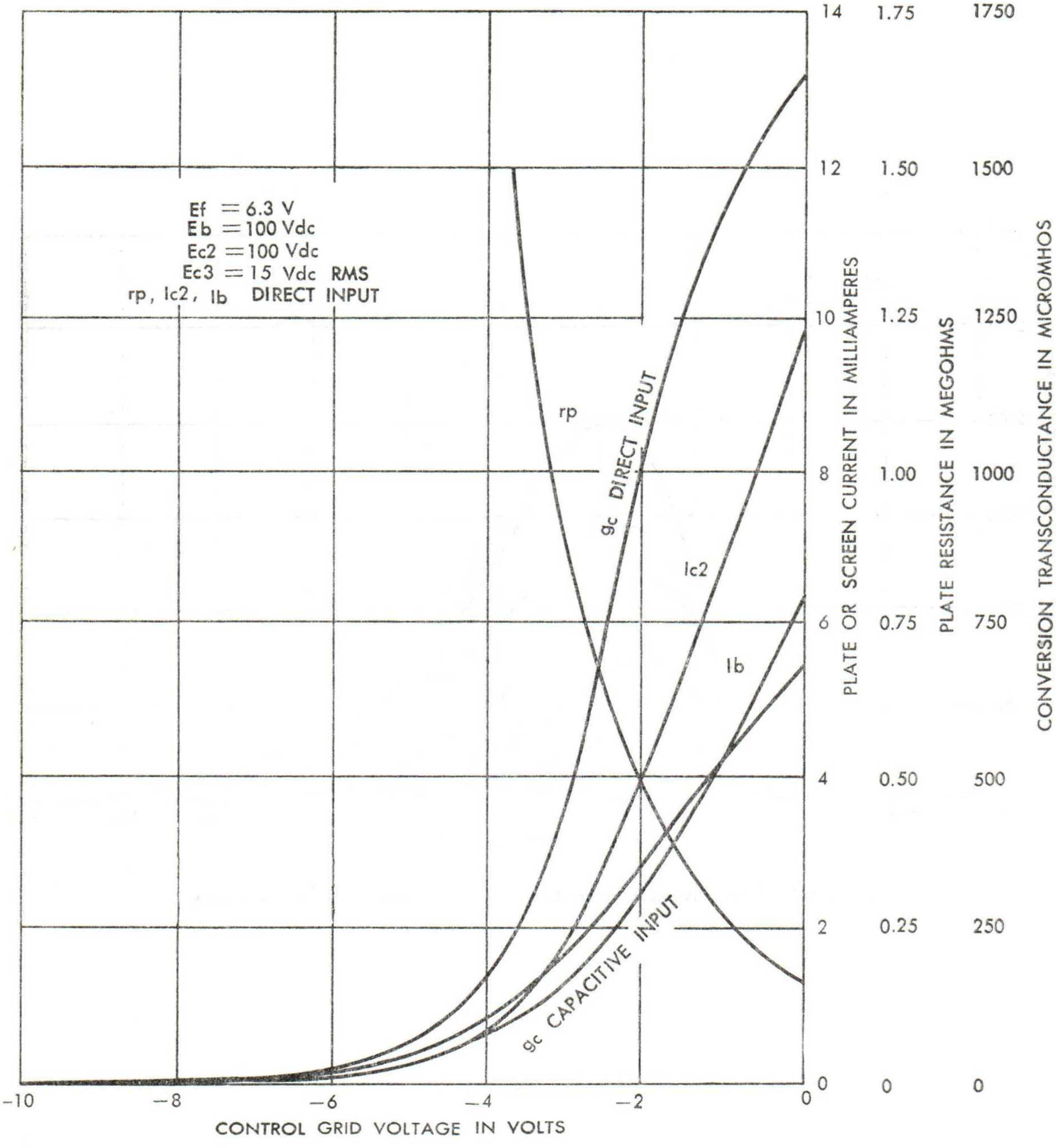


Figure 3-158. Typical Conversion Characteristics of JAN-5636.

SECTION
TUBE TYPE JAN-5639

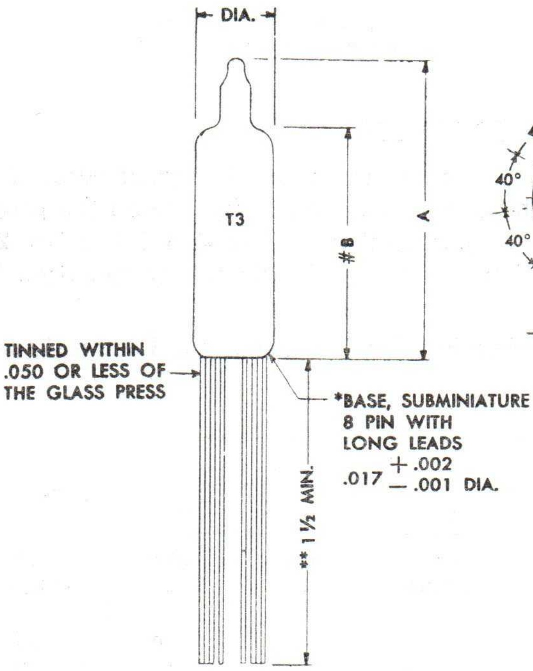
DESCRIPTION.

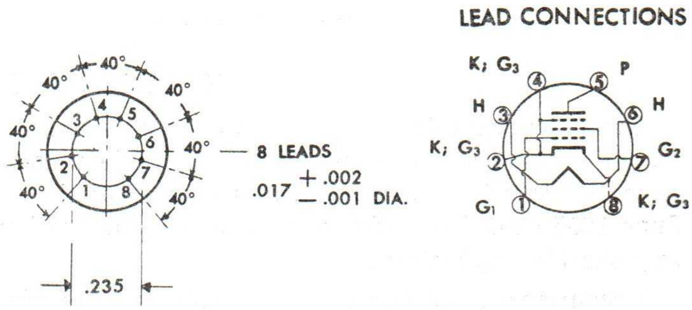
The JAN-5639 [1] is an 8-lead, button base subminiature pentode having a transconductance in the range of 7500 to 10,500 micromhos. This type has been used successfully in video circuits.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	0.450 A
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.





DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.750	1.450	.060	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-159. Outline Drawing and Base Diagram of JAN-5639.

RATINGS ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 0.3 V
Plate Voltage	165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
*Screen Voltage	155 Vdc
Control Grid Voltage, Maximum	0 Vdc
Control Grid Voltage, Minimum	—55 Vdc
Heater-Cathode Voltage	200 v
Grid Series Resistance	0.5 Meg
Plate Dissipation	3.5 W
*Screen Dissipation	1.0 W

[1] The values and specification comments presented in this Section are related to MIL-E-1/169C dated 23 June 1955.

* No test at this rating exists in the specification.

**Cathode Current	40 mAdc
Bulb Temperature	220°C
Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.
Test conditions and design center characteristics are as follows:

Heater Voltage	6.3 V
Plate Voltage	150 Vdc
Screen Grid Voltage	100 Vdc
Cathode Resistor	100 ohms
Heater Current	450 mA

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/169C dated 23 June 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		420	480	414	492	mA
Transconductance (1)	Sm		7500	10,500	—	—	umhos
Change in individual	Δ Sm / t		—	—	—	20	%
Transconductance (2)	Δ Sm / Ef		—	10	—	15	%
Plate Resistance	rp		.040	—	—	—	Meg
Plate Current (1)	Ib		14.0	28.0	—	—	mAdc
Screen Grid Current	Ic2		2.0	6.0	—	—	mAdc
Power Output	Po	Esig = 2 Vac Rp = 9000	0.75	—	—	—	W
Capacitance	Cg1p	0.405 in dia, shield	—	0.13	—	—	uuf
	Cin	0.405 in dia, shield	8.0	10.0	—	—	uuf
	Cout	0.405 in dia, shield	7.0	9.0	—	—	uuf
Grid Current	Ic	Ef = 0 Rg1 = 1.0 Meg	0	—1.0	0	—2.0	uAdc
Heater-Cathode	Ihk	Ehk = +100 Vdc	—	15	—	60	uAdc
Leakage	Ihk	Ehk = —100 Vdc	—	—15	—	—60	uAdc
Insulation of Electrodes	R(g-all)	Eg-all = —100 Vdc	100	—	50	—	Meg
	R(p-all)	Ep-all = —300 Vdc	100	—	50	—	Meg

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
High, 3.2.9
Low, 3.2.2, 3.2.6
28 Volt, 3.2.9
AC Operation, 1.3.3, 3.2.9
Screen Grid:
Supply, 3.2.7
Protection, 3.2.9
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
Cathode, 2.1.1, 3.2.9
Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature
Bulb and Environmental, 3.2.3

Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

SPECIAL OPERATING CONSIDERATIONS

The specification for this type imposes an initial power output requirement of 0.75 watt under test conditions with a 2 volt signal and Rp = 9000 ohms. Life Test assurance is not afforded, however.

VARIABILITY OF JAN-5639 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5639 as defined by MIL-E-1/169C dated 23 June 1955.

APPLICATION OF JAN-5639

The chart below shows the permissible operating area for JAN-5639 as defined by the ratings in MIL-E-1/169C dated 23 June 1955. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

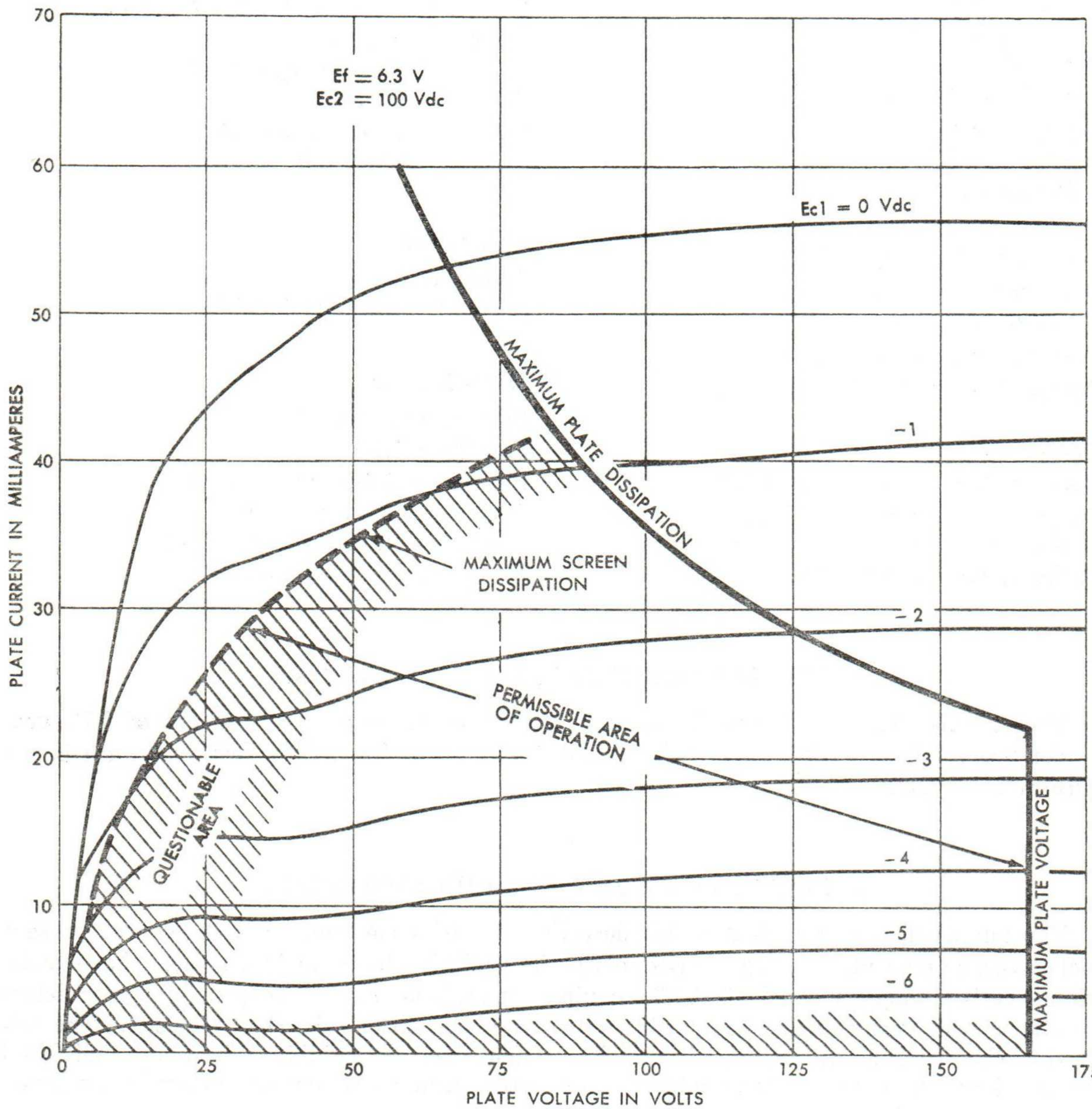


Figure 3-160. Typical Static Plate Characteristics of JAN-5639; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

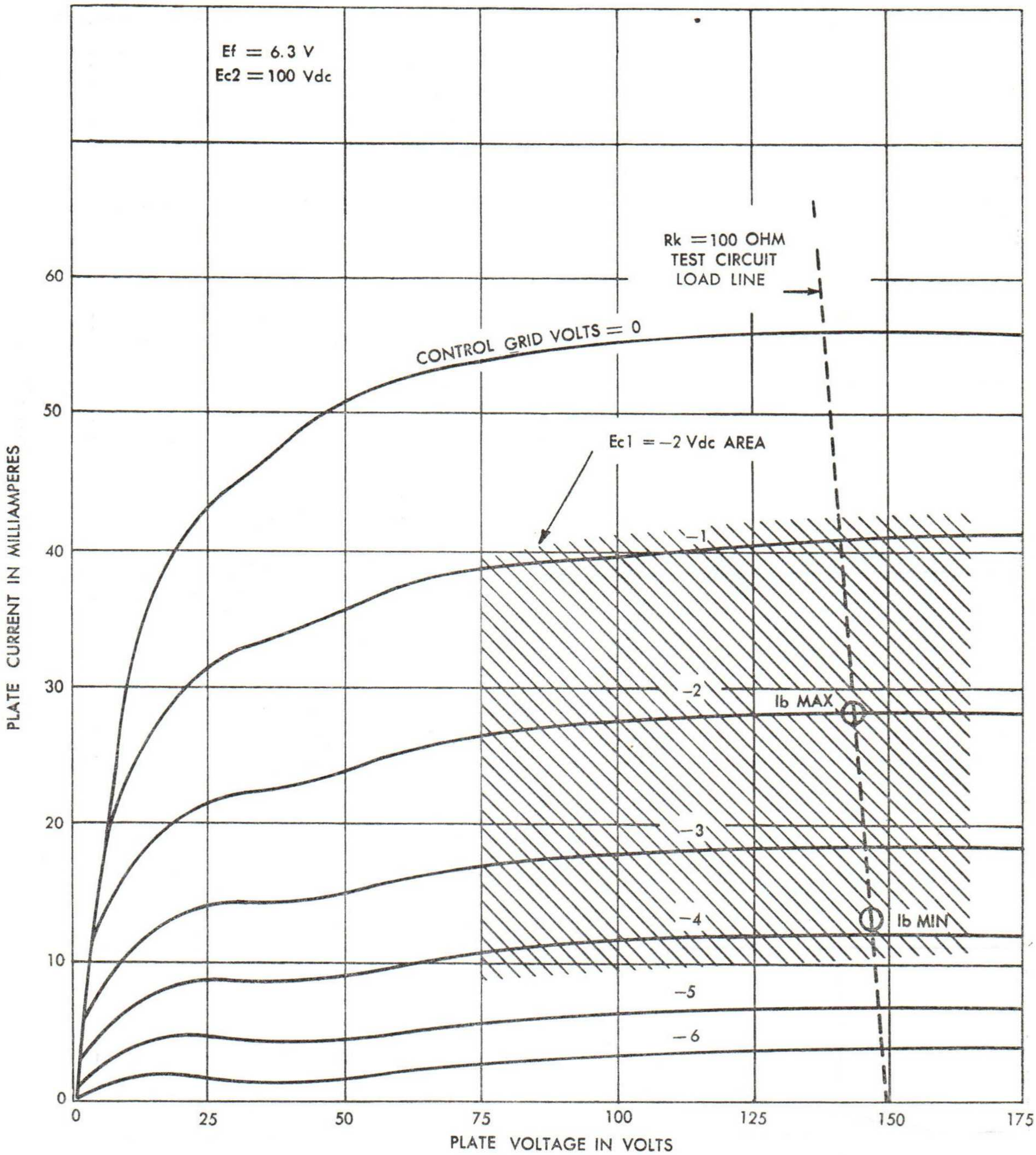


Figure 3-161. Limit Behavior of JAN-5639 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5639 as defined by MIL-E-1/169C dated 23 June 1955.

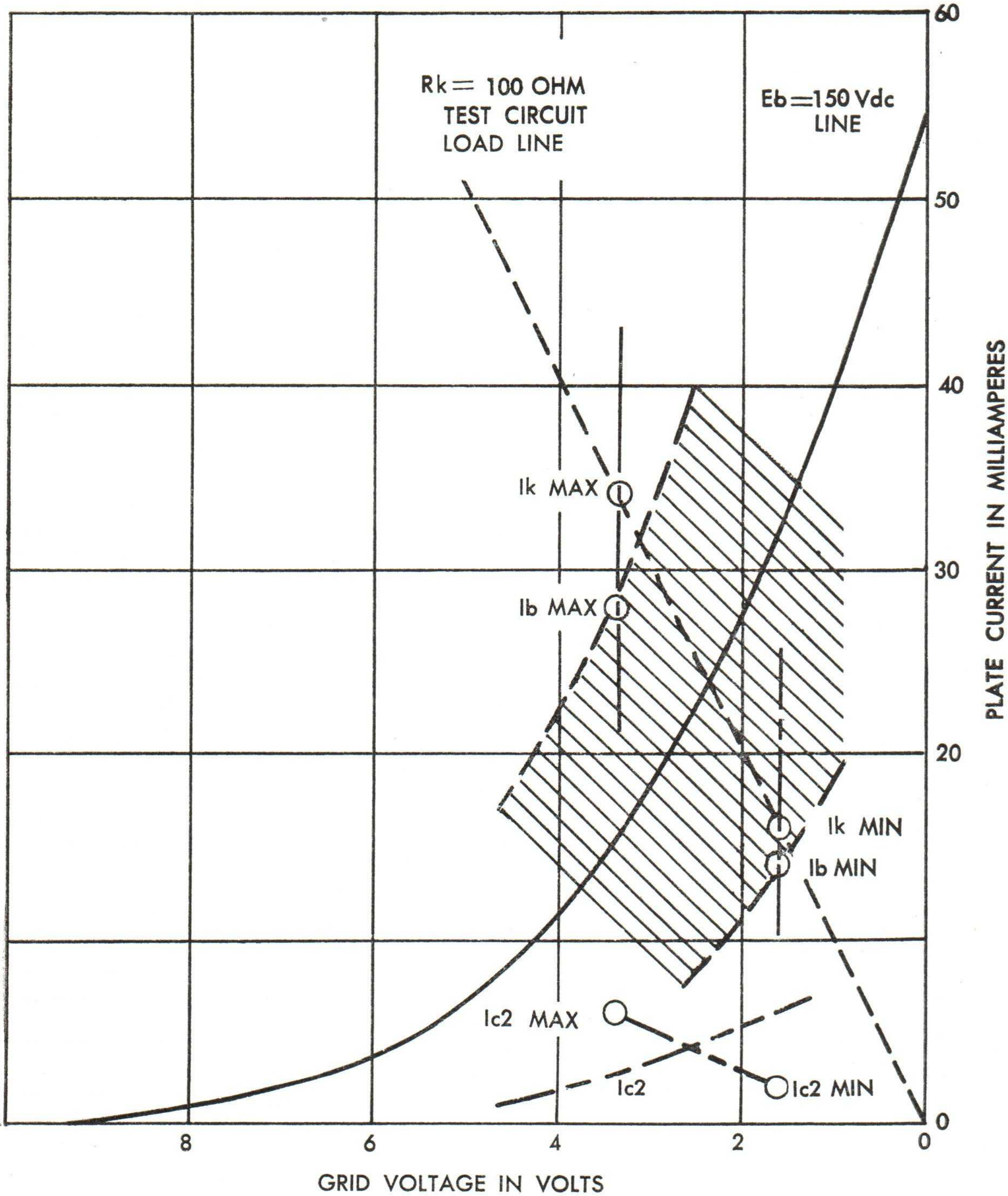


Figure 3-162. Limit Behavior of JAN-5639 Transfer Data; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-5639

The following typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristic of JAN–5639.

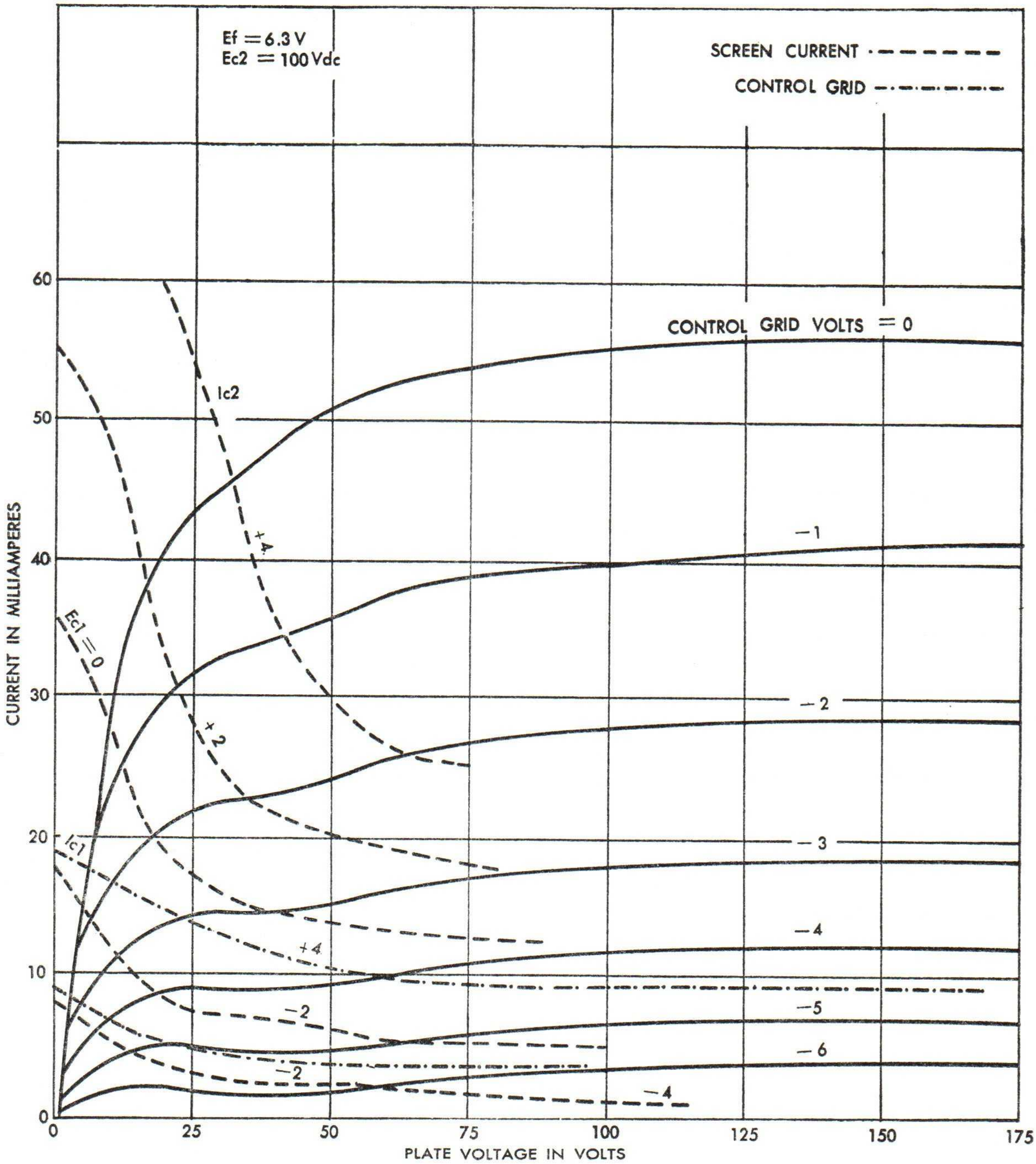


Figure 3-163. Typical Static Plate Characteristics of JAN-5639.

The chart below presents the Average Plate Transfer Data for JAN-5639.

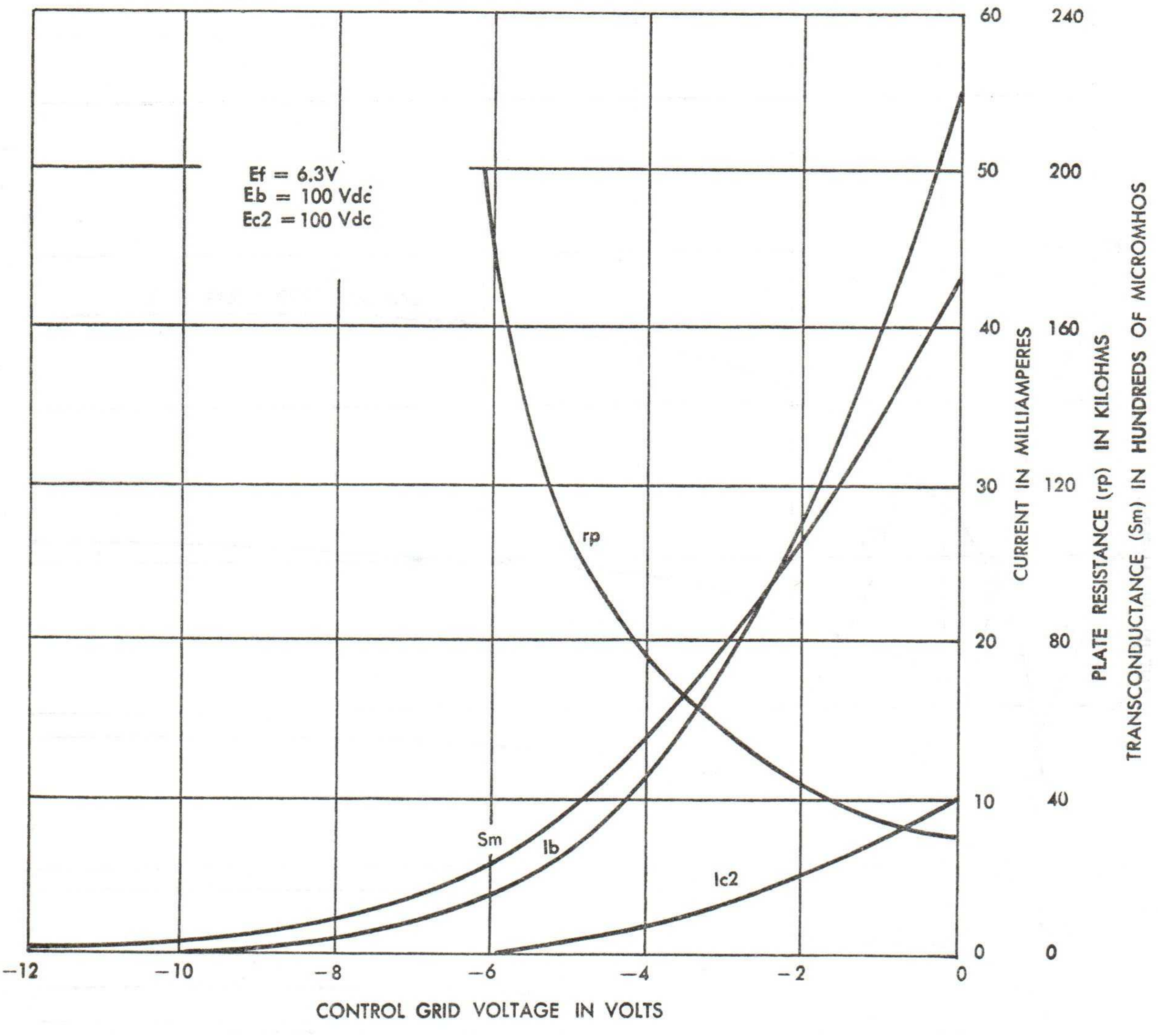


Figure 3-164. Typical Transfer Characteristics of JAN-5639.

SECTION
TUBE TYPE JAN-5641

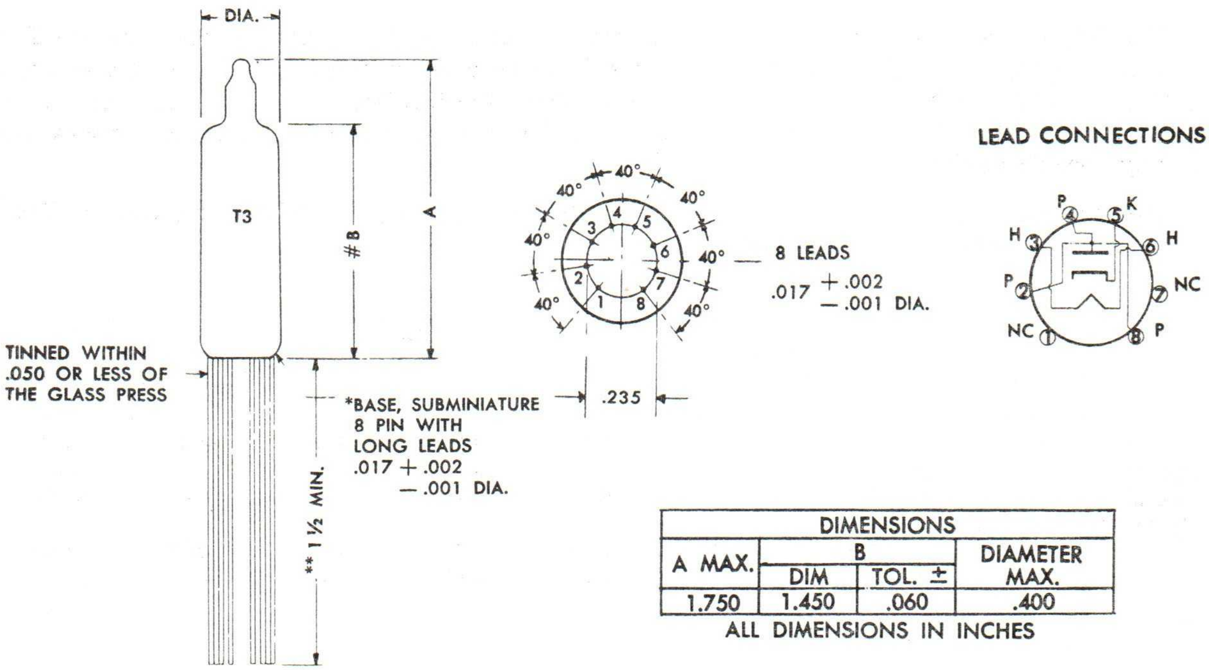
DESCRIPTION.

The JAN-5641 [1] is an eight pin, button base, subminiature, half wave high vacuum rectifier suitable for operation where the average dc current per plate does not exceed 50 milliamperes.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current .... 450 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.750	1.450	.060	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-165. Outline Drawing and Base Diagram of JAN-5641.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 V ± 0.3 V
Peak Inverse Plate Voltage .... 775 v
*Steady State Peak Plate Current per Plate .... 300 mA
Output Current, per plate .... 50 mAdc
Transient Peak Plate Current .... 1.1 A
Heater-Cathode Voltage .... ±465 v
Bulb Temperature .... +220°C
Altitude Rating .... 60,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/170A dated 26 October 1954.

* A test of this property at 250 mA exists.

TEST CONDITIONS AND DESIGN CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Secondary Voltage to Plate, Epp .... 275 Vac
Load Resistance (RL) .... 5000 ohms
Load Capacitor (CL) ....
Heater Current .... 450 mA

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/170A dated 26 October 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		420	480	414	492	mA
Operation	Io		47	—	43	—	mAdc
Emission	Is	Eb = 30 Vdc	100	—	—	—	mAdc
Heater-Cathode Leakage							
	Ihk	Ehk = +465 Vdc	—	50	—	100	uAdc
	Ihk	Ehk = —465 Vdc	—	—50	—	—100	uAdc

APPLICATION OF THE JAN-5641

Rating Chart I, II, and III represent areas of permissible operation within which any application of the JAN-5641 must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Rating Chart I is based on maximum rated peak inverse voltage (epx) of 775 volts and maximum rated dc output current (o) of 50 milliamperes. Point C corresponds to the simultaneous occurance of these two ratings and also corresponds to the life test conditions using capacitor input filter.

Rating Chart II for capacitor input filter applications, is based on maximum rated dc output current (Io) and maximum rated steady state peak plate current (Ib) of 300 milliamperes. Rectification efficiency must not exceed 0.65 under conditions of maximum rated dc output current.

Rating Chart III for capacitor input filter is based on maximum rated surge current (i surge) of 1.1 amperes per plate. Minimum permissible series resistance (Rs) is approximately 240 ohms per plate under conditions of maximum permissible supply voltage.

OTHER CONSIDERATIONS:

HEATER VOLTAGE: See paragraph 3.3.5.

ALTITUDE: See paragraph 3.3.3.

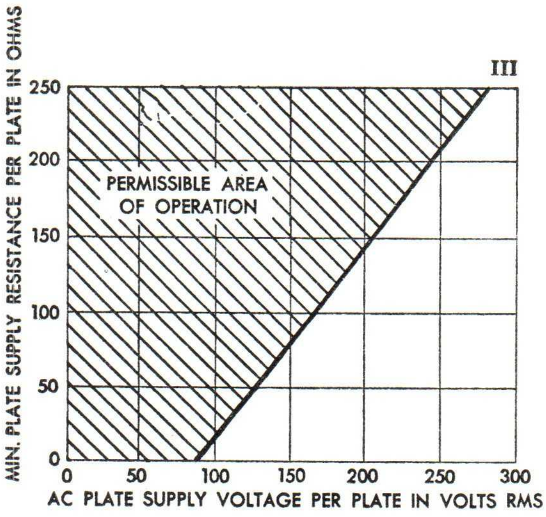


Figure 3-168. Rating Chart III for JAN-5641.

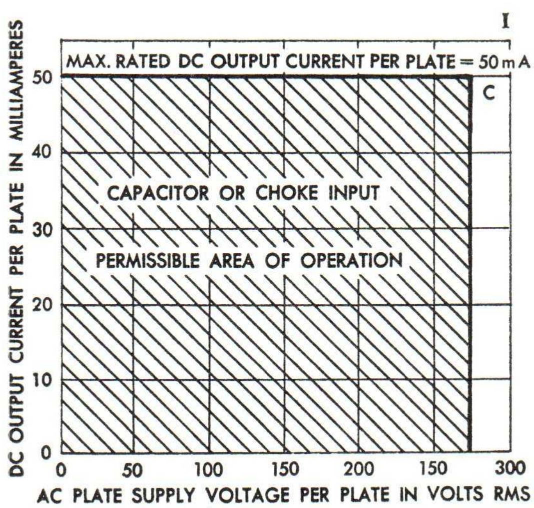


Figure 3-166. Rating Chart I for JAN-5641.

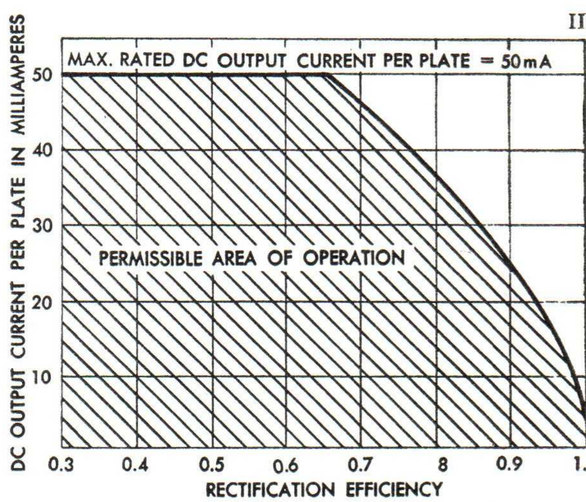


Figure 3-167. Rating Chart II for JAN-5641.

TYPICAL CHARACTERISTICS OF JAN-5641

The chart below presents the Static Plate Characteristic of JAN-5641, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes can not be derived from the specification which provides only a minimum limit on emission.

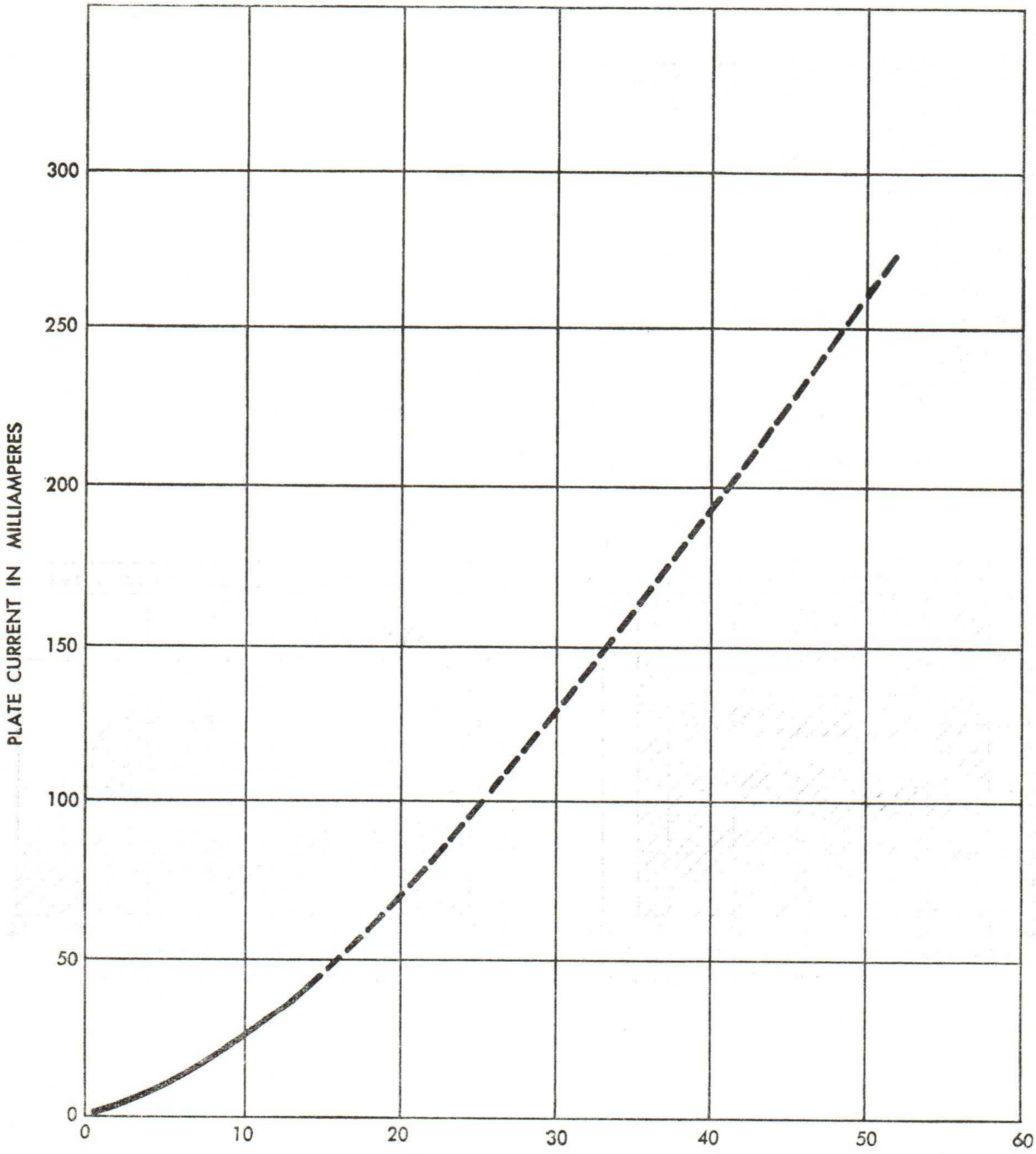


Figure 3-169. Typical Plate Characteristics of JAN-5641.

SECTION
TUBE TYPE JAN-5647

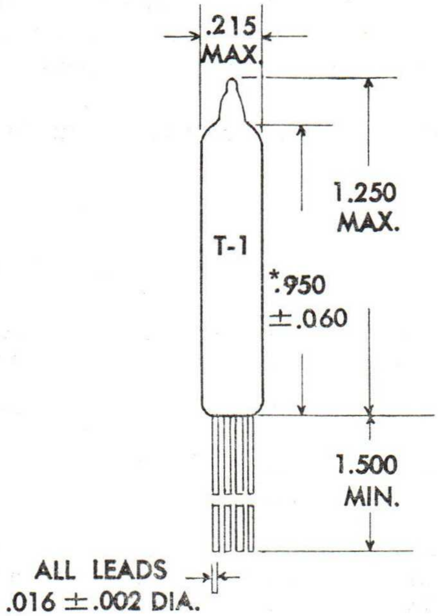
DESCRIPTION.

The JAN-5647 [1] is a four lead, button base, subminiature, diode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	150 mA
*Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



BUTTON BASE

PIN NUMBER	ELEMENT
1	PLATE (BLUE LEAD)
2	HEATER
3	HEATER
4	CATHODE (YELLOW LEAD)

*MEASURE FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAGE OF .160 I.D.
ALL DIMENSIONS IN INCHES

Figure 3-170. Outline Drawing and Base Diagram of Tube Type JAN-5647.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 0.3 V
Peak Inverse Plate Voltage	460 v
Heater-Cathode Voltage	360 v
Steady State Peak Plate Current	60 ma
Output Current	10 mAdc
Transient Peak Plate Current	350 ma
Bulb Temperature	220°C
Altitude Rating	60,000 ft

* Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/204B dated 23 June 1955.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.
Test conditions and design center characteristics are as follows.

Heater Voltage, Ef	6.3 V
Plate Supply Voltage, Epp	165 Vac
Load Resistance (Unity Power Factor), RL	15,000 ohms
Load Capacitance, CL	8 uf
Heater Current, If	150 mA

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/204B dated 23 June 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		140	160	138	164	mA
Plate Current	Ib	Ebb = 0; Rp = 40,000	5	25	...	...	uAdc
Operation	Io	See note below	9.3	...	8.5	...	mAdc
Change in Operation Current from Initial	ΔtIo		...	...	...	15	%
Emission	Is	Eb = 6.0 Vdc	25	...	...	...	mAdc
Capacitance (0.220 in	Cpk	Ef = 0	1.70	3.30	...	...	uuf
diameter shield)	Ckh	Ef = 0	4.3	5.7	...	...	uuf
	Cph	Ef = 0	1.0	2.6	...	...	uuf
Heater-Cathode Leakage	Ihk	Ehk = 360 Vdc	...	20	...	60	uAdc
	Ihk	Ehk = —360 Vdc	...	—20	...	—60	uAdc
Insulation of Electrodes	R(p–all)	Ep–all = —300 Vdc	20	...	10	...	Meg

Note: In a half wave circuit, adjust Zp so that a bogie tube gives Io = 10 mAdc. A bogie tube has a drop of Etd = 6.0 Vdc at Is = 45 mAdc.

APPLICATION

SIGNAL RECTIFIER SERVICE: In the application of JAN–5647 in signal rectifier service, Chart "A" relates boundaries of permissible operation and the questionable area of operation, to the plate characteristics.

Permissible steady state peak plate current is limited to 60 milliamperes to define boundary (1), and dc output current is limited to 10 milliamperes to define boundary (2). Area (3) is defined as questionable from the standpoint of uniformity and stability of plate current in low-level signal rectifier applications. Reference should be made to Section 1.3.4 for a review of the behavior of initial electron velocity and contact potential in tubes in general, where control grid currents discussed are equivalent to plate currents in signal diode application.

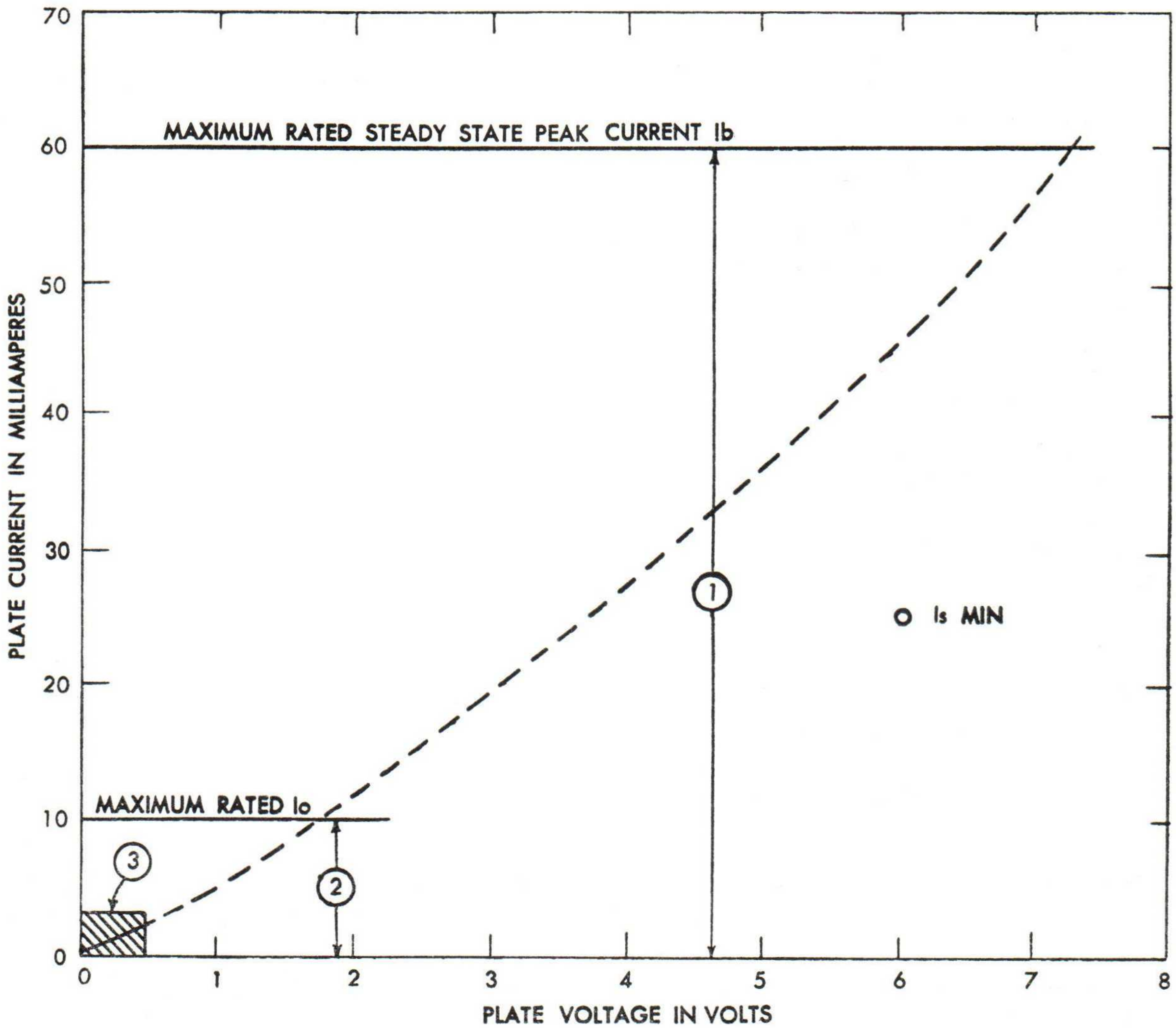


Figure 3-171. Typical Plate Characteristics of JAN-5647; Permissible Area of Operation.

Supply voltage rectifier service: Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN-5647 must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Rating Chart I is based on maximum rated peak inverse voltage (epx) of 460 volts and maximum rated dc output current (Io) of 10 milliamperes. Point C corresponds to the simultaneous occurrence of these two ratings permissible under capacitor- or choke-input filter conditions.

Rating Chart II for capacitor input filter applications is based on maximum rated dc output current (Io) and maximum rated steady state peak plate current (ib) of 60 milliamperes. Rectification efficiency must not exceed 0.68 under conditions of maximum rated dc output current.

Rating Chart III for capacitor input filter is based on maximum rated surge current (I surge) of 350 milliamperes. Minimum permissible series resistance (Rs is approximately 545 ohms under conditions of maximum permissible supply voltage.

OTHER CONSIDERATIONS:

HEATER VOLTAGE: See paragraph 3.4.3.

LOW)LECTRODE CURRENT: See paragraph 3.4.3.

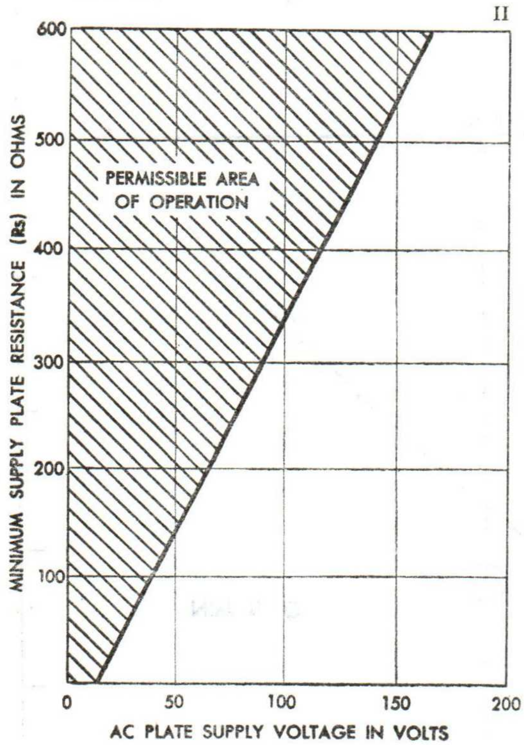


Figure 3-173. Rating Chart II for JAN-5647.

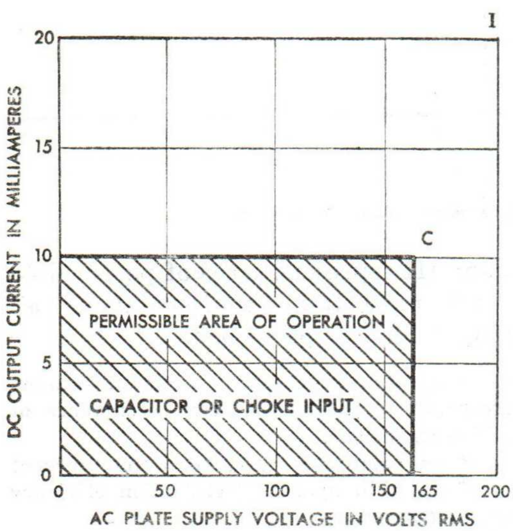


Figure 3-172. Rating Chart I for JAN-5647.

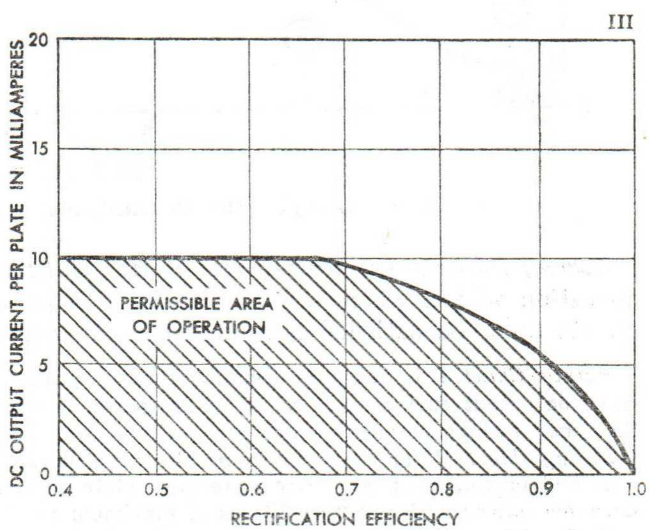


Figure 3-174. Rating Chart III for JAN-5647.

TYPICAL CHARACTERISTICS OF JAN-5647

The chart below presents the Static Plate Characteristic of JAN-5647, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes can not be derived from the specification which provides only a minimum limit on emission.

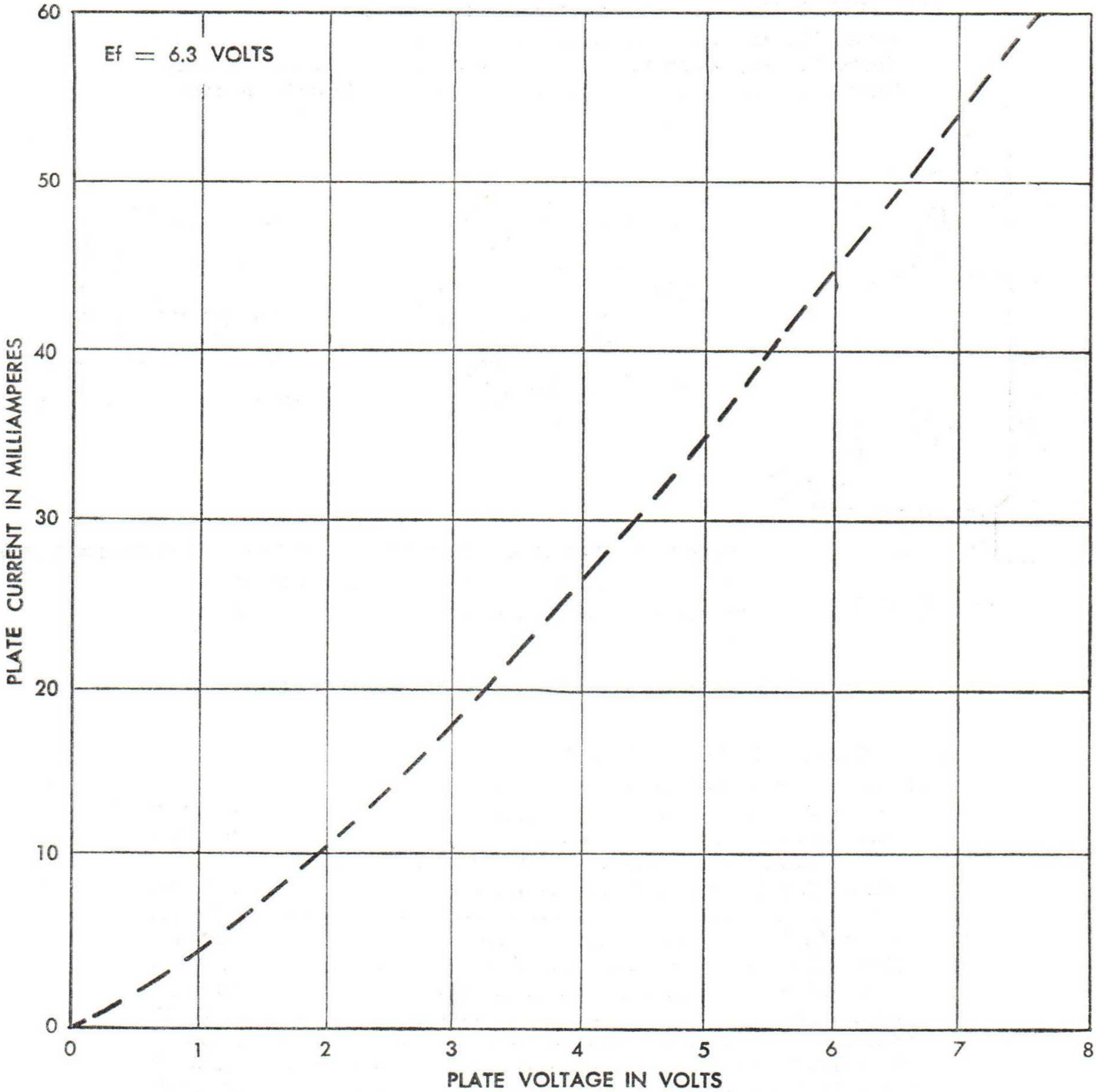


Figure 3-175. Typical Plate Characteristics of JAN-5647.

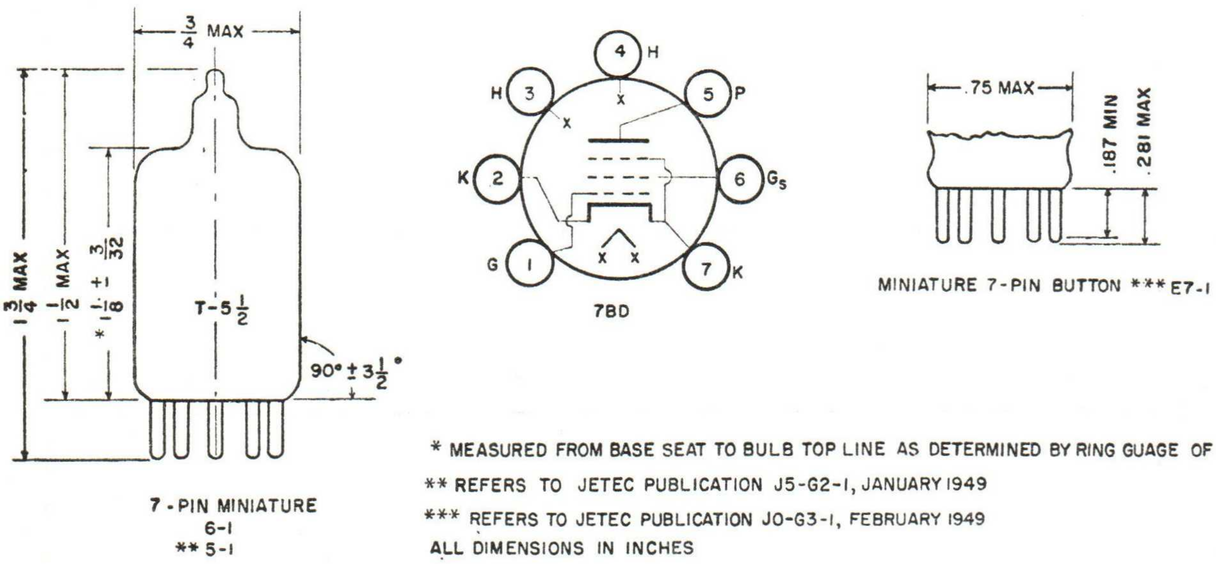
SECTION
TUBE TYPE JAN-5654/6AK5W

DESCRIPTION.

The JAN-5654/6AK5W [1] is a 7 pin miniature, sharp-cutoff pentode having a design center transconductance of 5000 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	175 mA
Cathode	Coated Unipotential



* MEASURED FROM BASE SEAT TO BULB TOP LINE AS DETERMINED BY RING GUAGE OF 7/18 I.D.
** REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949
*** REFERS TO JETEC PUBLICATION J0-G3-1, FEBRUARY 1949
ALL DIMENSIONS IN INCHES

Figure 3-176. Outline Drawing and Base Diagram of Tube Type JAN-5654 6AK5W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 0.3 V
Plate Voltage	200 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage, maximum	0 Vdc
Control Grid Voltage, minimum	—50 Vdc
Screen Grid Voltage	155 Vdc
Heater-Cathode Voltage	135 v
*Cathode Current, Maximum	20 mAdc
Plate Dissipation	1.65 W
*Screen Grid Dissipation	0.55 W
Bulb Temperature	165° C
*Altitude Rating	60,000 ft
Control Grid Series Resistor	0.1 meg
*Control Grid Current	1.0 mAdc

[1] The values and specification comments presented in this section are related to MIL-E-1/4A dated 5 December 1955.

* No test at this rating exists in the specification.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	120 Vdc
Control Grid Voltage, Ec1	—2 Vdc
Heater Cathode Voltage, Ehk	0 Vdc
Screen Grid Voltage, Ec2	120 Vdc
Heater Current, If	175 mA
Plate Current, Ib	7.5 mAdc
Screen Grid Current, Ic2	2.5 mAdc
Transconductance, Sm	5000 umhos
Interelectrode Capacitance (Shield No. 316):	
C in	4.0 uuf
C out	2.85 uuf

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/4A dated 5 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		160	190	160	190	mA
Transconductance (1)	Sm		3800	6200	...	...	umhos
Change in individual Transconductance (1)	$\Delta \frac{Sm}{t}$		...	...	...	20	%
Average change Avg	$\Delta \frac{Sm}{t}$		...	...	...	15	%
Transconductance (2	$\Delta \frac{Sm}{t}$		...	15	...	15	%
Plate Current (1)	Ib		5.0	11.0	...	...	mAdc
Plate Current (2)	Ib	Ec1 = —10 Vdc	...	200	...	...	uAdc
Plate Current (3)	Ib	Ec = —5.5 Vdc	5.0	...	...	...	uAdc
Screen Grid Current	Ic2		0.8	4.0	...	...	mAdc
Capacitance	Cg1p	Ef = 0	...	.020	...	...	uuf
(Shield #316)	Cin	Ef = 0	3.40	4.6	...	...	uuf
	Cout	Ef = 0	2.45	3.25	...	...	uuf
Grid Current	Ic1	Rg1 = 0.5 Meg	0	—0.1	0	—0.1	uAdc
Grid Emission	Isc	Ef = 7.5 V; Ec1 = —45 V; Rg1 = 0.1 Meg	0	—0.5	...	...	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	10	...	10	uAdc
	Ihk	Ehk = ..100 Vdc	...	—10	...	—10	uAdc
Insulation of electrodes	Rg-all	E = 100 Vdc; g1 Neg	100	...	50	...	Meg
	Rp-all	E = 300 Vdc; p Neg	100	...	50	...	Meg

APPLICATION OF JAN–5654/6AK5W

Figures 3–177 and 178 below show the permissible operating areas for JAN–5654/6AK5W as defined by the ratings in MIL–E–1/4A dated 5 December 1955. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

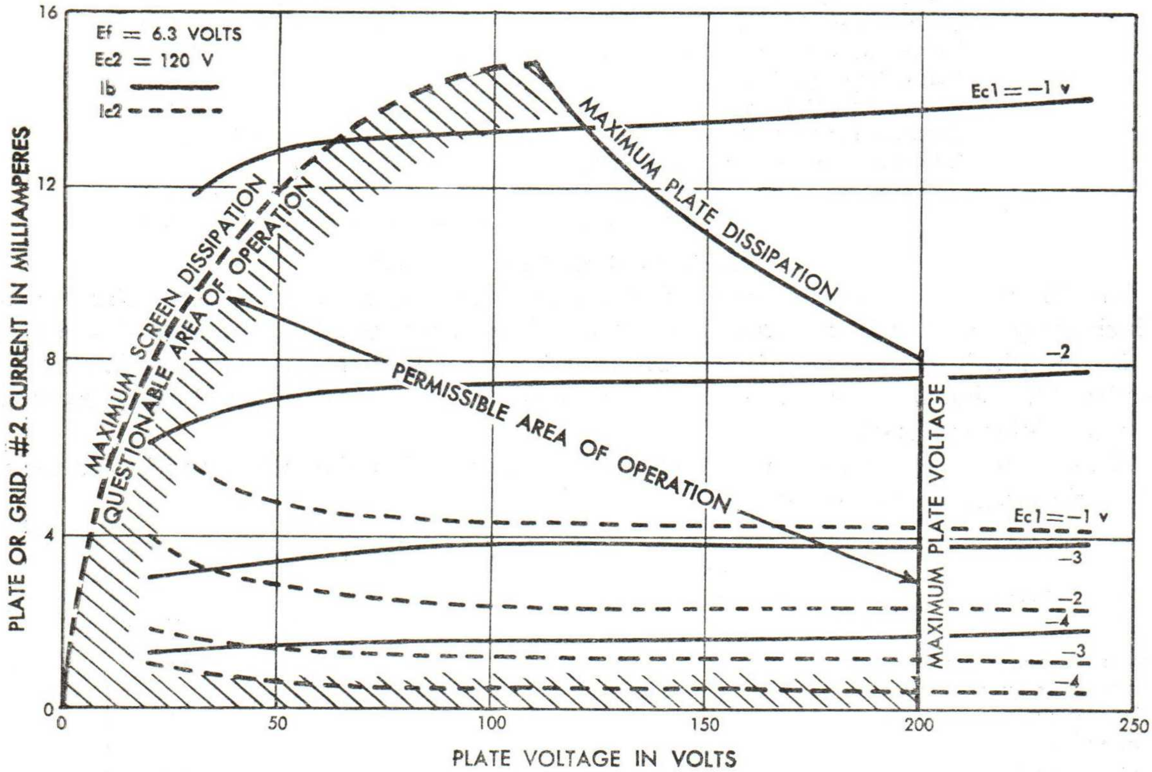


Figure 3-177. Typical Plate Characteristics of JAN-5654 6AK5W; Permissible Area of Operation.

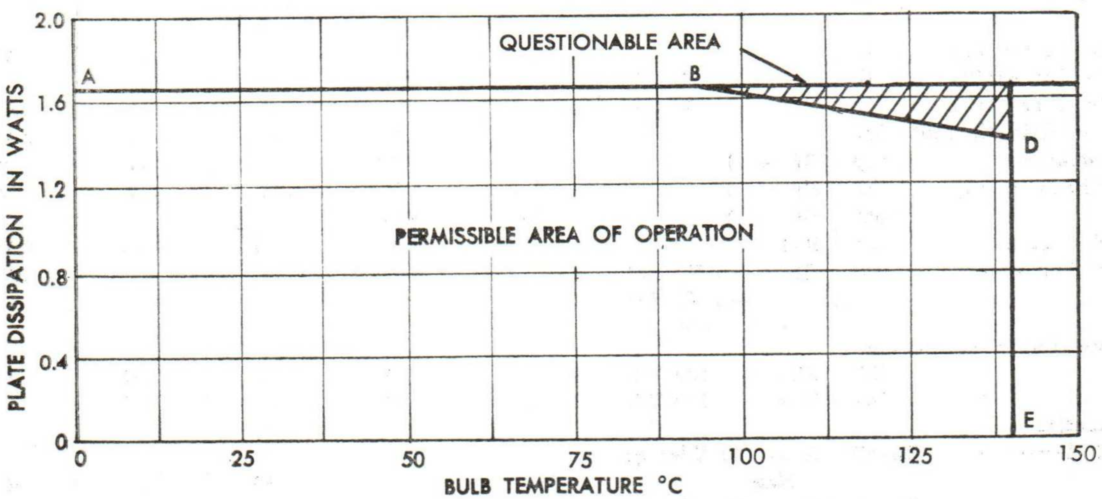


Figure 3-178. Plate Dissipation and Bulb Temperature in the Operating Area for Electron Tube Type JAN-5654 6AK5W.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature
Bulb and Environmental, 3.2.3

Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-5654/6AK5W CHARACTERISTICS

The published technical data which describe data and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

Figure 3-179 below presents the limit behavior of static plate characteristics for JAN-5654/6AK5W as defined by MIL-E-1/5A dated 5 December 1955.

Figure 3-180 presents the limit behavior of transfer data for JAN-5654/6AK5W as defined by the specification.

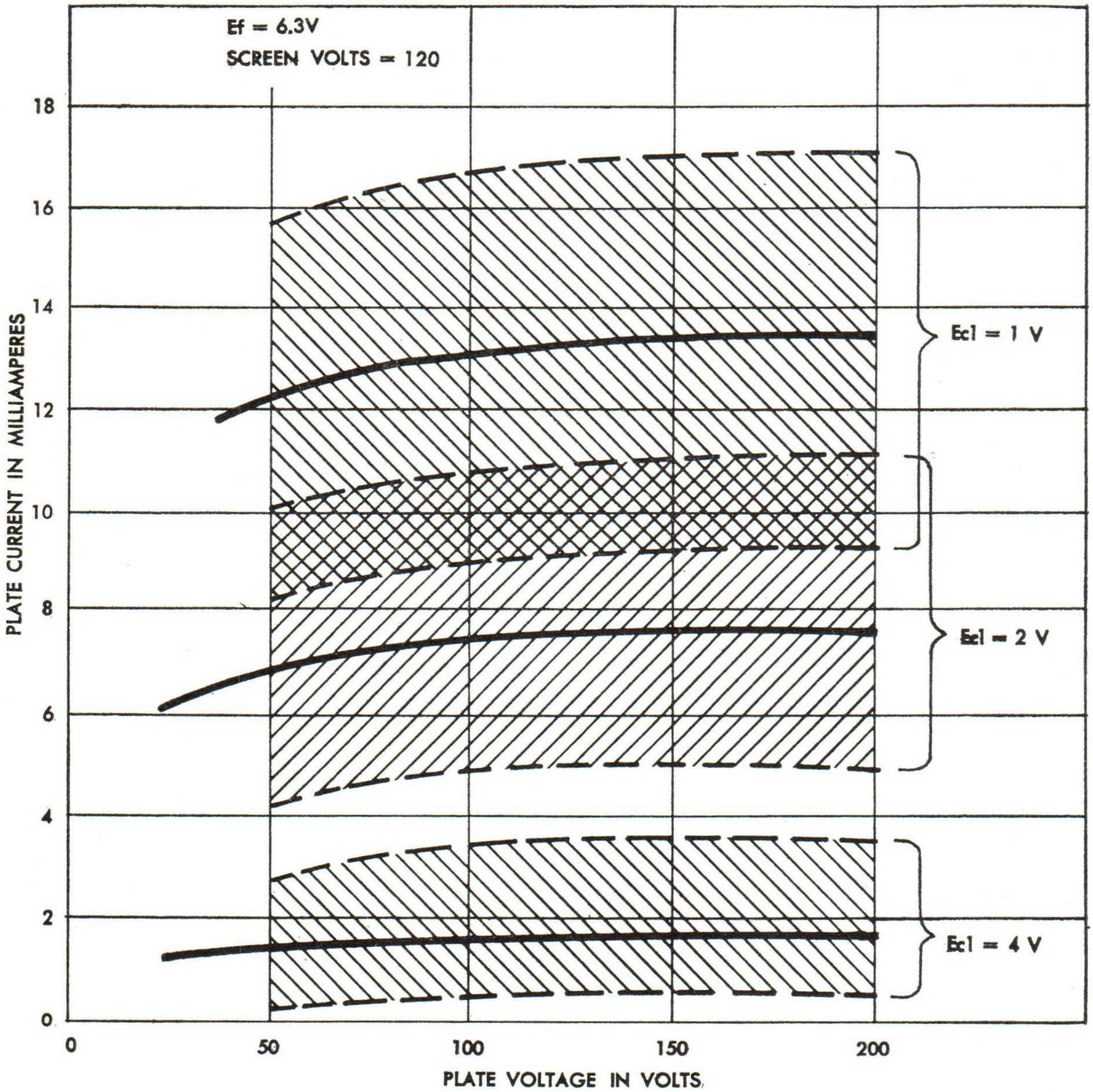


Figure 3-179. Typical Plate Voltage Limit Characteristics of Tube Type JAN-5654 6AK5W.

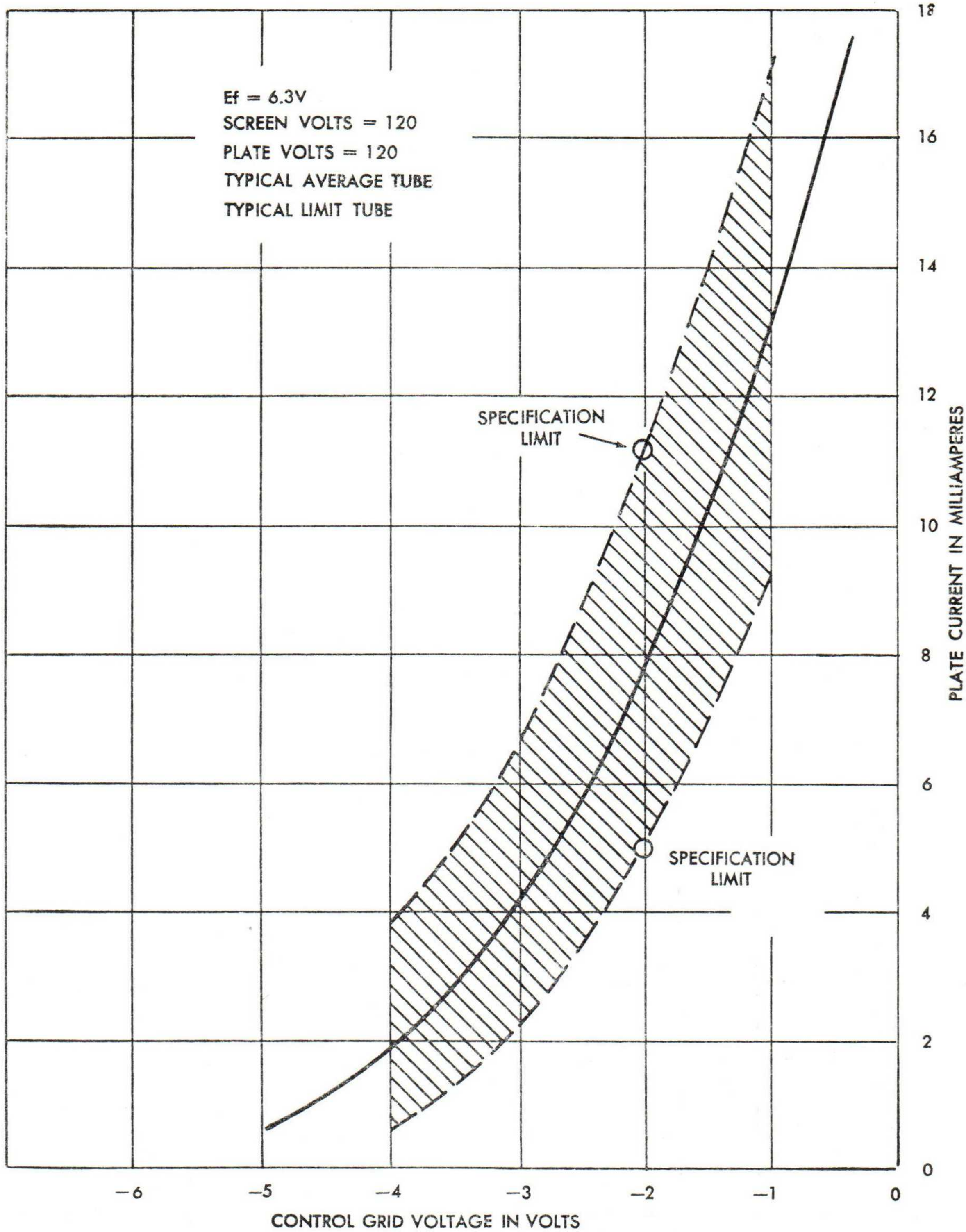


Figure 3-180. Typical Control Grid Voltage Limit Characteristics of Tube Type JAN-5654 6AK5W.

DESIGN CENTER CHARACTERISTICS OF JAN-5654/6AK5W

The following typical curves portrayed as Figures 3-181 through 3-182 have been obtained from current data being published by the original RETMA registrant of this type.

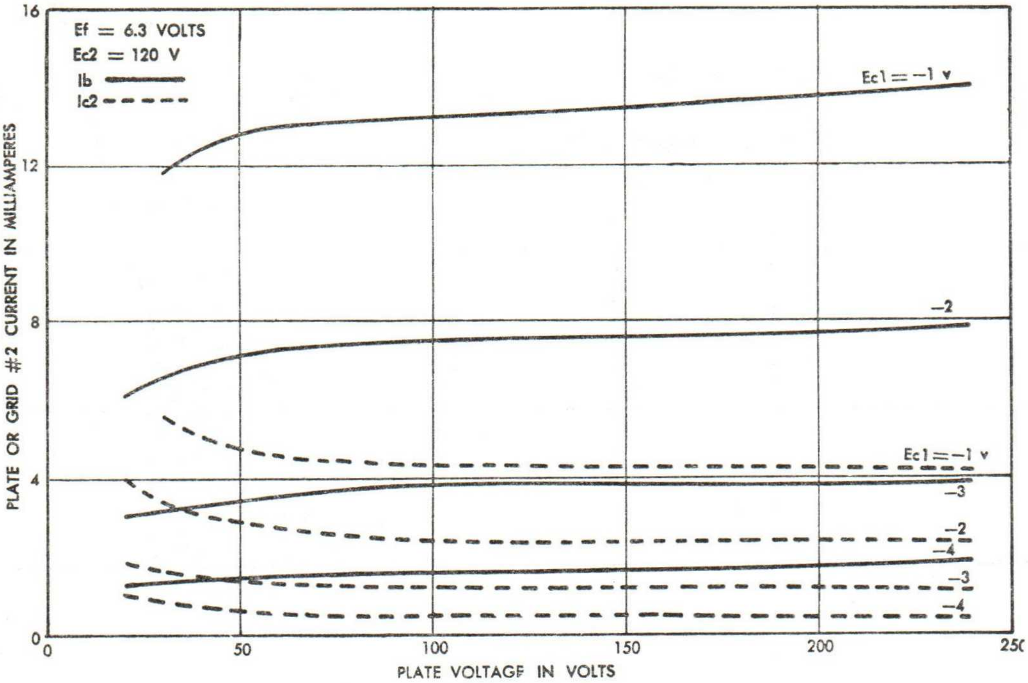


Figure 3-181. Typical Plate Characteristics of JAN-5654 6AK5W.

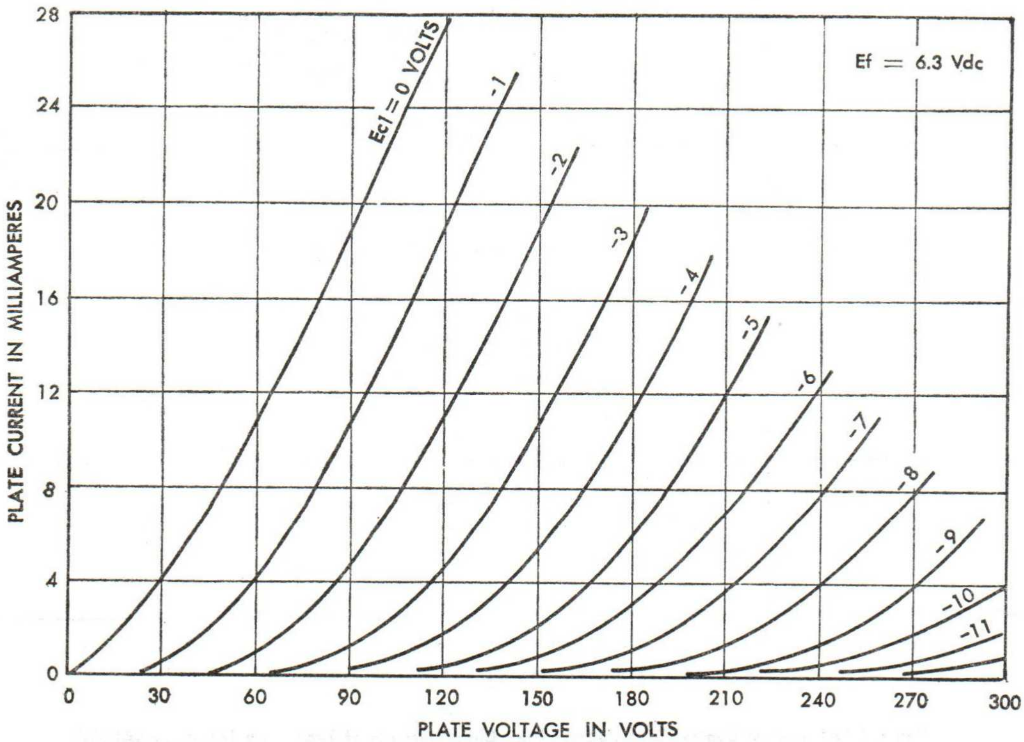


Figure 3-182. Typical Plate Characteristics of JAN-5654/6AK5W; Triode Connected.

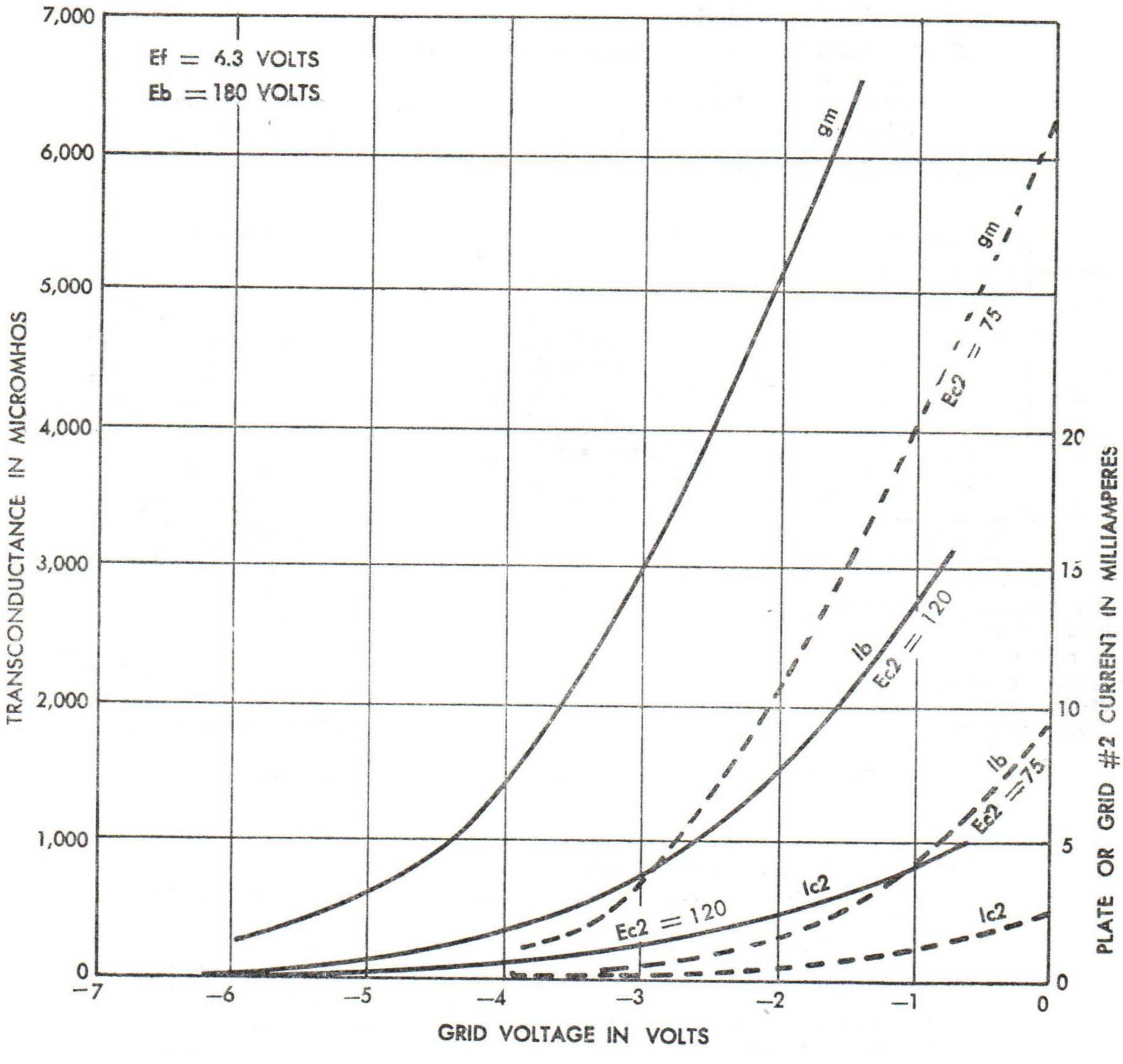


Figure 3-183. Typical Transfer Characteristics of JAN-5654/6AK6W.

SECTION
TUBE TYPE JAN-5670

DESCRIPTION.

The JAN-5670 [1] is a 9 pin miniature, medium-mu (35), twin triode having separate cathode connections.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	350 mA
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

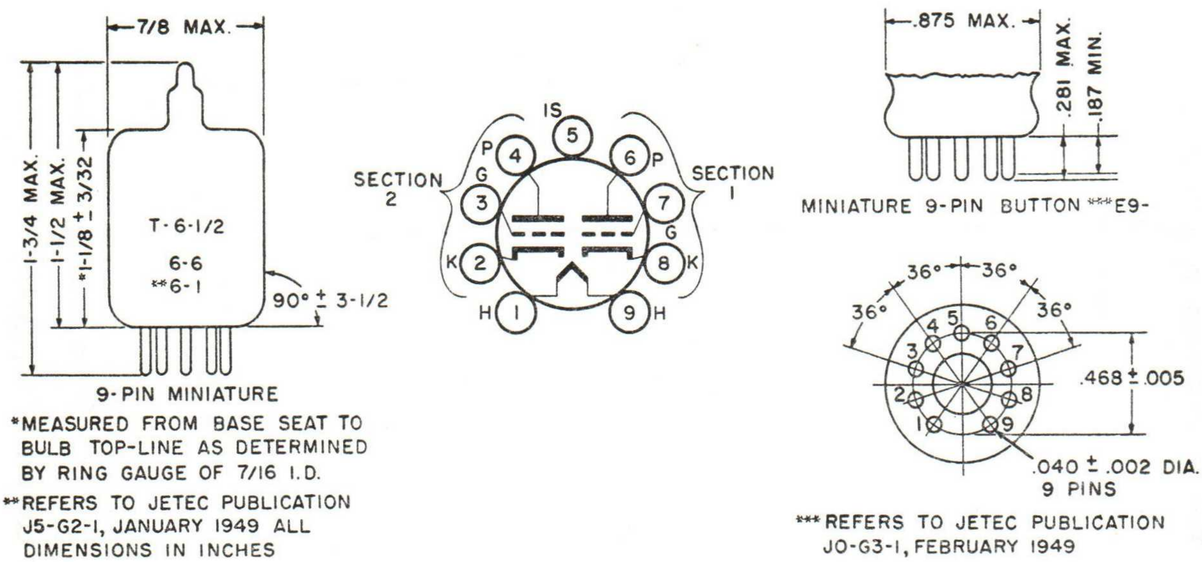


Figure 3-184. Outline Drawing and Base Diagram of Tube Type JAN-5670.

RATINGS ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± .6 V
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Heater-Cathode Voltage	±100 V
Control Grid Voltage, Maximum	0 V
Control Grid Voltage, Minimum	—55 Vdc
Control Grid Series Resistance/Grid	0.5 meg
*Control Grid Current	3.0 mAdc
**Cathode Current, Maximum (per cathode)	18 mAdc
Plate Dissipation (per plate)	1.35 W
Bulb Temperature	165° C
Altitude Rating	60,000 ft

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

[1] The values and specification comments presented in this section are related to MIL-E-1/5A dated 5 December 1955.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Heater Cathode Voltage, Ehk	0 V
Plate Voltage, Eb	150 Vdc
Cathode Resistance, Rk (per cathode)	240 ohms
Control Grid Voltage	0 Vdc
Heater Current, If	350 mA
Plate Current, Ib	8.2 mAdc
Transconductance, Sm	5500 umhos
Amplification Factor, u	35

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurment limits are provided. Specification MIL-E-1/5A dated 5 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		330	370	330	370	mA
Transconductance (1)	Sm		4500	6500	...	...	umhos
Transconductance (2)	Δ Sm / Ef		...	15	...	15	%
Change in Transconductance (1) of individuals	$\Delta \frac{Sm}{t}$		...	...	...	20	%
Transconductance (1) average change Avg	$\Delta \frac{Sm}{t}$		...	...	...	15	%
Amplification Factor	Mu		26	44	...	...	
Plate Current (1)	Ib		5.9	10.5	...	...	mAdc
Plate Current (1) difference between sections	Ib		...	1.8	...	...	mAdc
Plate Current (2)	Ib	Ec = —10 Vdc; Rp = 0.25 Meg	...	45	...	...	uAdc
Plate Current (3)	Ib	Ec = —4 Vdc	5	...	...	...	uAdc
Capacitance	Cgp	Ef = 0	0.8	1.4	...	...	uuf
(without shield)	Cin	Ef = 0	1.7	2.7	...	...	uuf
	Cout	Ef = 0	0.7	1.3	...	...	uuf
	Cpp	Ef = 0	...	0.10	...	...	uuf
Grid Current	Ic	Rg = 0.5 Meg. Max.	0	—0.3	0	—0.3	uAdc
Grid Emission	Isc	Ef = 7.5 Ec = —10 Vdc	0	—0.5	...	...	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	7	...	7	uAdc
	Ihk	Ehk = —100 Vdc	...	—7	...	—7	uAdc
Insulation of Electrodes	R(g-all)	Eg-all = —100 Vdc	100	...	50	...	Meg
	R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg

APPLICATION OF JAN-5670

The chart below shows the permissible operating area for JAN-5670 as defined by the ratings in MIL-E-1/5A dated 5 December 1955. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.1.2 through 3.1.6.

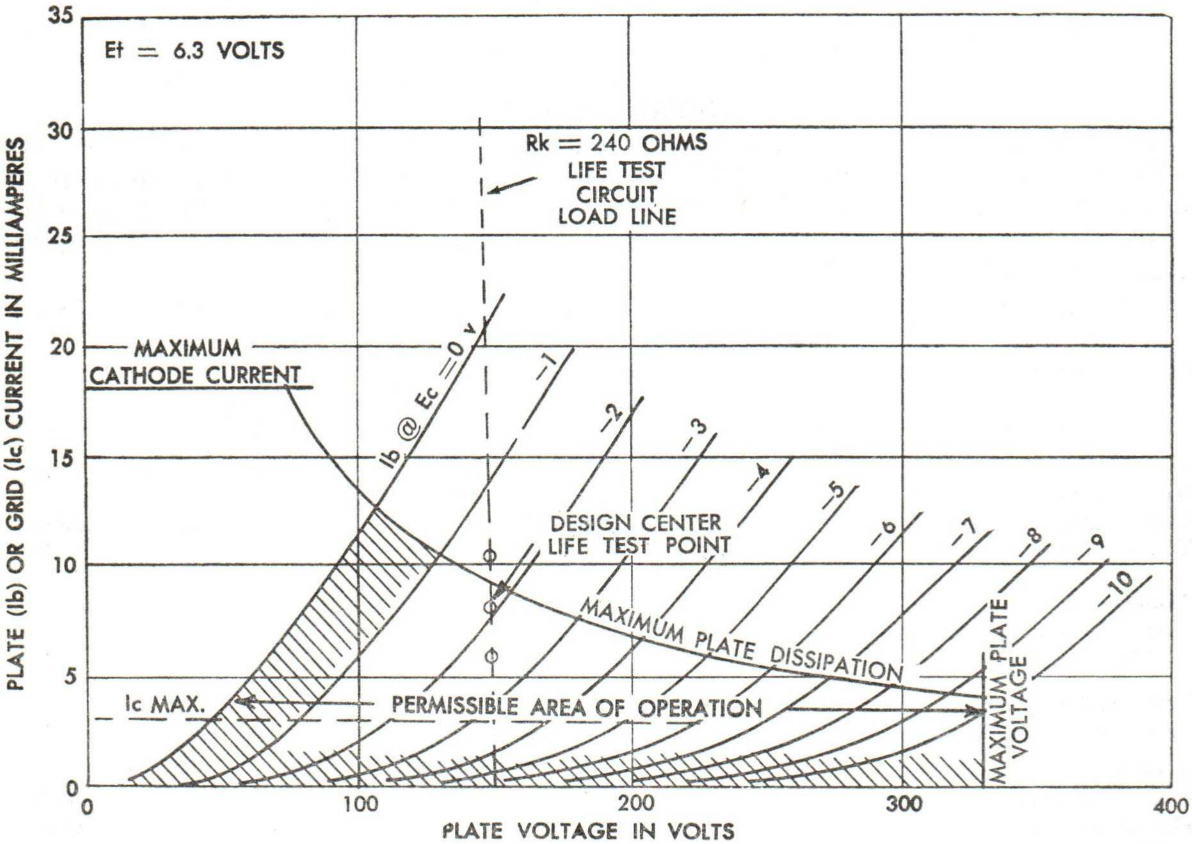


Figure 3-185. Typical Plate Characteristics of JAN-5670; Permissible Area of Operation.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:

- High, 3.1.5
- Low, 3.1.5
- Ac Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:

- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2

Plate, Low, 1.3.10, 3.1.3, 3.1.5

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.1.2

Control Grid Emission, 1.3.3

Cross Currents in Multistructure Tubes, 1.3.6

Cathode, Thermionic Instability, 1.3.8

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Temperature
Bulb and Environmental, 3.1.4

Miscellaneous
Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN–5670 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN–5670 as defined by MIL–E–1/5A dated 5 December 1955.

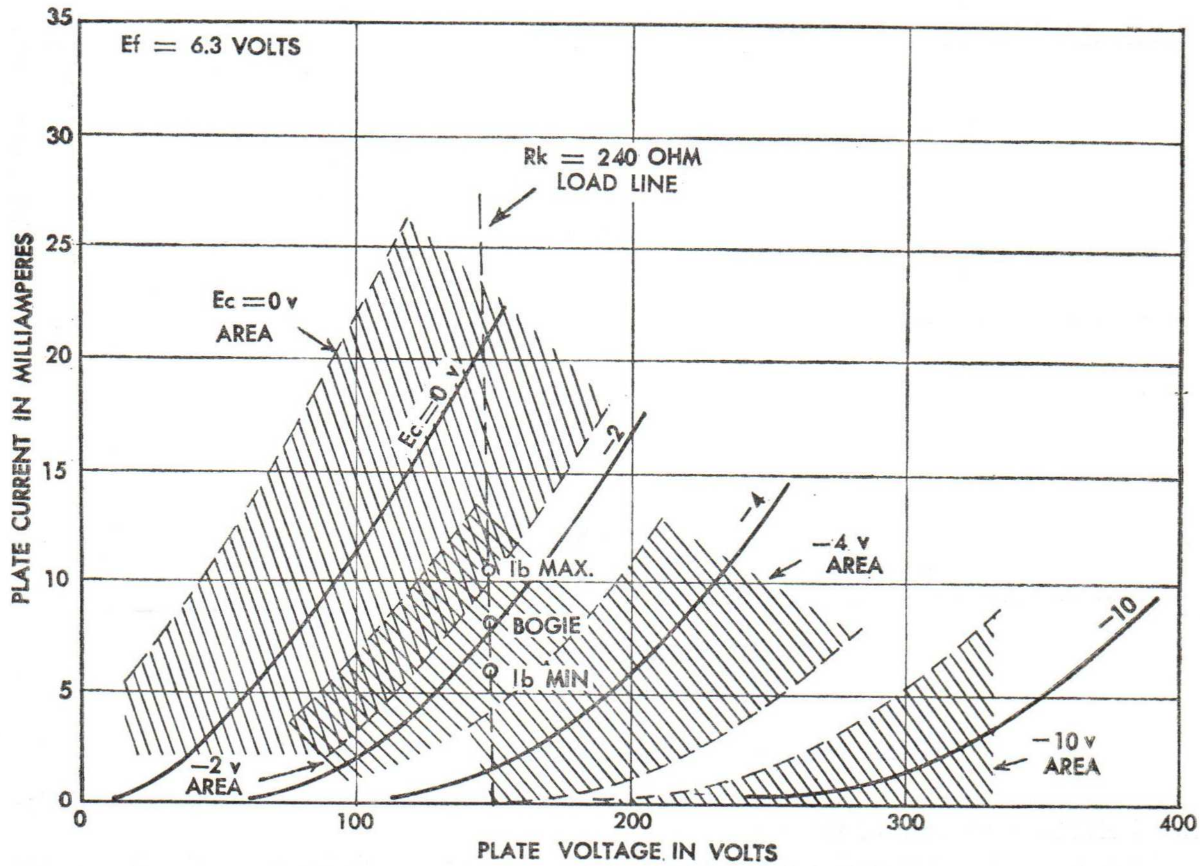


Figure 3-186. Limit Plate Characteristics of JAN-5670.

The chart below presents the limit behavior of transfer data for JAN-5670 as defined by MIL-E-1/5A dated 5 December 1955.

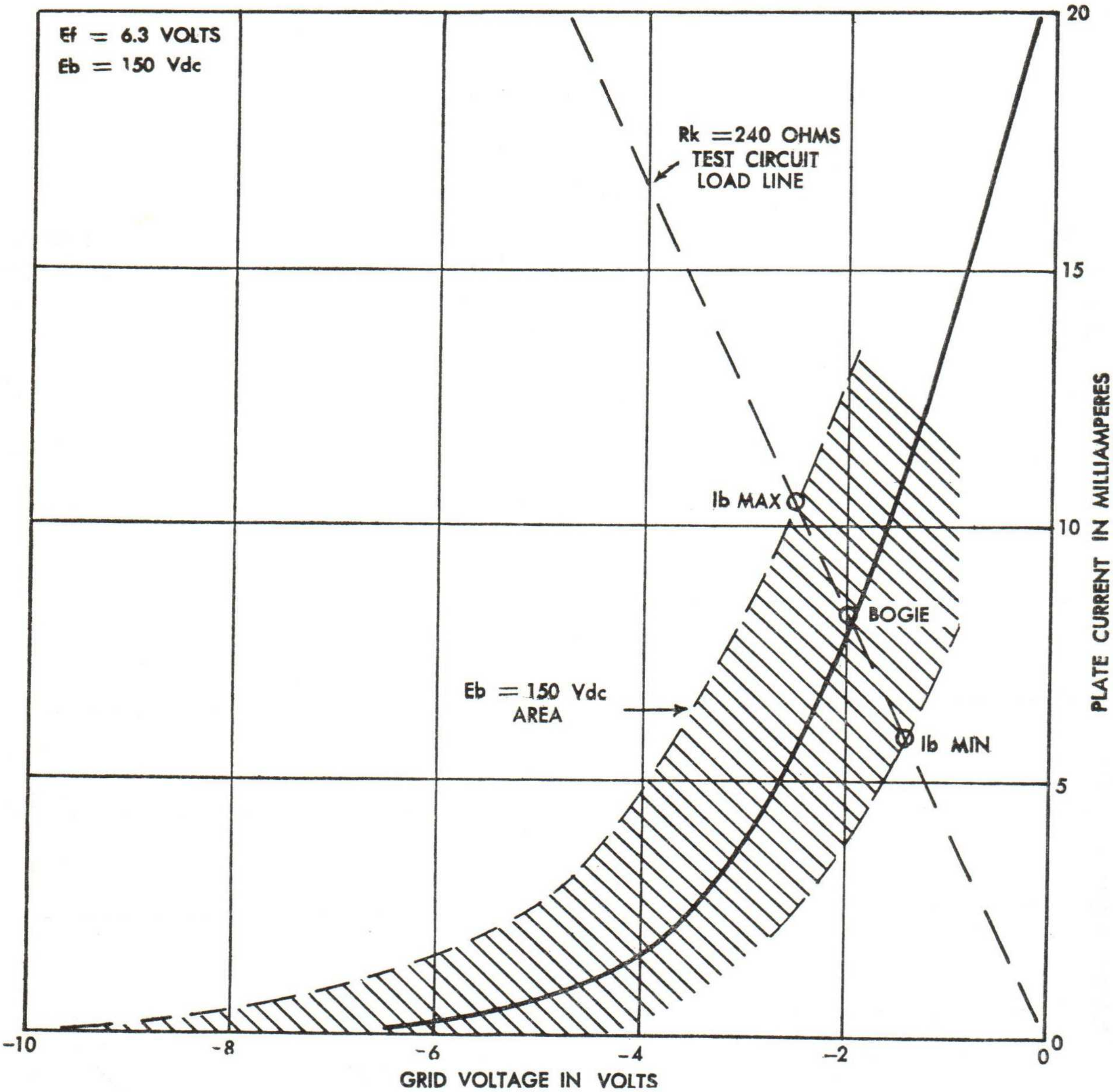


Figure 3-187. Limit Transfer Characteristics of JAN-5670.

DESIGN CENTER CHARACTERISTICS OF JAN-5670

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

Figures 3-188, 3-189, and 3-190 below present the Characteristics of JAN-5670 in the negative and positive grid region as well as the behavior of Sm, Mu, and rp as functions of Plate Current, Typical Transfer Characteristics.

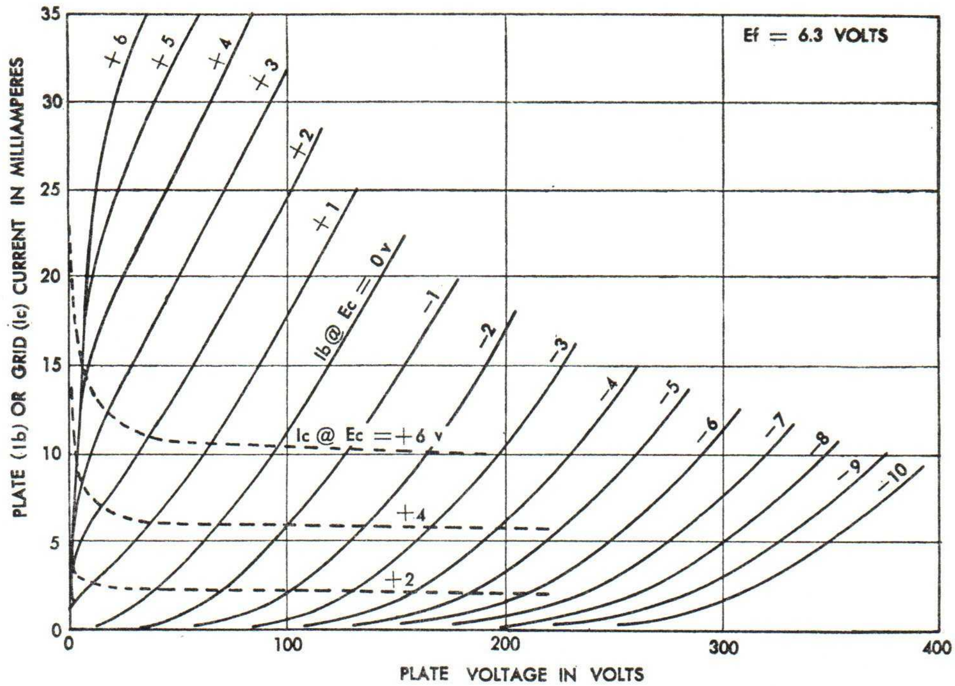


Figure 3-188. Typical Plate Characteristics of JAN-5670.

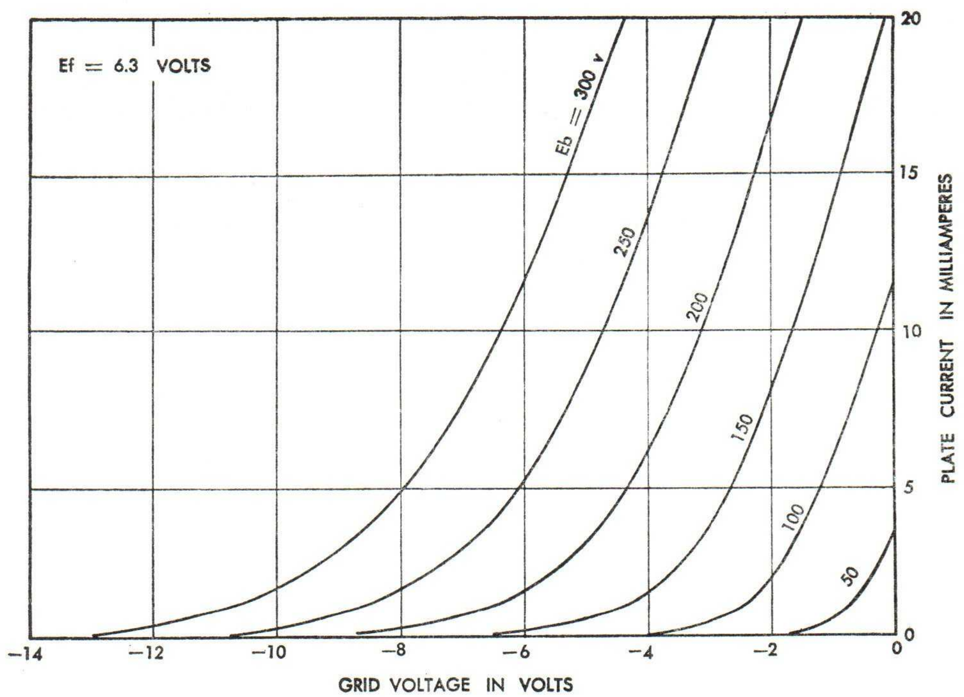


Figure 3-189. Typical Transfer Characteristics of JAN-5670.

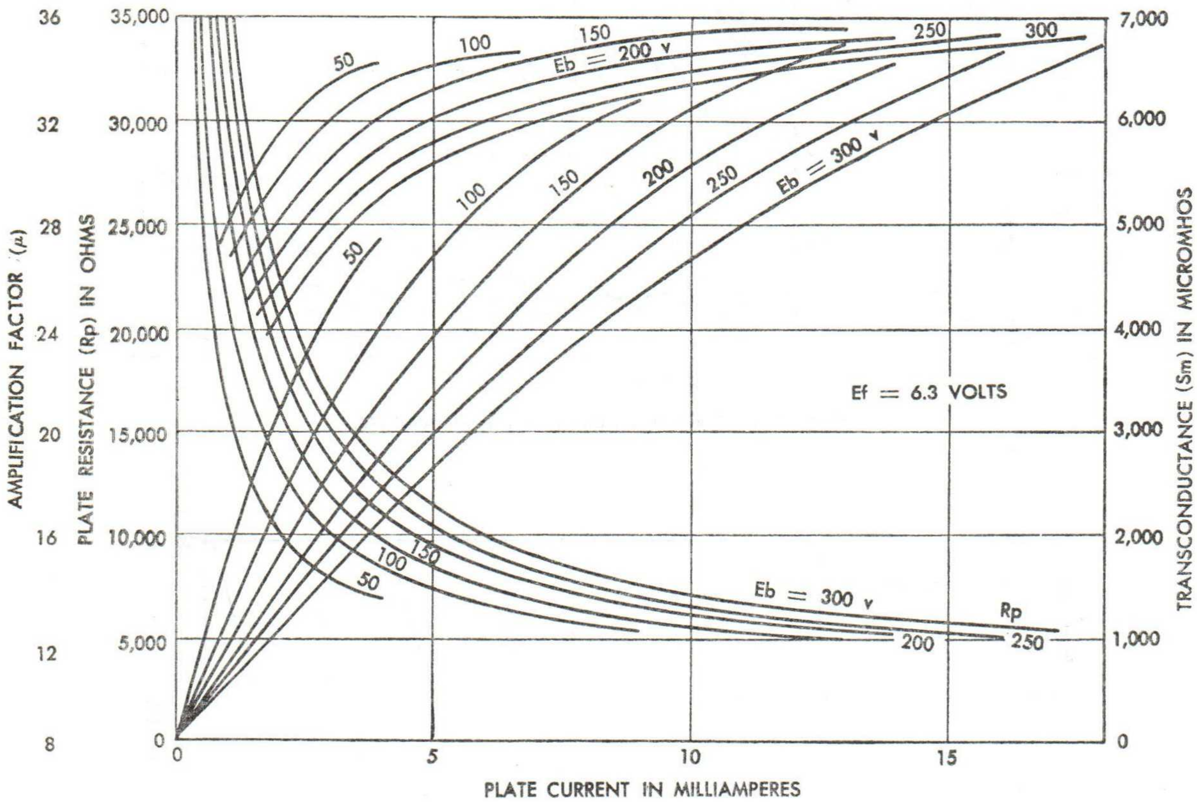
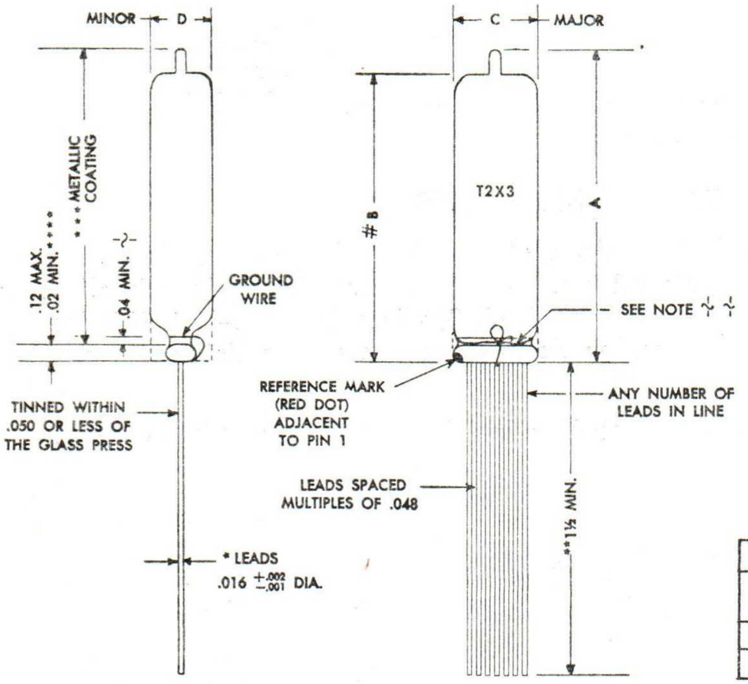


Figure 3-190. Typical Transfer Characteristics of JAN-5670; Variability of Sm.

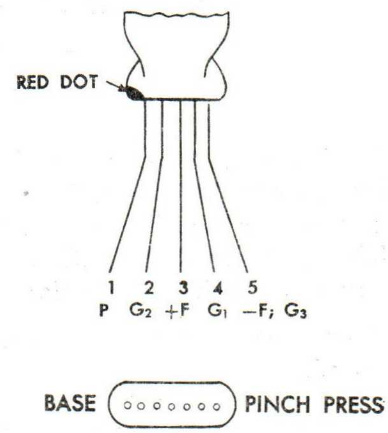
SECTION
TUBE TYPE JAN-5672

DESCRIPTION.

The JAN-5672 [1] is a 5-lead, pinch press, filamentary, subminiature, power amplifier pentode, having a transconductance in range, 475 to 825 micromhos.



LEAD CONNECTIONS



DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

*** WHEN SPECIFIED ON THE TSS

**** APPLIES TO PINCH PRESS TYPES ONLY (.02 MIN.)

† GROUND LEAD OVERLAPPED BY SHIELD BY A MINIMUM OF .04

†† SHIELD TO GROUND WIRE MAY BE FROM EITHER SIDE OF THE MAJOR DIMENSION. ALTERNATIVE CONSTRUCTION: UNUSED OR EXTRA RANDOM LEAD IN PRESS OR BUTTON MAY BE FOLDED BACK AND WRAPPED AROUND BULB TO MAKE CONTACT WITH SHIELD.

Figure 3-191. Outline Drawing and Base Diagram of JAN-5672.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

\# Heater Voltage .... 1.25 Vdc ± 20%
Plate Voltage .... 100 Vdc
Reference MIL-E-1C Section 6.5.1.1. *Plate Voltage*

\# Concerning this rating, MIL-E-1/280 for JAN-5672 states, "Do not use series filament circuits."

[1] The values and specification comments presented in this Section are related to MIL-E-1/280 dated 9 July 1953.

*Screen Grid Voltage .... 100 Vdc
Cathode Current, Maximum .... 5.5 mAdc
*Altitude Rating .... 10,000 ft.

TEST CONDITIONS AND CHARACTERISTICS
Test conditions and characteristics are as follows:
Heater Voltage, Ef .... 1.25 Vdc
Plate Voltage, Eb .... 67.5 Vdc
Control Grid Voltage, Ec1 .... —6.5 Vdc
Screen Grid Voltage, Ec2 .... 67.5 Vdc

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exists. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/280 dated 9 July 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		44	56	...	...	mA
Transconductance (1)	Sm		475	825	...	...	umhos
Plate Current (1)	Ib		2.1	4.1	...	...	mAdc
Screen Grid Current	Ic2		0.5	1.4	...	...	mAdc
Power Output	Po	Esig = 4,.55 Vac Rp = 20,000	50	...	35	...	mW
Control Grid Current	Ic1		0	—0.8	...	-1.5	uAdc
Insulation of Electrodes							
	R(g1-all)	Eg1-all = -100 Vdc	100	...	...	...	Meg
	R(p-all)	Ep-all= -100 Vdc	100	...	...	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
High, 3.2.9
Low, 3.2.2, 3.2.6
28 Volt, 3.2.9
AC Operation, 1.3.3, 3.2.9
Screen Grid:
Supply, 3.2.7
Protection, 3.2.9
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
Cathode, 2.1.1, 3.2.9
Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Temperature
Bulb and Environmental, 3.2.3

Current
Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation
Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Miscellaneous
Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

APPLICATION OF JAN–5672

The chart below shows the permissible operating area for JAN–5672 as defined by the ratings in MIL–E–1/280 dated 9 July 1953. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

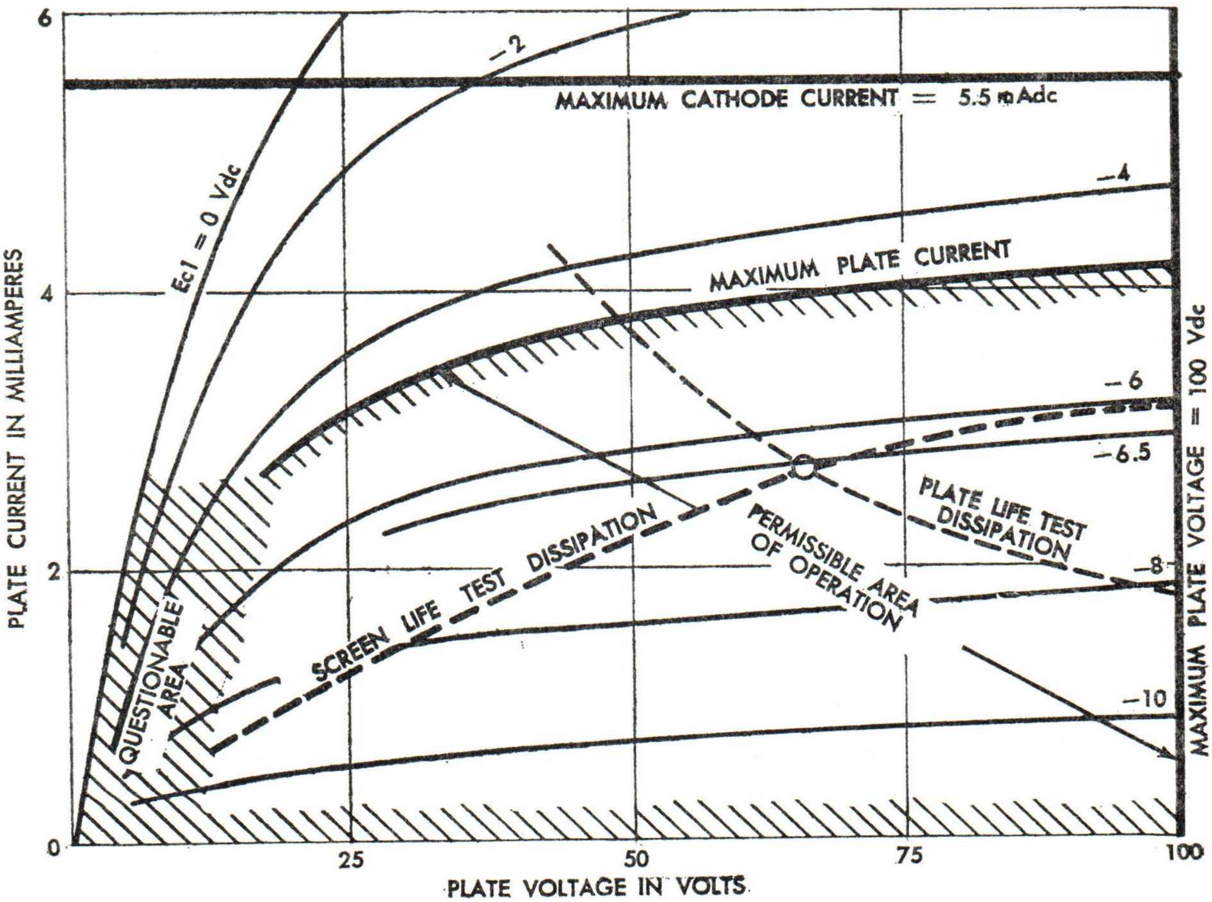


Figure 3-192. Typical Static Plate Characteristics of JAN-5672; Permissible Area of Operation.

VARIABILITY OF JAN-5672 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5672 as defined by MIL-E-1/280 dated 9 July 1953.

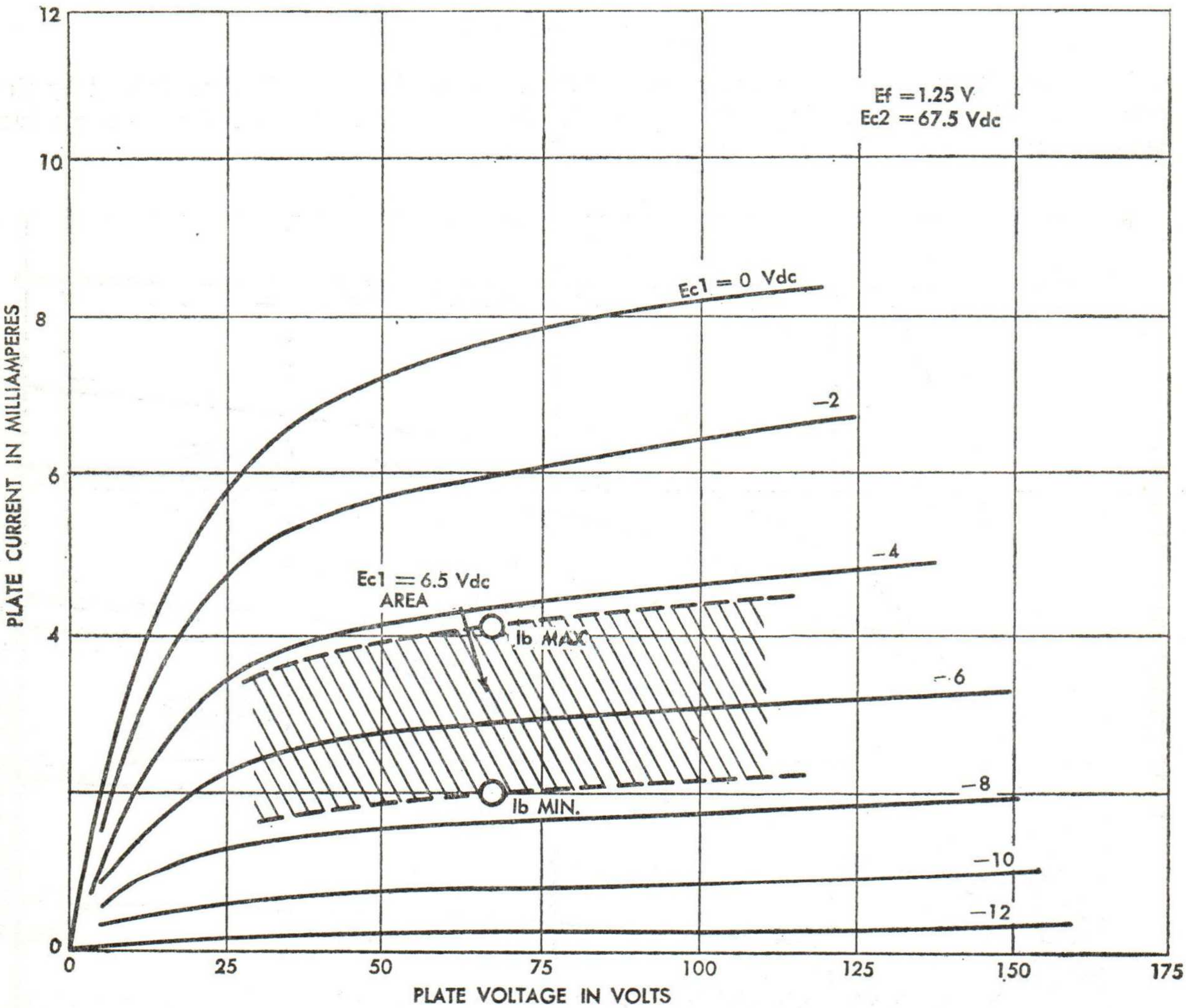


Figure 3-193. Limit Behavior of JAN-5672 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5672 as defined by MIL-E-1/280 dated 9 July 1953.

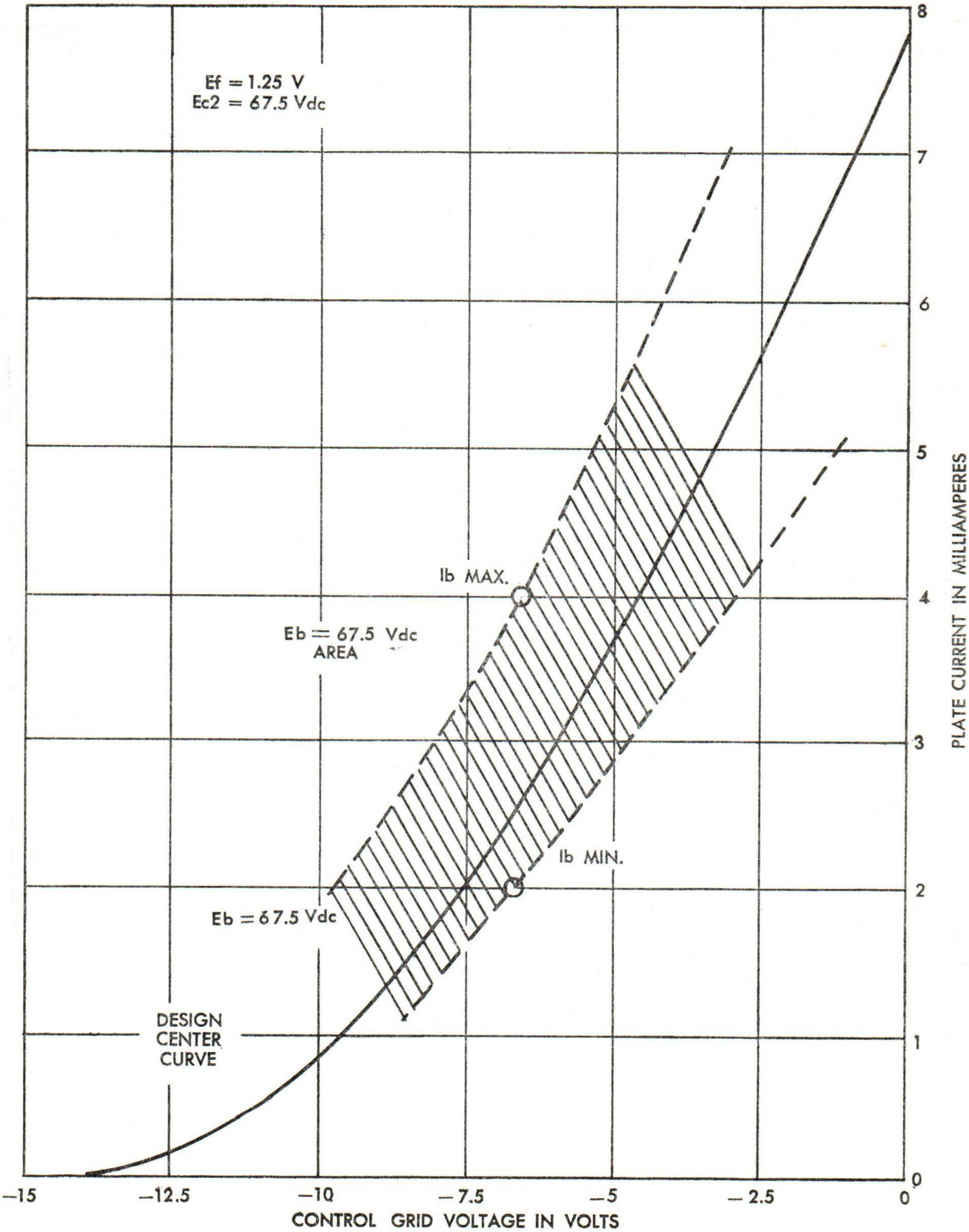


Figure 3-194. Limit Behavior of JAN-5672 Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-5672

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5672.

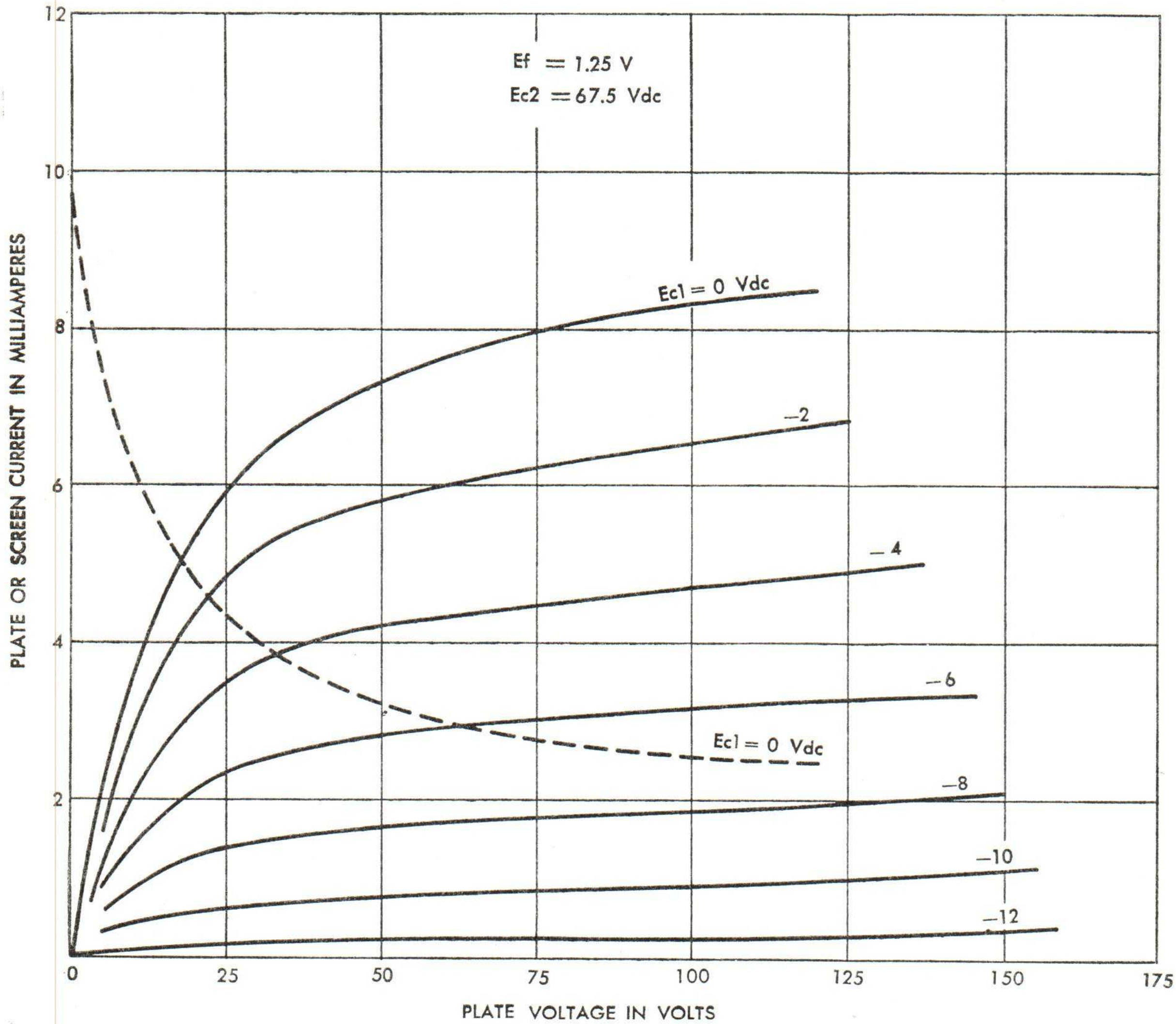


Figure 3-195. Typical Static Plate Characteristics of JAN-5672.

The chart below presents the typical plate transfer data for JAN-5672.

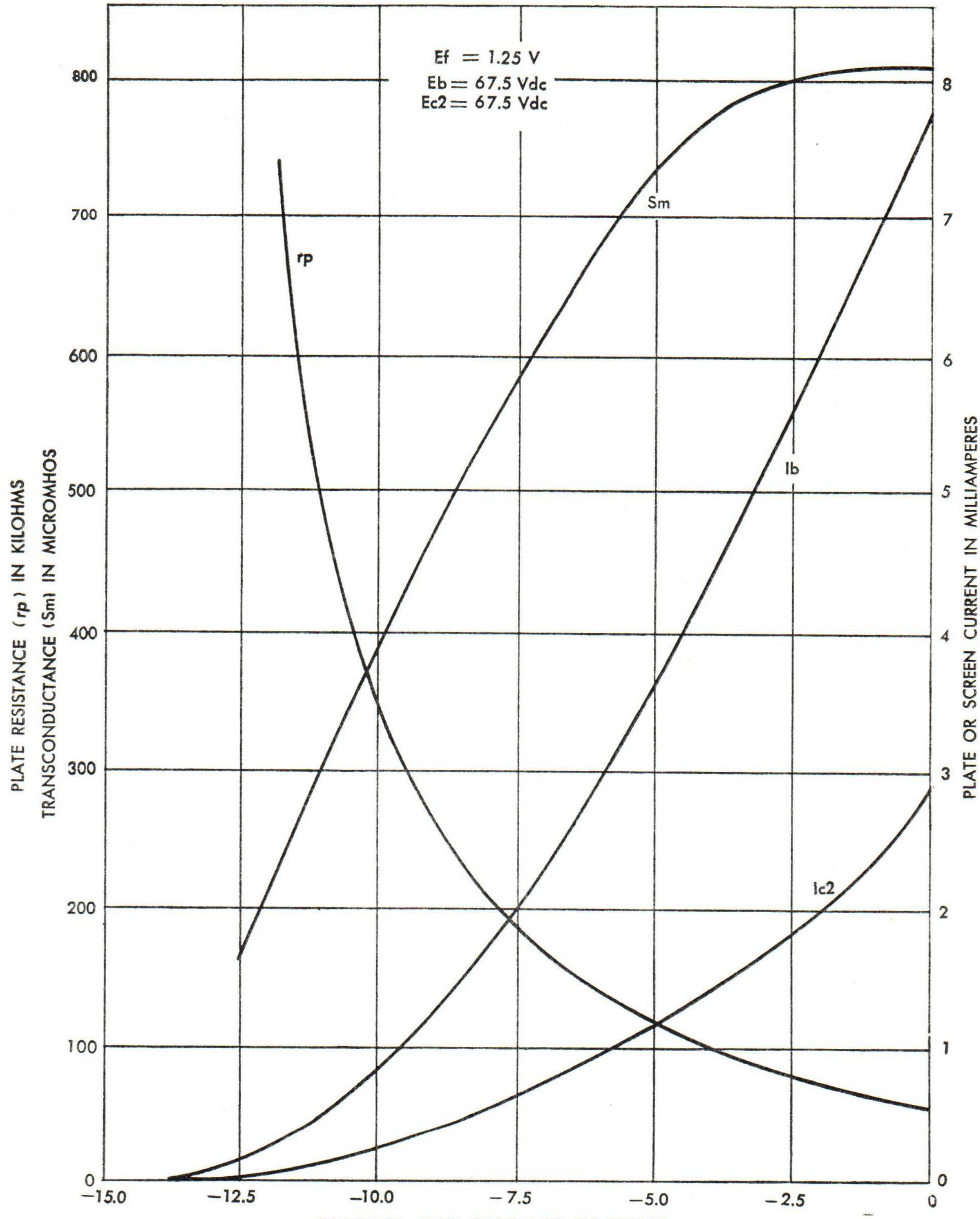


Figure 3-196. Typical Transfer Characteristics of JAN-5672.

SECTION
TUBE TYPE JAN–5686

DESCRIPTION.
The JAN–5686[1] is a 9 pin miniature, RF beam power pentode having a transconductance in the range, 2600 to 4000 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

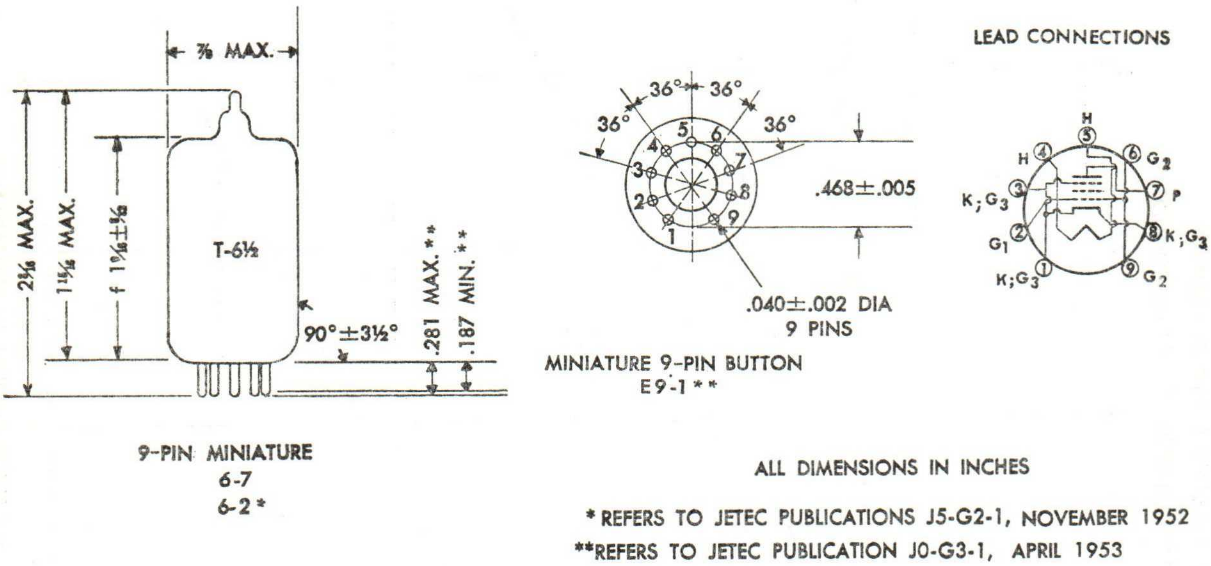


Figure 3-197. Outline Drawing and Base Diagram of JAN-5686.

RATINGS, ABSOLUTE SYSTEM.
The absolute system ratings are as follows:

Heater Voltage	6.3 V 10%
*Plate Voltage	275 Vdc
Reference MIL–E—1C Section 6.5.1.1. *Plate Voltage*	
*Control Grid Voltage, Maximum	—165 Vdc
*Screen Grid Voltage	275 Vdc
Heater-Cathode Voltage	100 V
**Plate Current, Maximum	44 mAdc
Control Grid Current, Maximum	3.3 mAdc
*Plate Dissipation	8.25 W
*Screen Grid Dissipation	3.3 W
*Power Input (Plate)	11.0 W

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/171 dated 20 May 1953.

TEST CONDITIONS AND CHARACTERISTICS

Test conditions and characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Control Grid Voltage, Ec1 .... —15.2 Vdc
Screen Grid Voltage, Ec2 .... 250 Vdc

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/171 dated 20 May 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		320	380	...	...	mA
Transconductance (1)	Sm		2600	4000	...	...	umhos
Plate Current (1)	Ib		21	35	...	...	mAdc
Screen Grid Current	Ic2		1.0	6.0	...	...	mAdc
Power Output	Po	Esig = 8.8 Vac; Rp = 9000 ohms	2.2	...	...	...	W
Power Oscillation	Po	Esig adjusted for Ic1 = 2 mAdc Rc1=25,000 ohms Ib = 40 mAdc F = 5 Mc	5.25	...	4.25	...	W
Capacitance	Cgp	Ef = 0	...	0.08	...	...	uuf
(Shielded as	Cin	Ef = 0	5.0	8.0	...	...	uuf
Specified)	Cout	Ex = 0	7.0	10.0	...	...	uuf
Control Grid Current	Ic1		0	—2.0	...	—2.0	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	0	40	...	...	uAdc
	Ihk	Ehk =—100 Vdc	0	—40	...	...	uAdc
Insulation of Electrodes	R(g1-all)	Eg1-all =—100 Vdc	100	...	...	...	Meg
	R(p -all)	Ep -all = —300 Vdc	100	...	...	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
Supply, 3.2.7
Protection, 3.2.9
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
Cathode, 2.1.1, 3.2.9
Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

SPECIAL CONSIDERATIONS

Current specification for this tube type provides a Class C power oscillation test at a frequency of 125 megacycles with initial limit on power output of 4.3 watts minimum under test conditions of Ecl = —50 volts dc; and signal voltage such as to cause plate current of 40 mAdc Life test end point, measured under these test conditions is 4.25 watts minimum.

APPLICATION

The chart below shows the permissible operating area for JAN-5686 as defined by the ratings in MIL-E-1/171 dated 20 May 1953. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

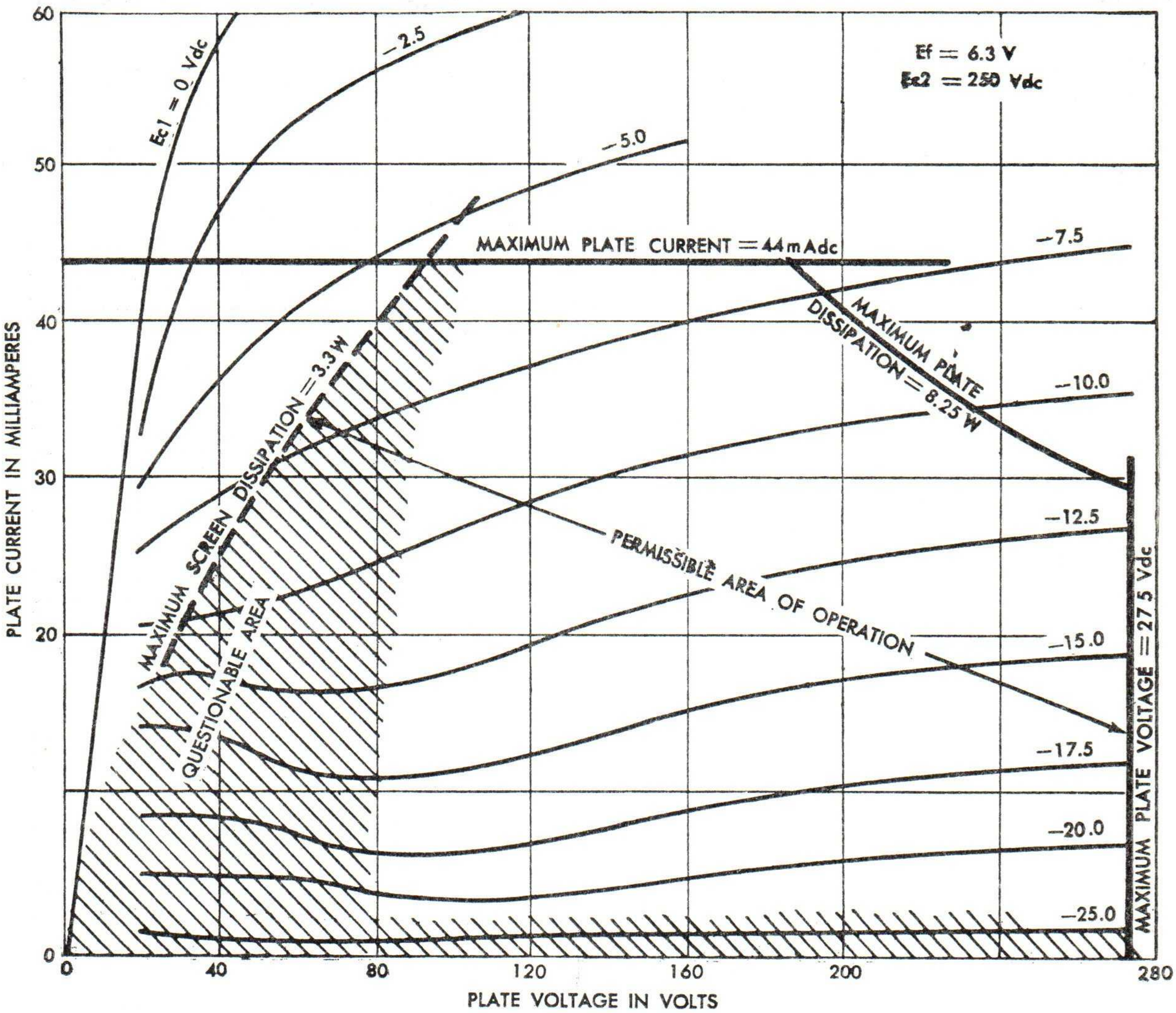


Figure 3-198. Typical Static Plate Characteristics of JAN-5686; Permissible Area of Operation.

VARIABILITY OF JAN-5686 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5686 as defined by MIL-E-1/171 dated 20 May 1953.

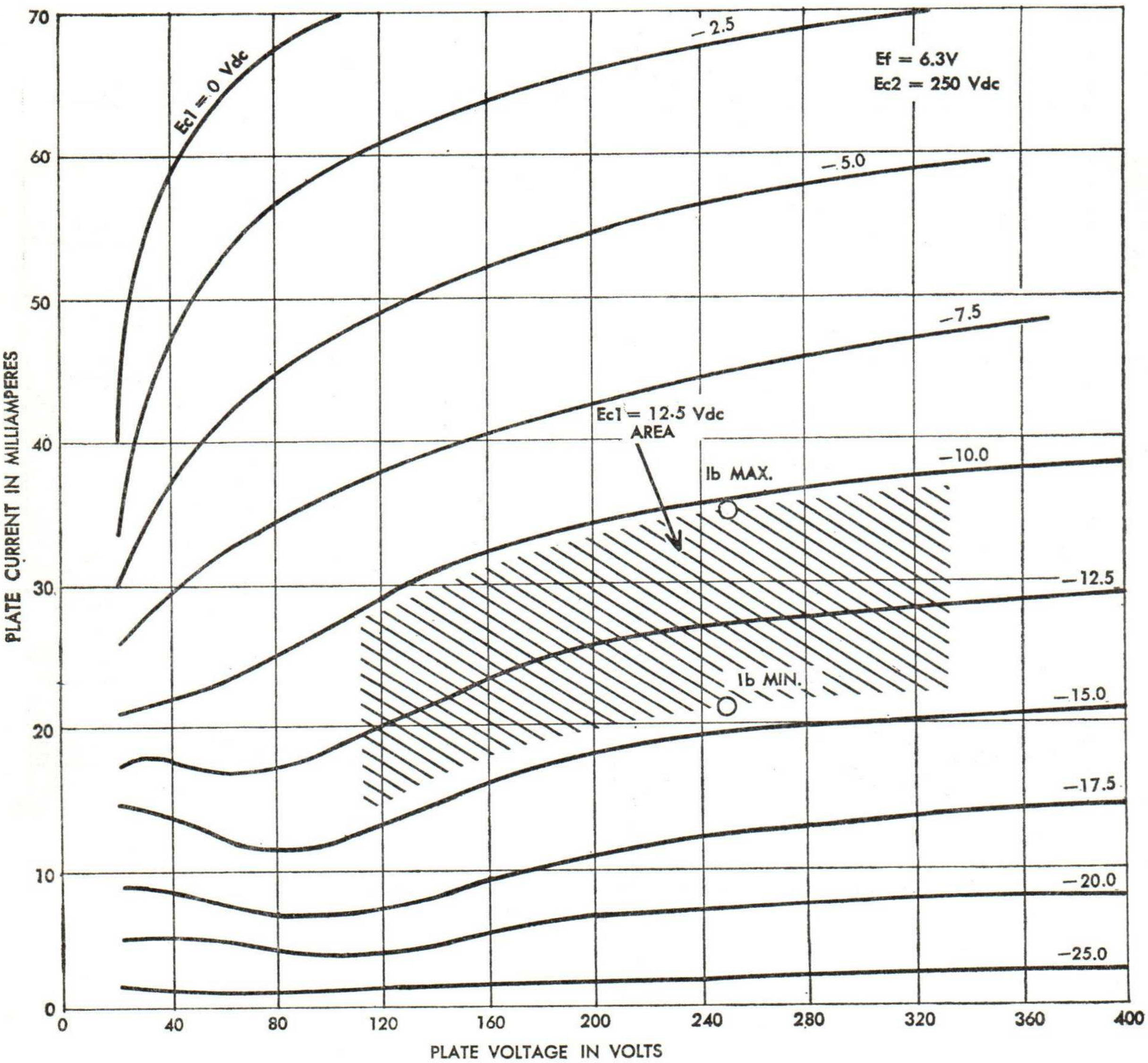


Figure 3-199. Limit Behavior of JAN-5686 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5686 as defined by MIL-E-1/171 dated 20 May 1953.

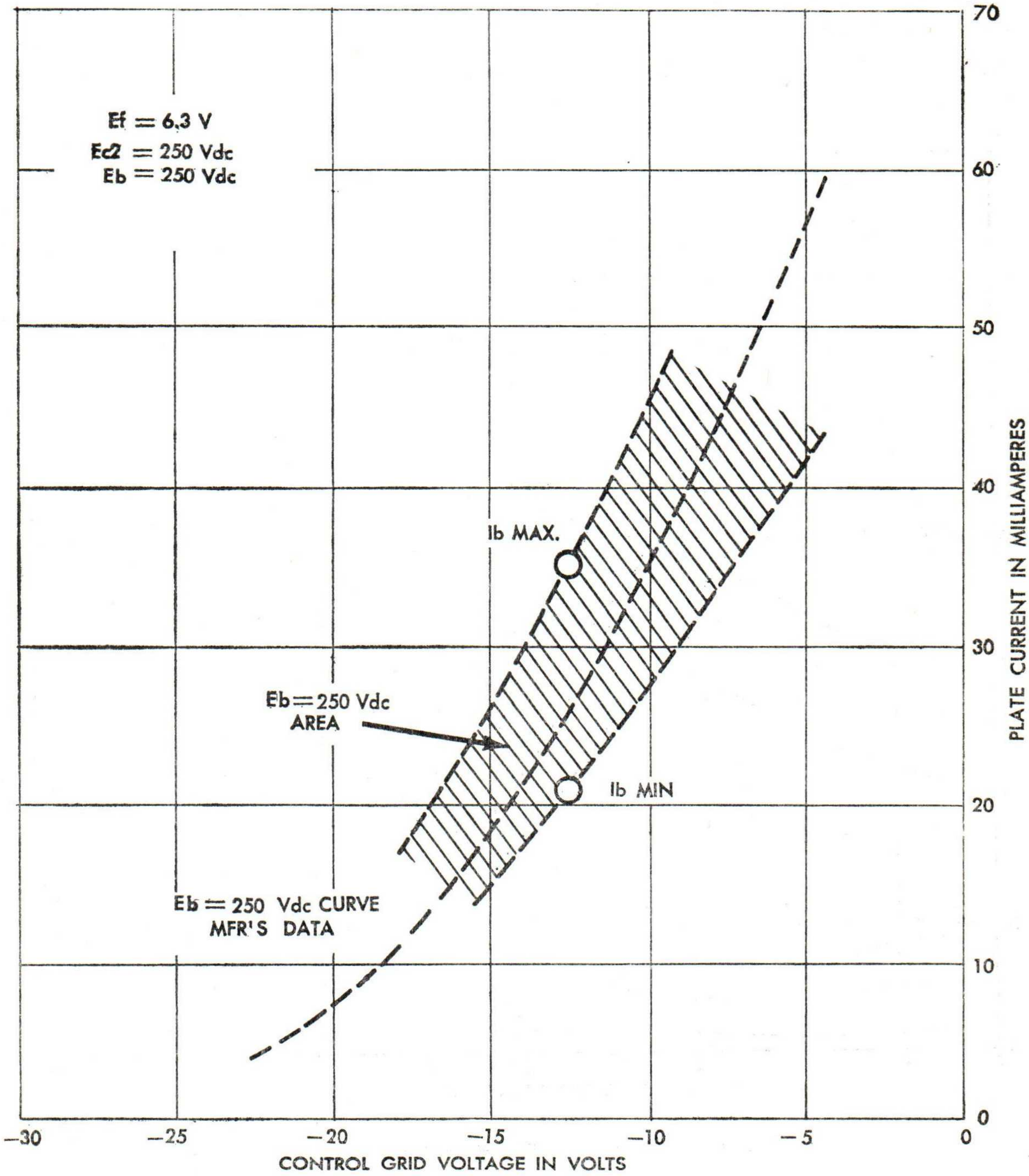


Figure 3-200. Limit Behavior of JAN-5686 Transfer Data; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-5686

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5686.

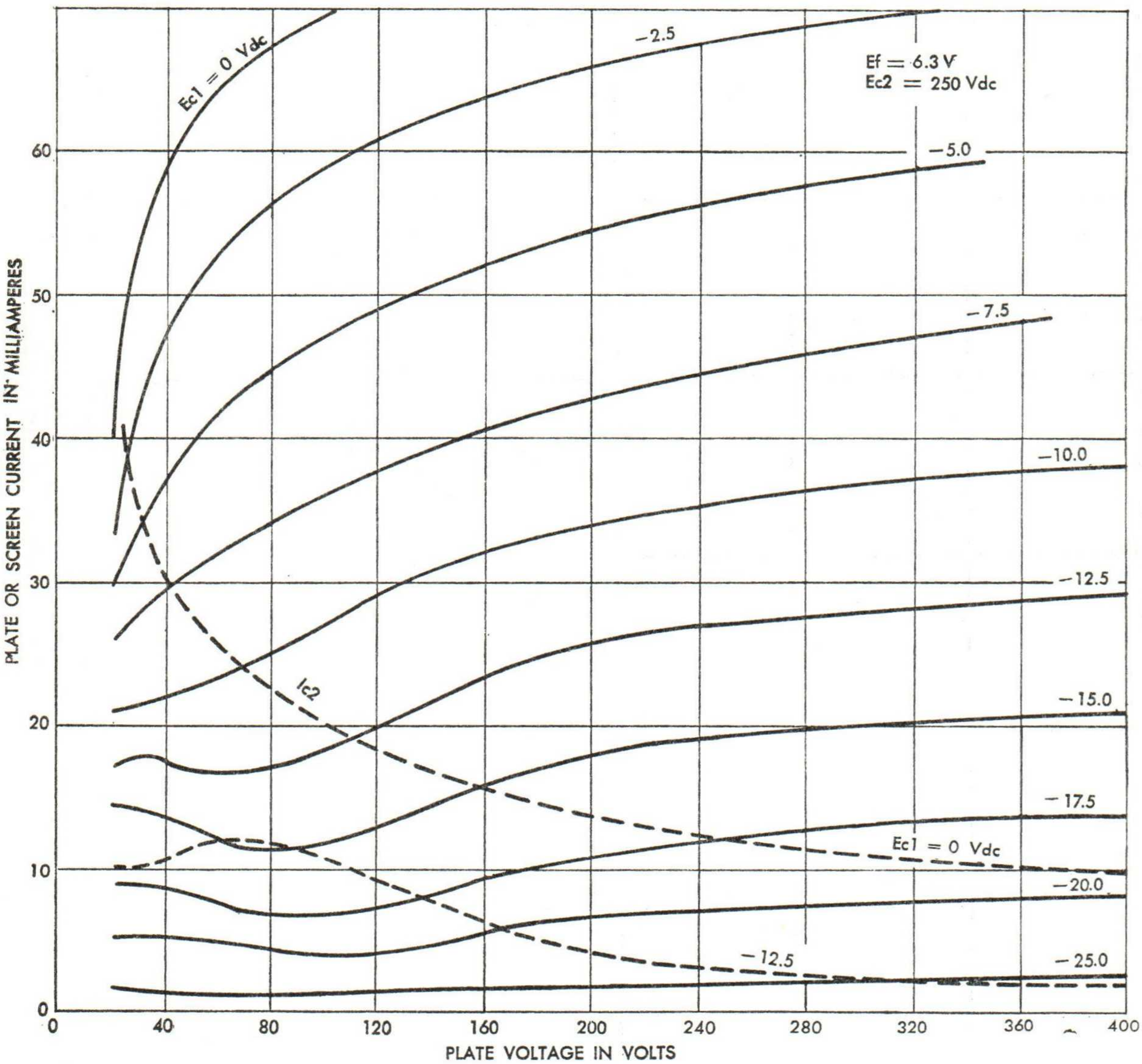


Figure 3-201. Typical Static Plate Characteristics of JAN-5686.

SECTION
TUBE TYPE JAN–5687

DESCRIPTION.

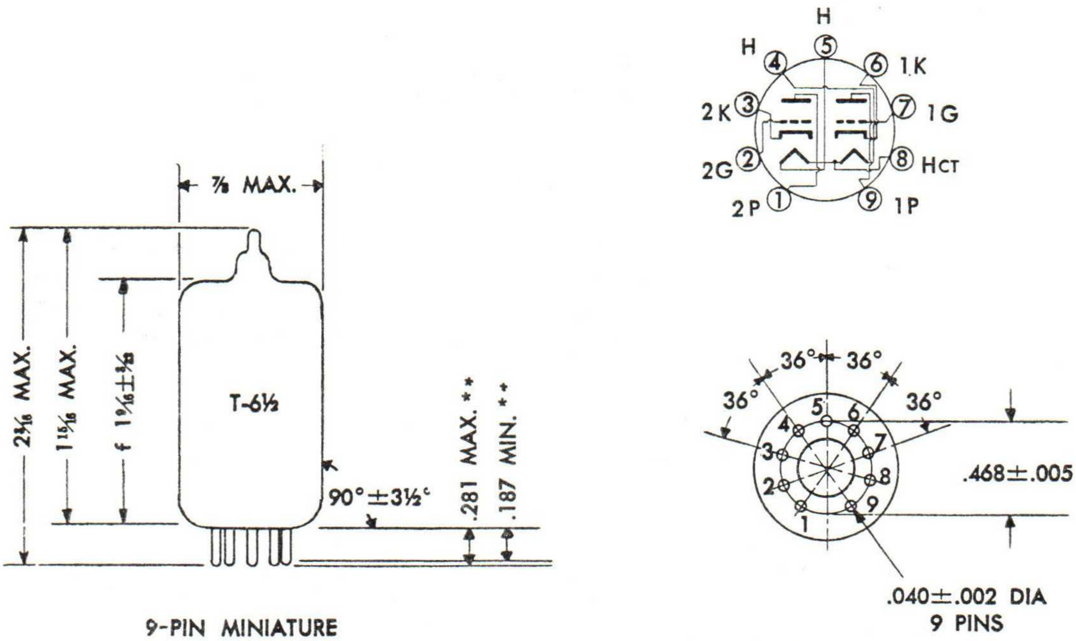
The JAN–5687 [1] is a 9 pin, miniature, general purpose twin triode having a Mu in the range of 15.0 to 20.5 and transconductance in the range 8000 to 14000 umhos. Each triode is electrically independent, although the two heaters have a common connection

ELECTRICAL. The electrical characteristics are as follows:

	Series	Parallel
Heater Voltage	6.3 V	12.6 V
Heater Current	.84–.96 A	.42–.48 A
Cathode	Coated Unipotential	

MOUNTING. Any type of mounting is adequate.

LEAD CONNECTIONS



9-PIN MINIATURE
6-7
6-2 *

MINIATURE 9-PIN BUTTON
E9-1**

ALL DIMENSIONS IN INCHES

* REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952

**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

f MEASURE FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

Figure 3-202. Outline Drawing and Base Diagram of Tube Type JAN-5687.

[1] The values and specification comments presented in this section are related to MIL-E-1/80C dated 14 May 1956.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	Series 12.6 ± 10%
	Parallel 6.3 ± 10%
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Heater-Cathode Voltage	100 v
**Cathode Current (each cathode)	65 mAdc
*Plate Dissipation (each plate)	4.2 W
*Bulb Temperature	+220° C
*Altitude Rating	10,000 ft
Peak Plate Inverse Voltage	1000 v

TEST CONDITIONS

Test Conditions are as follows:

Heater Voltage, Ef	12.6 V
Plate Voltage, Eb	120 Vdc
Grid Voltage, Ec	—2.0 Vdc

* No test at this rating exists in the specification.

** No specification assurance of life exists under conditions of cathode current approaching the maximum. Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/80C dated 14 May 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If	Ef = 6.3 Vdc	0.84	0.96	...	...	A
Transconductance (1)	Sm		8000	14000	6000	...	umhos
Amplification Factor	Mu		15.0	20.5	...	...	
Plate Current (1)	Ib		27	45	22	...	mAdc
Plate Current (3)		Ec = —25 Vdc Eb = 300 Vdc	...	1.0	...	...	mAdc
Emission	Is	Eb = Ec = 15 Vdc	125	...	...	...	mAdc
Grid Current	Ic	Units in Parallel	0	—5.0	...	...	uAdc
Heater-Cathode	Ihk	Ehk = +100 Vdc	0	30	...	...	uAdc
Leakage	Ihk	Ehk = —100 Vdc	0	—30	...	...	uAdc

APPLICATION OF JAN-5687

Figure 3-203 below shows the permissible operating area for JAN-5687 as defined by the ratings in MIL-E-1/80C dated 14 May 1956. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.6.

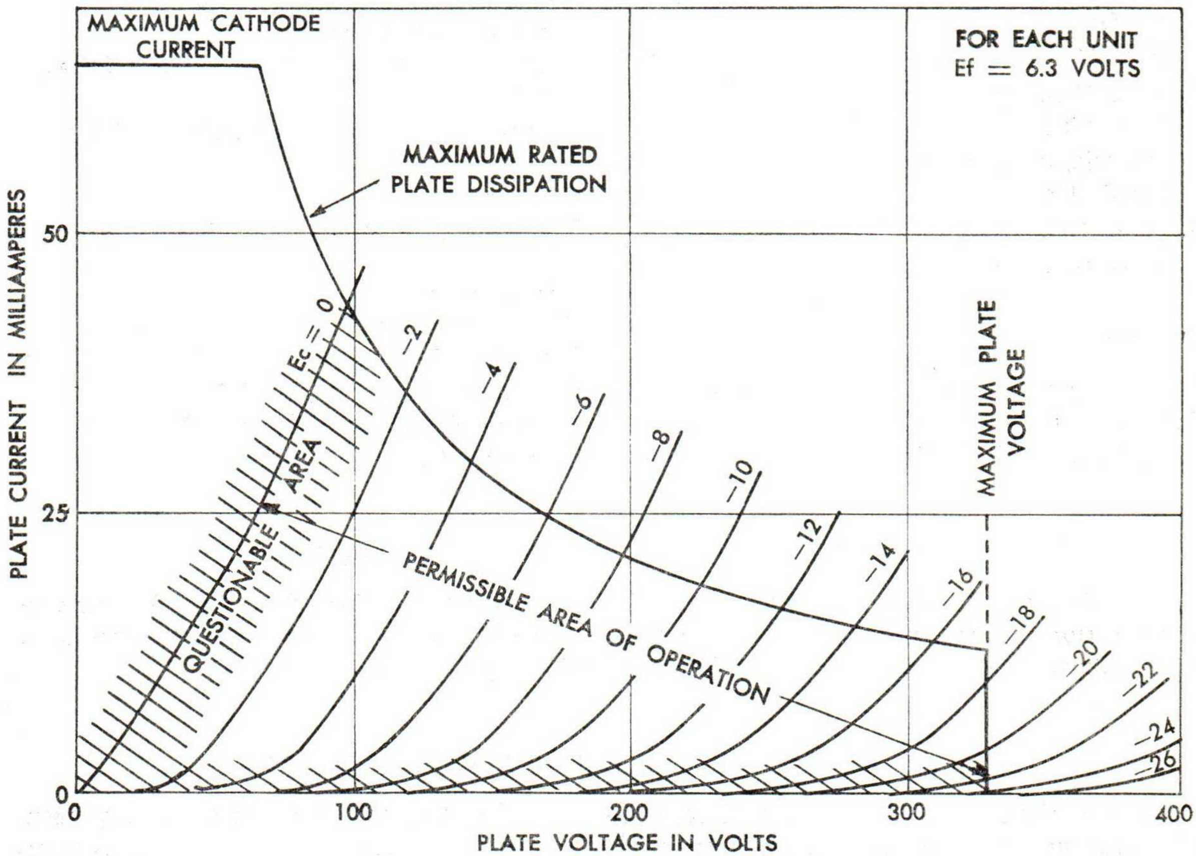


Figure 3-203. Typical Plate Characteristics of JAN-5687; Permissible Area of Operation.

The following lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
  High, 3.1.5
  Low, 3.1.5
  AC Operation, 1.3.3, 3.1.5
  28 Volt, 3.1.5
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.1.2
  Cathode, 2.1.1, 3.1.5
  Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL OPERATING CONSIDERATIONS

A special test for plate emission with AC anode voltage applied offers initial assurance of operation in this manner. AC plate voltage is often encountered in servo amplifiers, power phase detection circuitry or other industrial applications.

VARIABILITY OF JAN-5687 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define that the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of transfer plate characteristics for JAN-5687 as defined by MIL-E-1/80C dated 14 May 1956.

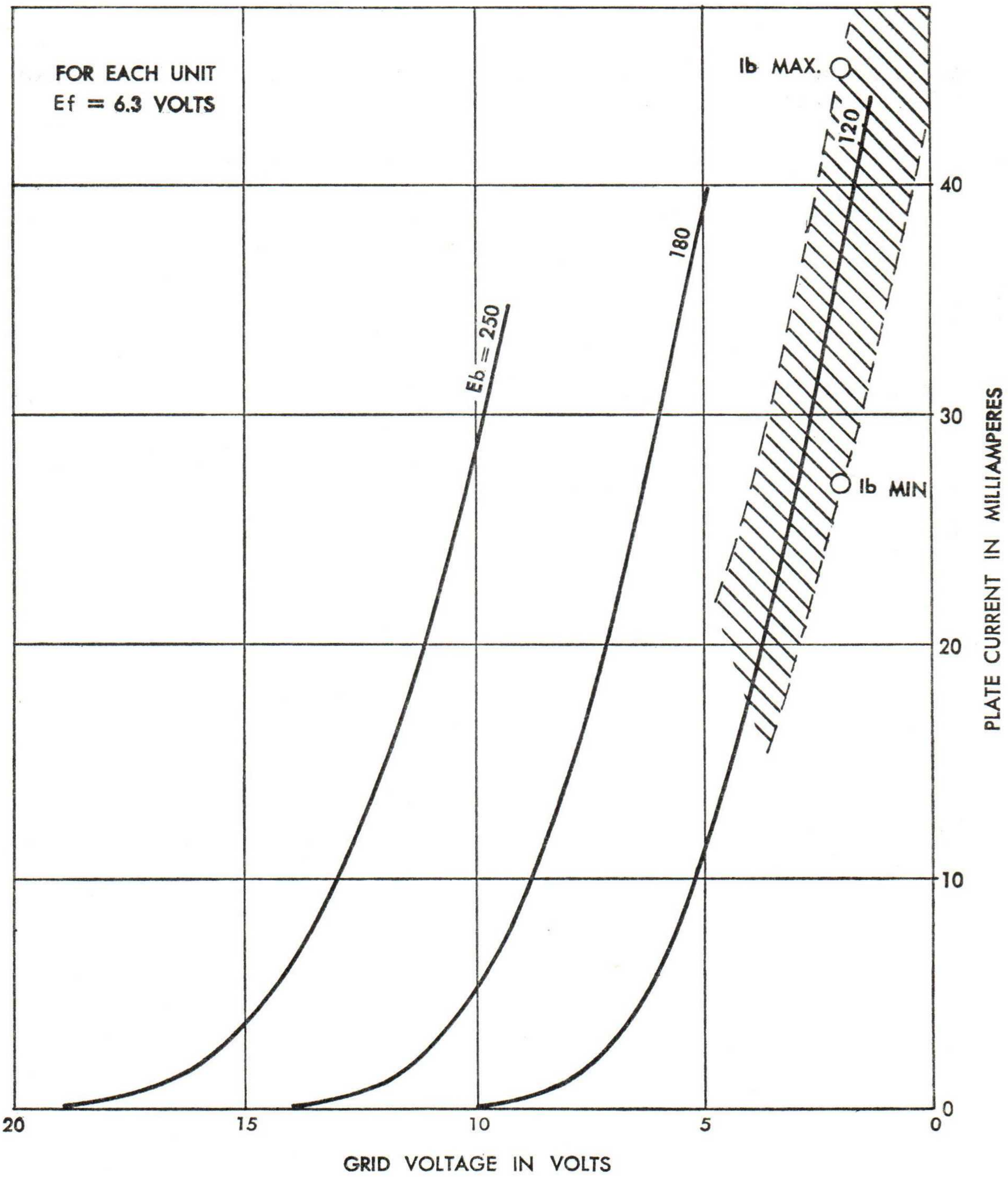


Figure 3-204. Limit Transfer Characteristics of JAN-5687.

The chart below presents the limit behavior of static plate data for JAN-5687 as defined by MIL-E-1/80C dated 14 May 1956.

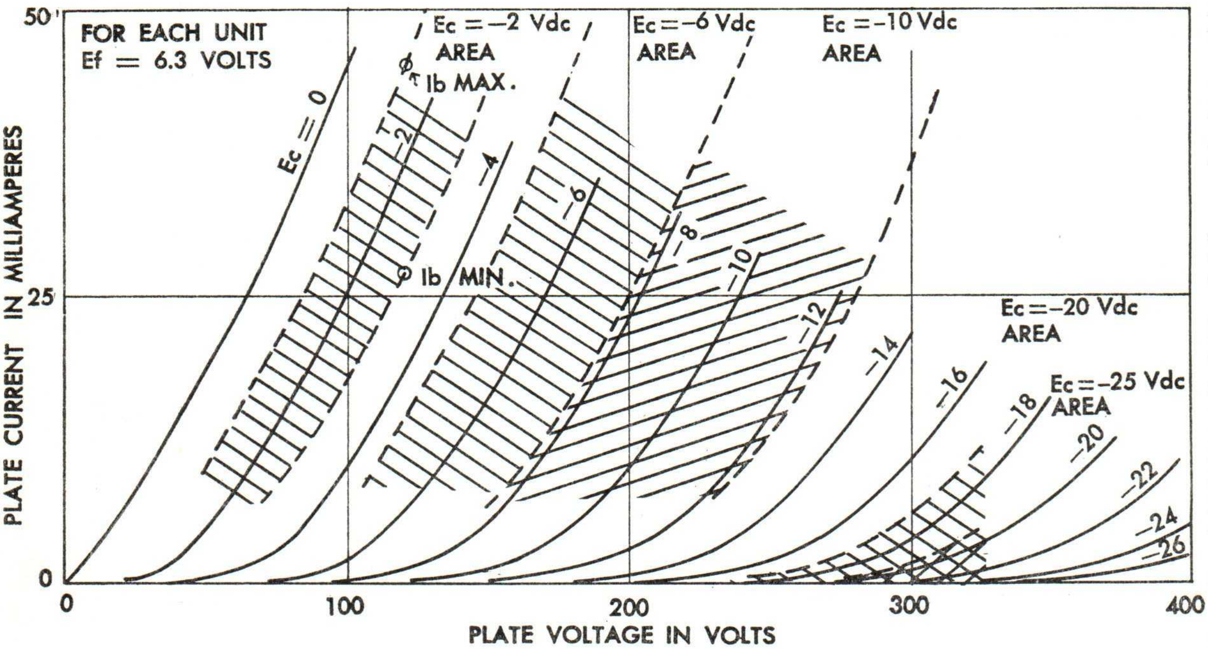


Figure 3-205. Limit Plate Characteristics of JAN-5687.

DESIGN CENTER CHARACTERISTICS OF JAN-5687

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

The chart below presents the Static Plate and Grid Characteristics of JAN-5687 for the positive grid region.

CAUTION: Operation defined by this chart is not supported by any specification tests or rating.

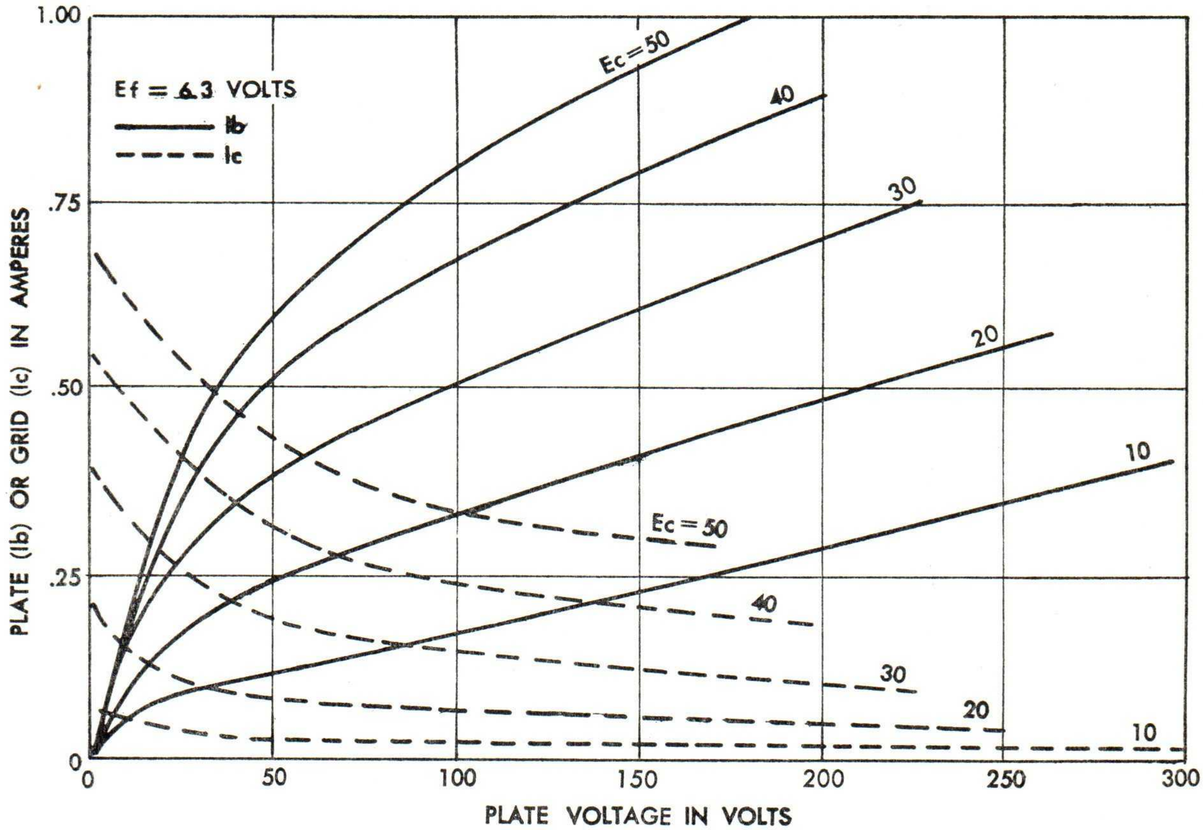


Figure 3-206. Typical Plate and Grid Characteristics of JAN-5687.

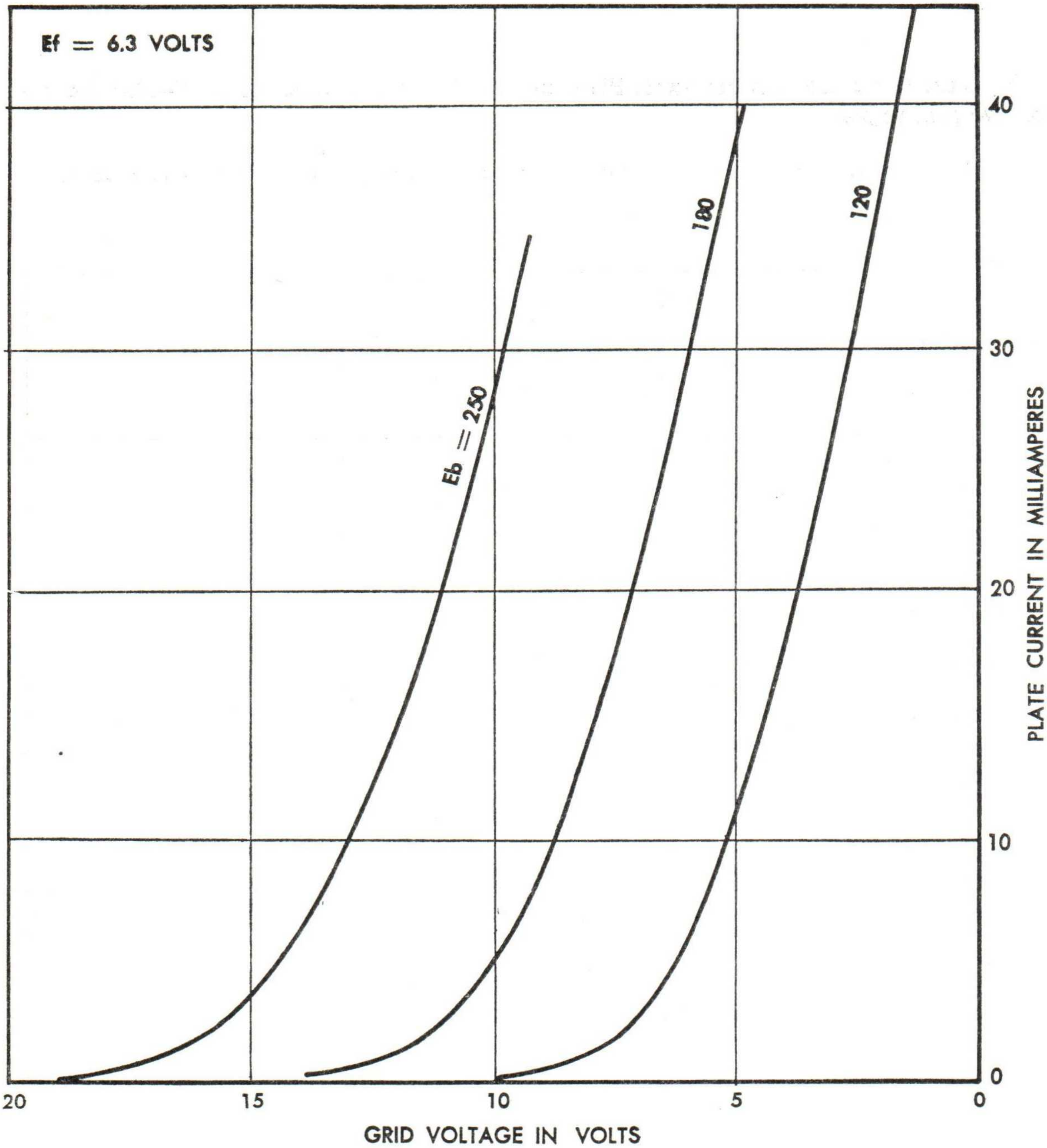


Figure 3-207. Typical Transfer Characteristics of JAN-5687.

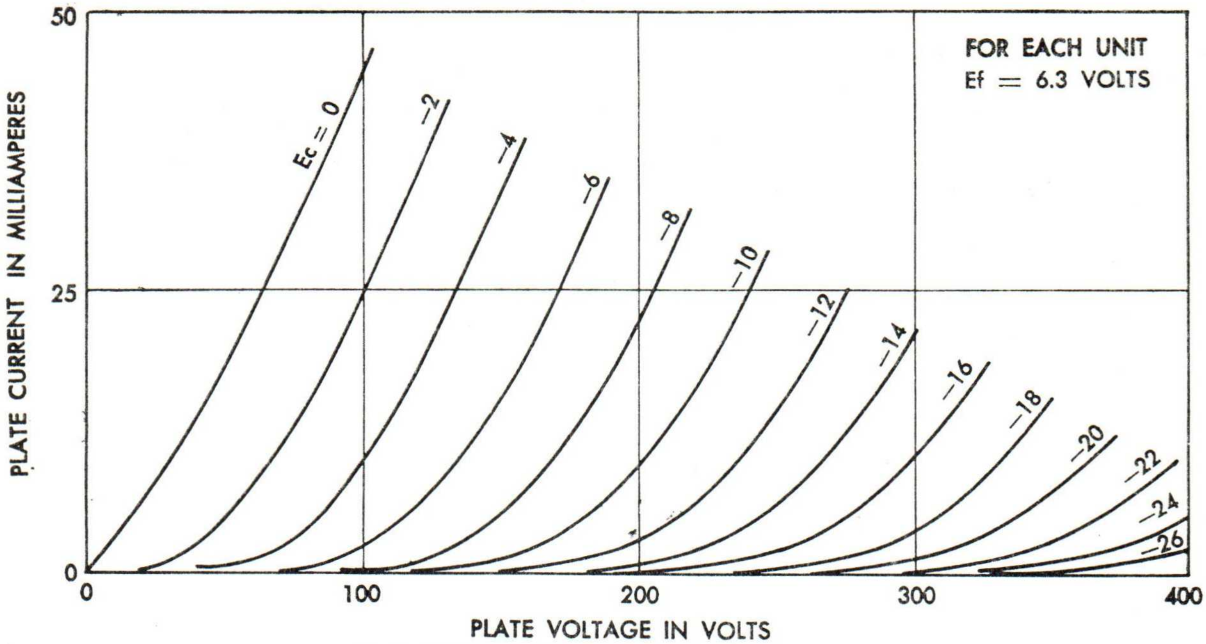


Figure 3-208. Typical Plate Characteristics of JAN-5687.

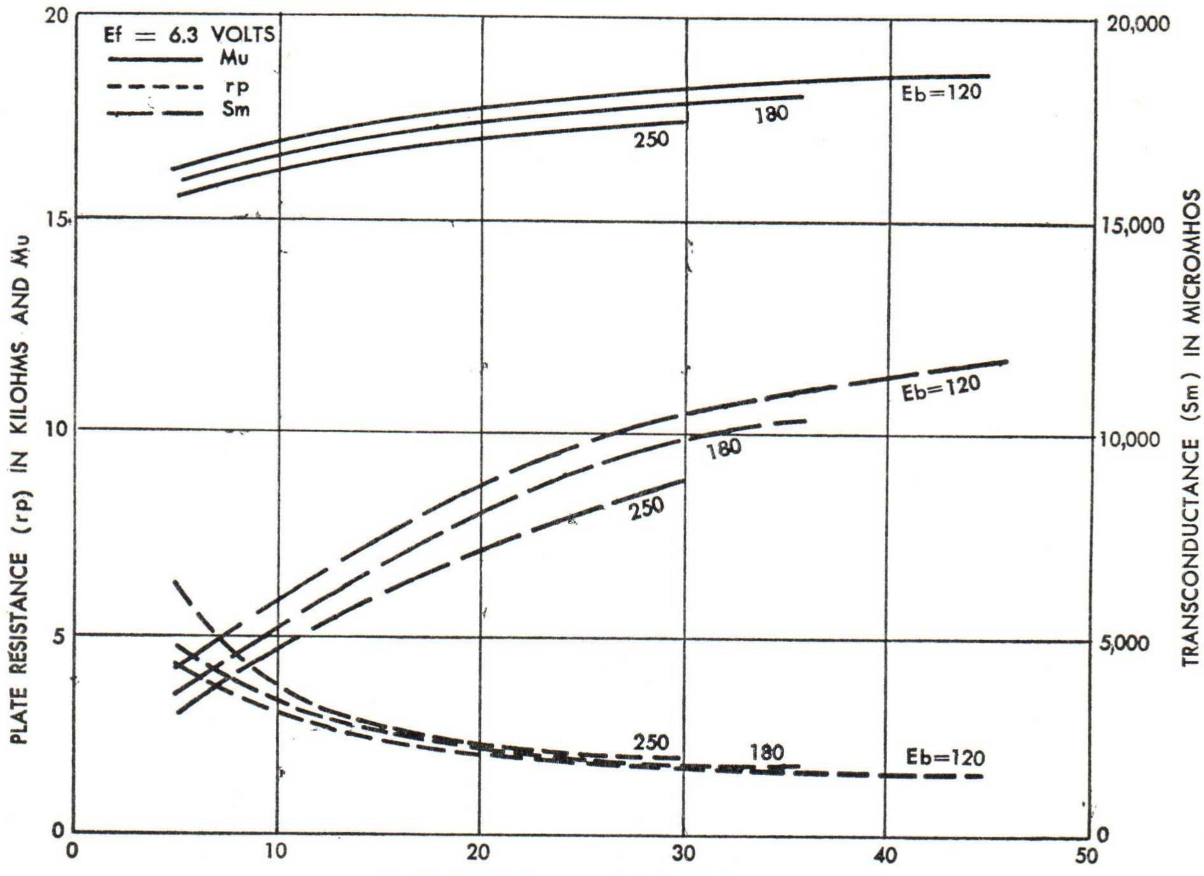


Figure 3-209. Typical Sm, Mu, and rp Characteristics of JAN-5687.

SECTION
TUBE TYPE JAN–5702WA

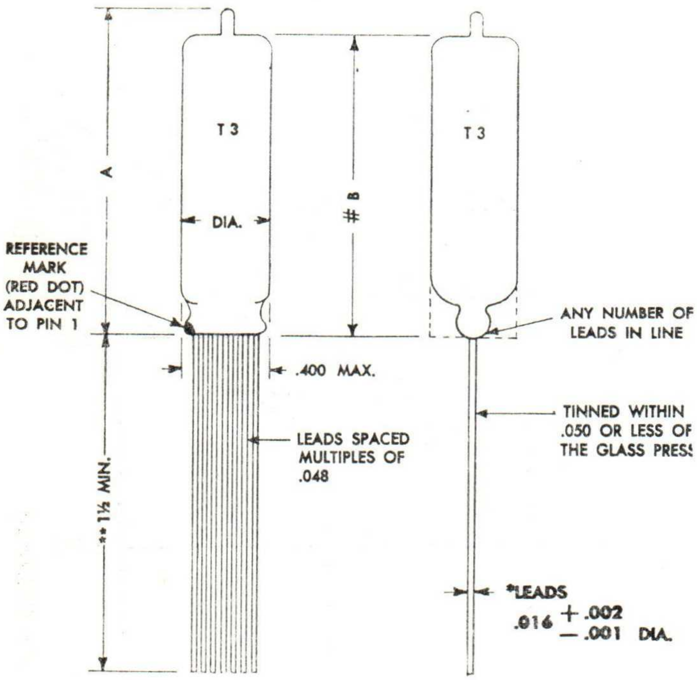
DESCRIPTION.

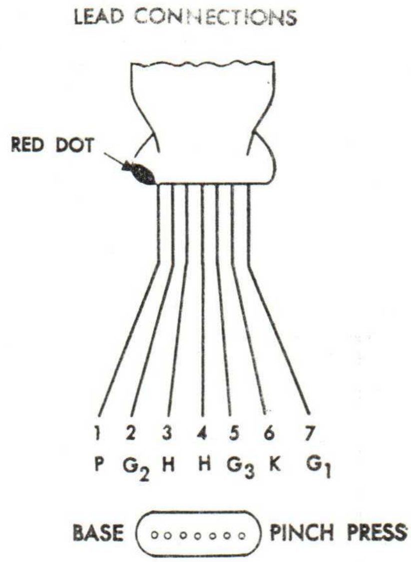
The JAN–5702WA [1] is a 7 lead, pinch press, subminiature, sharp cutoff pentode having a design center transconductance of 5000 micrombos. The JAN–5702WA is similar in plate characteristics to JAN–5840 and the miniature type **JAN–5654/6AK5W.**

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current .... 183–217 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.





DIMENSIONS			
A MAX.	B		DIAMETER MAX
	DIM	TOL. ±	
1.500	1.250	.100	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-210. Outline Drawing and Base Diagram of JAN-5702WA.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.6 V
Plate Voltage .... 200 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*
Screen Voltage .... 155 Vdc

[1] The values and specification comments presented in this section are related to MIL-E-1/82B dated 25 July 1956.

*Control Grid Voltage, Minimum	—55 Vdc
Suppressor Grid Voltage, Maximum	0 Vdc
*Plate Dissipation	1.10 W
*Screen Dissipation	0.40 W
Heater–Cathode Voltage	200 v
**Cathode Current, Maximum	20 mAdc
**Cathode Current, Minimum	0.5 mAdc
*Bulb Temperature	265° C
*Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	120 Vdc
Screen Grid Voltage, Ec2	120 Vdc
Suppressor Grid Voltage, Ec3	0 Vdc
Cathode Resistance, Rk	200 ohms
Plate Current, Ib	7.5 mAdc
Screen Grid Current, Ic2	2.6 mAdc
Transconductance, Sm	5000 umhos

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/82B dated 25 July 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		183	217	183	217	mA
Transconductance (1)	Sm		4200	5800	...	...	umhos
Change in individual	$\Delta\frac{Sm}{t}$		...	...	...	25	%
Plate Resistance	rp		.15	...	...	...	Meg
Plate Current	Ib		5.5	9.5	...	...	mAdc
Screen Grid Current	Ic2		1.7	3.5	...	...	mAdc
Capacitance	Cg1–p	Ef = 0	...	0.03	...	...	uuf
(Shielded as Specified)	Cin	Ef = 0	3.6	5.1	...	...	uuf
	Cout	Ef = 0	2.6	3.7	...	...	uuf
Control Grid Current	Ic1		0	—0.1	0	—0.3	uAdc
Heater–Cathode Leakage	Ihk	Ehk = +100 Vdc	...	7	...	10	uAdc
	Ihk	Ehk = —100 Vdc	...	—7	...	—10	uAdc
Insulation of Electrodes	R(g1—all)	Eg1–all = —100 Vdc	100	...	50	...	Meg
	R(p —all)	Ep–all = —300 Vdc	100	...	50	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-5702WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristics curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

APPLICATION OF JAN–5702WA

The chart below shows the permissible operating area for JAN–5702WA as defined by the ratings in MIL–E–1/82B dated 25 July 1956. A discussion of the permissible operating area for pentodes may be found in paragraph 3.1.3.

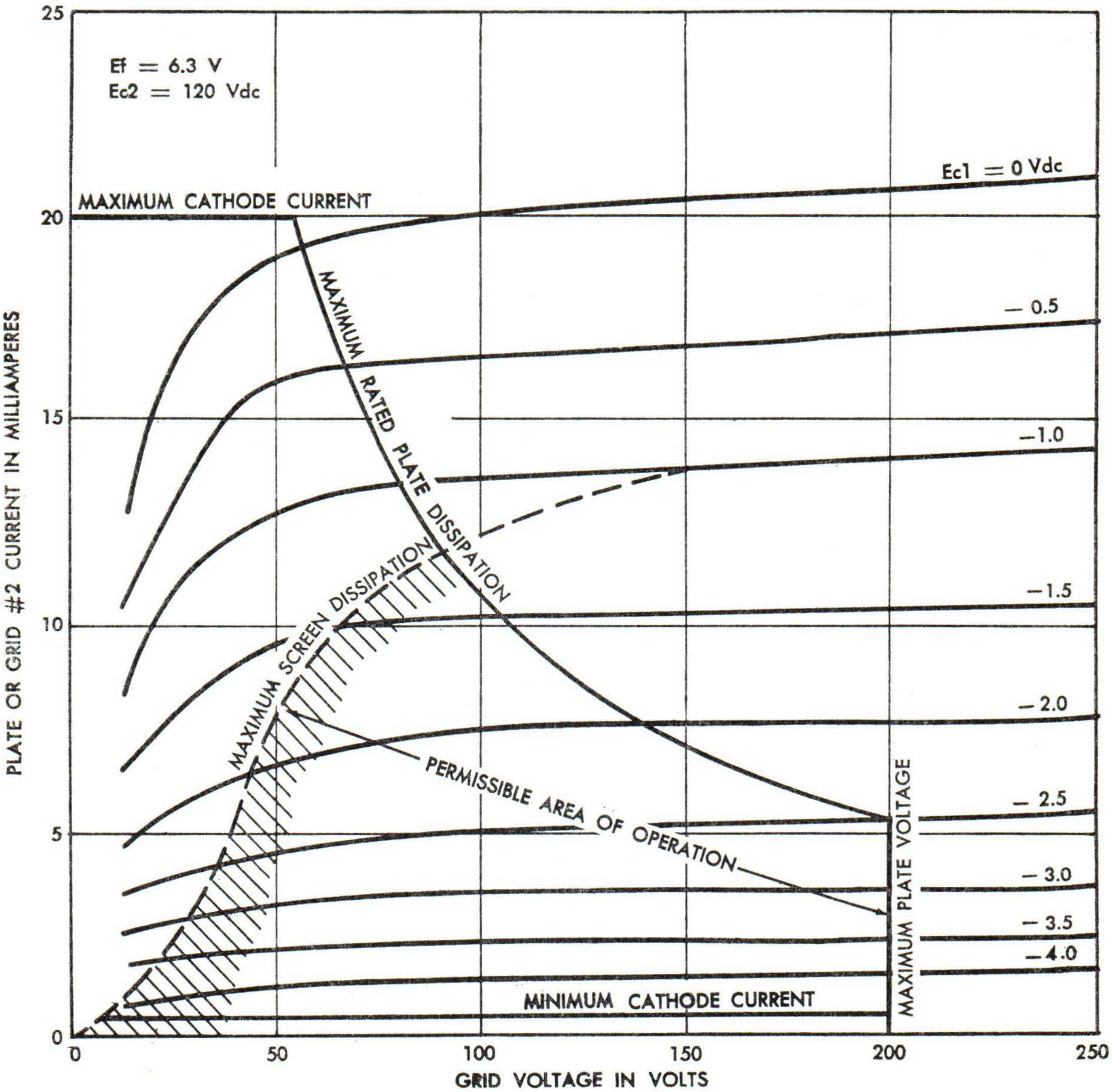


Figure 3-211. Typical Static Plate Characteristics of JAN-5702WA; Permissible Area of Operation.

The chart below presents the limit behavior of static plate characteristics for JAN–5702WA as defined by MIL–E–1/82B dated 25 July 1956.

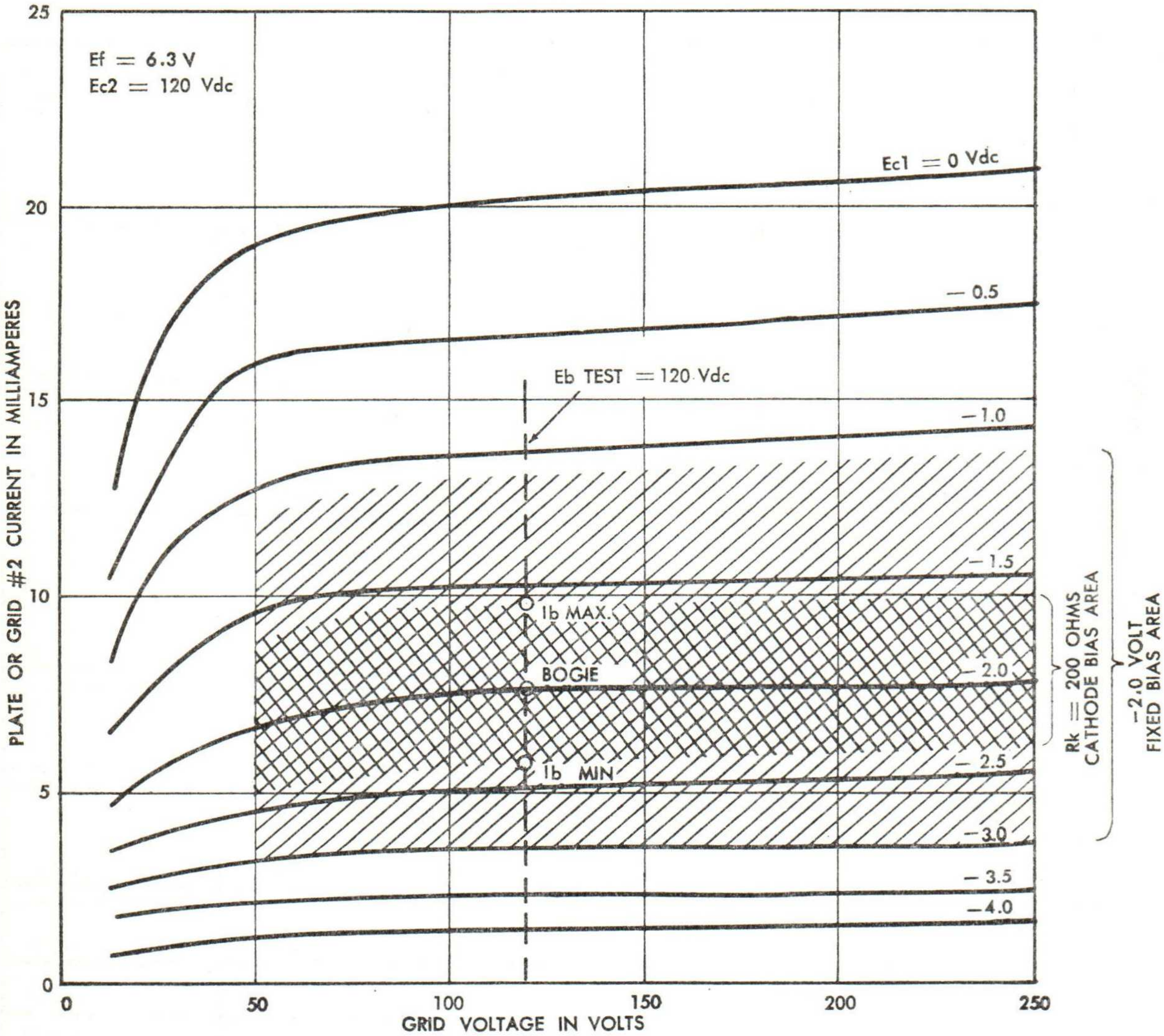


Figure 3-212. Limit Behavior of JAN-5702WA Static-Plate Data; Variability of Ib.

The chart below presents the limit behavior of static Screen Grid characteristics for JAN–5702WA.

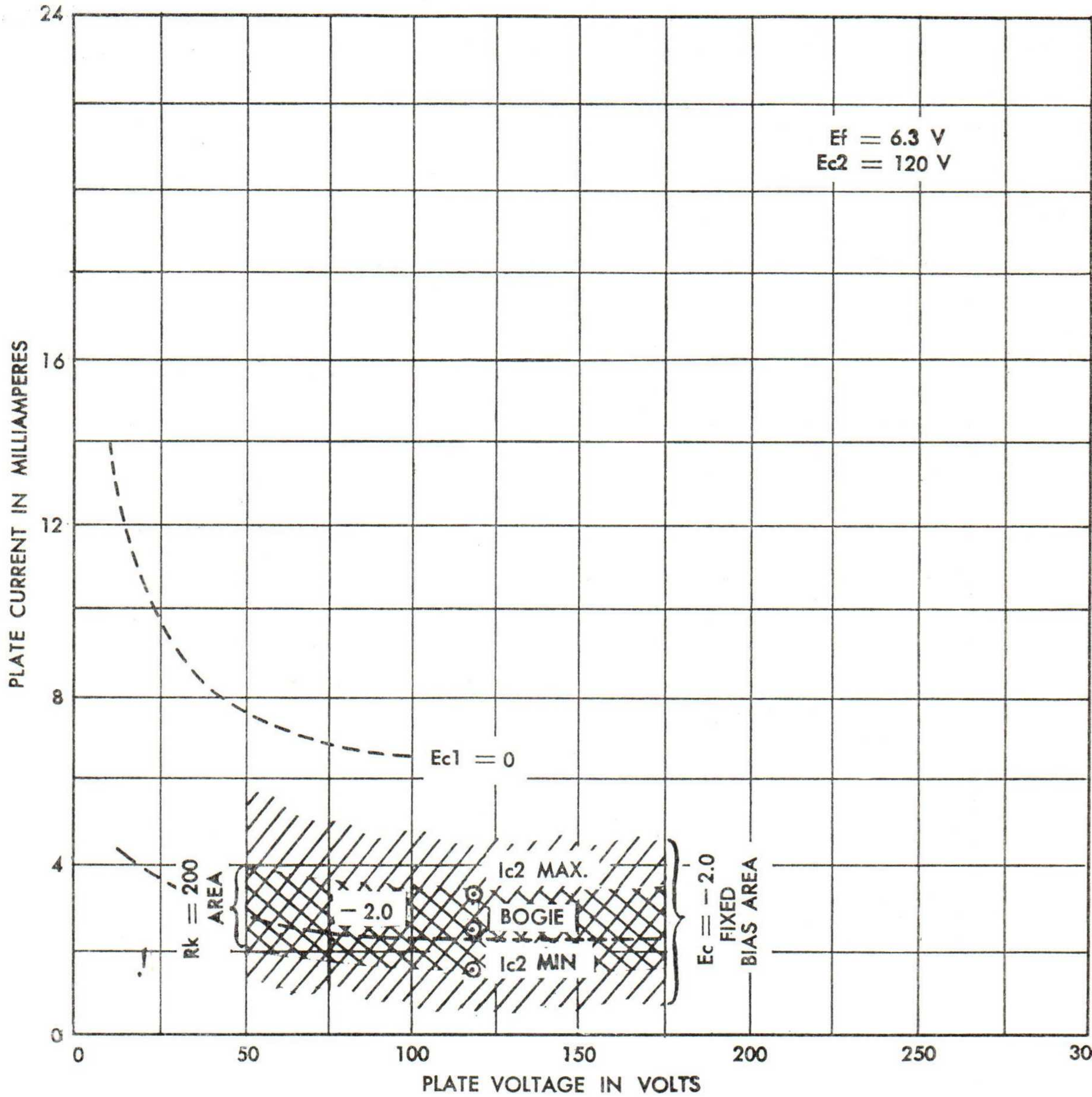


Figure 3-213. Limit Behavior of JAN-5702WA Static -PlateData; Variability of Ic2.

The chart below presents the limit behavior of plate transfer data for JAN–5702WA as defined by MIL–E–1/82B dated 25 July 1956.

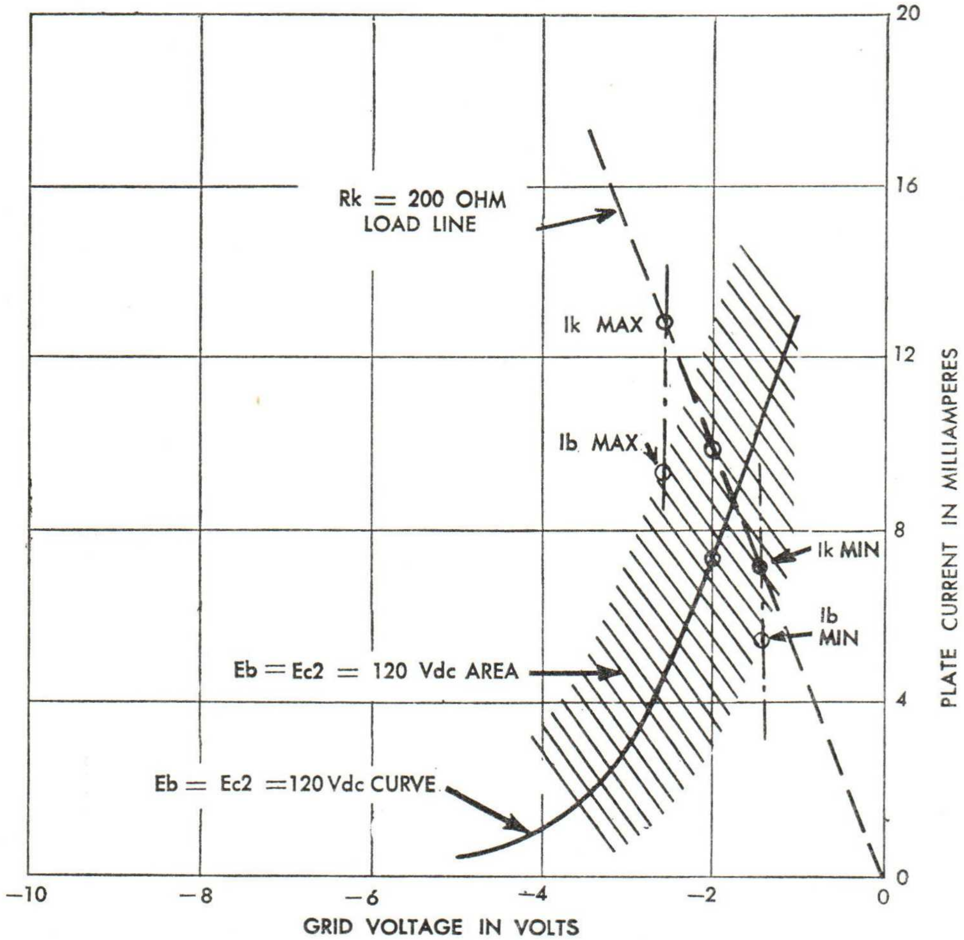


Figure 3-214. Limit Behavior of JAN-5702WA Transfer Data; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN 5702WA

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5702WA.

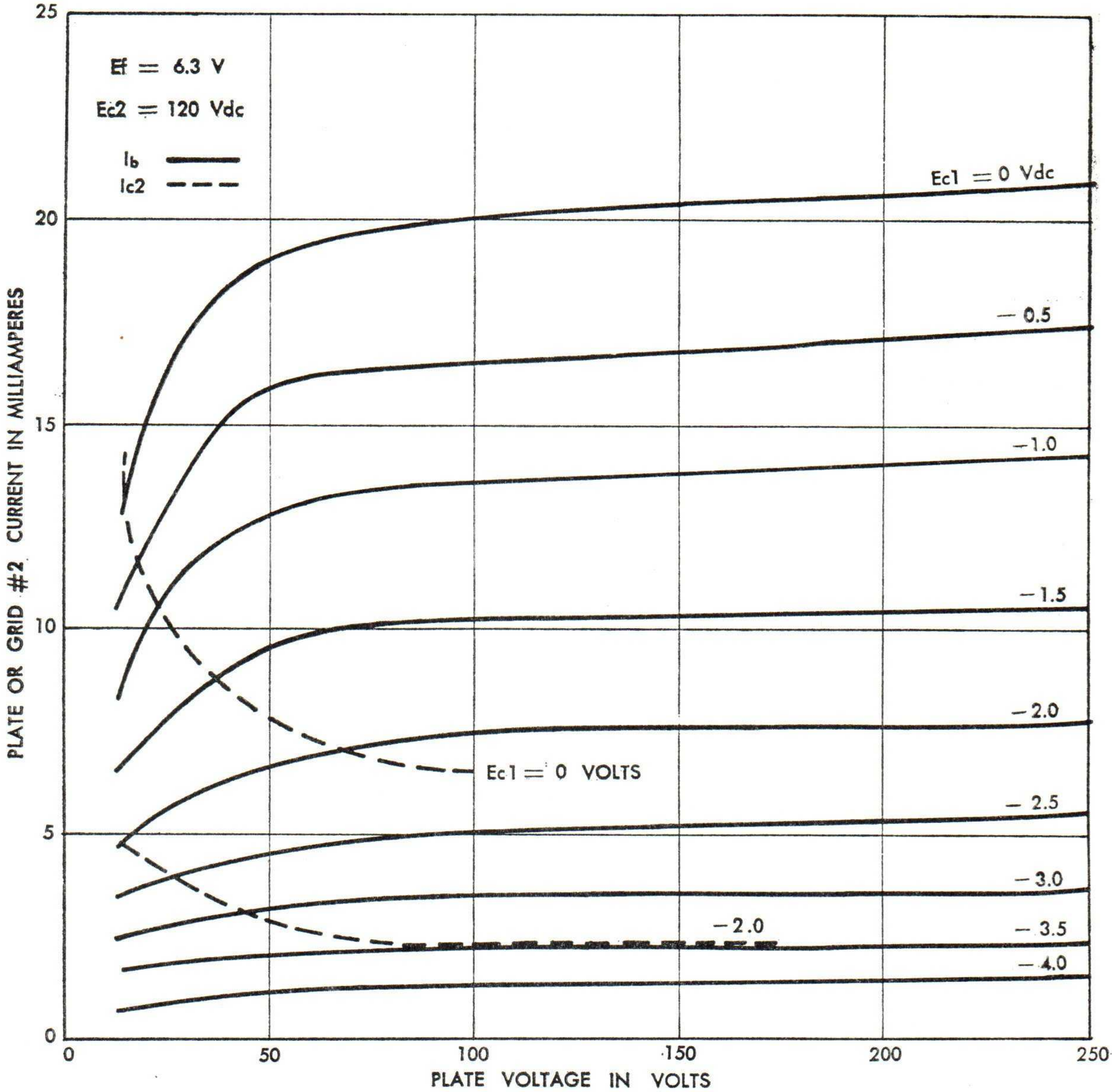


Figure 3-215. Typical Static-Plate Characteristics of JAN-5702WA.

The chart below presents the Typical Plate Transfer Data for JAN-5702WA.

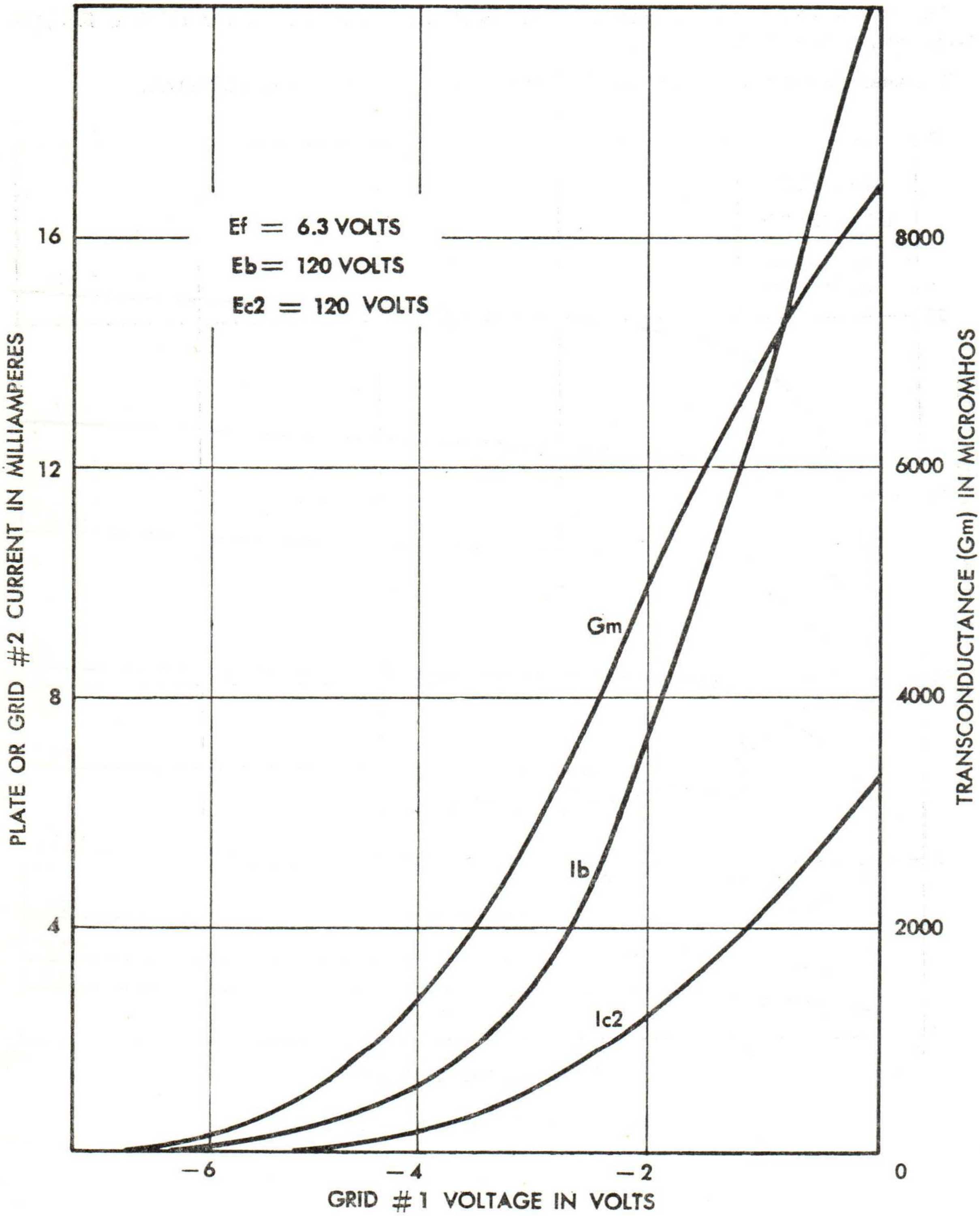


Figure 3-216. Typical Transfer Data for JAN-5702WA; Ec2 = 120.

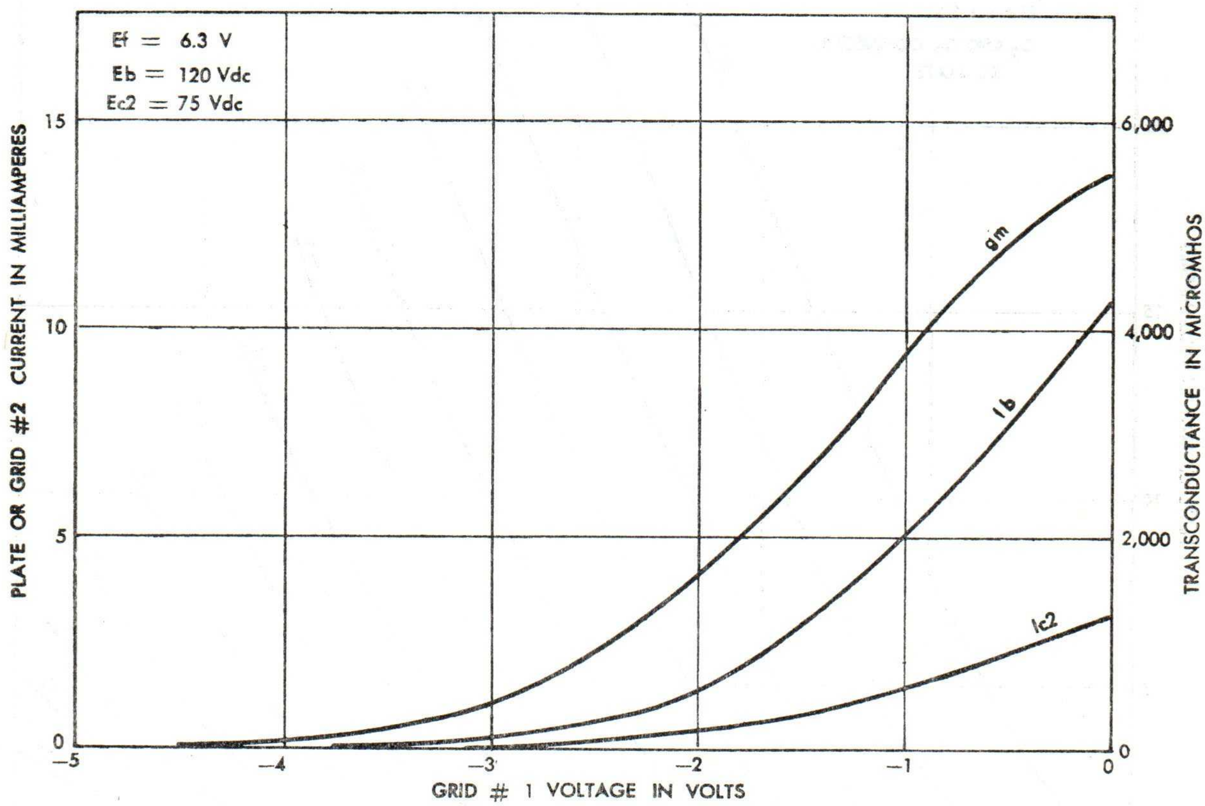


Figure 3-217. Typical Transfer Data for JAN-5702WA; Ec2 = 75 Vdc.

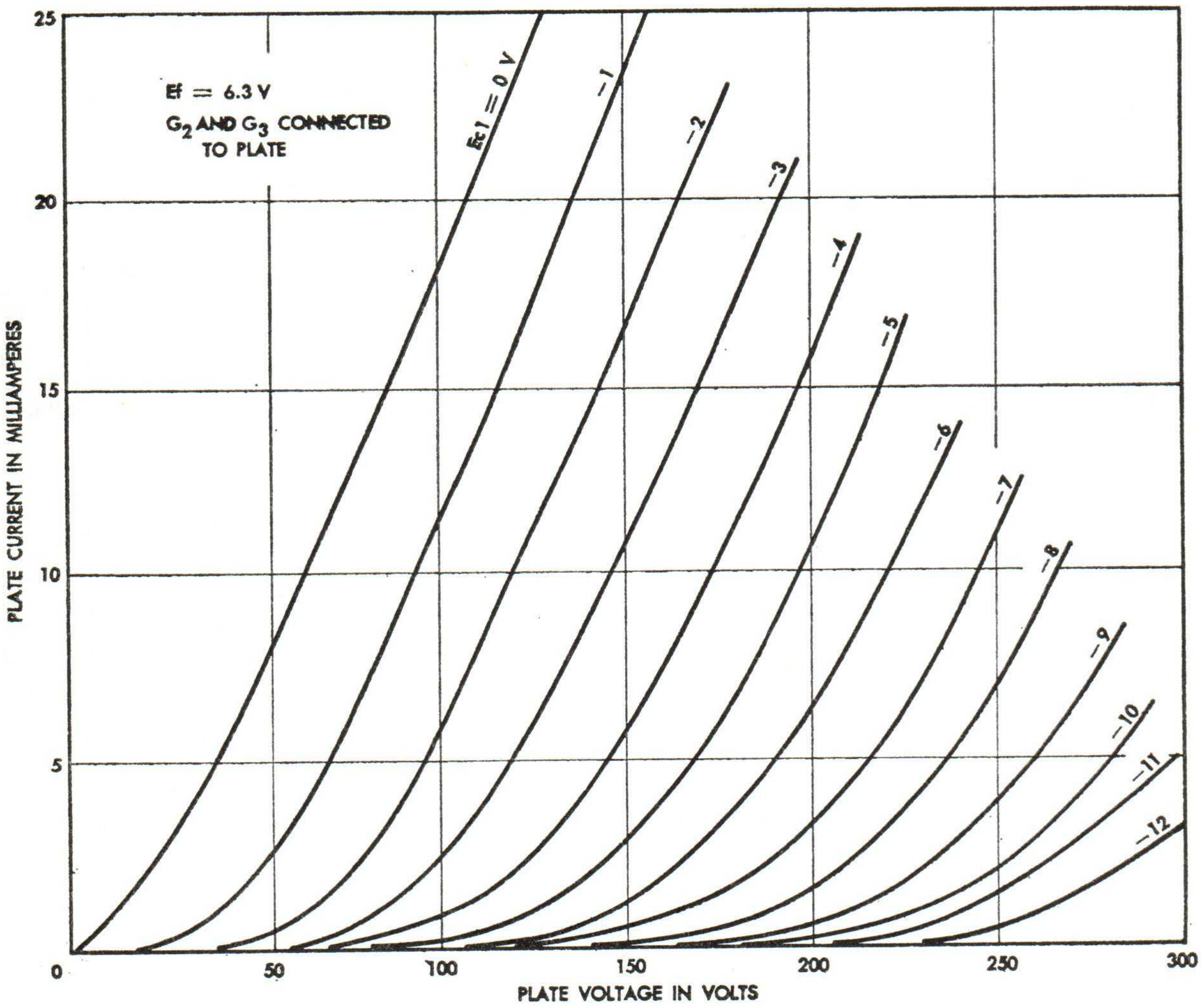


Figure 3-218. Typical Static Plate Characteristics of JAN-5702WA; Triode Connected.

SECTION
TUBE TYPE JAN-5703WA

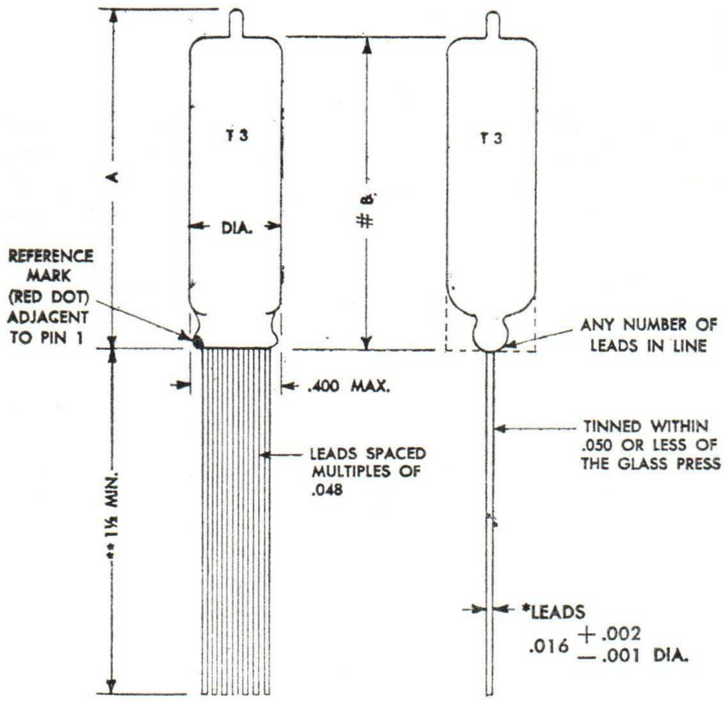
DESCRIPTION.

The JAN-5703WA [1] is a 5 lead, pinch-press subminiature triode having a Mu in the range of 21 to 30 and transconductance of 5100 micromhos. The JAN-5703WA is similar in plate characteristics to the JAN-5718 and the JAN-6111. This tube type has given satisfactory service in a variety of applications including oscillator circuits at 500 Mc.

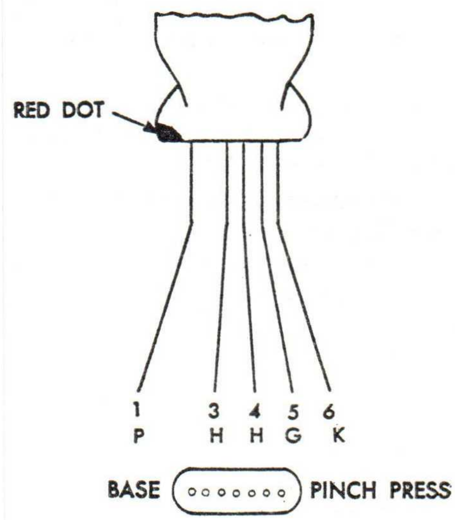
ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 200 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



LEAD CONNECTIONS



DIMENSIONS			
A MAX.	B		DIAMETER MAX
	DIM	TOL. ±	
1.500	1.250	.100	.400

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-219. Outline Drawing and Base Diagram for JAN-5703WA.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.6 V
Plate Voltage .... 200 V
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Plate Dissipation .... 1.35 W
Heater-Cathode .... 200 v

[1] The values and specification comments presented in this section are related to MIL-E-1/293C, dated 17 September 1956.

**Plate Current .... 15 mAdc
*Grid Current .... 5.5 mAdc
Bulb Temperature .... +220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 120 Vdc
Grid Voltage, Ec .... 0 Vdc
Heater-Cathode Voltage, Ehk .... 0 Vdc
Cathode Resistance, Rk .... 220 ohms
Heater Current, If .... 200 mA
Plate Current, Ib .... 9.4 mAdc
Transconductance, Sm .... 5100 umhos

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measument limits are provided. Specification MIL-E-1/293C dated 17 September 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		183	217	177	223	mA
Transconductance (1)	Sm		4200	6000	...	...	umhos
Change in individual	$\Delta \frac{Sm}{t}$		...	...	...	30%	...
Transconductance (2)	Sm	Ef = 5.5 V	...	10%	...	15% (500 hrs)	
Change with Ef	$\Delta \frac{Sm}{Ef}$						
Amplification Factor	Mu		21	30	...	...	...
Plate Current (1)	Ib		6.8	12.0	...	...	mAdc
Plate Current (2)	Ib	Ec = —8.5 Vdc	...	50	...	...	uAdc
Plate Current (3)	Ib	Ec = —5 Vdc	20	...	...	...	uAdc
Power Oscillation	Po	F = 500 Mc; Eb = 150 Vdc Rg/Ib = 20 mAdc	600	...	...	...	mW
Capacitance	Cgp	Ef = 0	.9	1.6	...	...	uuf
(Without Shield)	Cin	Ef = 0	2.0	3.2	...	...	uuf
	Cout	Ef = 0	.5	.9	...	...	uuf
Grid Current (1)	Ic		0	—0.3	0	—1.0	uAdc
Heater-Cathode Leakage							
	Ihk	Ehk = +100	...	5	...	15	uAdc
	Ihk	Ehk = —100		—5	...	—15	uAdc
Insulation of Electrodes							
	R(g-all)	Eg-all = —100 Vdc	100	...	...	...	Meg
	R(p-all)	Ep-all = —300 Vdc	100	...	...	...	Meg

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL CONSIDERATIONS

In addition to the general considerations referenced in the preceding table, the JAN-5703WA as specified by MIL-E-1/293C has additional assurance, initially at least, of radio frequency operation by an acceptance test of oscillation at 500 MC.

APPLICATION OF JAN–5703WA

The chart below shows the permissible operating area for JAN–5703WA as defined by the ratings in MIL–E–1/293C dated 17 September 1956. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2.

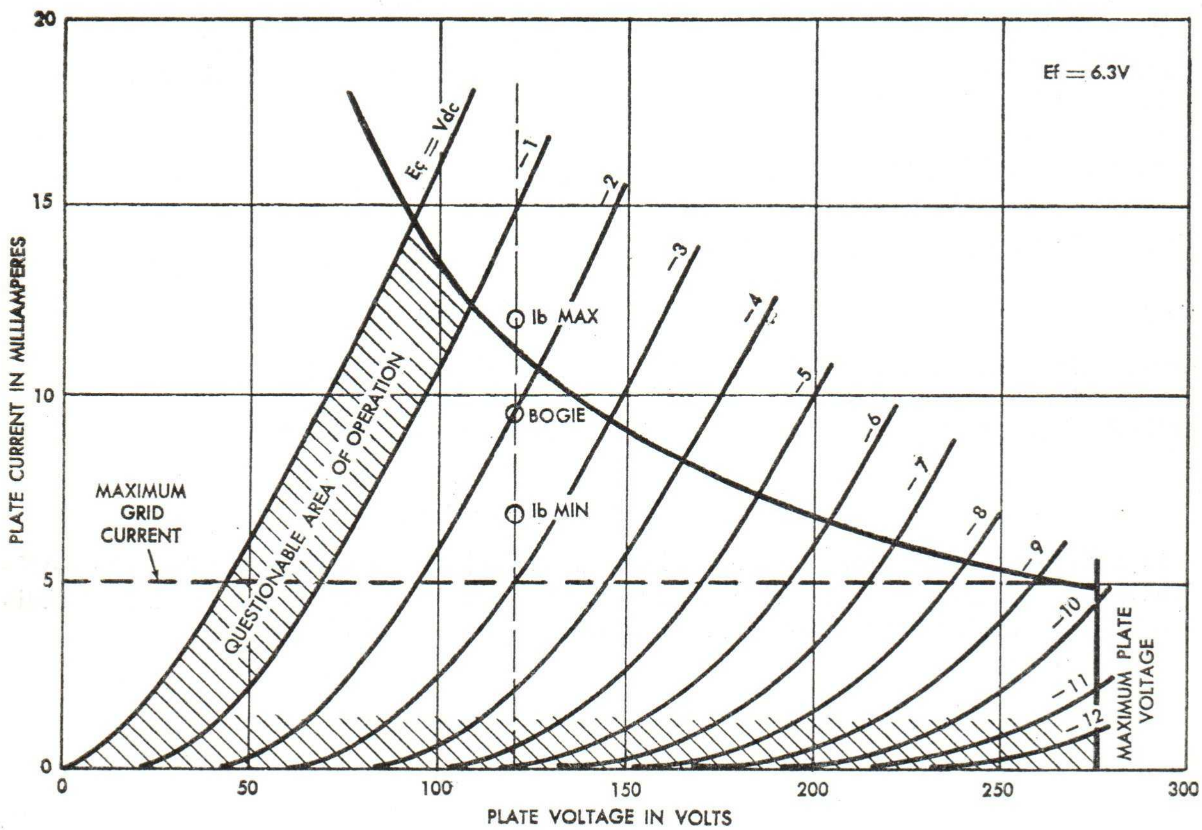


Figure 3-220. Typical StaticPlate Characteristics of JAN-5703WA; Permissible Area of Operation.

VARIABILITY OF JAN-5703WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristics curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5703WA as defined by MIL-E-1/293C dated 17 September 1956.

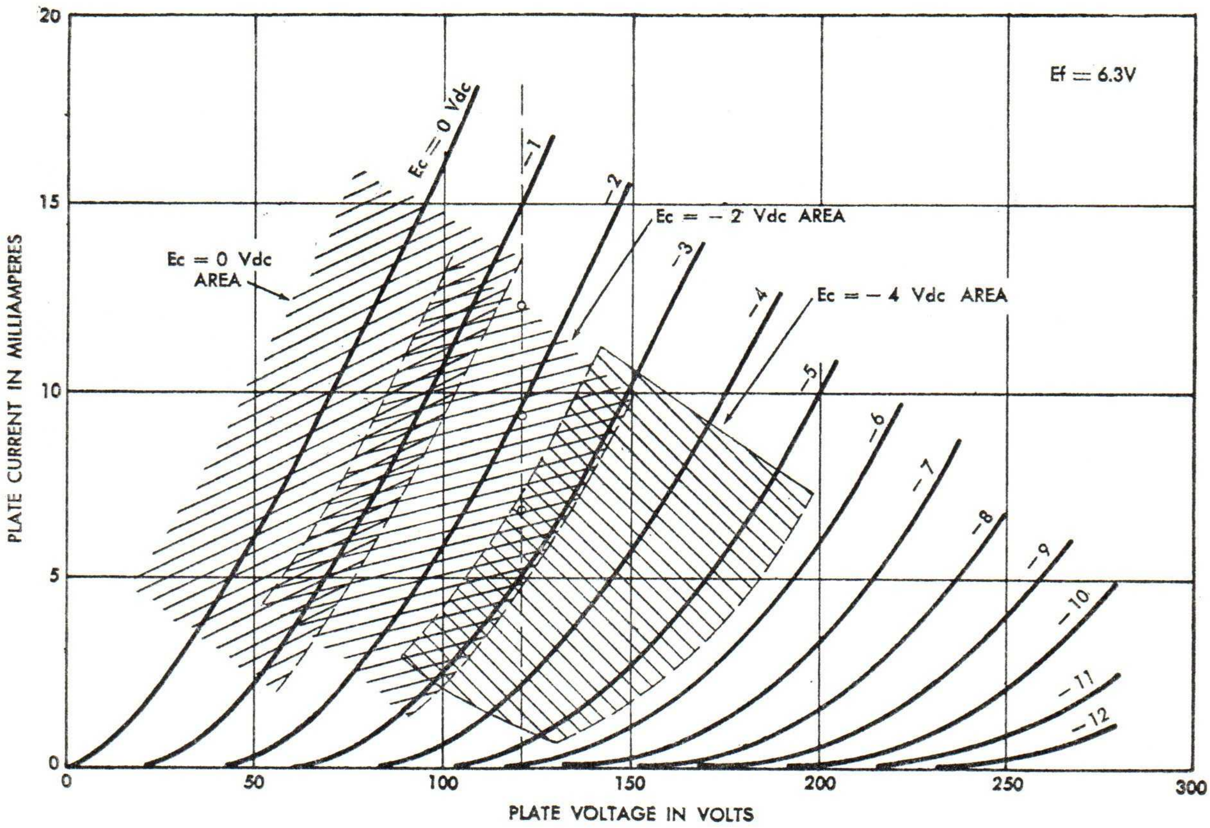


Figure 3-221. Limit Behavior of JAN-5703WA Static-Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5703WA as defined by MIL-E-1/293C dated 17 September 1956.

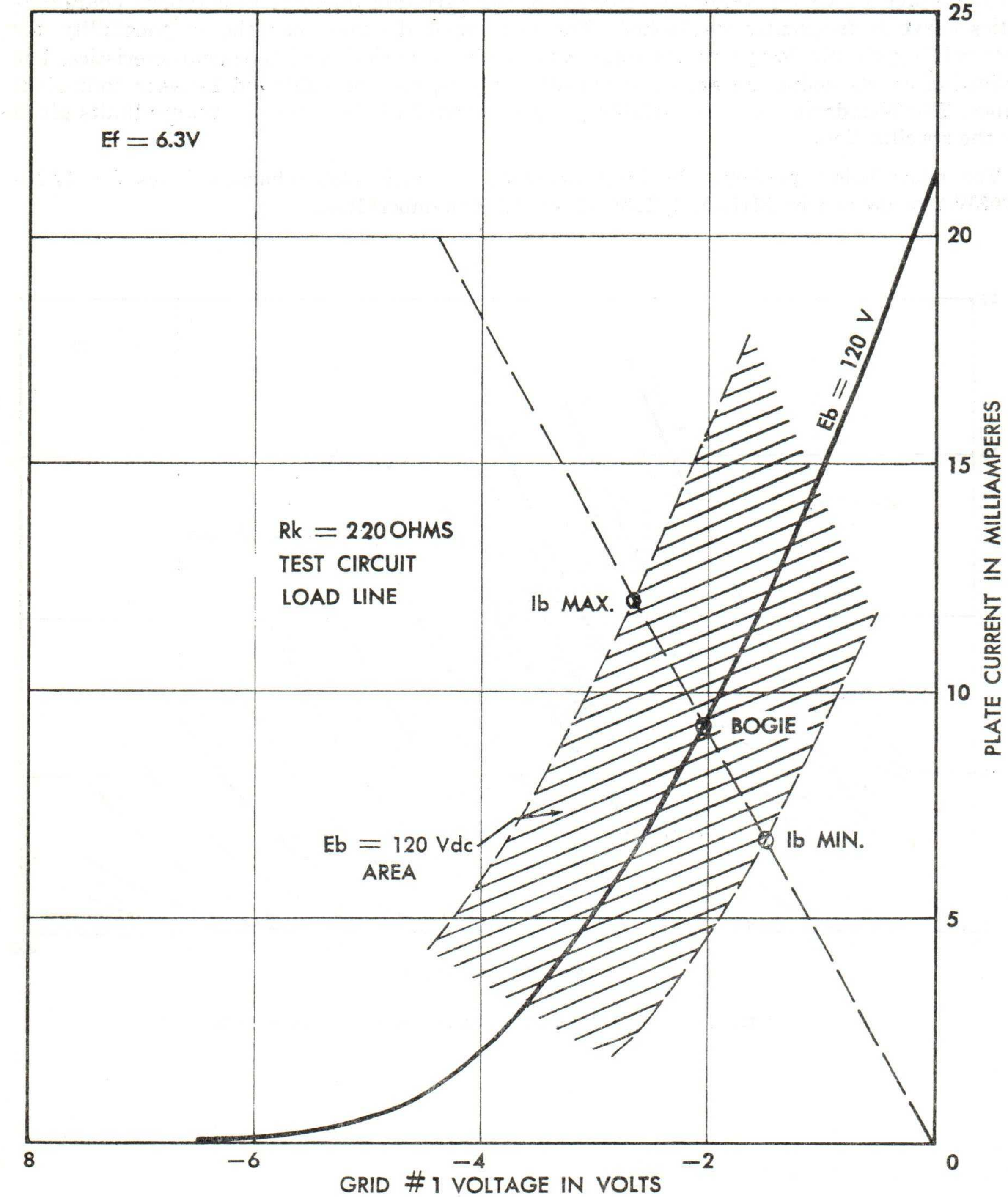


Figure 3-222. Limit Behavior of JAN-5703WA; Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-5703WA

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristicsof JAN-5703WA.

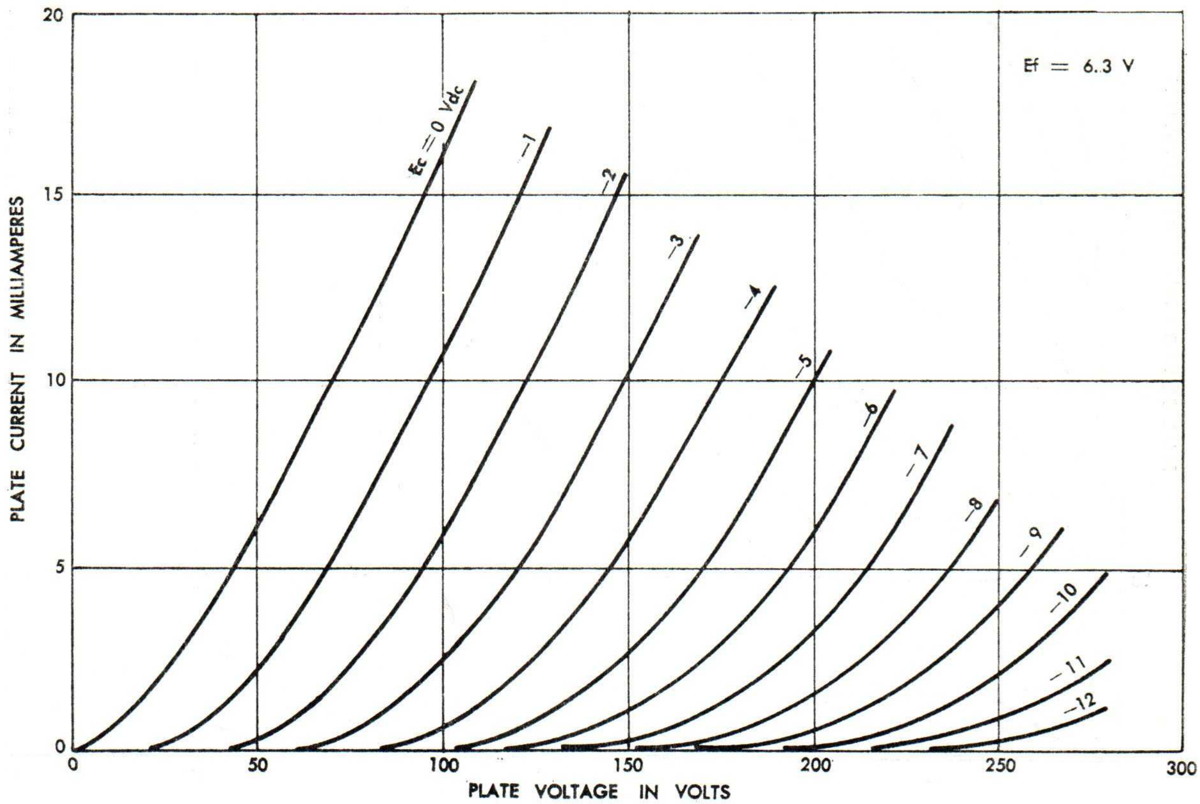


Figure 3-223. Typical Static-Plate Characteristics of JAN-5703WA.

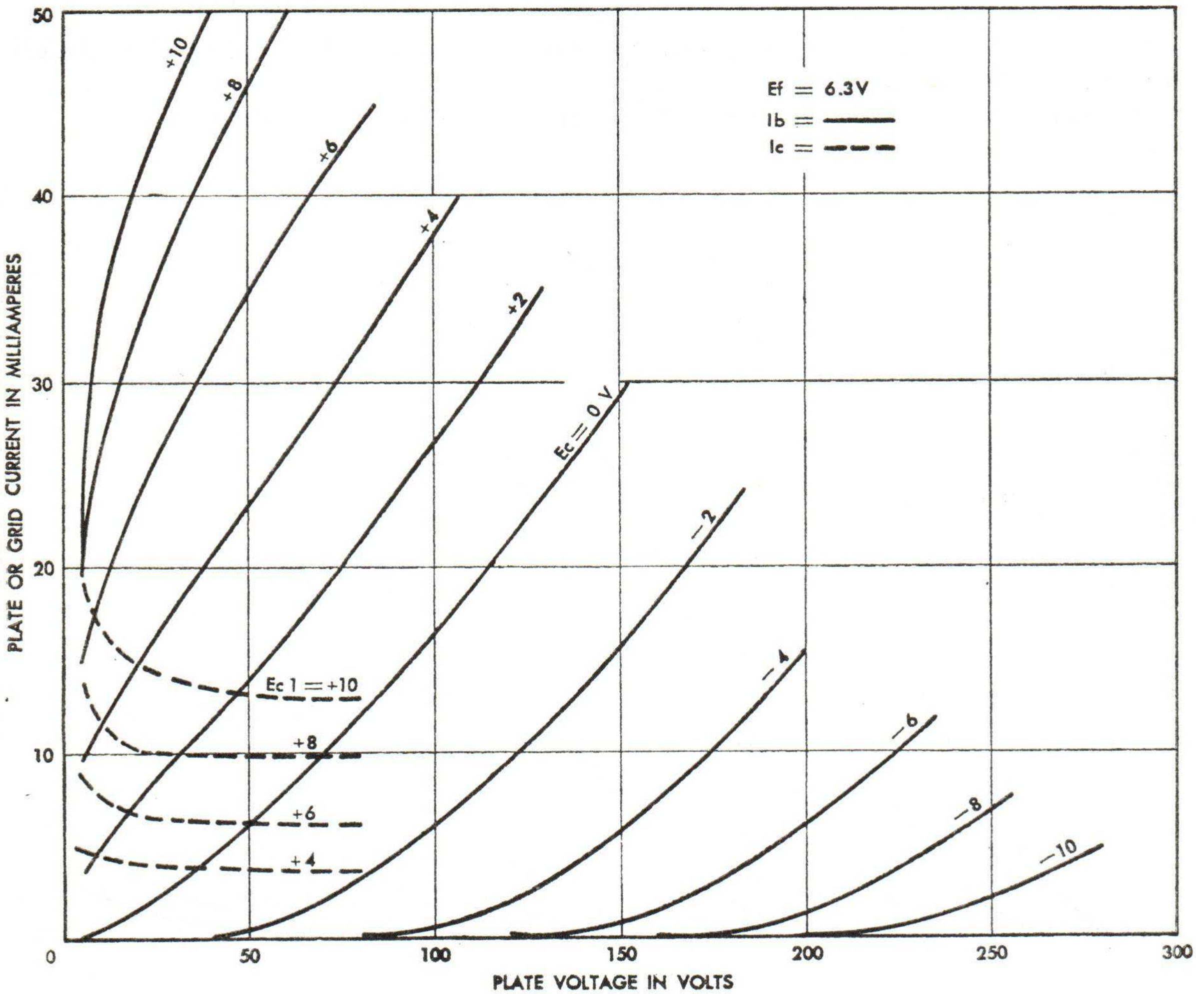


Figure 3-224. Typical Static-Plate Characteristics for JAN-5703WA; Positive Grid Region.

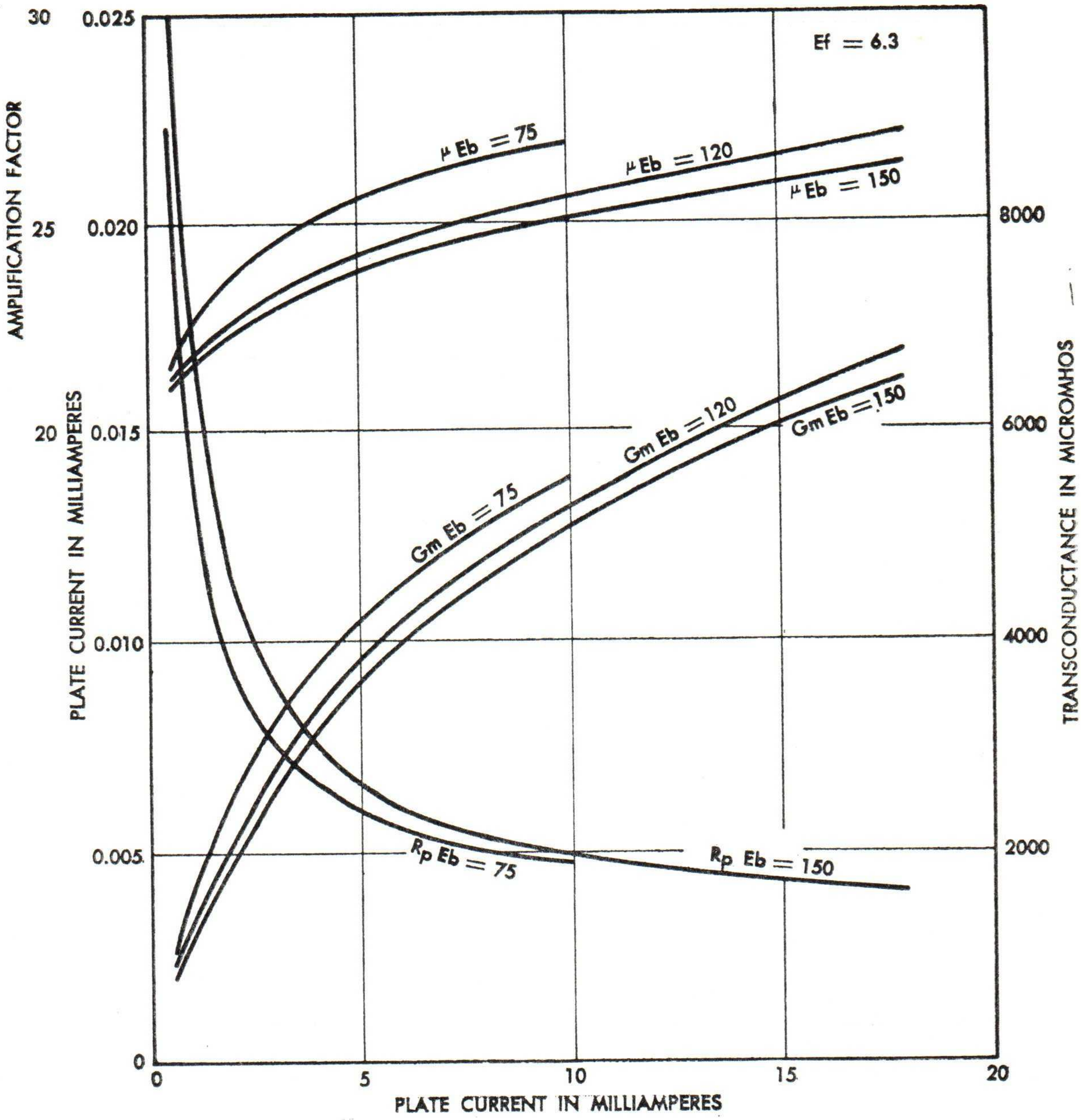


Figure 3-225. Typical Characteristics of JAN-5703WA; Functions of Ib.

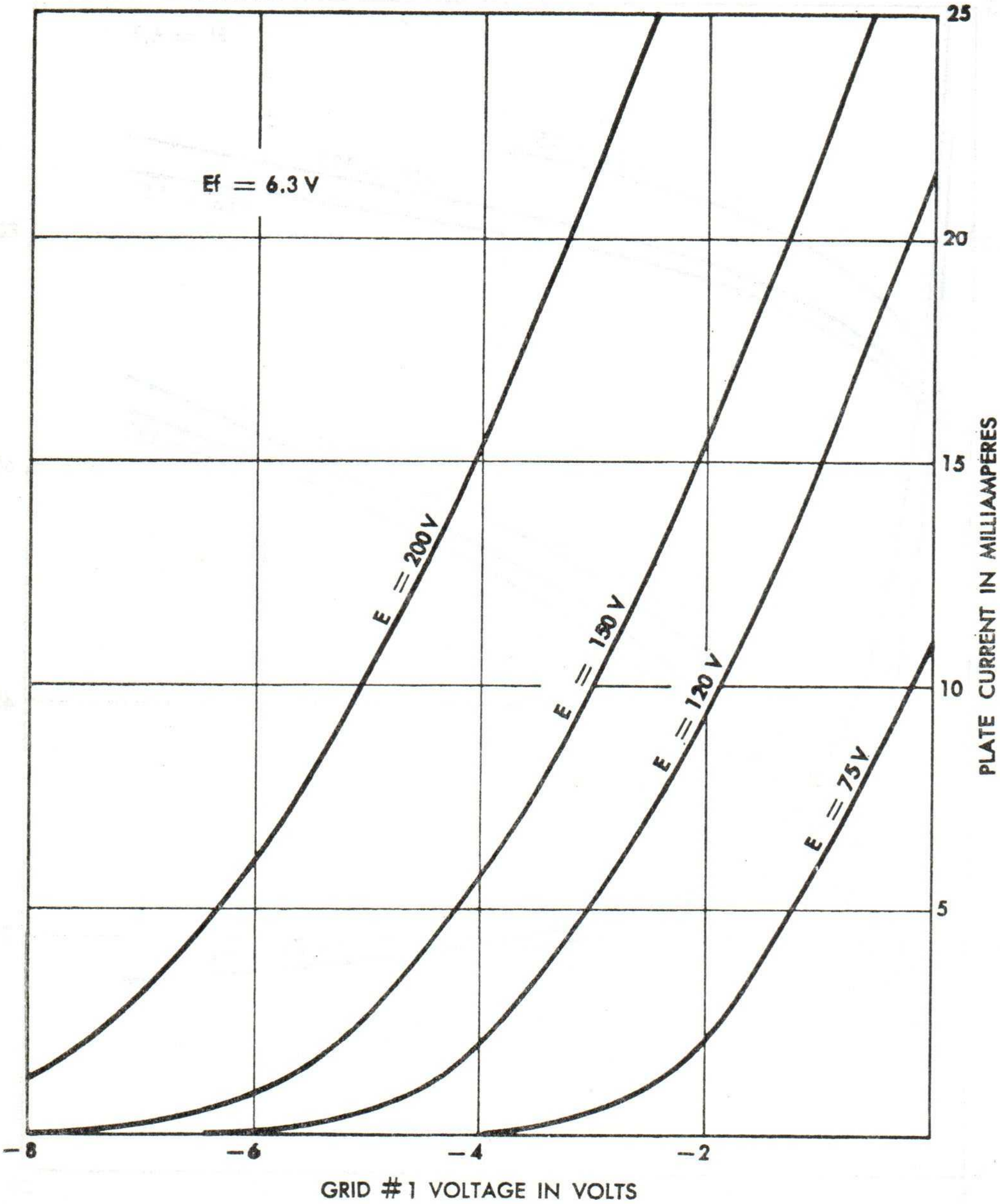


Figure 3-226. Typical Transfer Data for JAN-5703WA.

SECTION

TUBE TYPE JAN-5718

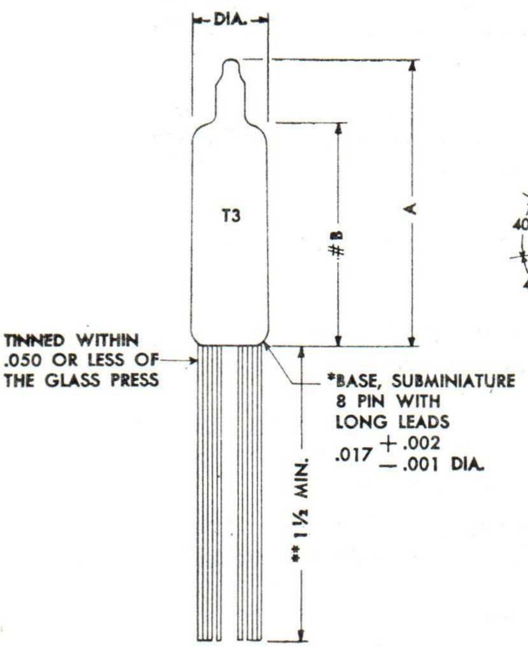
DESCRIPTION

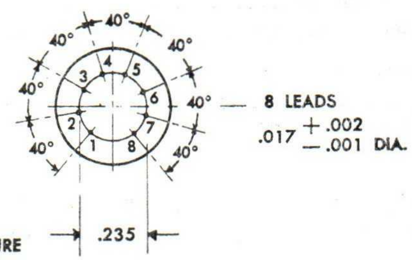
The JAN-5718 [1] is an 8 lead, button-base subminiature triode having a Mu in the range of 23 to 31 and design center transconductance of 5800. The JAN-5718 is similar in plate characteristics to the JAN-5897. Each of these types has found satisfactory service in amplifier, 500 mc oscillator, and other general purpose triode applications.

ELECTRICAL. The electrical characteristics are as follows:

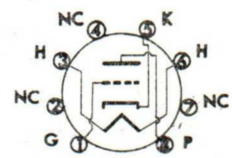
Heater Voltage	6.3 V
Heater Current, Design Center	150 mA
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.





LEAD CONNECTIONS



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.375	1.075	.060	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-227. Outline Drawing and Base Diagram of JAN-5718.

[1] The values and specification comments presented in this Section are related to MIL-E-1/172B dated 5 August 1955.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 0.3 V
Plate Voltage	165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Grid Voltage, Maximum	0 Vdc
Grid Voltage, Minimum	—55 Vdc
Heater-Cathode Voltage	200 v
Grid Series Resistance	1.2 Meg
**Plate Current	22.0 mAdc
*Grid Current	5.5 mAdc
Plate Dissipation	0.9 W
Bulb Temperature	+220° C
Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	100 Vdc
Grid Voltage, Ec	0 Vdc
Heater-Cathode Voltage, Ehk	0 v
Cathode Resistance, Rk	150 ohms
Heater Current, If	150 mA
Plate Current, Ib	8.5 mAdc
Transconductance, Sm	5800 umhos

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
  High, 3.1.5
  Low, 3.1.5
  AC Operation, 1.3.3, 3.1.5
  28 Volt, 3.1.5
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.1.2
  Cathode, 2.1.1, 3.1.5
  Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Dissipation
Plate, 2.1, 3.1.4

Current
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature
Bulb and Environmental, 3.1.4

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Miscellaneous
Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL CONSIDERATIONS

In addition to the general considerations referenced in the preceding table, the JAN-5718, as specified by MIL-E-1/172B, has initial assurance of radio frequency operation by an acceptance test of oscillation at 500-Mc.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/172B dated 5 August 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		140	160	138	164	mA
Transconductance (1)	Sm		4800	6800	...	...	umhos
Change in individual	Δ Sm/t		...	...	...	20	%
Transconductance (2)	Δ Sm/Ef		...	10	...	15	%
Amplification Factor	Mu		23	31	...	...	...
Plate Current (1)	Ib		6.0	11.0	...	...	mAdc
Plate Current (2)	Ib	Ec = —7,0 Vdc; Rk = O	...	100	...	...	uAdc
Plate Current (3)	Ib	Ec = —4.0 Vdc; Rk = O	20	...	...	...	uAdc
Power Oscillation	Po	F = 500 Mc; Eb = 150 Vdc Rg/Ib = 20 mAdc	600	...	...	...	mW
Capacitance	Cgp	Ef = O	1.1	1.8	...	...	uuf
(Without shield)	Cin	Ef = O	1.6	2.8	...	...	uuf
	Cout	Ef = O	0.5	0.9	...	...	uuf
Grid Current	Ic	Eb = 150 Vdc, Rk = 380 ohms Rg = 1.0 Meg	0	—0.4	0	—0.6	uAdc
Grid Emission	Ic	Ef = 7.5 V; Ec = —7.0 Vdc; Rg = 1.0 Meg	0	—0.4	...	...	uAdc
Heater-Cathode	Ihk	Ehk = +100 Vdc	...	5	...	10	uAdc
Leakage	Ihk	Ehk = —100 Vdc	...	—5	...	—10	uAdc
Insulation of	R(g-all)	Eg-all = —100 Vdc	100	...	50	...	Meg
Electrodes	R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg

APPLICATION OF JAN–5718

The chart below shows the permissible operating area for JAN–5718 as defined by the ratings in MIL–E–1/172B dated 5 August 1955. A discussion of the permissible operating area for triodes pentodes may be found in paragraphs 3.1.2.

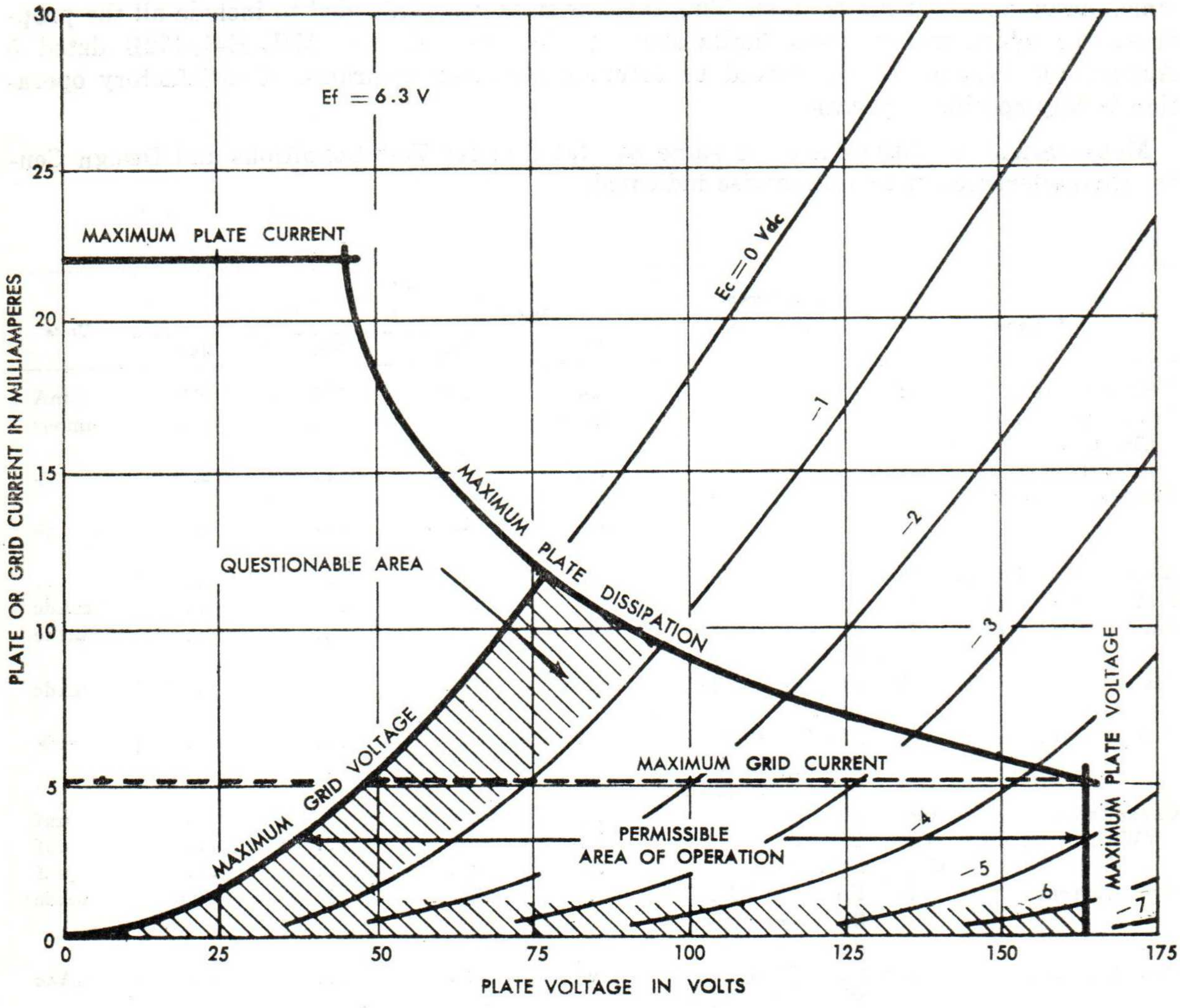


Figure 3-228. Typical Static Plate Characteristics of JAN-5718; Permissible Area of Operation.

VARIABILITY OF JAN-5718 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5718 as defined by MIL-E-1/172B dated 5 August 1955.

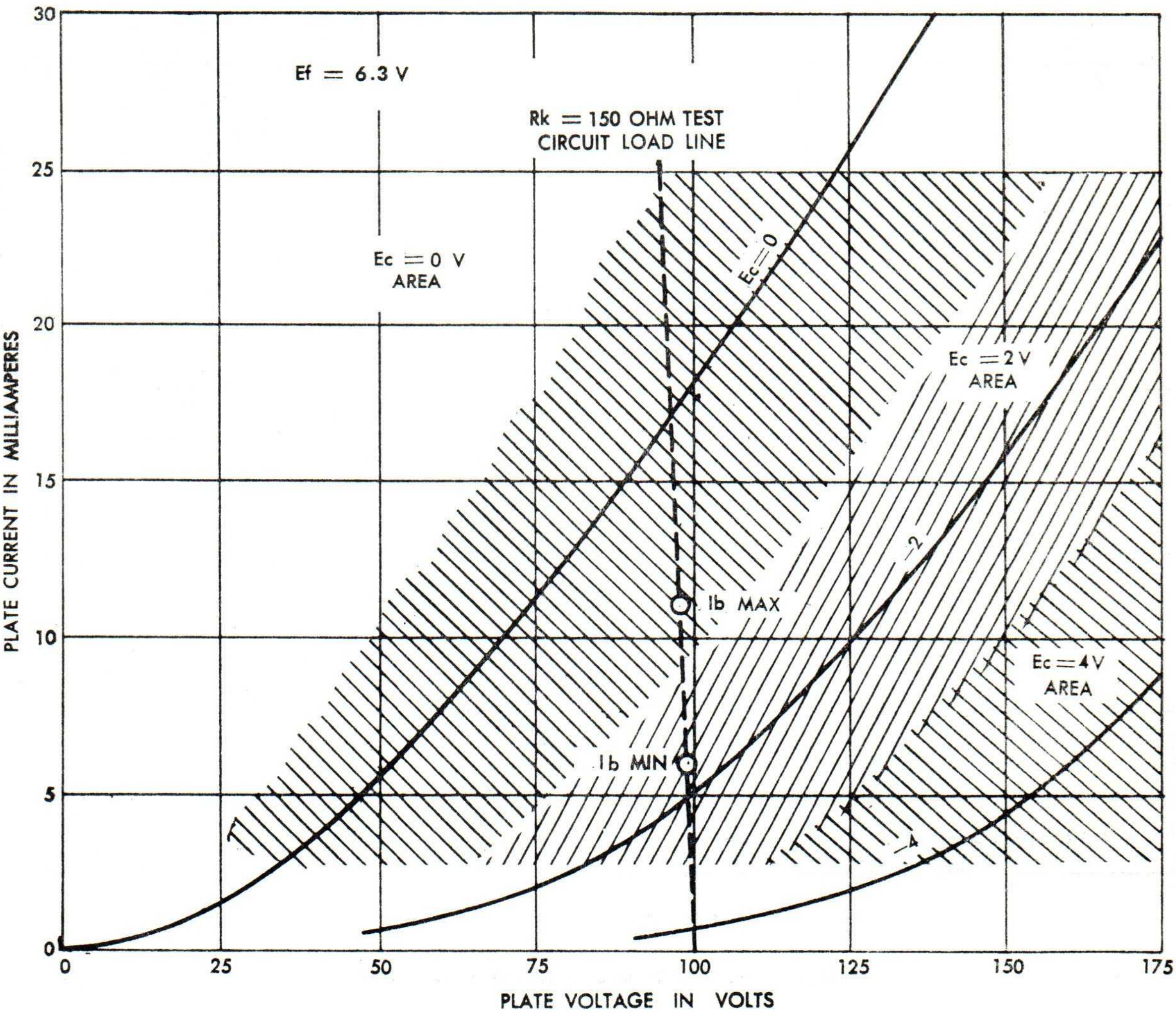


Figure 3-229. Limit Behavior of JAN-5718; Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5718 as defined by MIL-E-1/172B dated 5 August 1955.

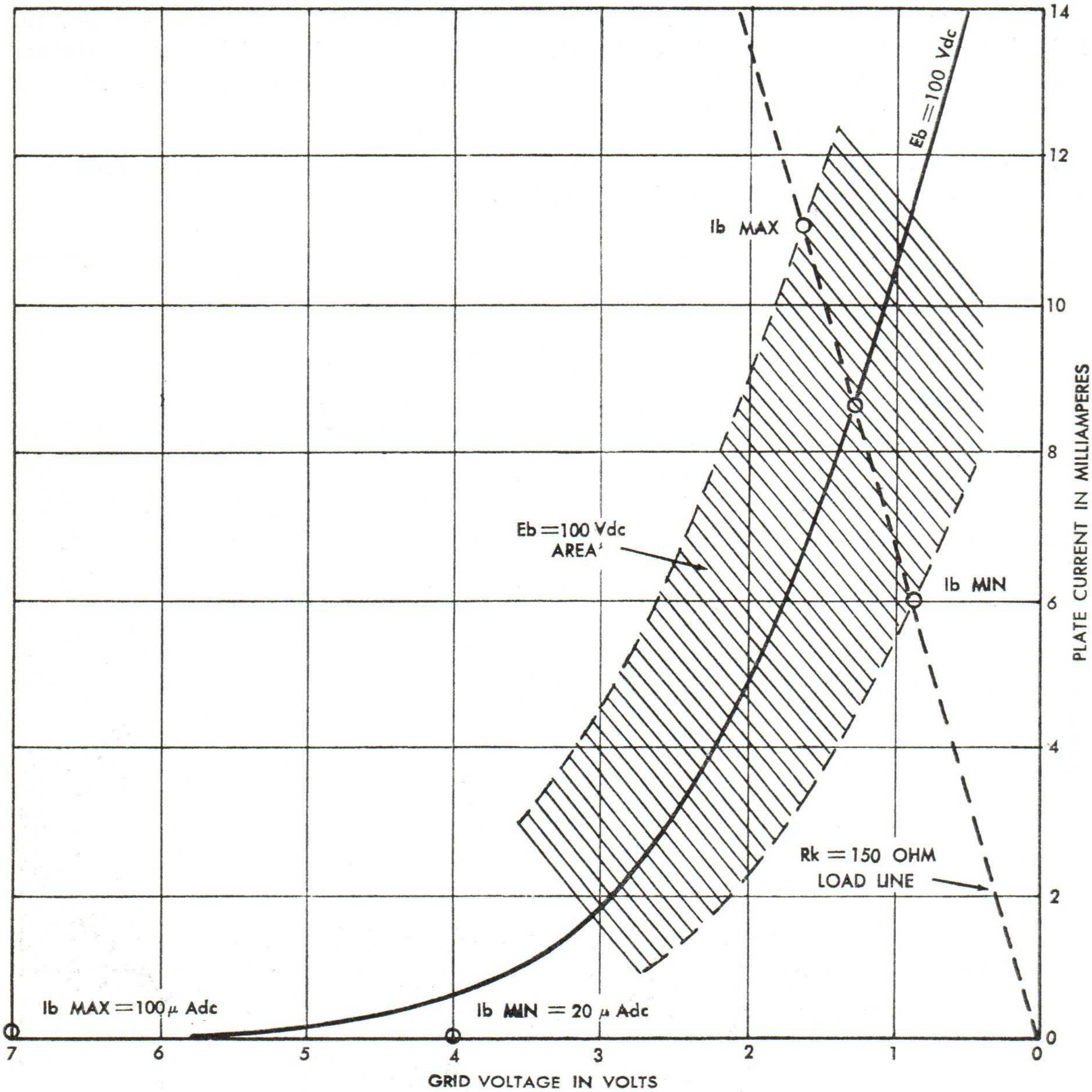


Figure 3-230. Limit Behavior of JAN-5718 Transfer Data.

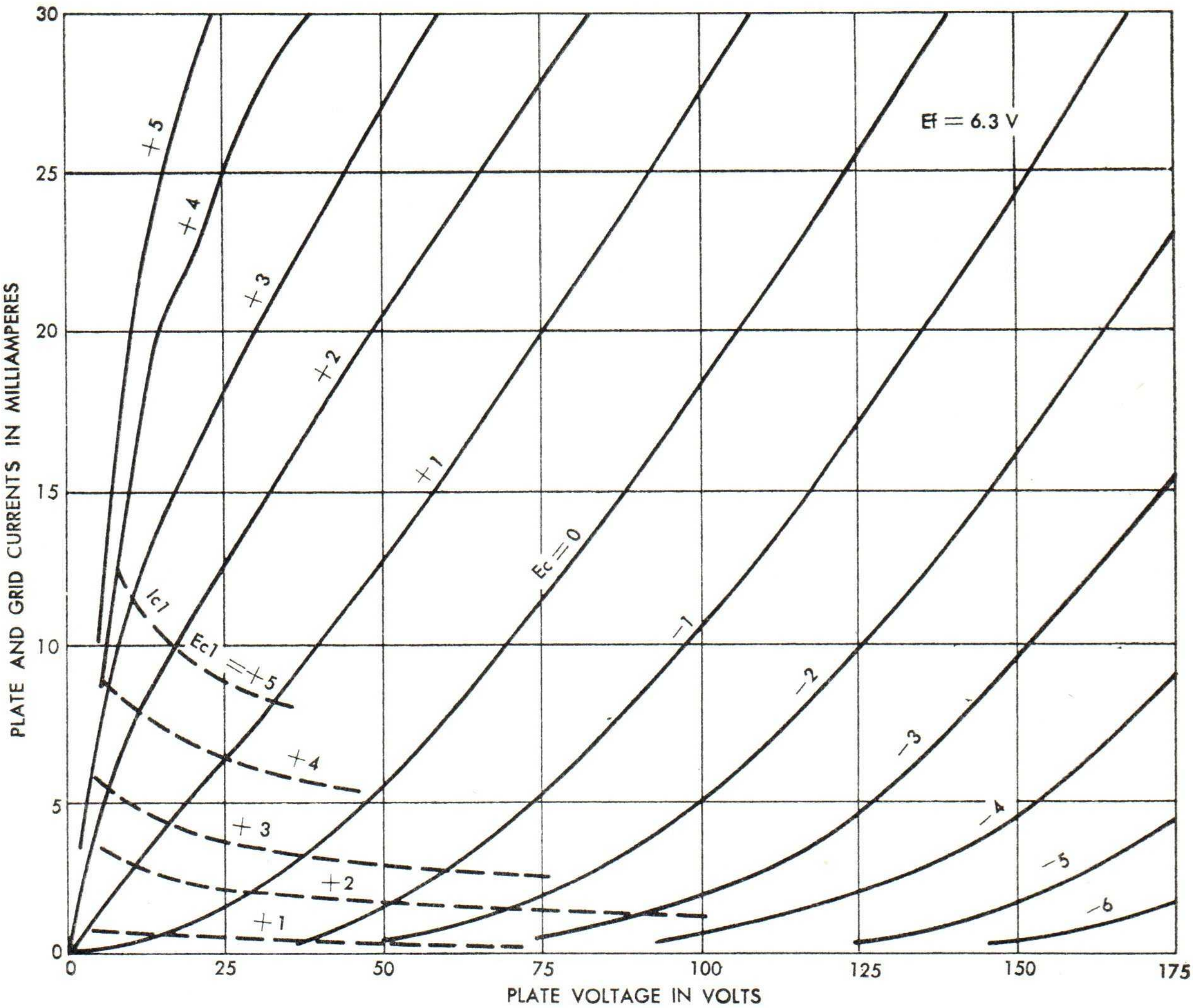


Figure 3-231. Typical Static Plate Characteristics of JAN-5718.

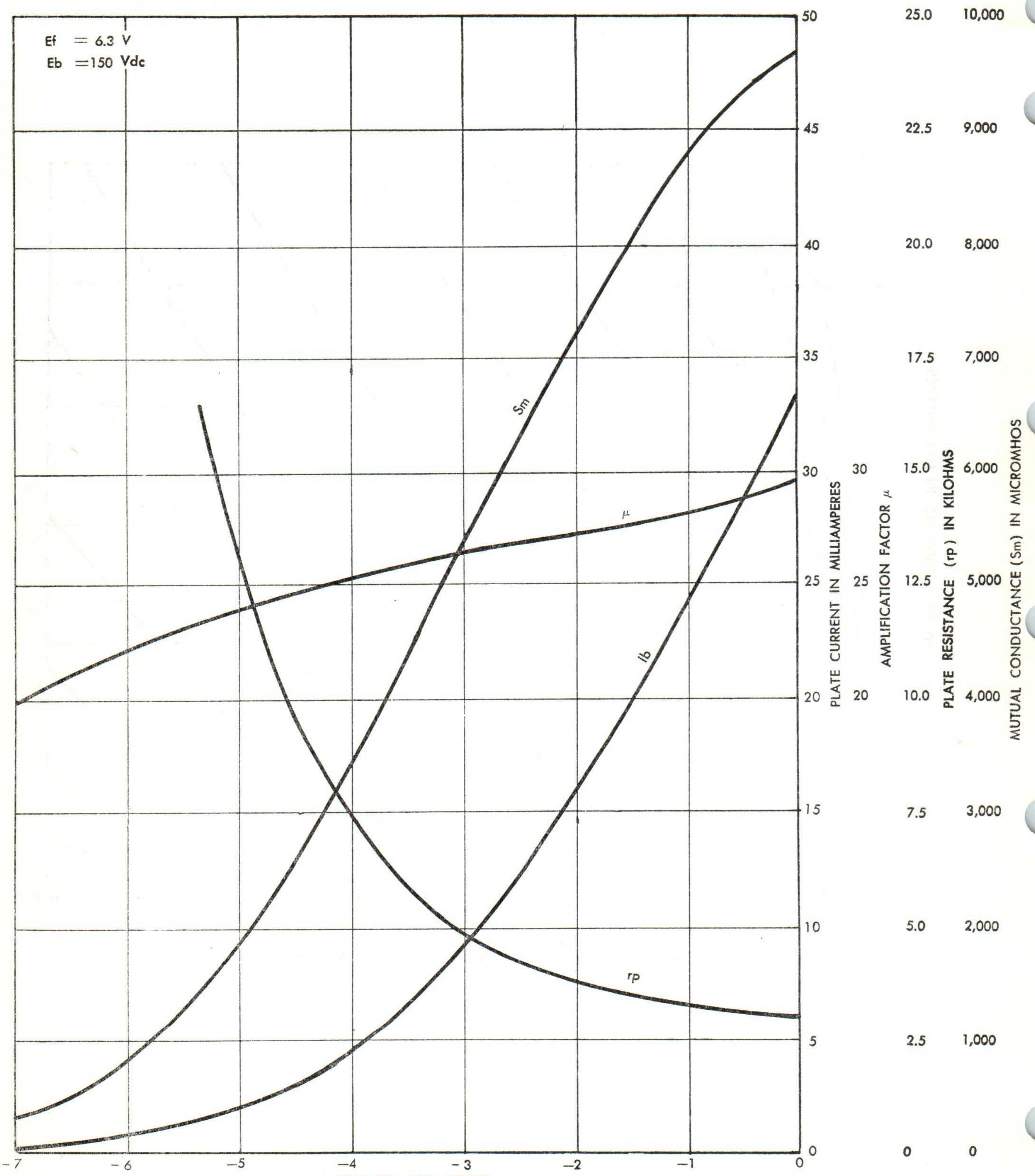


Figure 3-232. Typical Transfer Characteristics for JAN-5718; Eb = 150V and 100V.

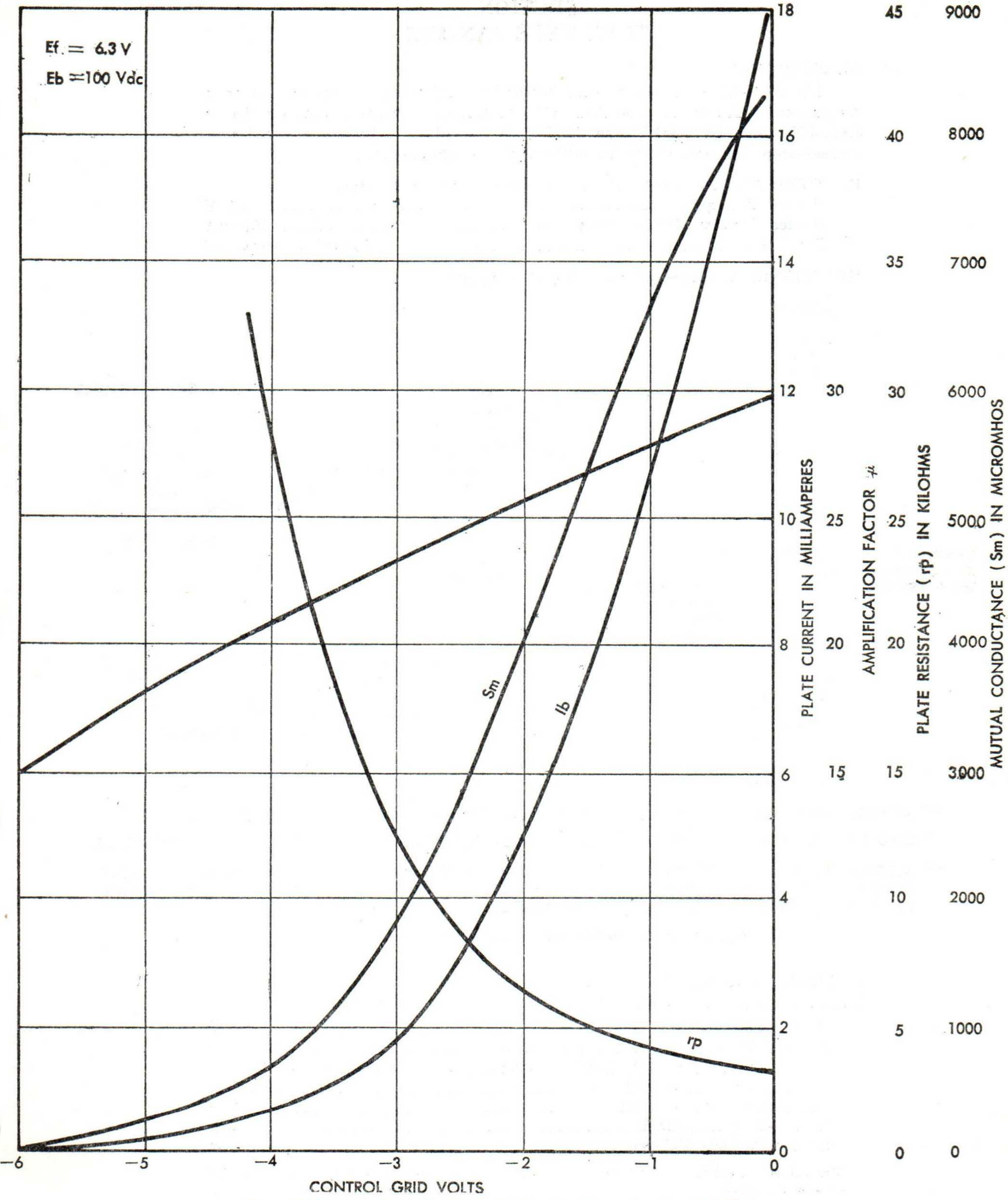


Figure 3-233. Typical Transfer Characteristics Sm, Mu, and rp for JAN-5718.

SECTION
TUBE TYPE JAN–5719

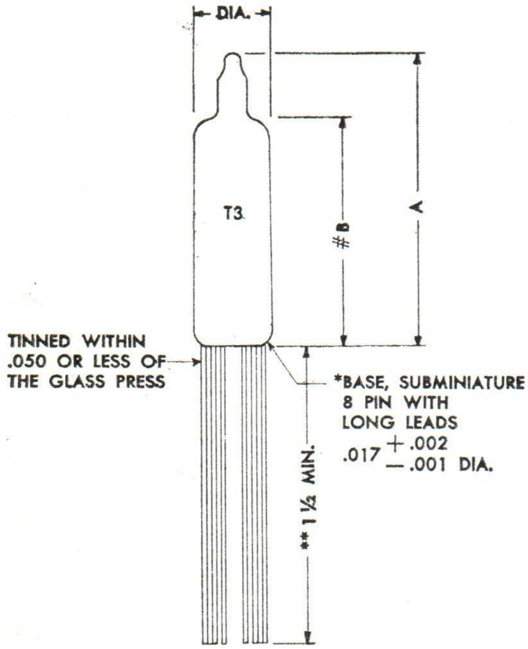
DESCRIPTION.

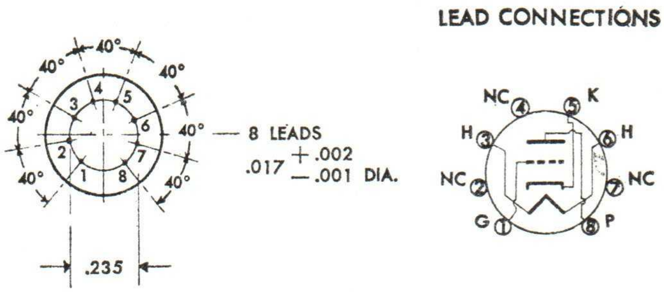
The JAN–5719 [1] is an 8 lead, button-base subminiature triode having a design center Mu of 70. The JAN–5719 is similar in plate characteristics to JAN–5751 and JAN–6112. The JAN–5719 has given satisfactory service in voltage-amplifier and other low-current triode applications.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	150 mA
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.





DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.375	1.075	.060	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-234. Outline Drawing and Base Diagram of JAN-5719.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 0.3 V
Plate Voltage	165 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage, Maximum	0 Vdc
Control Grid Voltage, Minimum	—55 Vdc
Grid Series Resistance	1.2 Meg
Heater–Cathode Voltage	200 v

[1] The values and specification comments presented in this Section are related to MIL-E-1/173C dated 5 August 1955.

*Plate Current .... 3.3 mAdc
Plate Dissipation .... 0.10 W
Bulb Temperature .... +220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 100 Vdc
Heater-Cathode Voltage .... 0 v
Cathode Resistance, Rk .... 1500 ohms
Heater Current, If .... 150 mA
Transconductance, Sm .... 1700 umhos
Amplification Factor, Mu 70

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/173C dated August 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		140	160	138	164	mA
Transconductance (1)	Sm		1400	2000	...	...	umhos
Change in individual	$\Delta \frac{Sm}{t}$		...	...	...	20	%
Transconductance (2)	$\Delta \frac{Sm}{Ef}$		...	10	...	15	%
Amplification Factor	Mu		60	80	...	...	...
Plate Current (1)	Ib		0.50	0.90	...	...	mAdc
Plate Current (2)	Ib	Ec = —2.5 Vdc	...	50	...	...	uAdc
Plate Current (3)	Ib	Ec = —1.8 Vdc	5	...	...	...	uAdc
Capacitance	Cgp	Ef = 0	0.6	1.0	...	...	uuf
	Cin	Ef = 0	1.2	2.2	...	...	uuf
(Without shield)	Cout	Ef = 0	0.4	0.8	...	...	uuf
Grid Current	Ic	Eb = 150 Vdc; Rk = 2700 Rg = 1.0 Meg	0	—0.3	0	—.6	uAdc
Heater-Cathode Leakage							
	Ihk	Ehk = 100 Vdc	...	5.0	...	10.0	uAdc
	Ihk	Ehk = —100 Vdc	...	—5.0	...	—10.0	uAdc
Insulation of Electrodes							
	R(g–all)	Eg — all = —100 Vdc	100	...	25	...	Meg
	R(p–all)	Ep — all = —300 Vdc	100	...	25	...	Meg

APPLICATION OF JAN-5719

The chart below shows the permissible operating area for JAN-5719 as defined by the ratings in MIL-E-1/173C dated 5 August 1955. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2.

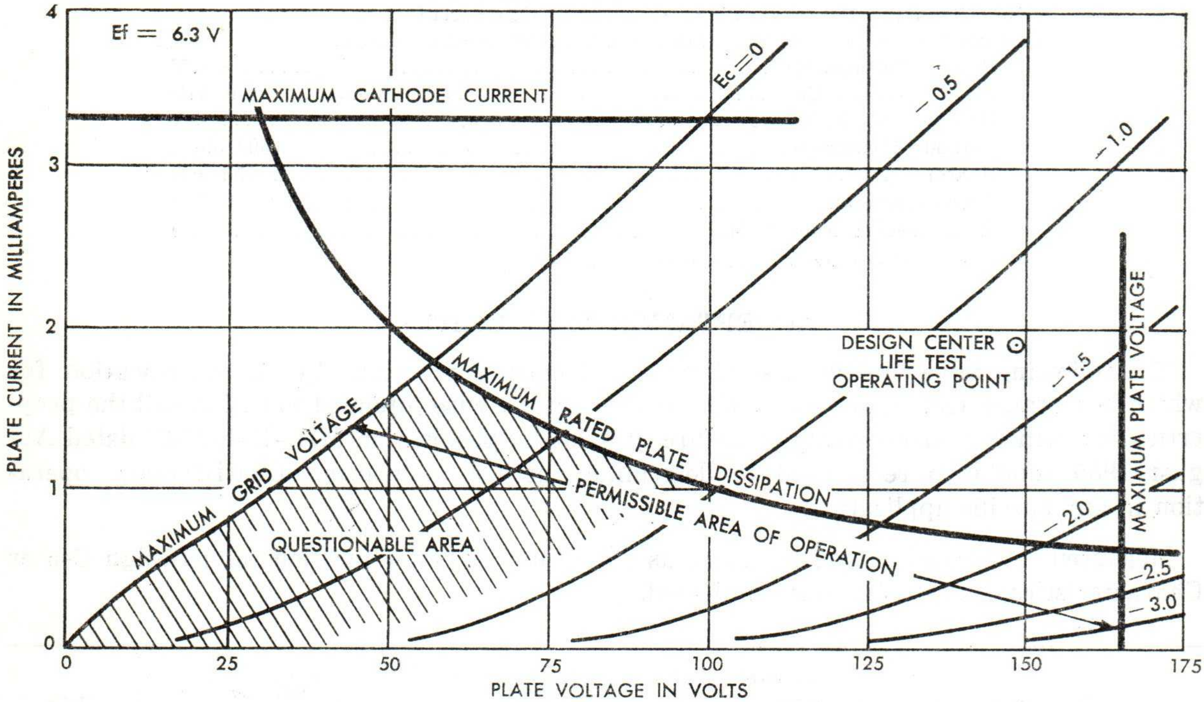


Figure 3-235. Typical Static Plate Characteristics for JAN-5719; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of the Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:

- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:

- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2

Plate, Low, 1.3.10, 3.1.3, 3.1.5

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.1.2

Control Grid Emission, 1.3.3

Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5

Shielding, 3.1.4

Intermittent Operation, 3.1.5

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.1.5

SPECIAL CONSIDERATIONS

In addition to the general considerations referenced in the preceding table, the JAN-5719 as specified by MIL-E-1/173C has initial assurance of AC amplification and plate current cut-off as follows:

Plate Current Cut-Off is defined by two tests, one imposing a maximum Ib of 50 uAdc with 2.5 volt bias and a minimum Ib of 5 uAdc with 1.8 volt bias;

AC Amplification using grid leak bias, 100 volt plate supply, and 0.5 megohm plate load resistance. Any operation in this region other than that described must be questioned, however, considering the variable effects that are manifested in the low-current and zero-bias regions.

VARIABILITY OF JAN-5719 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5719 as defined by MIL-E-1/173C dated 5 August 1955.

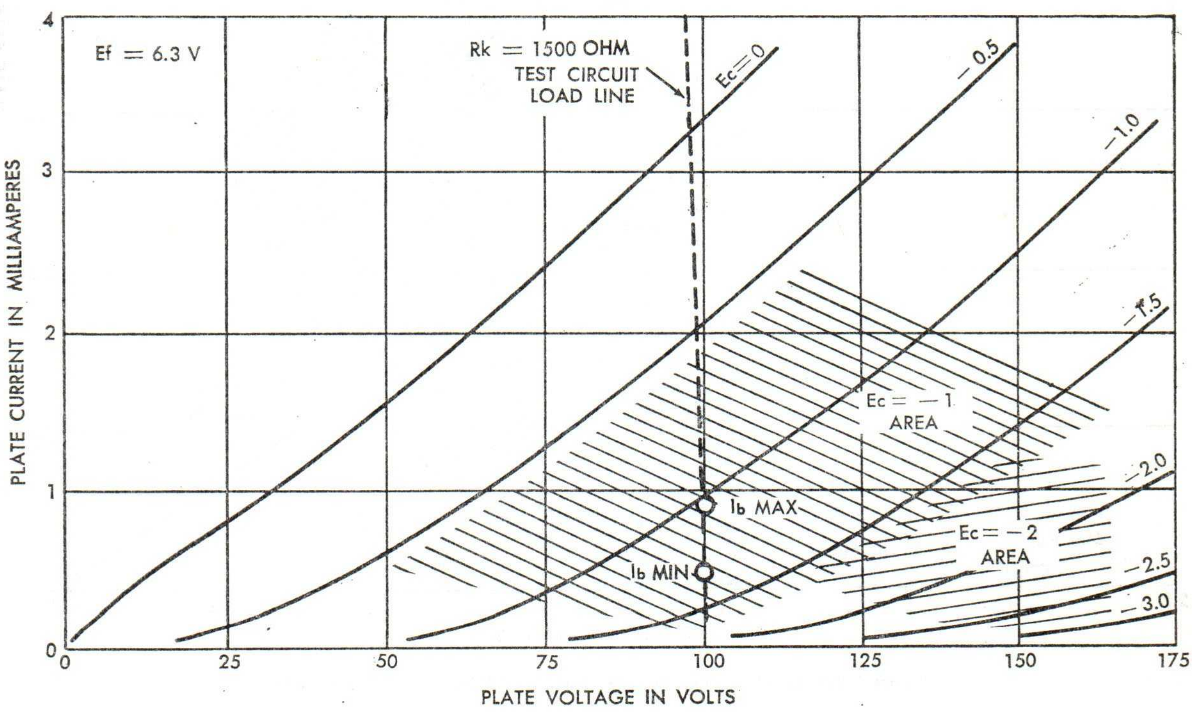


Figure 3-236. Limit Behavior of Static Plate Characteristics for JAN-5719.

The chart below presents the limit behavior of plate transfer data for JAN-5719 as defined by MIL-E-1/173C dated 5 August 1955.

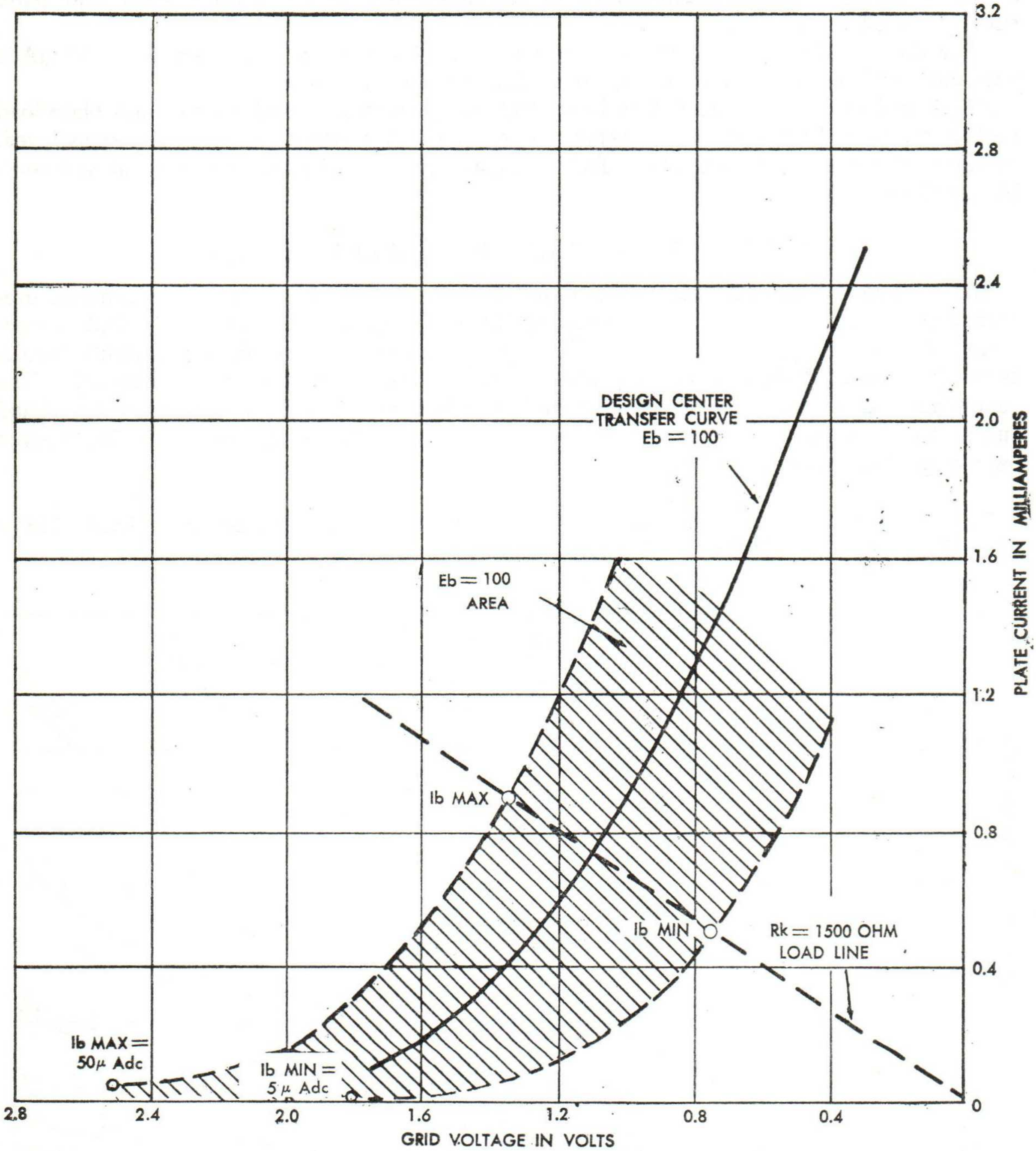


Figure 3-237. Limit Behavior Transfer Data for JAN-5719; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-5719

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5719.

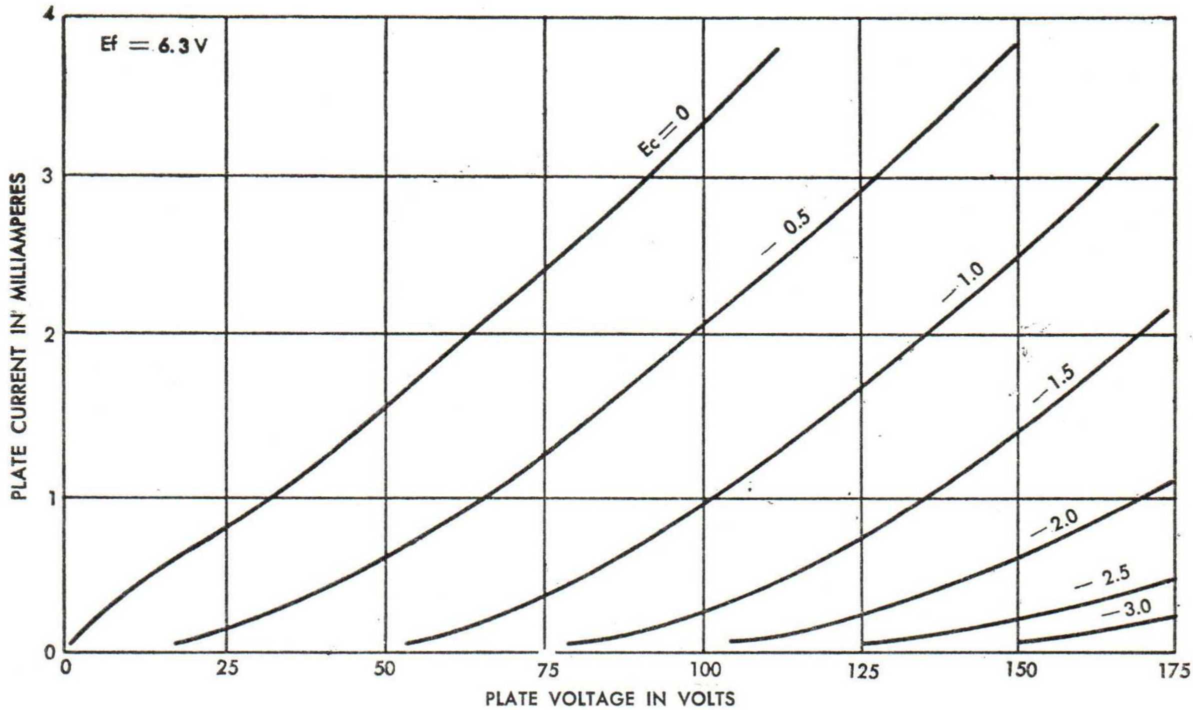


Figure 3-238. Typical Static Plate Characteristics for Jan-5719.

The chart below presents the Typical Sm, Mu and rp characteristics for JAN-5719.

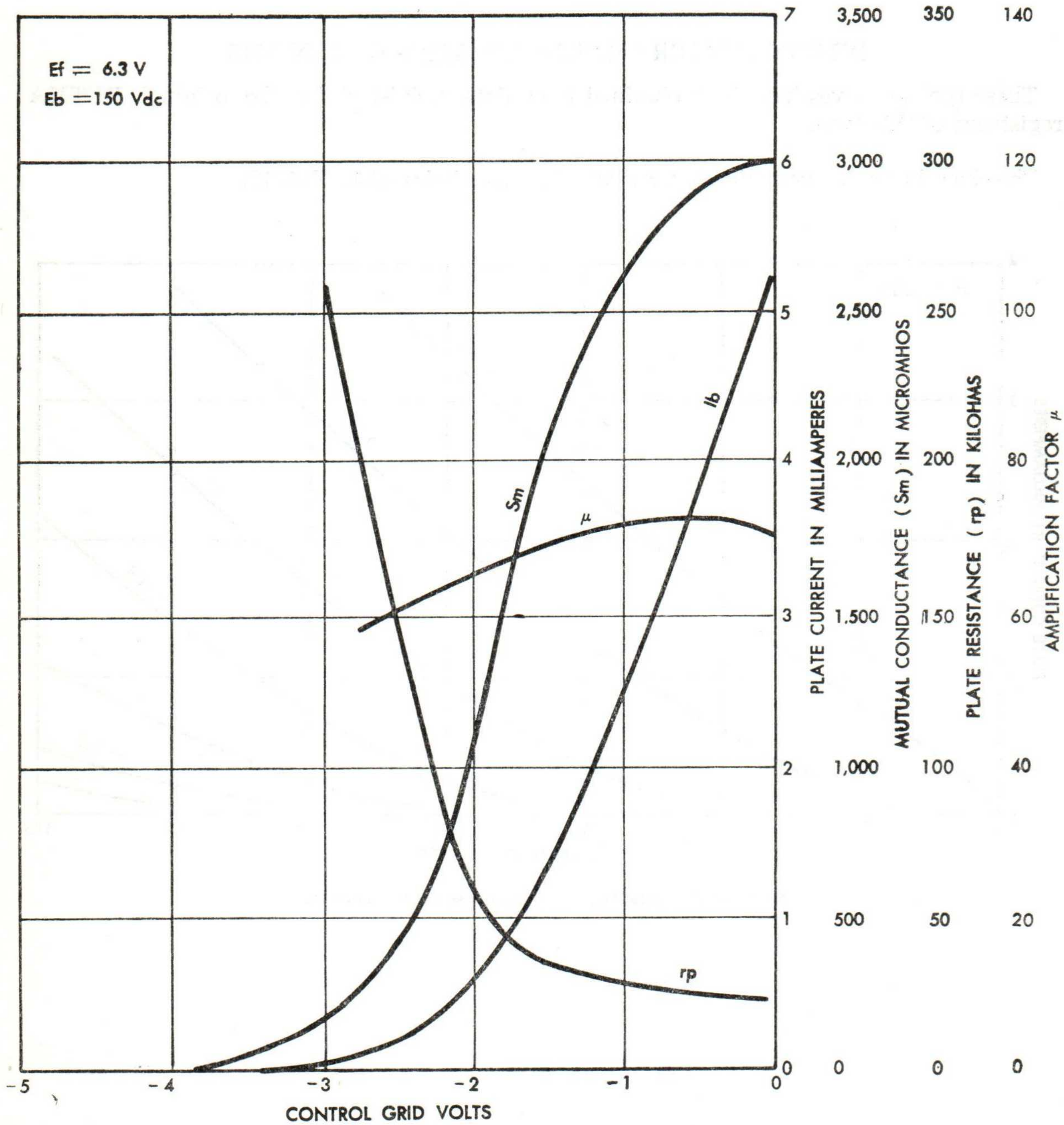


Figure 3-239. Typical Sm, Mu, rp Static Characteristics of JAN-5719.

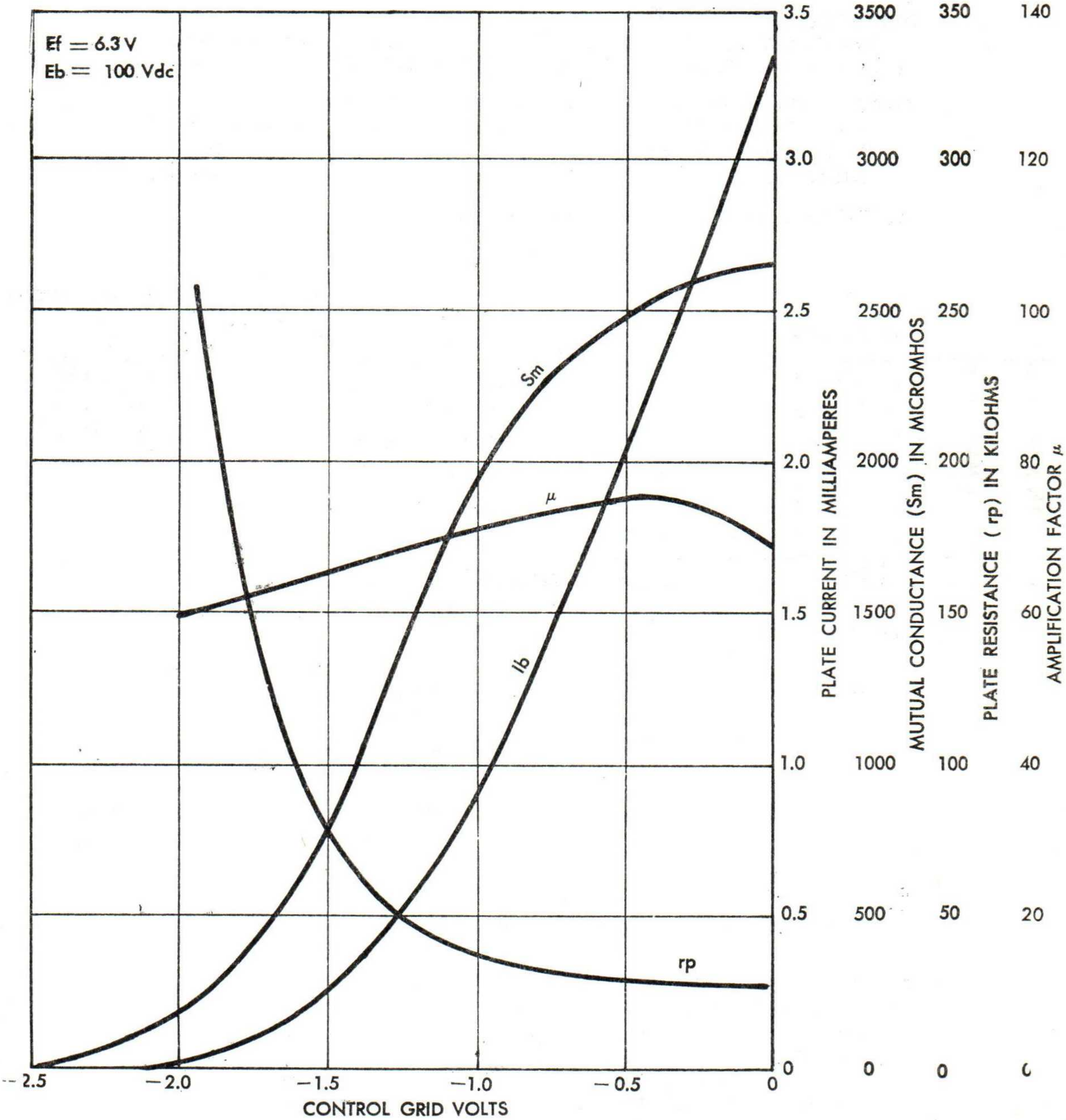


Figure 3-240. Typical Transfer Data for JAN-5719; Eb = 100 Vdc.

SECTION
TUBE TYPE JAN–5725/6AS6W

DESCRIPTION.

The JAN–5725/6AS6W [1] is a 7 pin miniature, sharp cutoff, dual control having a transconductance in the range, 2500 to 4500 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage, AC or DC	6.3 V
Heater Current, Design Center	200 Vdc
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

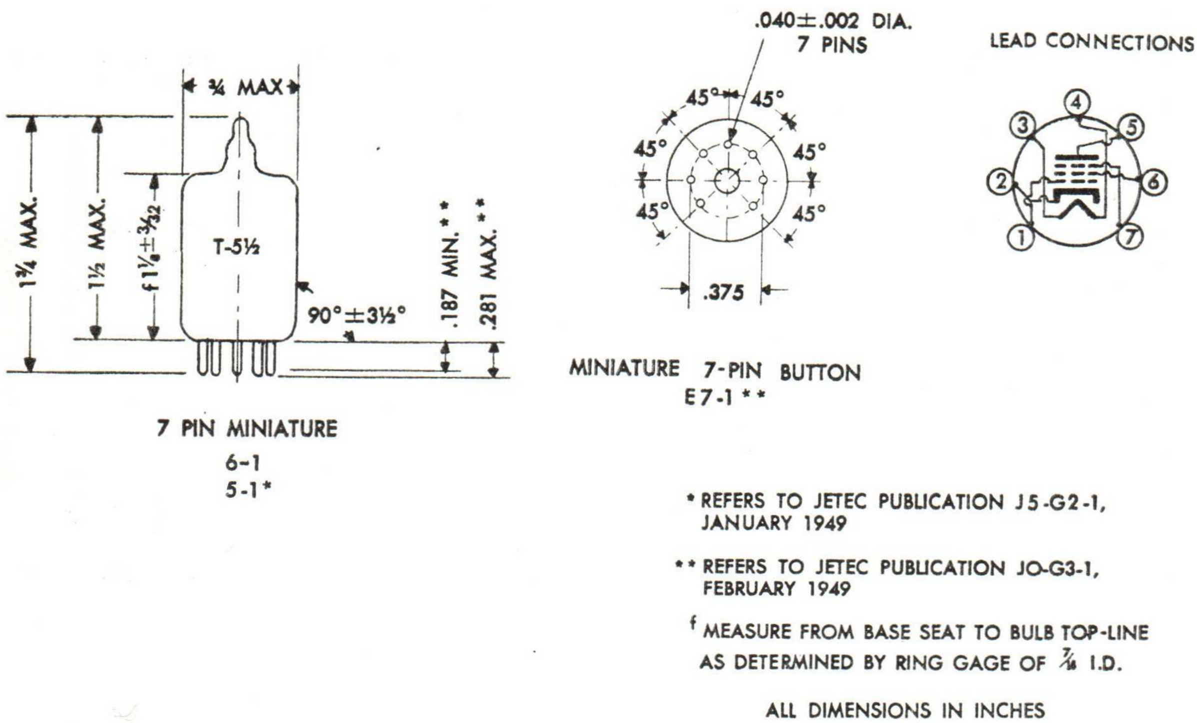


Figure 3-241. Outline Drawing and Base Diagram of Tube Type Jan-5725/6AS6W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3V ± .6V
Plate Voltage	200 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage Maximum, Ec1	0 Vdc
Minimum, Ec1	—55Vdc
Suppressor Grid Voltage Maximum, Ec3	30 Vdc
Minimum, Ec3	—55 Vdc
Screen Grid Voltage, Ec2	155 Vdc
Heater Cathode Voltage, Ehk	100 v
Control Grid Series Resistance, Rg1	0.1 meg

[1] The values and specification comments presented in this section are related to MIL-E-1/6C dated 25 July 1956.

**,*Cathode, Current, Ik	20 mAdc
Plate Dissipation, Pp	1.65 W
Control Grid Current, Ic1	1.0 mAdc
Screen Grid Dissipation, Pg2	0.55 W
Suppressor Grid Current, Ic3	0.2 mAdc
Bulb Temperature, T envelope	165° C
*Altitude	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	120 Vdc
Control Grid Voltage, Ec1	—2.0 Vdc
Screen Grid Voltage, Ec2	120 Vdc
Suppressor Voltage	0 Vdc
Heater Cathode Voltage	0 V
Heater Current, If	175 mA
Plate Current, Ib	5.2 mAdc
Transconductance, Sm (control grid to Plate)	3200 mmhos

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.5.8

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.5.2, 3.5.6
- 28 Volt, 3.5.8
- Ac Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.5.8

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.5.7
- Cathode, 2.1.1, 3.5.8
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.5.8

Contact Potential, 1.3.1, 3.5.7, 3.5.8

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.5.8

Screen Grid Series, 3.5.2, 3.2.9

Cathode Interface, 1.3.10, 3.5.8

Cathode, 1.3.7, 2.1.1, 3.5.8

Temperature

Bulb and Environmental, 3.5.3

Current

Cathode, 1.3.10, 3.5.5, 3.5.8

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.5.7

Screen Grid, 3.5.2

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.5.7

Control Grid Emission, 1.3.3

Cathode, Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.5.3

Screen Grid, 2.1, 3.5.2, 3.5.6

Miscellaneous

Pulse Operation, 3.5.8

Shielding, 3.5.3

Intermittent Operation, 3.5.8

Triode Connection, 3.5.8

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.2.9

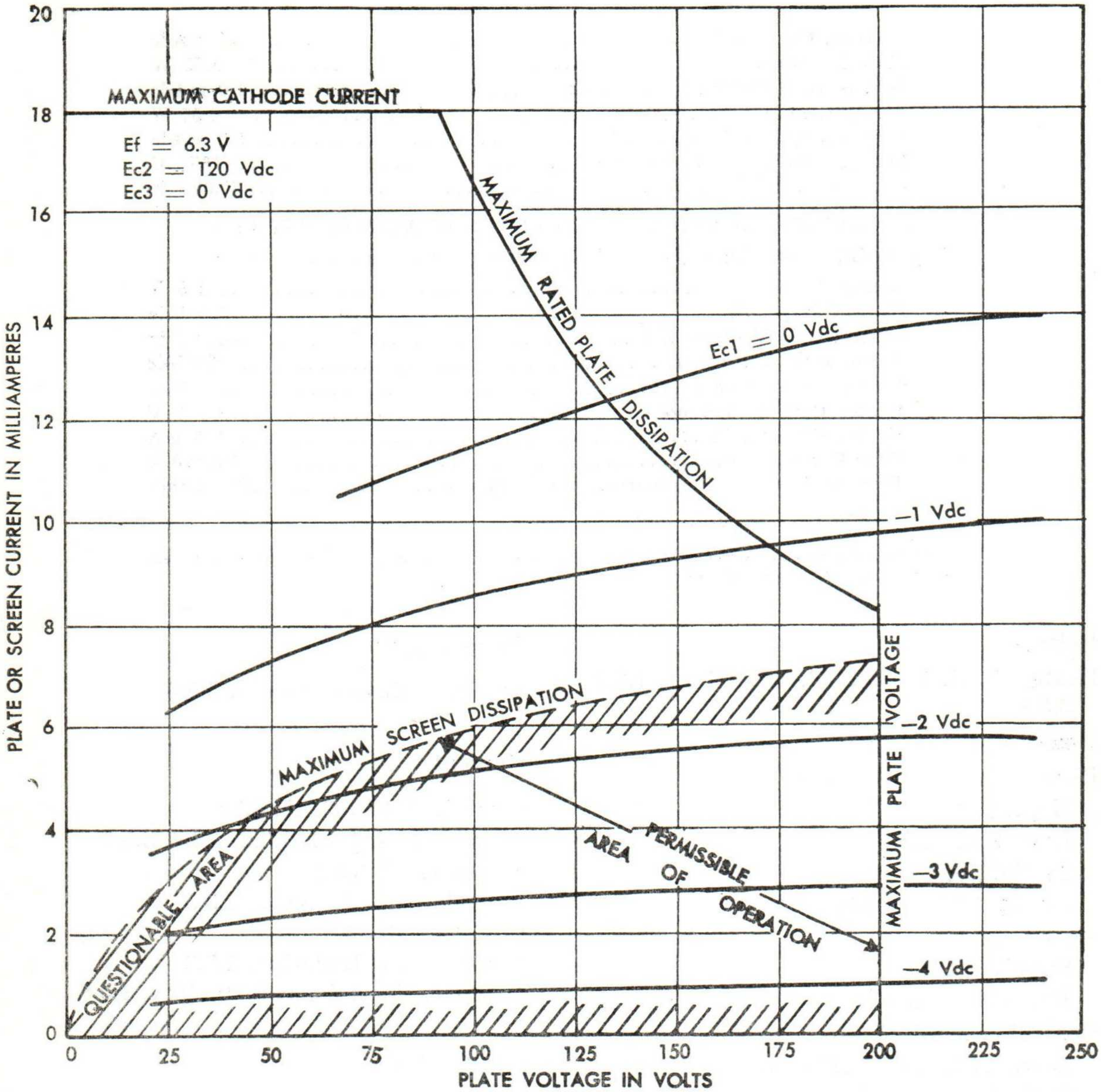


Figure 3-242. Typical Plate Characteristics of JAN-5725/6AS6W; Permissible Area of Operation.

VARIABILITY OF JAN-5725/6AS6W CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

Figure 3-243, 3-244, 3-245, and 3-246 present the limit behavior of static plate and transfer characteristics for JAN 5725/6AS6W as defined by MIL-E-1/6C dated 25 July 1956.

DESIGN CENTER CHARACTERISTICS OF JAN-5725/6AS6W

These typical curves have been obtained from current data being published by the original RETMA registrant of this type.

Figures 3-247, 3-248, 3-249, and 3-250 present the Static Plate Characteristics of JAN-5725/6AS6W.

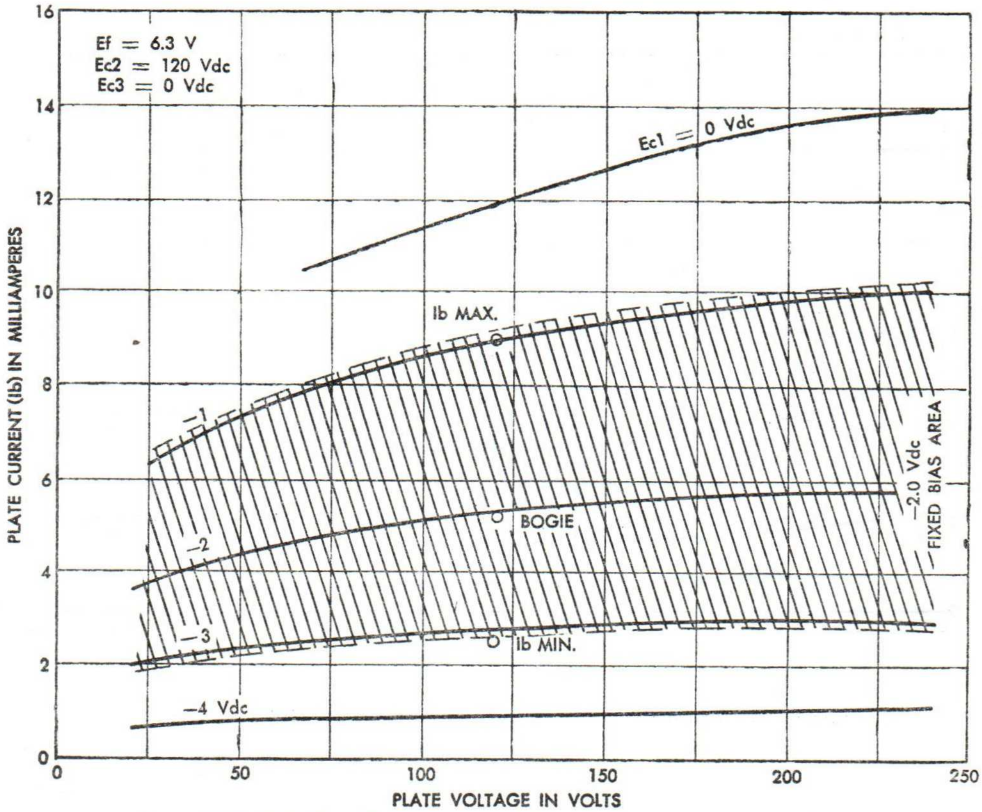


Figure 3-243. Limit Plate Characteristics of JAN 5725/6AS6W; Variability of Ib.

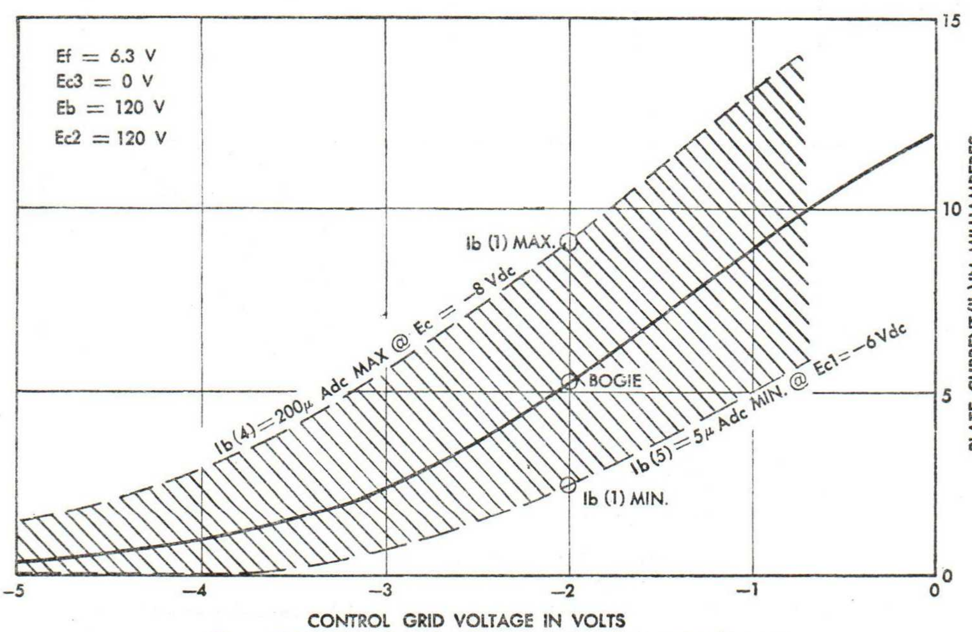


Figure 3-244. Limit Transfer Characteristics of JAN 5725/6AS6W.

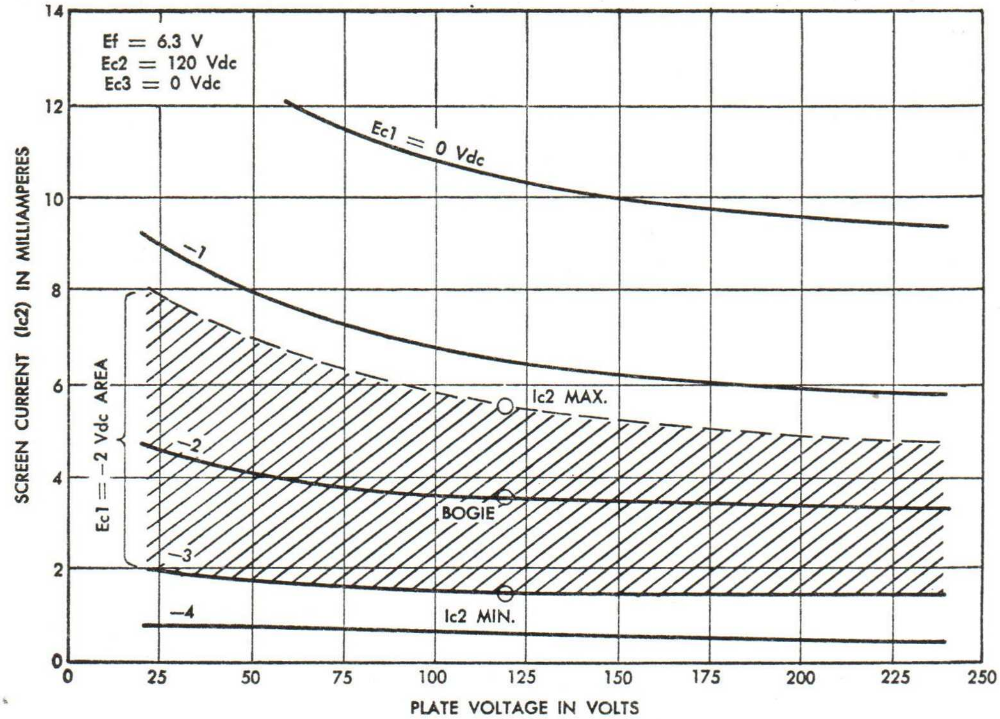


Figure 3-245. Limit Plate Characteristics of JAN 5725/6AS6W; Variability of Ic2.

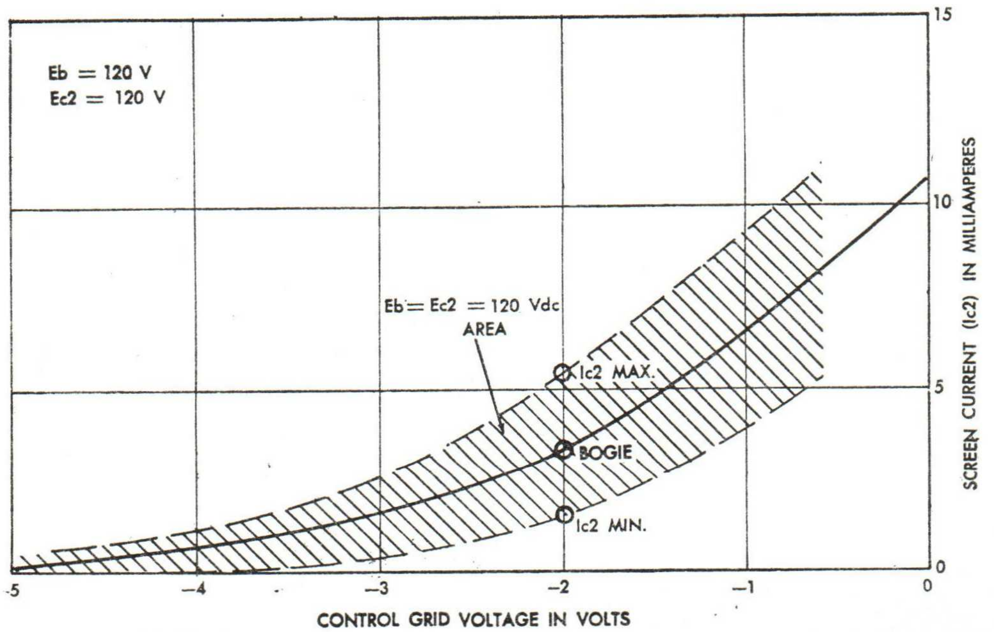


Figure 3-246. Limit Transfer Characteristics of JAN 5725/6AS6W; Variability of Ic2.

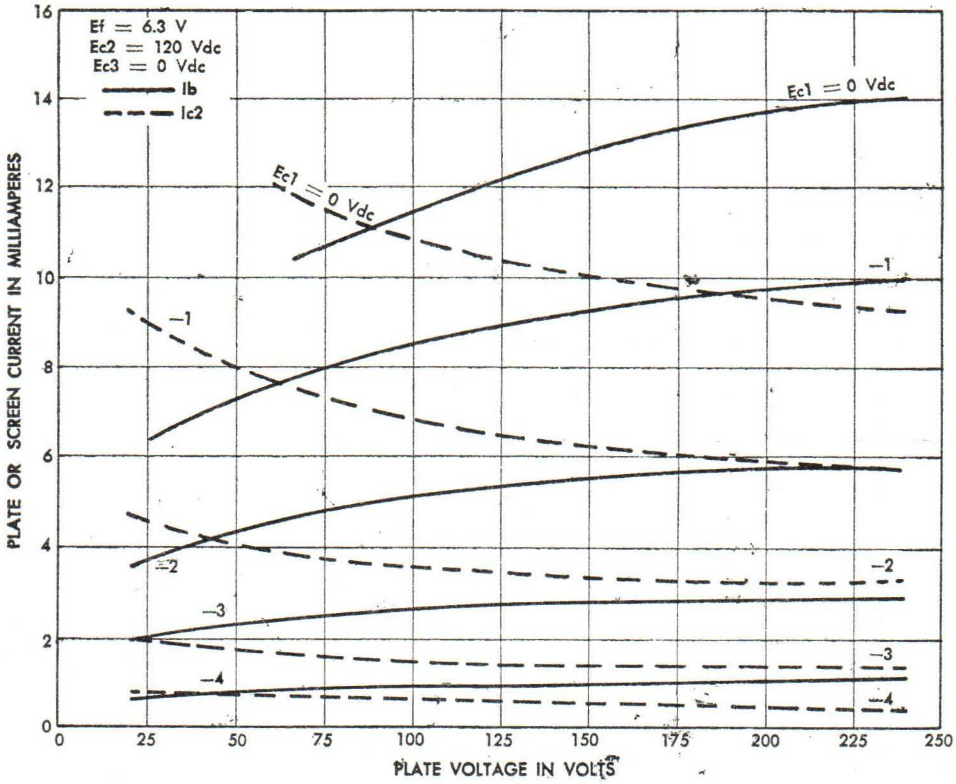


Figure 3-247. Typical Characteristics of JAN 5725/6AS6W.

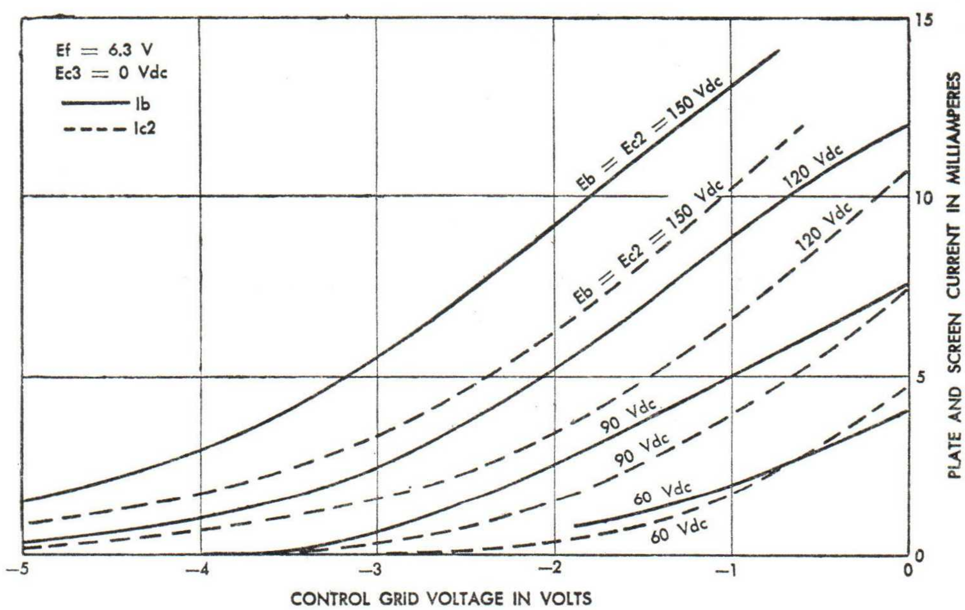


Figure 3-248. Typical Transfer Characteristics of JAN 5725/6AS6W.

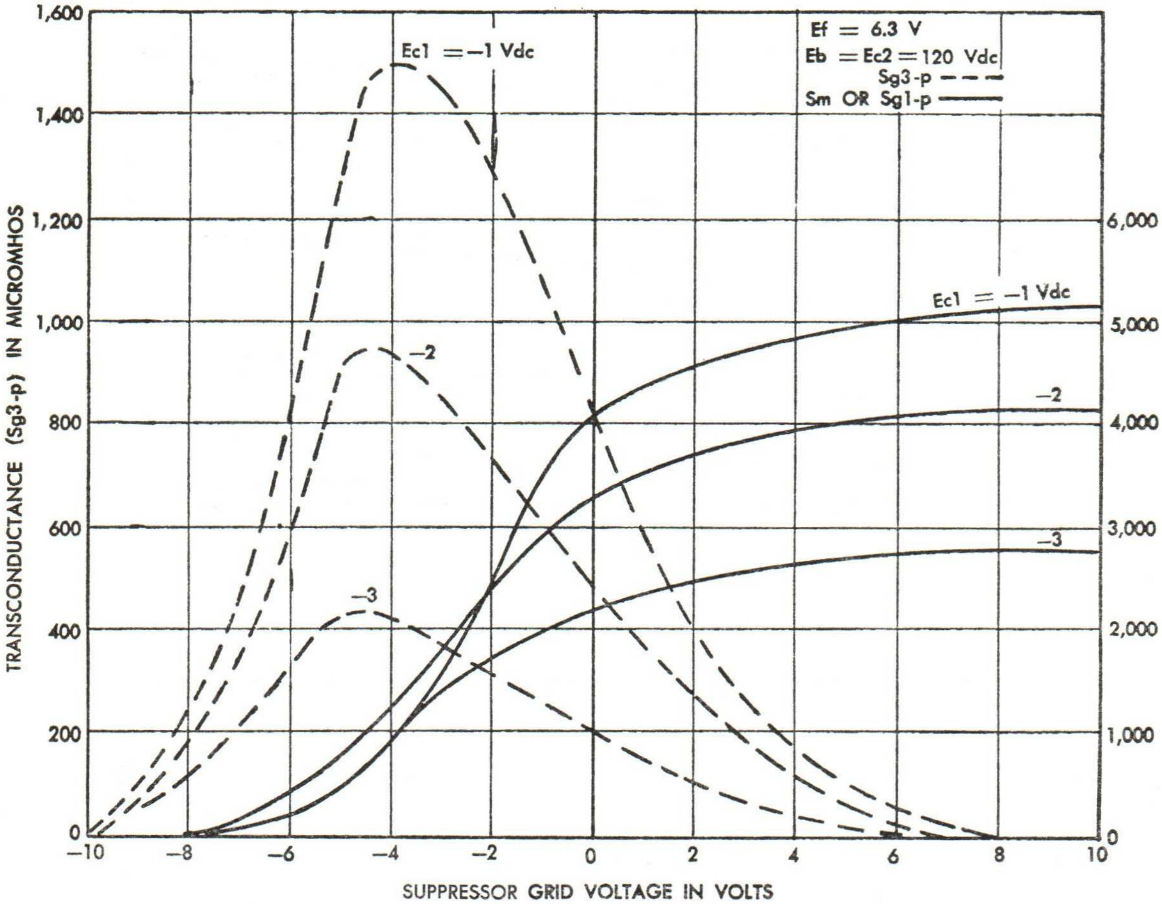


Figure 3-249. Typical Suppressor Transconductance Characteristics of JAN 5725/6AS6W; Variability of Ib, Ic2.

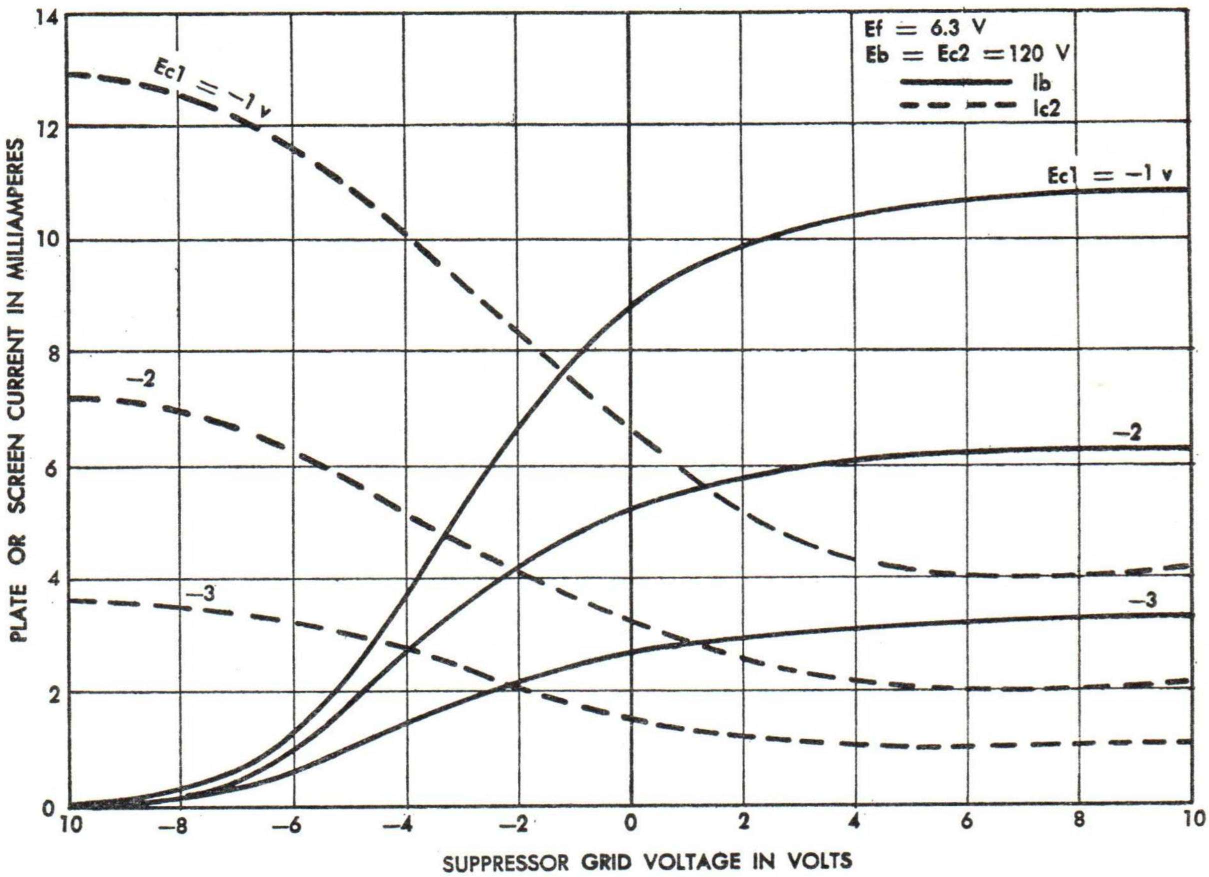


Figure 3-250. Typical Suppressor Transconductance Characteristics of JAN 5725/6AS6W; Variability of Ib, Ic2.

SECTION
TUBE TYPE JAN-5726/6AL5W

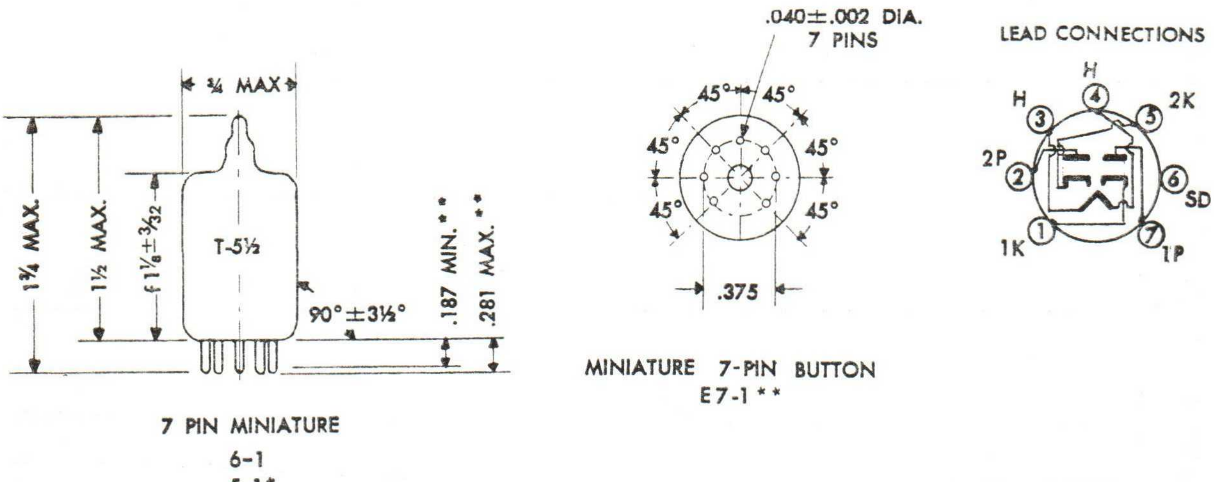
DESCRIPTION.

The JAN-5726/6AL5W [1] is a seven pin, button base, miniature, double diode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current	300 mA
*Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



* REFERS TO JETEC PUBLICATION J5-G2-1, NOVEMBER 1952

** REFERS TO JETEC PUBLICATION JO-G3-1, APRIL 1953

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-251. Outline Drawing and Base Diagram of Tube Type Jan-5726/6AL5W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 0.6 V
Peak Inverse Plate Voltage	360 v
Steady State Peak Plate Current (per Plate)	60 mA
Output Current (per plate)	10 mAdc
Transient Peak Plate Current	350 mA
Heater Cathode Voltage	± 360 V
**Bulb Temperature	140° C
**Altitude Rating	10,000 ft

* Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

** No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/7A dated 3 May 1954.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Supply Voltage (per plate), Epp	165 Vac
Load Resistance (RL)	11,000 ohms
Load Capacitor (CL)	8 uf
Heater Current	300 mA
Output Current (both plates), Io	18 mA

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/7A dated 3 May 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		275	325	275	325	mA
Operation	Io	See Note Below	16	...	14	...	mAdc
Plate Current	Ib	Ebb = O; Rp = 40,000 ohms	2.0	20	...	...	uAdc
Difference between sections	ΔIb		...	5	...	...	uAdc
Emission	Is	Eb = 10 Vdc	40	...	...	...	mAdc
Capacitance (Shielded as Specified	C1p to 2p	EF = O	...	0.026	...	...	uuf
	C1p to h+1k+sd	Ef = O	2.4	4.0	...	...	uuf
	C2p to h+2k+sd	Ef = O	2.4	4.0	...	...	uuf
	C1k to h+1p+sd	Ef = O	3.1	4.7	...	...	uuf
	C2k to h+2p+sd	Ef = O	3.1	4.7	...	...	uuf
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	10	...	20	uAdc
	Ihk	Ehk = —100 Vdc	...	—10	...	—20	uAdc
Insulation of Electrodes	R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg

Note. In a full wave circuit, adjust Zp (per plate) so that a bogie tube gives Io = 18 mAdc, and ib = 50 mAdc per plate. A bogie tube has a tube drop Etd = 10 Vdc at Is = 60 mAdc per plate.

APPLICATION

SIGNAL RECTIFIER SERVICE: In the application of JAN-5726/6AL5W in signal rectifier service, Chart "A" relates boundaries of permissible operation and the questionable area of operation, to the plate characteristic.

Permissible steady state peak plate current is limited to 60 milliamperes per plate, to define boundary (1), and dc output current is limited to 10 milliamperes per plate to define boundary (2). Area (3) is defined as questionable from the standpoint of uniformity and stability of plate current in low-level signal rectifier applications. Although the specification enforces a control on plate current balance between the two sections to within 5 mi-

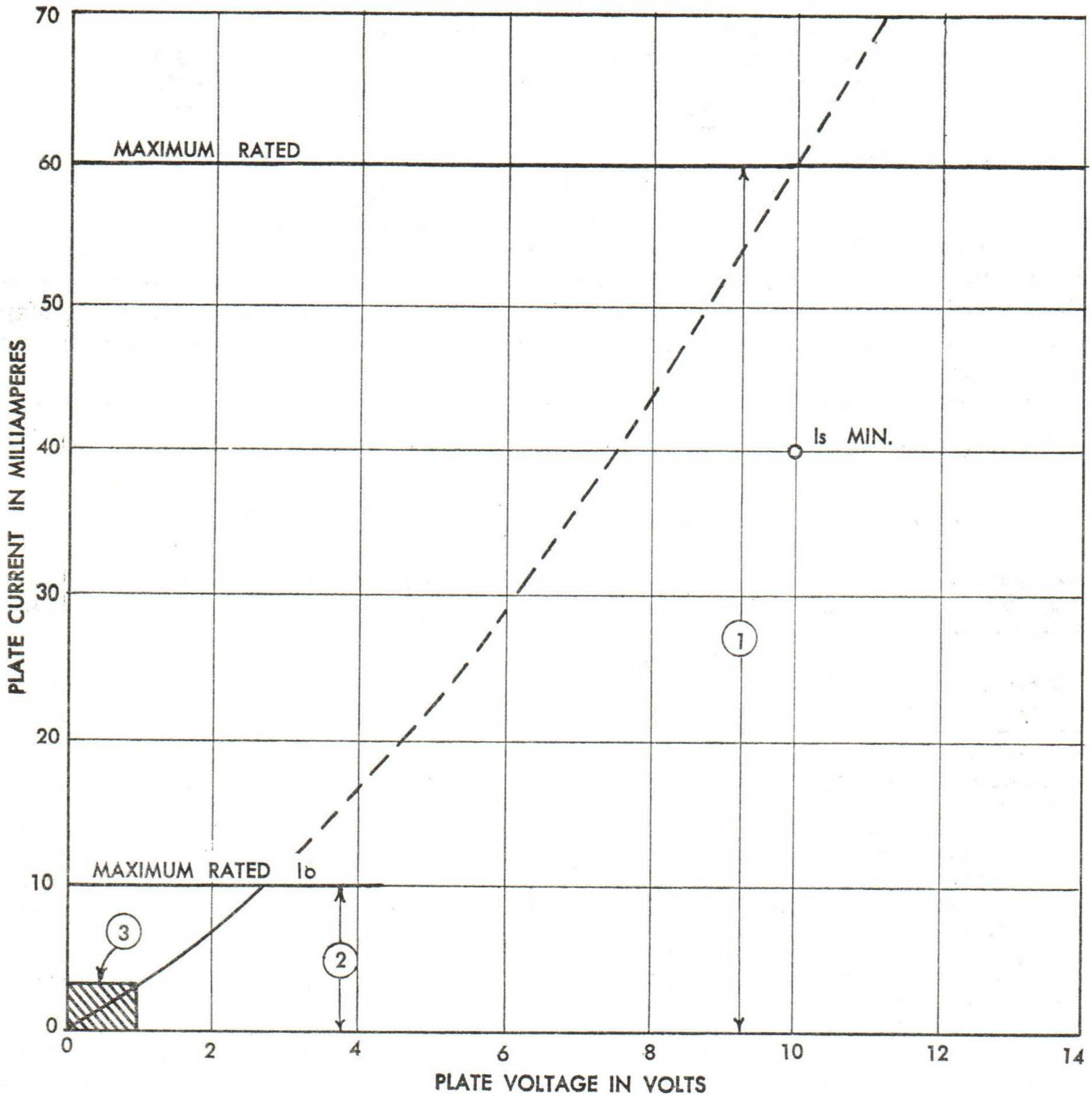
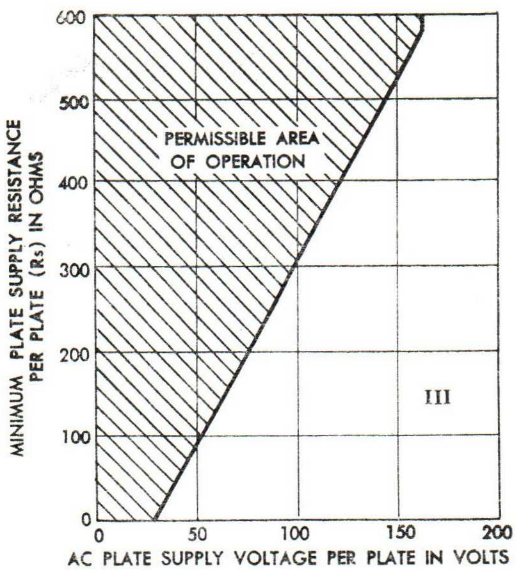
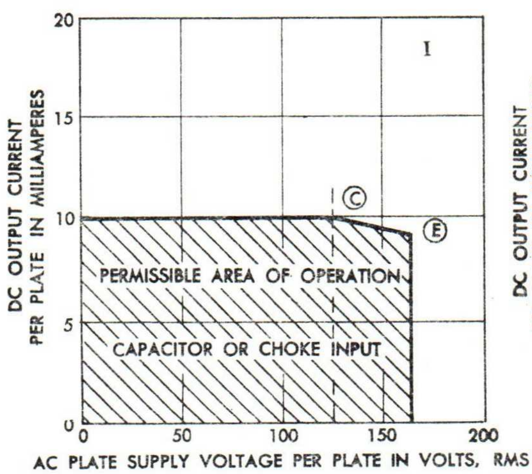


Figure 3-252. Chart A — JAN-5726/6AL5W; Permissible Limits of Operation.

croamperes under MIL–E–1 test conditions, there is little assurance of such balance under conditions of heater operation differing from test conditions. Reference should be made to Section 1.3.1 for a review of the behavior of initial electron velocity and contact potential in tubes in general, where the control grid currents discussed are equivalent to plate currents in signal diode application.

SUPPLY VOLTAGE RECTIFIER SERVICE. Rating Charts, I, II, and III represent areas of permissible operation within which any aplication of the JAN–5726/6AL5W must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.





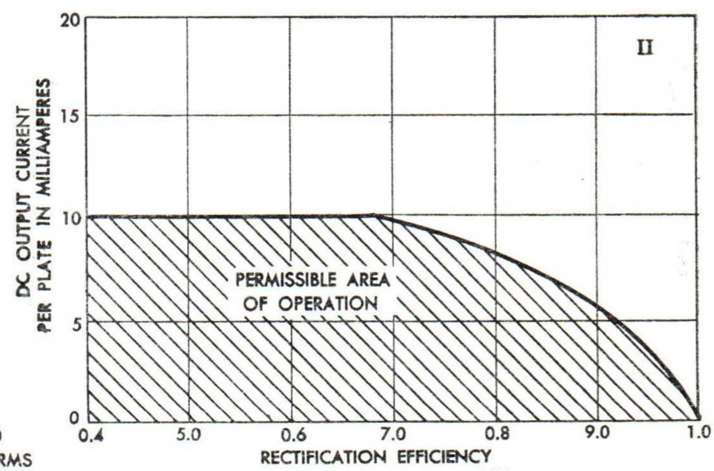


Figure 3-253. *Rating Chart I* is based on maximum rated peak inverse voltage per plate (epx) of 360 volts and maximum rated dc output current per plate (Io) of 10 milliamperes. Point C corresponds to the occurrence of these two ratings, permissible under choke or capacitor-input filter conditions. Point. E is based on life test conditions, with capacitor input filter.

Figure 3-254. *Rating Chart II* for capacitor input filter applications is based on maximum rated dc output current per plate (Io) and maximum rated steady state peak plate current (Ib) of 60 milliamperes per plate. Rectification efficiency must not exceed 0.67 under conditions of maximum rated dc output current.

Figure 3-255. *Rating Chart III* for capacitor input filter is based on maximum rated surge current (i surge) of 350 milliamperes per plate. Minimum permissible series resistance (Rs) is approximately 580 ohms per plate under conditions of maximum permissible supply voltage per plate.

OTHER CONSIDERATIONS:

Heater Voltage: See paragraph 3.4.3.
Low Electrode Current: See paragraph 3.4.3.

AVERAGE CHARACTERISTICS OF JAN–5726/6AL5W

The charts below present the Static Plate Characteristic of JAN–5726/6AL5W reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

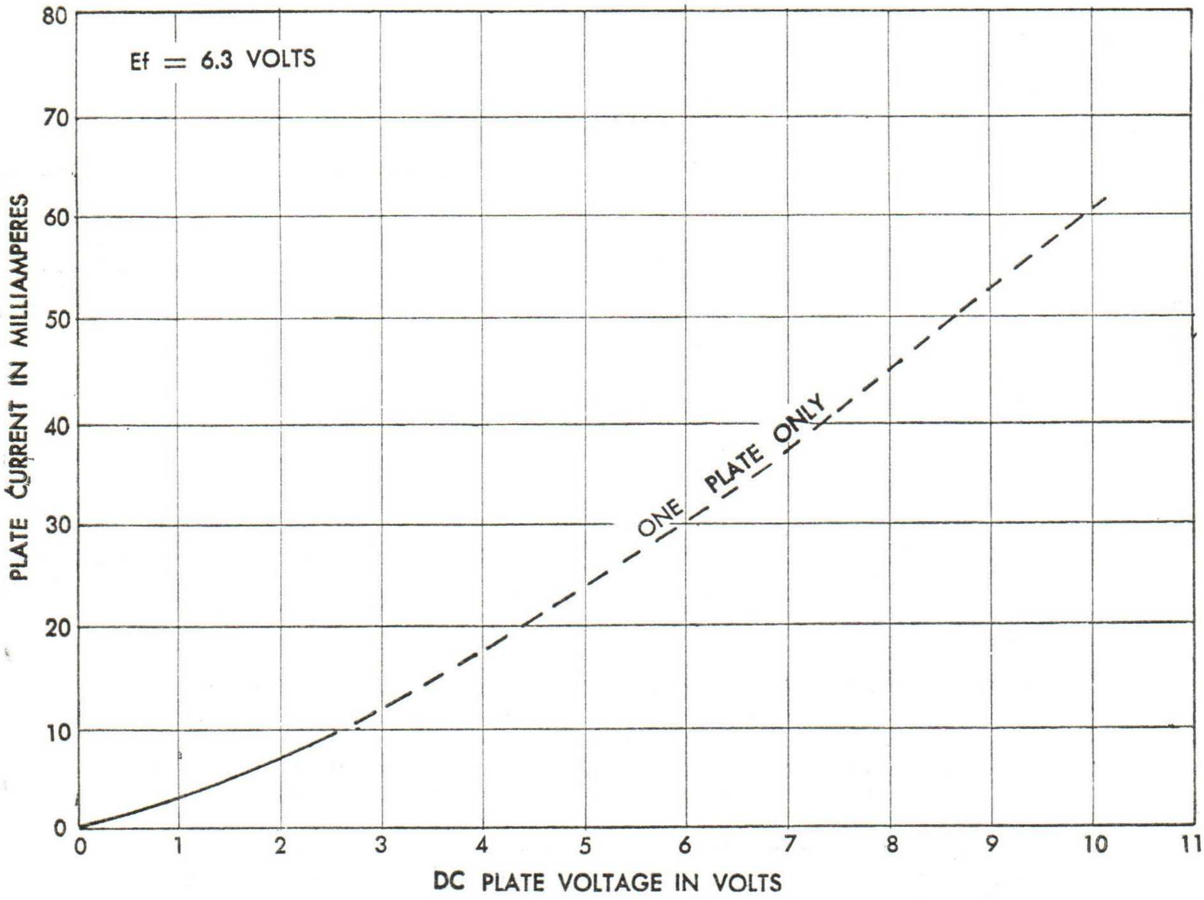


Figure 3-256. Typical Plate Characteristics of JAN-5726/6AL5W.

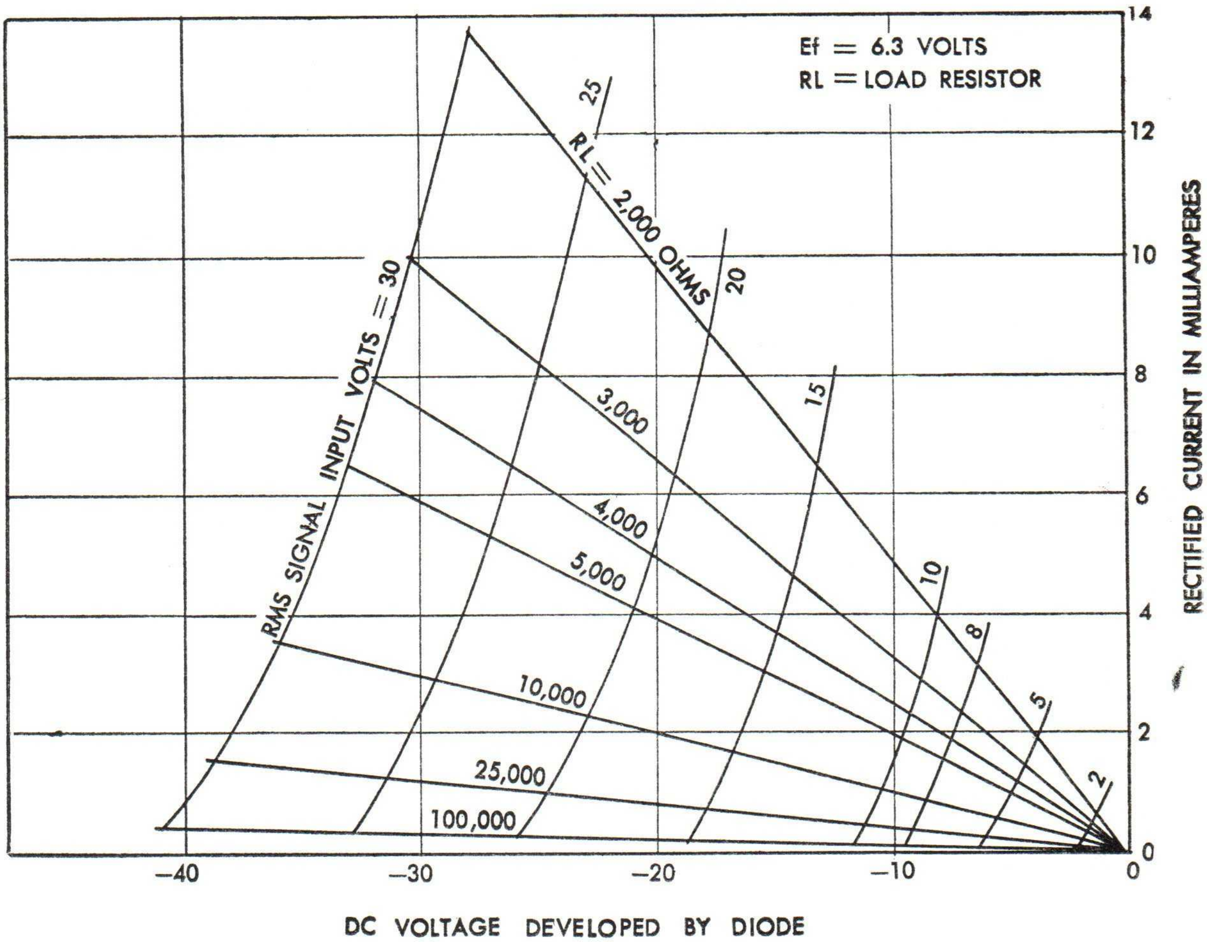


Figure 3-257. Typical Rectifier Characteristics of JAN-5726/6AL5W.

SECTION
TUBE TYPE JAN-5744WA

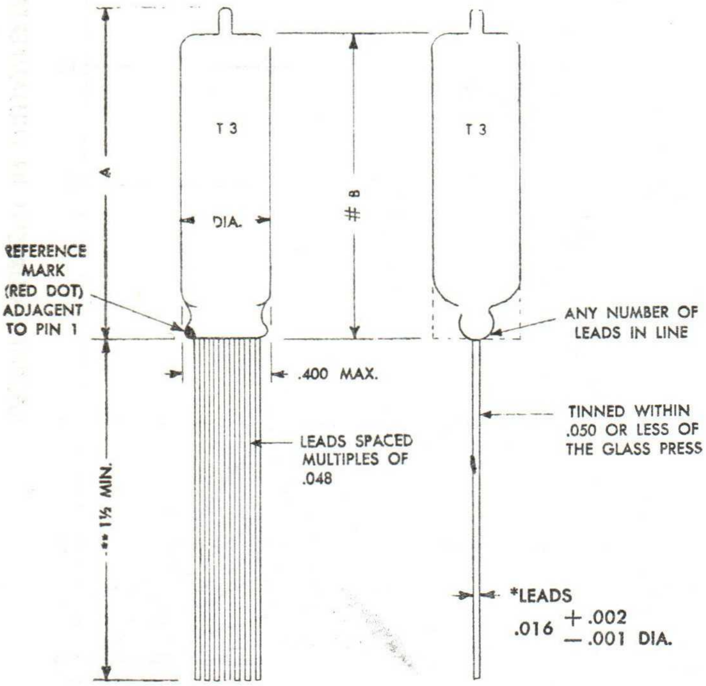
DESCRIPTION.

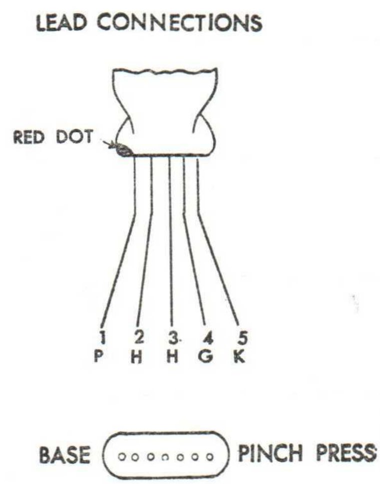
The JAN-5744WA [1] is a 5 lead, flat press subminiature triode having a design center transconductance of 4000 micromhos and a Mu of 70. The JAN-5744WA has given satisfactory service in voltage amplifier and other low current applications.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current .... 183-217 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.





DIMENSIONS			
A MAX.	B		DIAMETER MAX
	DIM	TOL. ±	
1.500	1.250	.100	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-258. Outline Drawing and Base Diagram of JAN-5744WA.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3 V ± 0.6 V
Plate Voltage .... 275 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Grid Voltage Minimum .... —55 Vdc
Heater-Cathode Voltage .... 200 v

[1] The values and specification comments presented in this section are related to MIL-E-1/84C dated 25 July 1956.

**Plate Current, Maximum .... 6.5 mAdc
* Plate Current, Minimum .... 0.5 mAdc
*Plate Dissipation .... 1.3 W
Bulb Temperature .... +265° C
*Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Cathode Resistance, Rk .... 500 ohms
Heater-Cathode Voltage .... 0 Vdc
Heater Current, If .... 200 mA
Plate Current, Ib .... 4.2 mAdc
Transconductance, Sm .... 4000 umhos
Amplification Factor, Mu 70

* No test of operation at this rating exists in the specification.

** No specification assurance of life exists under conditions of cathode current approaching the maximum.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/84C dated 25 July 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		183	217	183	217	mA
Transconductance (1)	Sm		3200	4800	...	...	umhos
Change in individual Transconductance (2)	$\frac{\Delta Sm}{t}$		...	...	...	25	%
	$\frac{\Delta Sm}{Ef}$	Ef = 5.5 V	...	10	...	...	%
Amplification Factor	Mu		60	80	...	...	...
Plate Current (1)	Ib		2.8	5.7	...	...	mAdc
Plate Current (2)	Ib	Ec = 6.5	...	50	...	...	mAdc
Capacitance	Cgp	Ef = 0	0.65	0.95	...	...	uuf
(Shielded as specified)	Cin	Ef = 0	2.0	3.4	...	...	uuf
	Cout	Ef = 0	1.7	3.1	...	...	uuf
Grid Current (1)	Ic		0	–0.3	...	–0.6	uAdc
Grid Current (2)	Ic	Ef = 7.0 V	0	–0.3	...	–1.0	uAdc
Heater-Cathode Leakage							
	Ihk	Ehk = +100 Vdc	...	10	...	30	uAdc
	Ihk	Ehk = —100 Vdc	...	–10	...	–30	uAdc
Insulation of Electrodes							
	R(g–all)	Eg–all = —100 Vdc	100	...	50	...	Meg
	R(P–all)	Ep–all = 300 Vdc	100	...	50	...	Meg

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages
Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
High, 3.1.5
Low, 3.1.5
AC Operation, 1.3.3, 3.1.5
28 Volt, 3.1.5
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.1.2
Cathode, 2.1.1, 3.1.5
Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance
Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interference, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation
Plate, 2.1, 3.1.4

Current
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature
Bulb and Environmental, 3.1.4

Miscellaneous
Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

APPLICATION OF JAN–5744WA

The chart below shows the permissible operating area for JAN–5744WA as defined by the ratings in MIL–E–1/84C dated 25 July 1956. A discussion of the permissible operating area for triode may be found in paragraph 3.1.2.

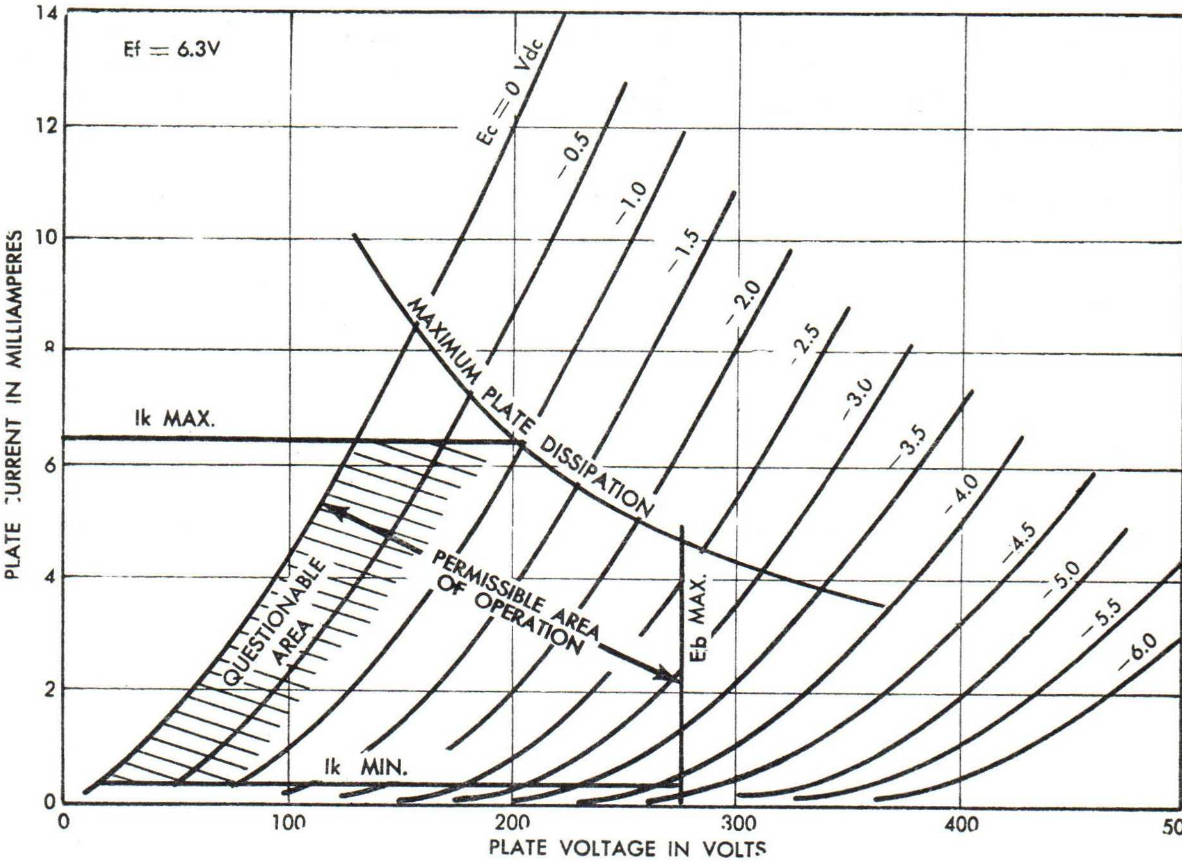


Figure 3-259. Typical Static-Plate Characteristics of JAN-5744WA; Permissible Area of Operation.

SPECIAL CONSIDERATIONS

In addition to the considerations noted above, JAN–5744WA as reflected in Specification MIL–E–1/84C provides limited assurance of operation in the low plate-voltage, low plate-current region by an acceptance test for ac amplification using grid leak bias, 100 volt plate supply, and 0.5 megohm plate load resistance. Any operation in this region other than that described above must be questioned, however, considering the variable effects that are manifested in the low-current and zero-bias regions.

VARIABILITY OF JAN–5744WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN–5744-WA as defined by MIL–E–1/84C dated 25 July 1956.

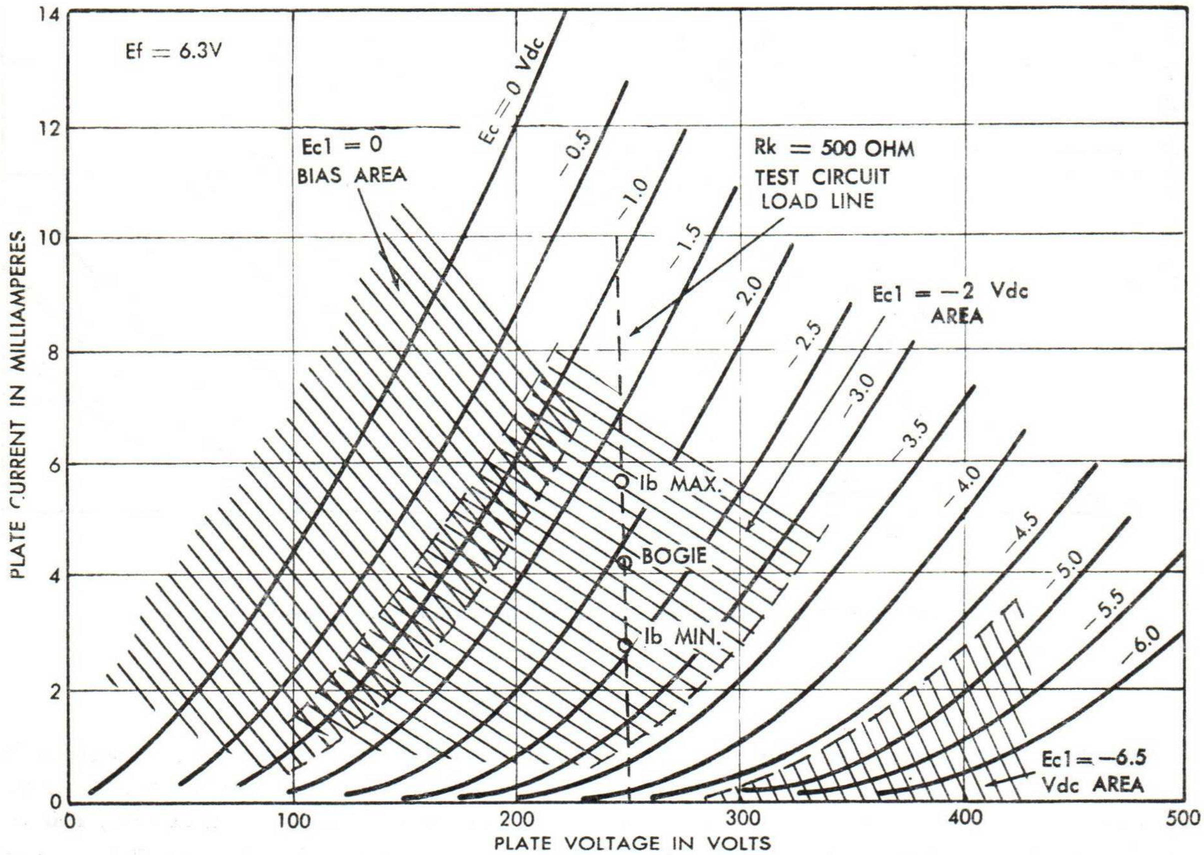


Figure 3-260. Limit Behavior of JAN-5744WA Static-Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5744WA as defined by MIL-E-1/84C dated 25 July 1956.

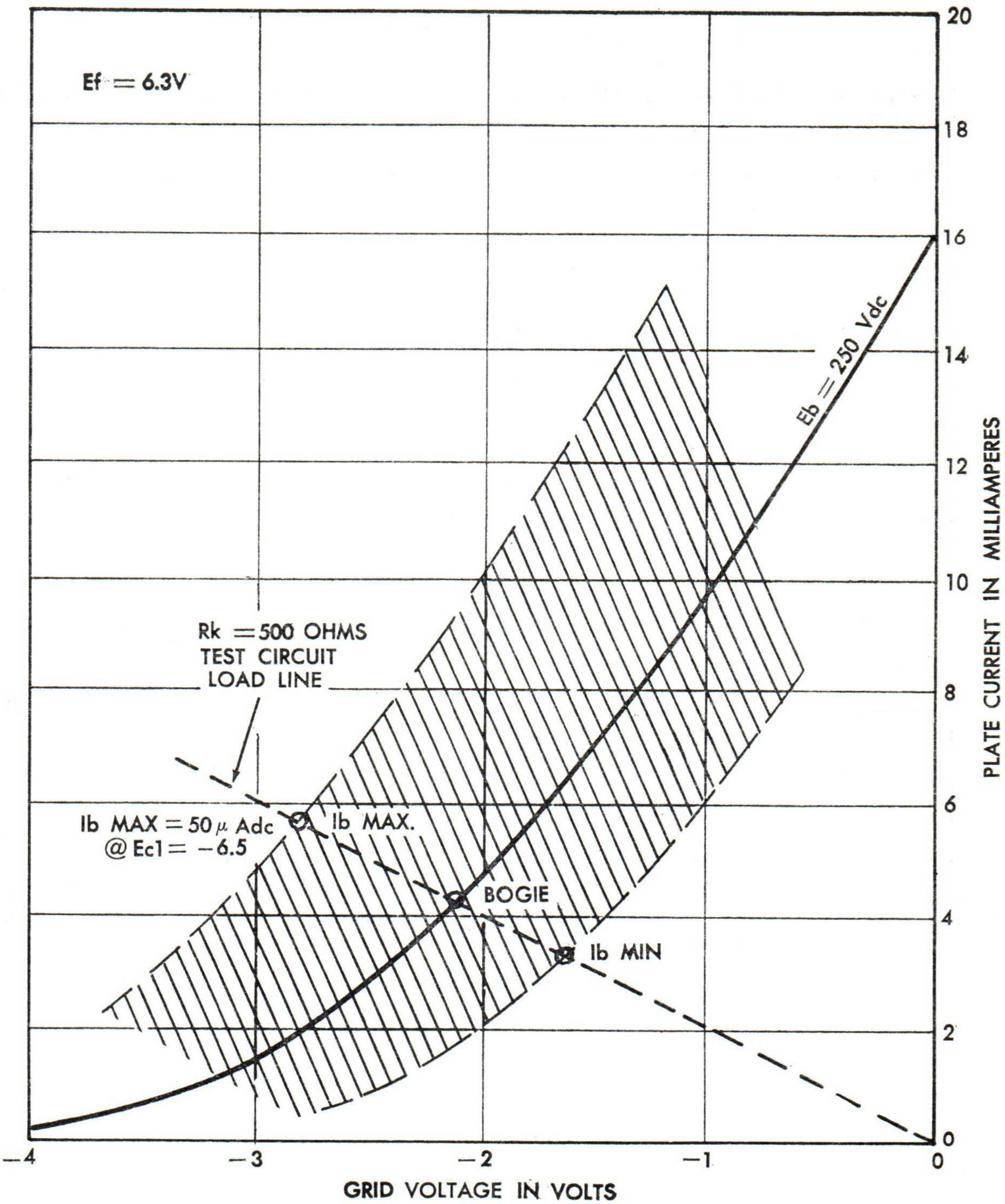


Figure 3-261. Limit Behavior of JAN-5744WA Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-5744WA

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5744WA.

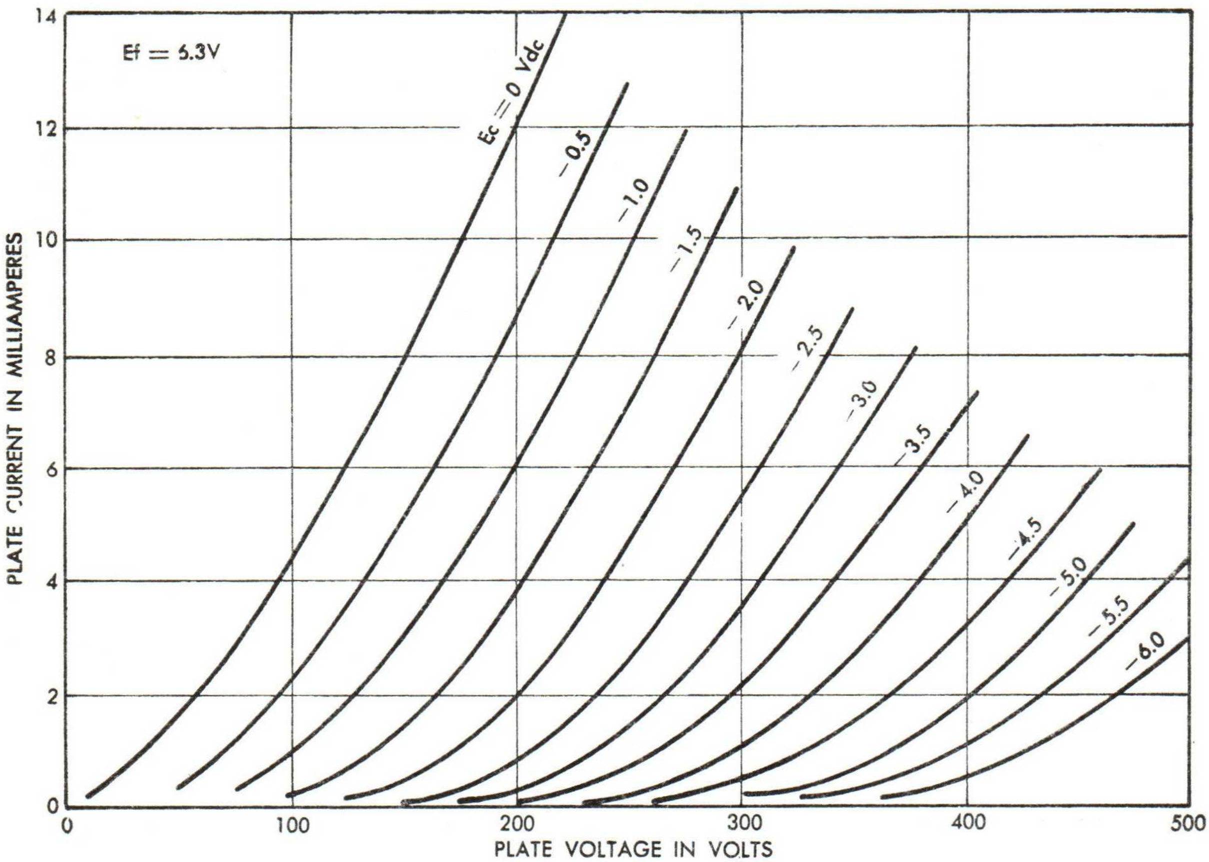


Figure 3-262. Typical Static-Plate Characteristics of JAN-5744WA.

The chart below presents the typical transfer characteristics of JAN-5744WA.

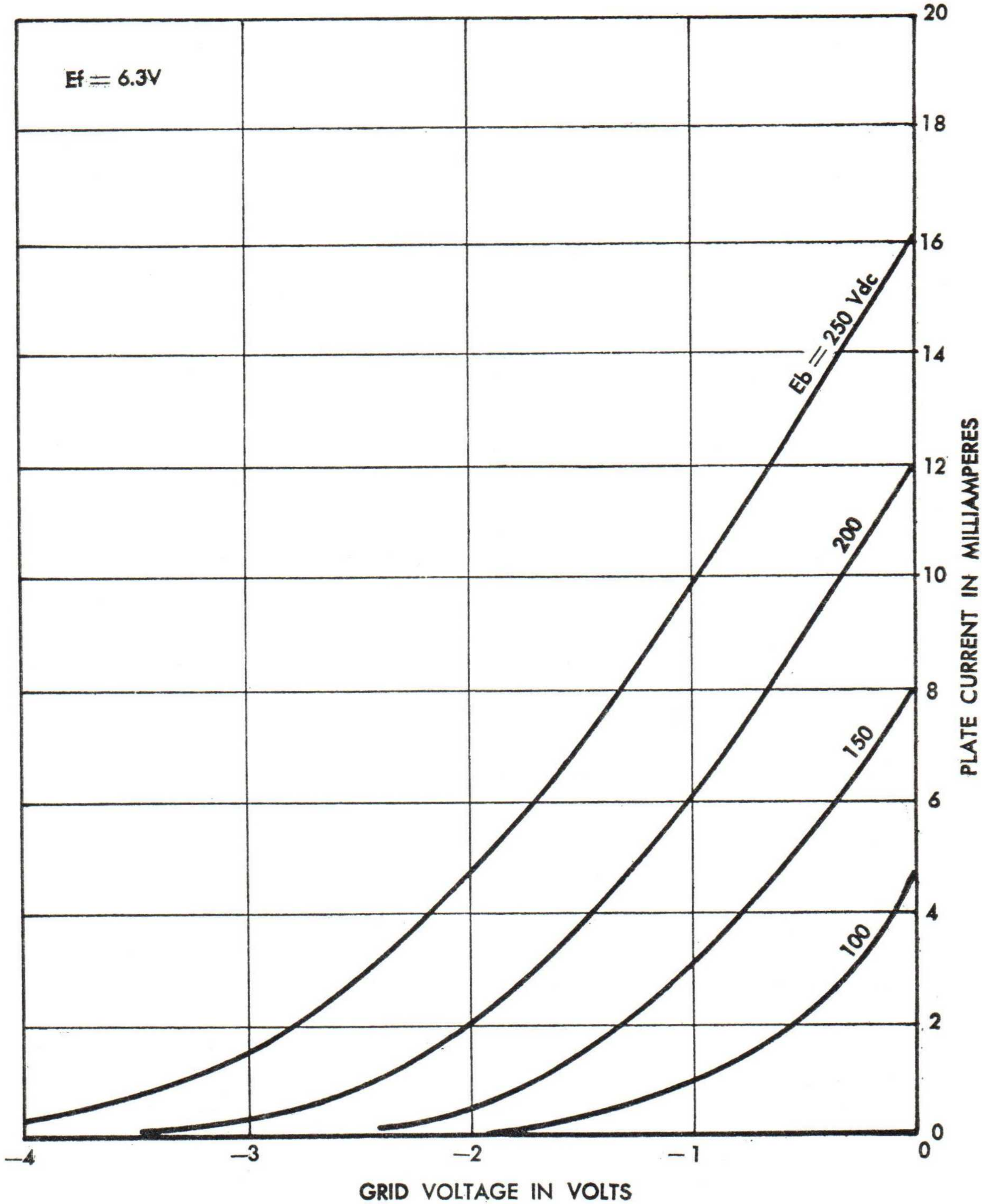


Figure 3-263. Typical Transfer Characteristics for JAN-5744WA.

The chart below presents the Average Sm, Mu and rp characteristics for JAN-5744WA.

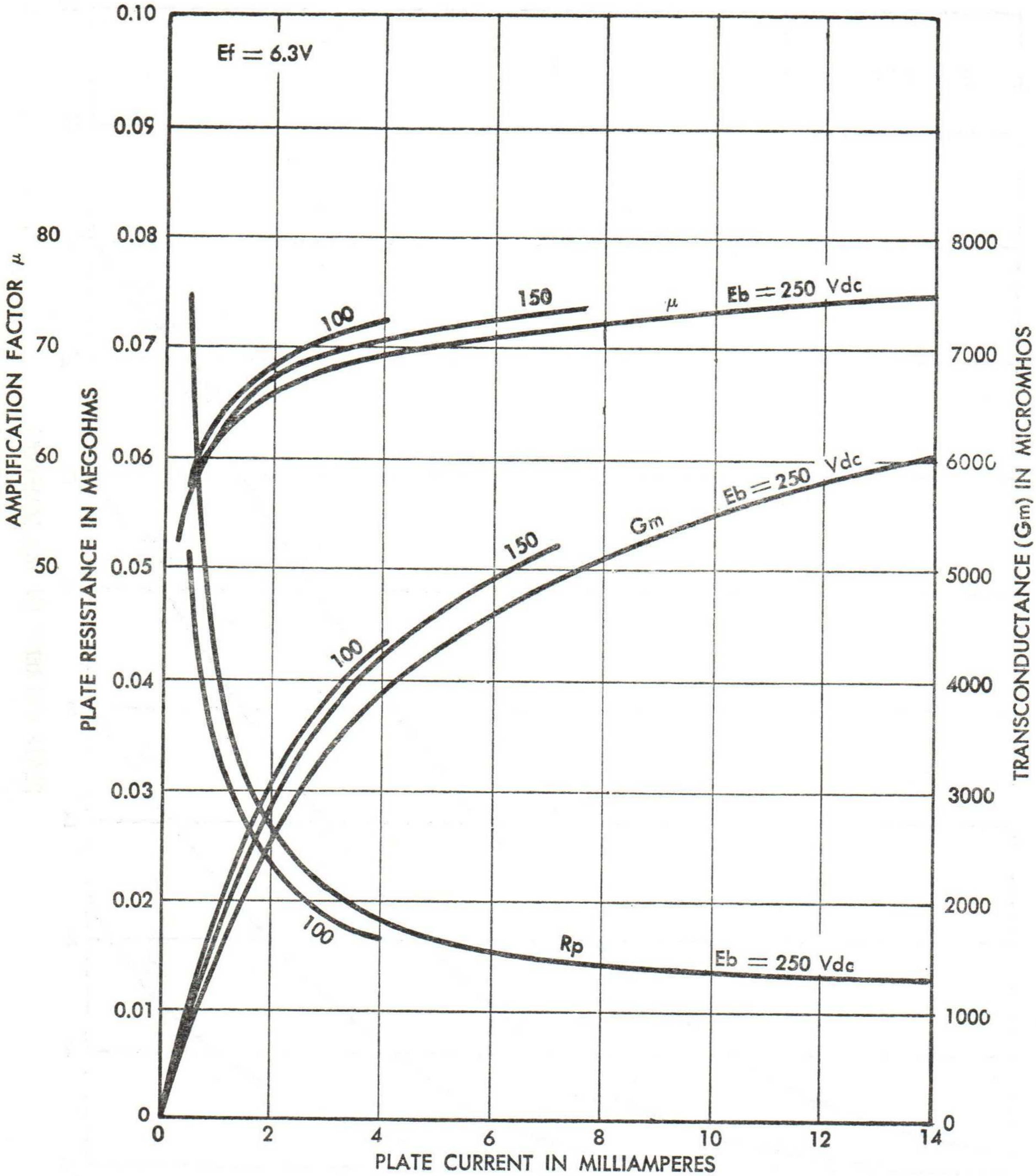


Figure 3-264. Typical Sm, rp and Mu Characteristics of JAN-5744WA.

SECTION

Tube Type JAN-5749/6BA6W

DESCRIPTION.

The JAN-5749/6BA6W [1] is a 7 pin miniature, Remote Cutoff, Pentode.

Electrical, The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	300 ma
Cathode	Coated Unipotential

Mounting. Any type of mounting is adequate.

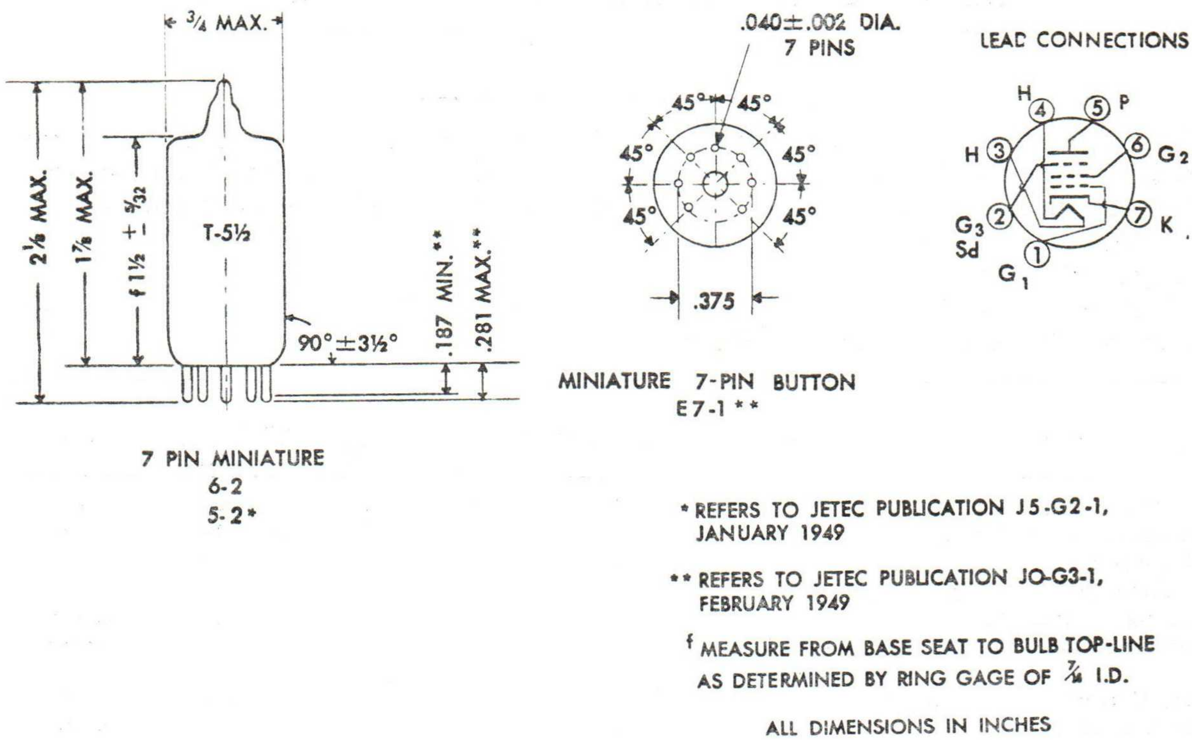


Figure 3-265. Outline Drawing and Base Diagram of Tube Type JAN-5749/6BA6W.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 10% v
*Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Screen Grid Voltage	150 Vdc
Heater Cathode Voltage	+ 100 v

[1] The values and specification comments presented in this section are related to MIL-E-1/8 dated 13 January 1953.

* No test at this rating exists in the specification.

*Plate Dissipation .... 3.3 W
*Screen Grid Dissipation .... 0.7 W
*Bulb Temperature .... 165 °C
*Altitude Rating .... 10,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.
Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Control Grid Voltage, Ec .... 0 Vdc
Screen Grid Voltage, Ec2 .... 100 Vdc
Suppressor Grid Voltage, Ec3: Tie grid 3 to negative terminal of cathode resistor
Cathode Resistance, Rk .... 68 ohms
Heater Current, If .... 300 mA
Plate Current, Ib .... 11.0 mA
Transconductance, Sm .... 4400 umhos
Transconductance, Sm. at EC1 = —20, Rk = 0 .... 40 umhos

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/8 dated 13 January 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits Initial Min	Limits Initial Max	Limits Life test Min	Limits Life test Max	Units
Heater Current	If		275	325	275	325	mA
Transconductance (1)	Sm		3600	5200	3000	5200	umhos
Change in Average	Sm Δ t		...	...	...	17	%
Transconductance (2)	Sm	Ef = 5.5 V	3100	...	...	...	umhos
Transconductance (3)	Sm	Ec1 = —20 Vdc; Rk = 0; Ck = 0	5	100	...	...	umhos
Plate Current	Ib		8.5	13.5	...	...	mAdc
Screen Current	Ic2		...	5.6	...	...	mAdc
Capacitance	Cg1-p	Ef = 0	...	.0035	...	...	uuf
(Without shield)	Cin	Ef = 0	4.4	6.6	...	...	uuf
	Cout	Ef = 0	3.5	6.5	...	...	uuf
Grid Current	Ic1	Ec1 = —1.0 Vdc Rg1 = .25 Meg	...	—1.0	...	—1.0	uAdc
Heater-Cathode Leakage	Ihk	Ehk = + 100 Vdc	...	10	...	10	uAdc
	Ihk	Ehk = —100 Vdc	...	—10	...	—10	uAdc

APPLICATION OF JAN-5749/6BA6W

The chart below shows the permissible operating area for JAN-5749/6BA6W as defined by the ratings in MIL-E-1/8 dated 13 January 1953. A discussion of the permissible operating area pentodes may be found in paragraphs 3.2.2 through 3.2.7.

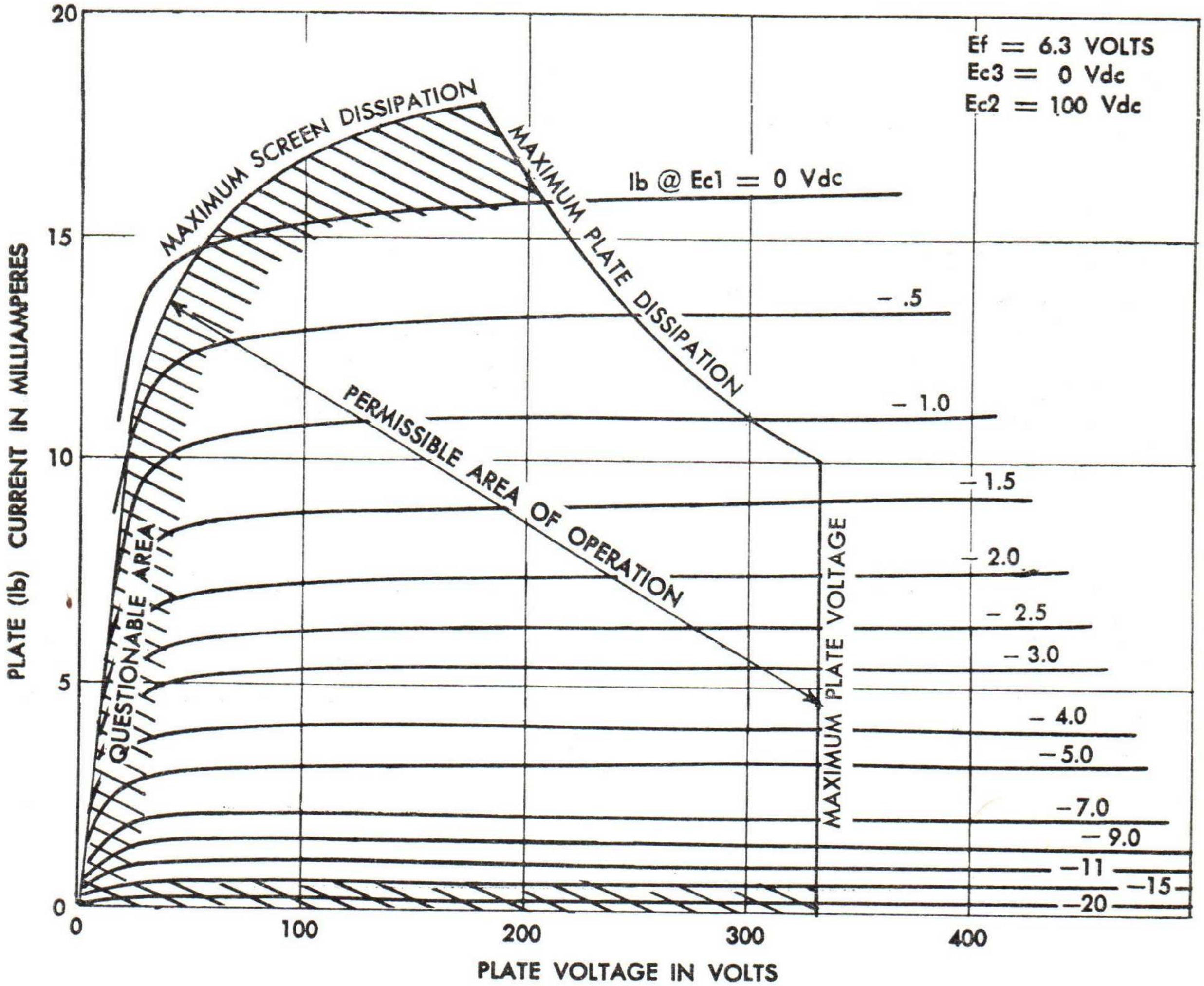


Figure 3-266. Typical Plate Characteristics of JAN 5749/6BA6W; Permissible Area of Operation.

The following table lists general considerations for the aplications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9

Screen Grid Series, 3.2.2, 3.2.9

Cathode Interface, 1.3.10, 3.2.9

Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-5749/6BA6W CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5749/6BA6W as defined by MIL-E-1/8 dated 13 January 1953.

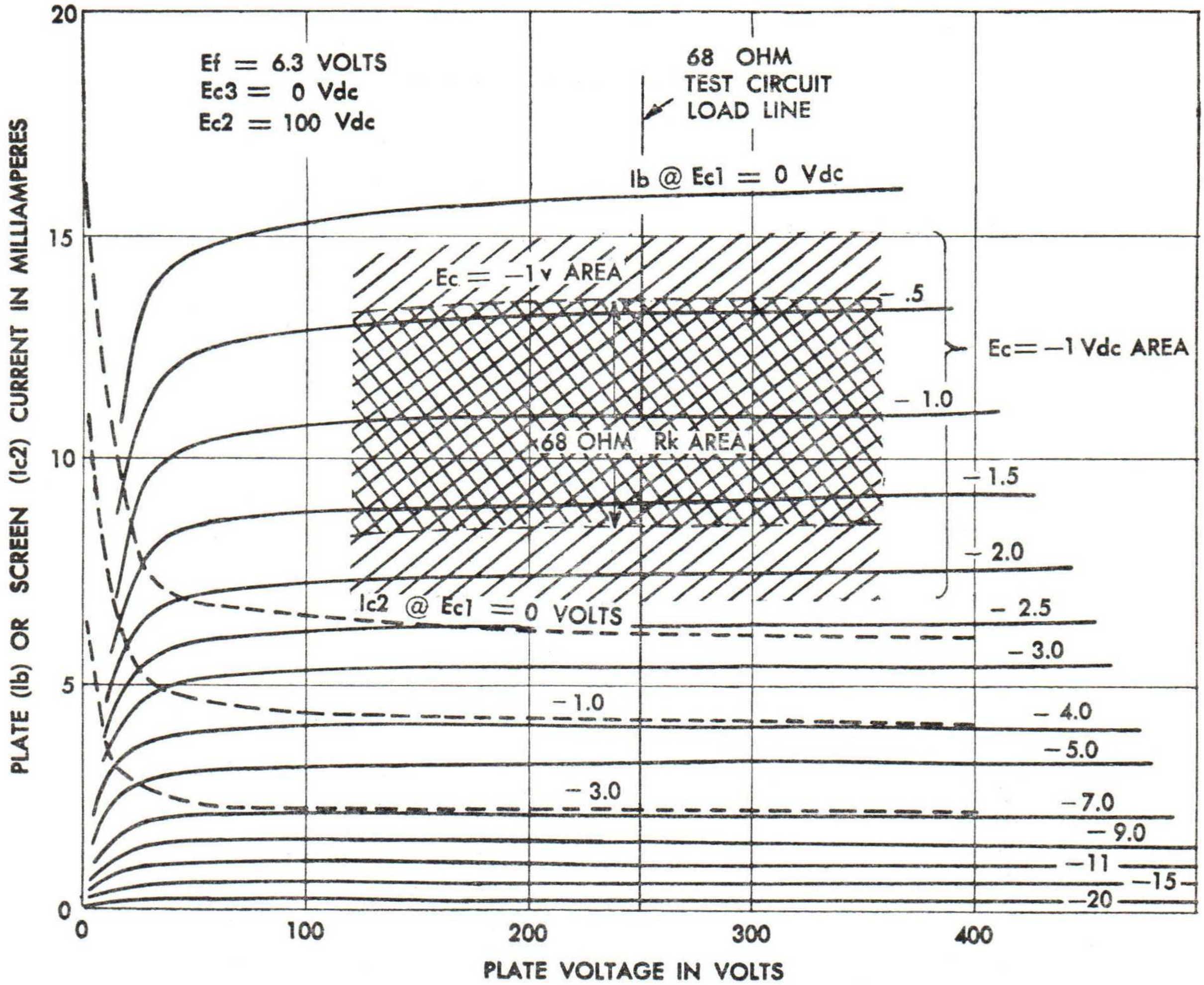


Figure 3-267. Limit Plate Characteristics of JAN 5749/6BA6W; Variability of Ib.

Figure 3-268 below presents the limit behavior of plate transfer data for JAN-5749/6BA6W as defined by MIL-E-1/8 dated 13 January 1953.

DESIGN CENTER CHARACTERISTICS OF JAN-5749/6BA6W

These typical curves have been obtained from data published by the original RETMA registrant of this type.

Figure 3-269 below presents the Static Plate Characteristics of JAN-5749/6BA6W.

Fiugres 3-270 through 3-272 present Typical Transfer characteristics of JAN-5749/6BA6W.

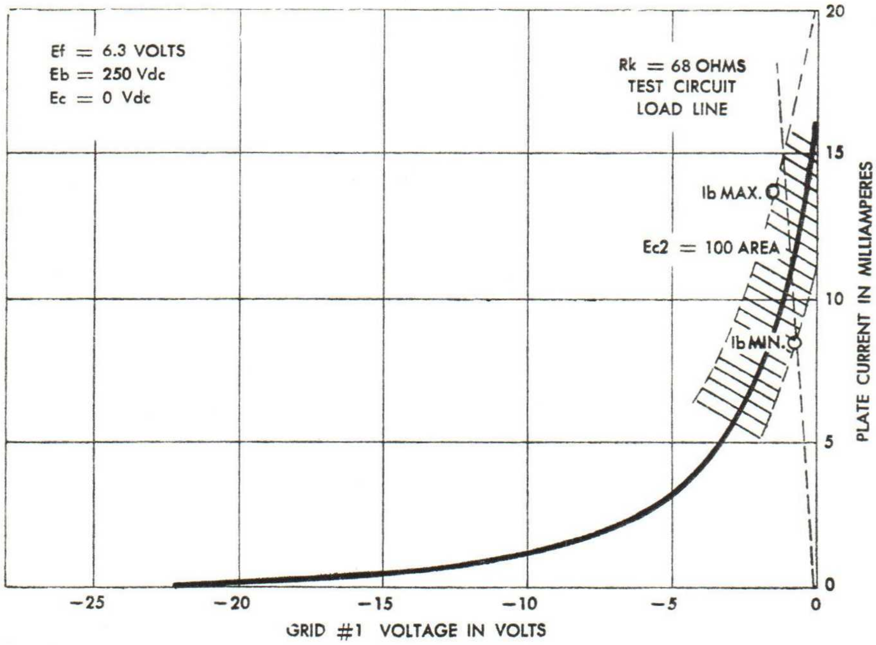


Figure 3-268. Limit Transfer Characteristics of JAN-5749/6BA6W.

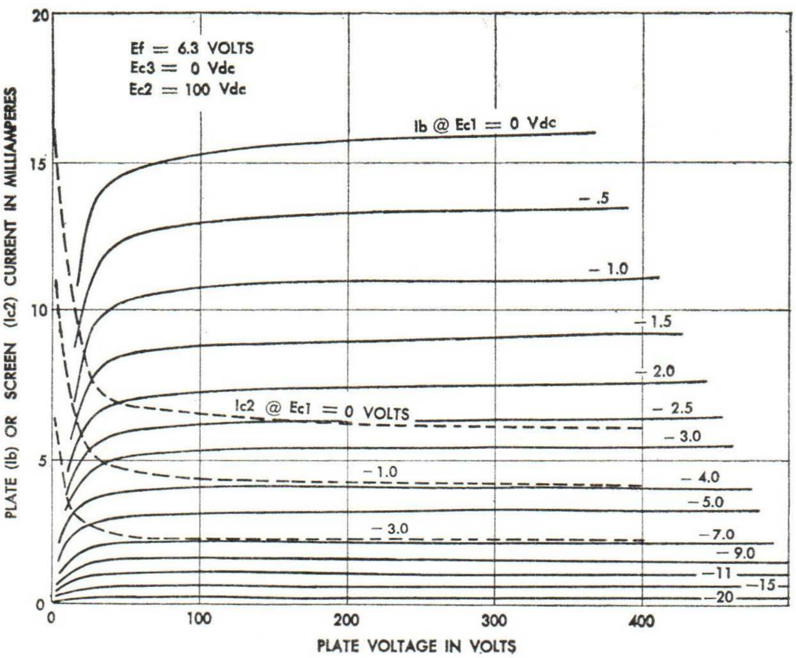


Figure 3-269. Typical Plate Characteristics of JAN-5749/6BA6W.

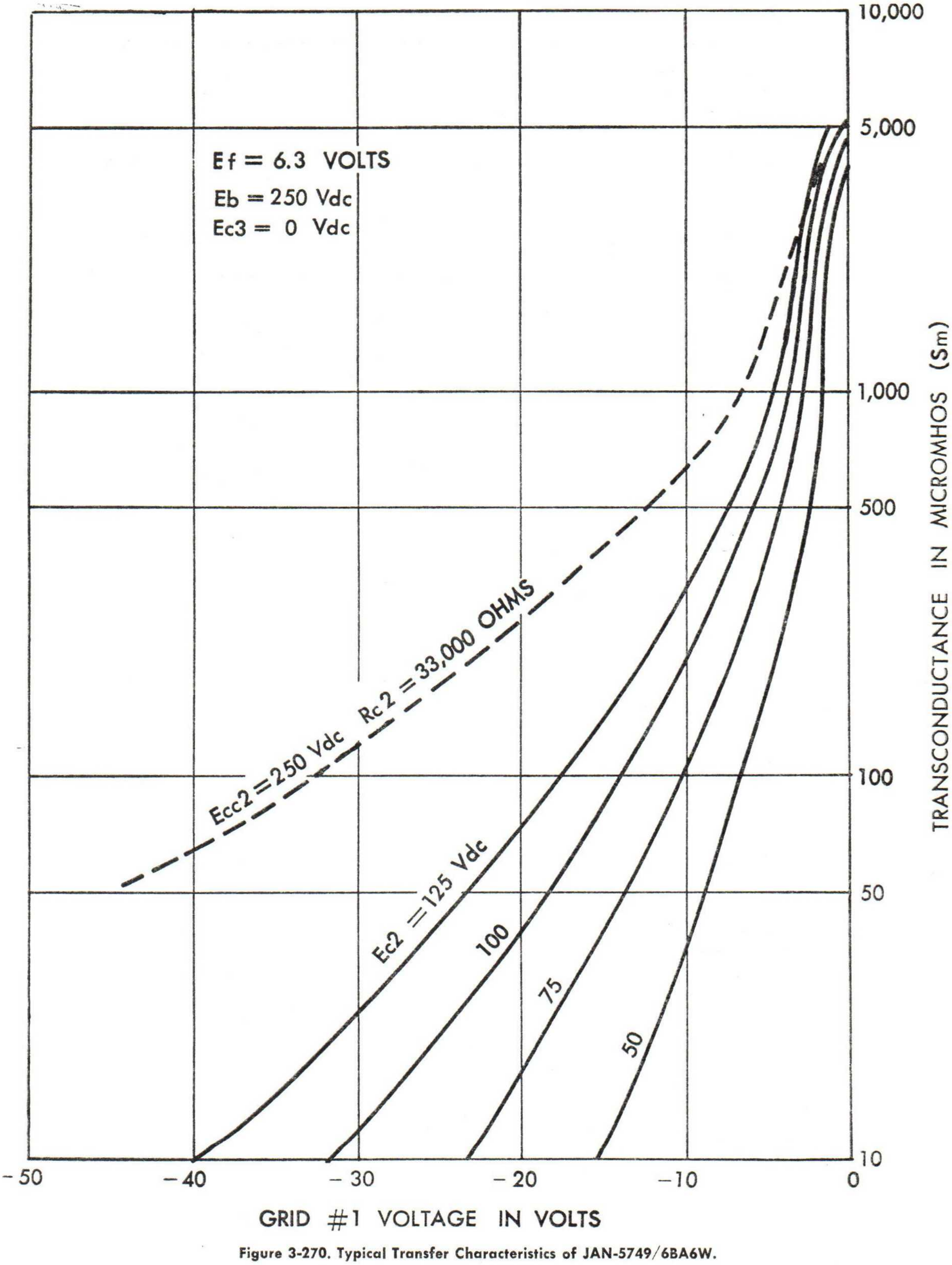


Figure 3-270. Typical Transfer Characteristics of JAN-5749/6BA6W.

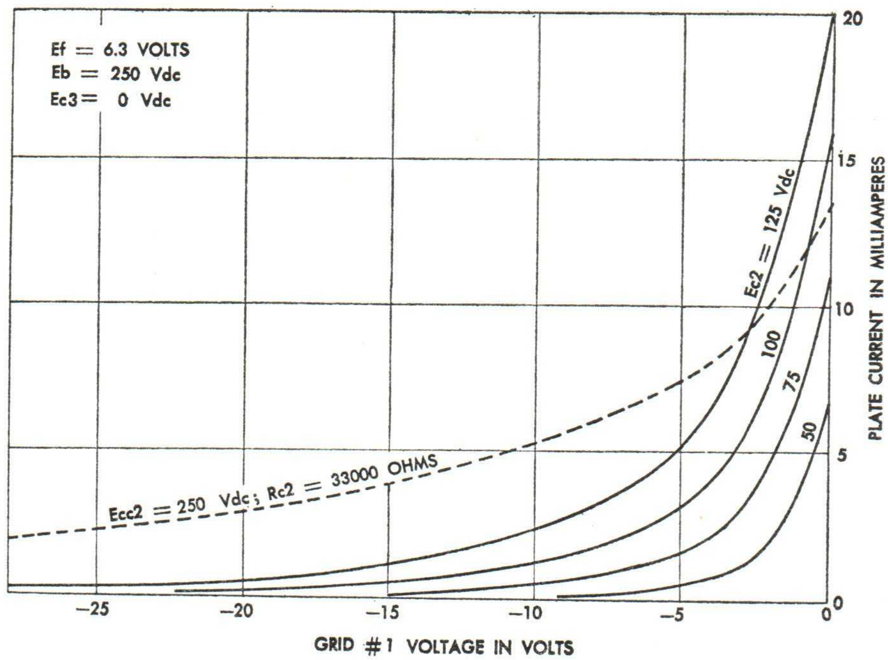


Figure 3-271. Typical Transfer Characteristics of JAN 5749/6BA6W.

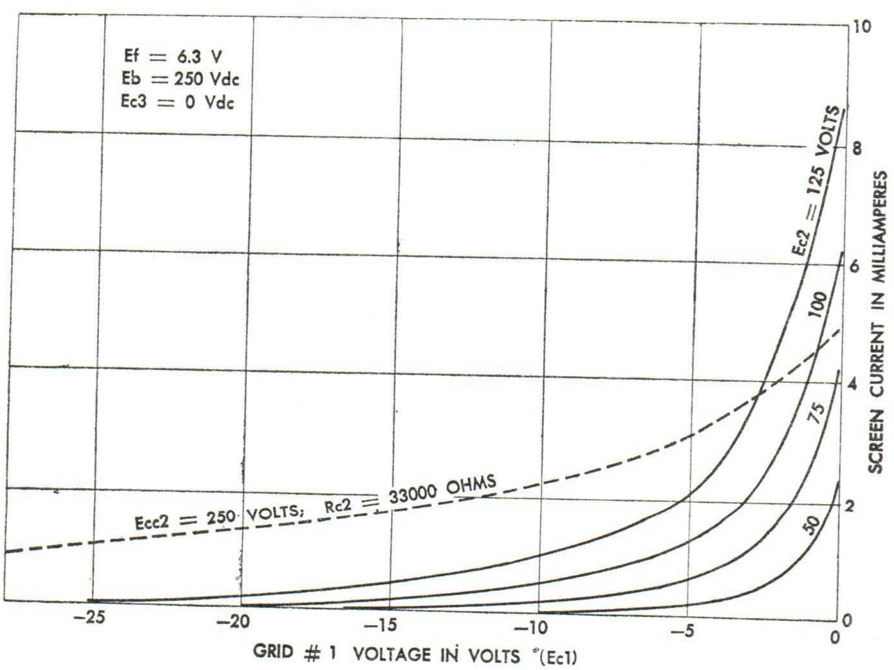


Figure 3-272. Typical Screen Transfer Characteristics of JAN 5749/6BA6W.

SECTION
TUBE TYPE JAN-5750/6BE6W

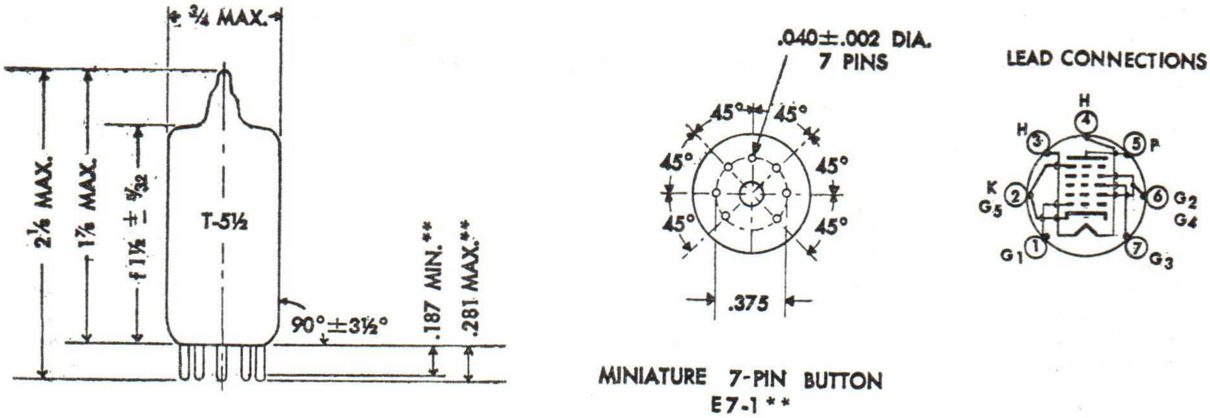
DESCRIPTION.

The JAN-5750/6BE6W [1] is a seven pin, miniature, pentagrid converter.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Heater Current, Design Center	300 mA
*Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



7 PIN MINIATURE
6-2
5-2*

* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

f MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF ¾ I.D.

ALL DIMENSIONS IN INCHES

Figure 3-273. Outline Drawing and Base Diagram of JAN-5750/6BE6W.

RATINGS, DESIGN MAXIMUM

The design maximum ratings are as follows:

Heater Voltage	6.3 ± 0.6 V
Plate Voltage, Eb	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Oscillator Grid Current, Ic1	1.0 mAdc
Screen Grid Voltage, Ec2 & 4	110 Vdc
Signal Grid Voltage, Ec3	Max 0 Vdc
	Min —55 dc
Heater-Cathode Voltage, Ehk	100 v

[1] The values and specification comments presented in this section are related to MIL-E-1/9A dated 26 December 1956.

* Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

The following table sets forth important requirements for which specification limits exist in the specification. This table is not intended to include every measured property. Reference should be made to specification MIL–E–1/9A dated 26 December 1956 to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as those stated under test conditions, unless otherwise stated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		275	325	275	325	mA
Conversion Transconductance	Sc	Rg1 = 20,000*	300	700	250	700	umhos
Average Shift	Avg ΔSc					17	%
Conversion Transconductance (2)	Sc	Ec1 = 0 Ec3 = —30 Vdc Rg1 = 20,000*	1	50	...	...	umhos
Plate Current (1)	Ib	Eb = 100 Vdc Ec1 = —14 Vdc	...	50	...	...	uAdc
Plate Current (2)		Rg1 = 20,000*	1.5	3.5	...	...	mAdc
Screen Current	Ic2 & 4	Rg1 = 20,000*	...	10.6	...	...	mAdc
Cathode Current	Ik	Rg1 = 20,000*	7.5	14.8	...	...	mAdc
Grid Current	Ic3	Ec3 = —2.0 Vdc Rg3 = 0.5 Meg Rg1 = 20,000 ohms*	...	...	...	...	uAdc
Oscillator Transconductance (1)	Sm	Eb = 100 Vdc	6000	9600	...	...	umhos
Oscillator Transconductance (2)	Sm	Eb = 100 Vdc Ef = 5.5 V	4700	...	...	...	umhos
Oscillator Grid Current	Ic1	Rg1 = 20,000*	0.38	0.64	0.33	0.64	mAdc
Heater Cathode Leakage	Ihk	Ehk = +100 Vdc Ehk = —100 Vdc	...	10	...	20	uAdc
Insulation Resistor	Rg1-all	Ec1-all = —100 Vdc	100	...	50	...	Meg
	Rg3-all	Ec3-all = —100 Vdc	100	...	50	...	Meg
	Rp -all	Ep3-all = —300 Vdc	100	...	50	...	Meg

* Test in a 20 Kc Hartley circuit with a 48,000 ohm oscillating load.

Cathode Current, Ik	15.5 mAdc
Plate Dissipation, Pp	1.1 W
Screen Grid Dissipation, Pg2 & 4	1.1 W
Bulb Temperature	165° C
Altitude	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage	6.3 V
Plate Voltage	250 Vdc
Screen Grid Voltage, Ec2 & 4	100 Vdc
Signal Grid Voltage	0
Heater Current	300 mA
Conversion Transconductance Rg1 = 20,000 ohms	500 umhos
Oscillator Grid Current (OSC)	.50 mAdc
Plate Current Rg1 = 20,000 ohms	2.5 mAdc
Screen Grid Current Rg1 = 20,000 ohms	7.6 mAdc
Cathode Current	10.6 mAdc
Oscillator Transconductance Eb = 100 Vdc	7800 umhos

The following table lists paragraph numbers of general considerations for the application of JAN-5750/6BE6W.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.5.8

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.5.2, 3.5.6
- 28 Volt, 3.5.8
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.5.8

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7, 3.5.7
- Cathode, 2.1.1, 3.5.8
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.5.8

Contact Potential, 1.3.1, 3.5.7, 3.5.8

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.5.8

Screen Grid Series, 3.5.2, 3.2.9

Cathode Interface, 1.3.10, 3.5.8

Cathode, 1.3.7, 2.1.1, 3.5.8

Temperature

Bulb and Environmental, 3.5.3

Current

Cathode, 1.3.10, 3.5.5, 3.5.8

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.5.7

Screen Grid, 3.5.2

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.5.7

Control Grid Emission, 1.3.3

Cathode, Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.5.3

Screen Grid, 2.1, 3.5.2, 3.5.6

Miscellaneous

Pulse Operation, 3.5.8

Shielding, 3.5.3

Intermittent Operation, 3.5.8

Triode Connection, 3.5.8

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.2.9

SPECIAL CONSIDERATIONS

In addition to the considerations listed above, a special test has been incorporated to preclude the possibility of the blocking phenomenon or loss of control by the signal grid.

VARIABILITY OF JAN-5750/6BE6W

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts defines the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

APPLICATION OF JAN-5750/6BE6W

RATINGS: The ratings of JAN-5750/6BE6W are given in the design maximum system. The graphical presentation of the permissible area of operation for a multi-element tube of this type is too complex. The designer of equipment must therefore refer to the "Ratings" section for this tube as well as Part II of the Handbook for adequate dissertation of "Design Maximum" Ratings.

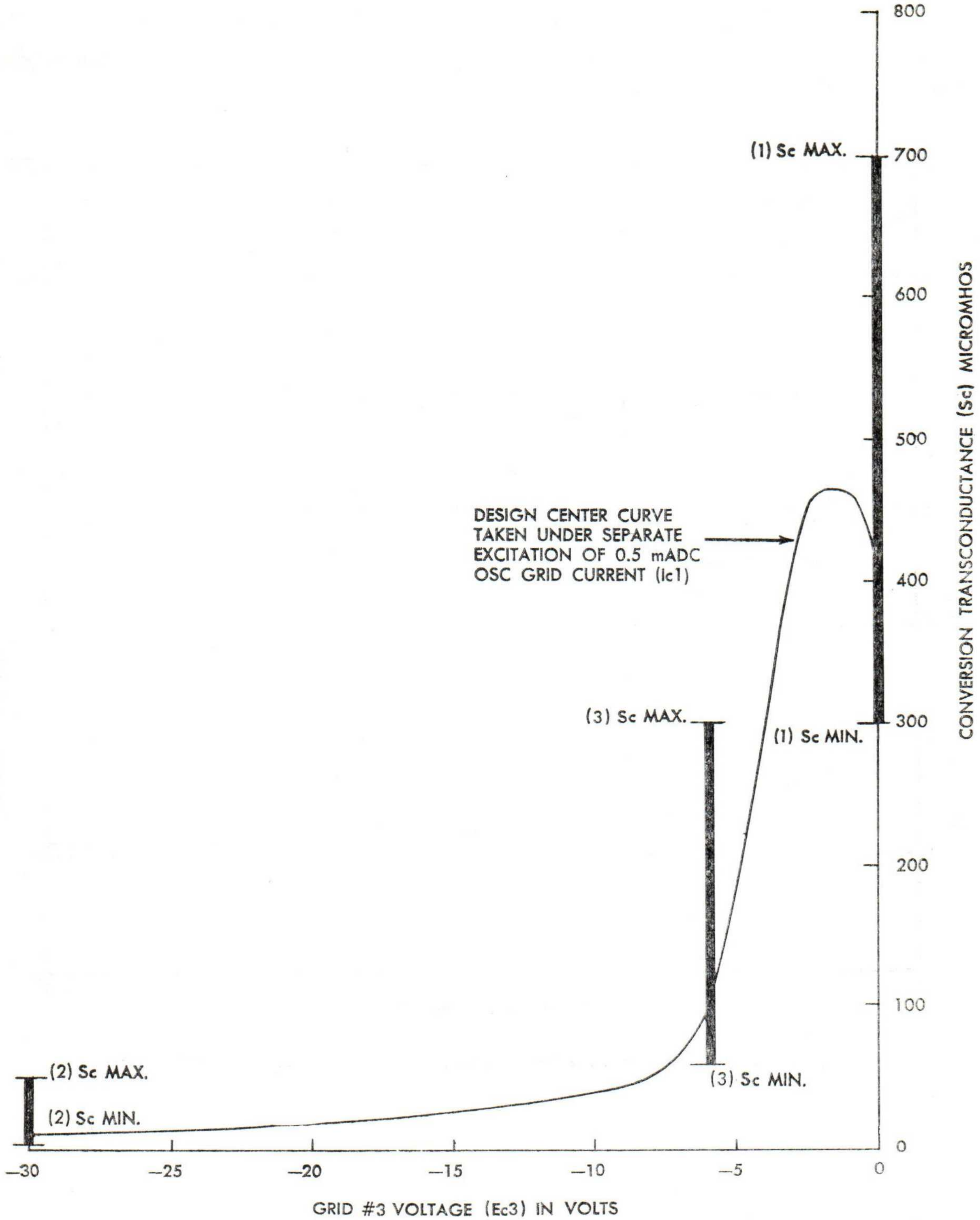


Figure 3-274. Limit Transfer Behavior of JAN-5750/6BE6W.

DESIGN CENTER CHARACTERISTICS OF JAN-5750/6BE6W

Design center characteristics have been withdrawn from data published by the original RETMA Registrant of the type.

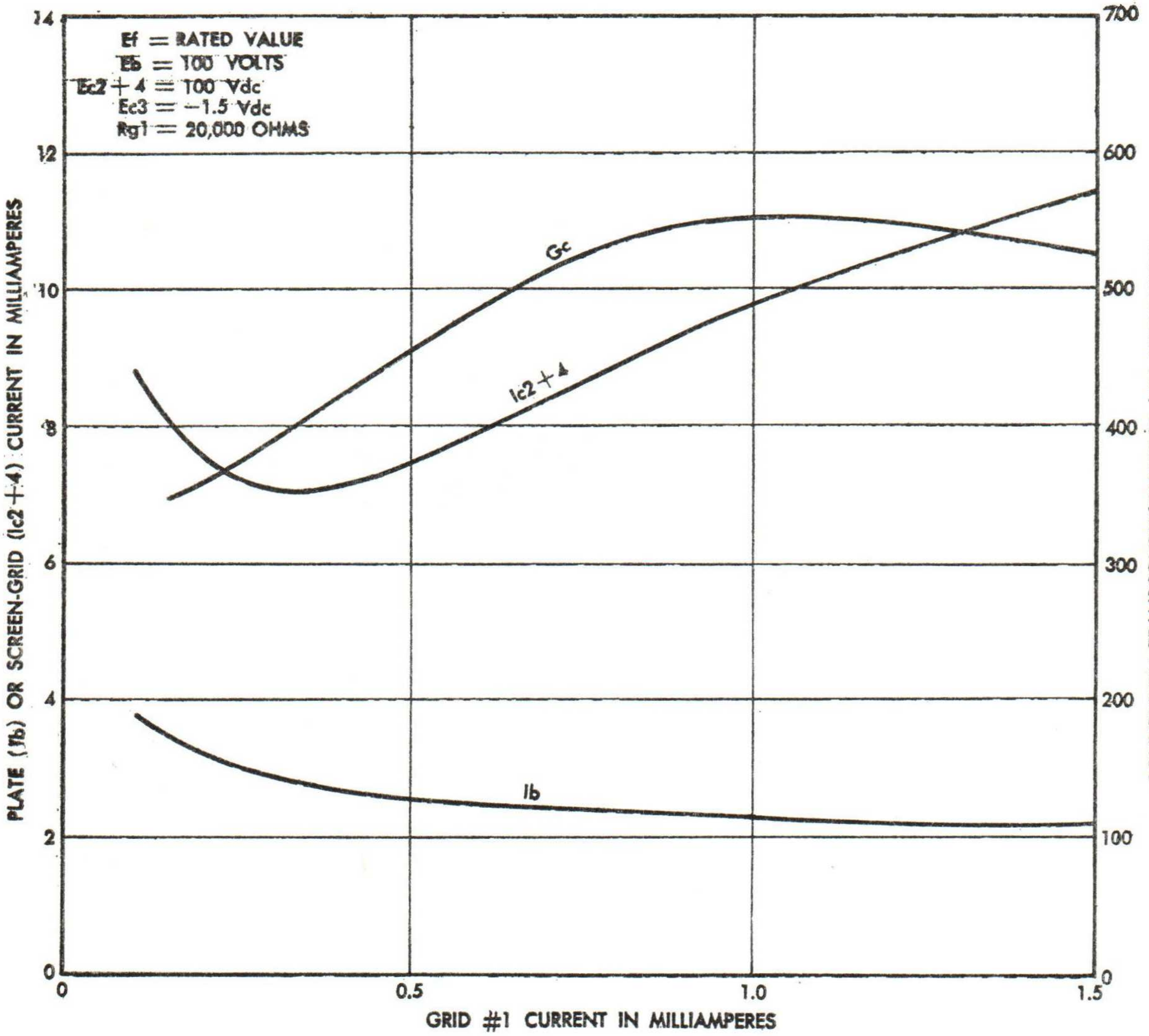


Figure 3-275. Typical Static Plate and Conversion Behavior at Eb = 100 Vdc of JAN-5750/6BE6W.

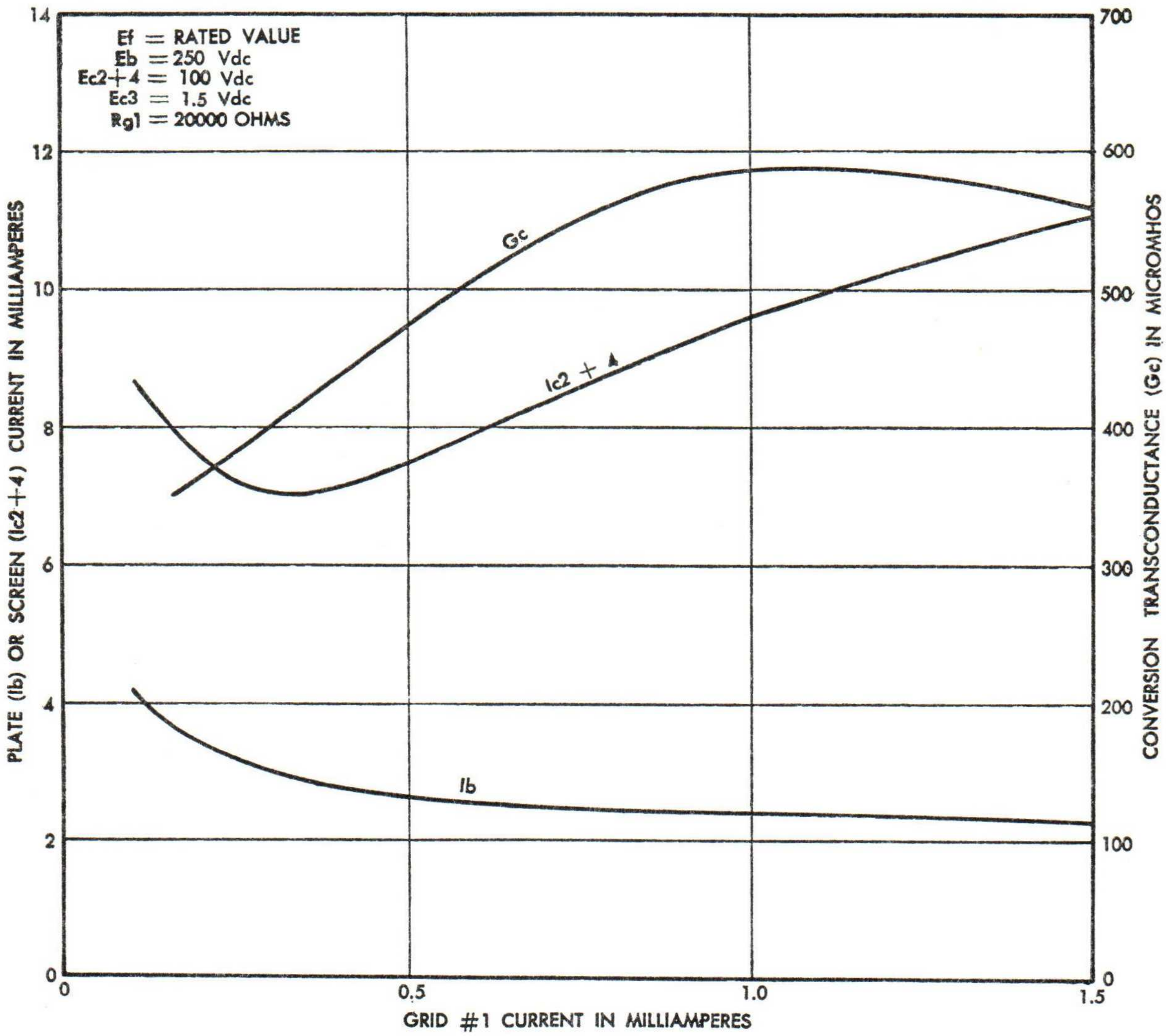
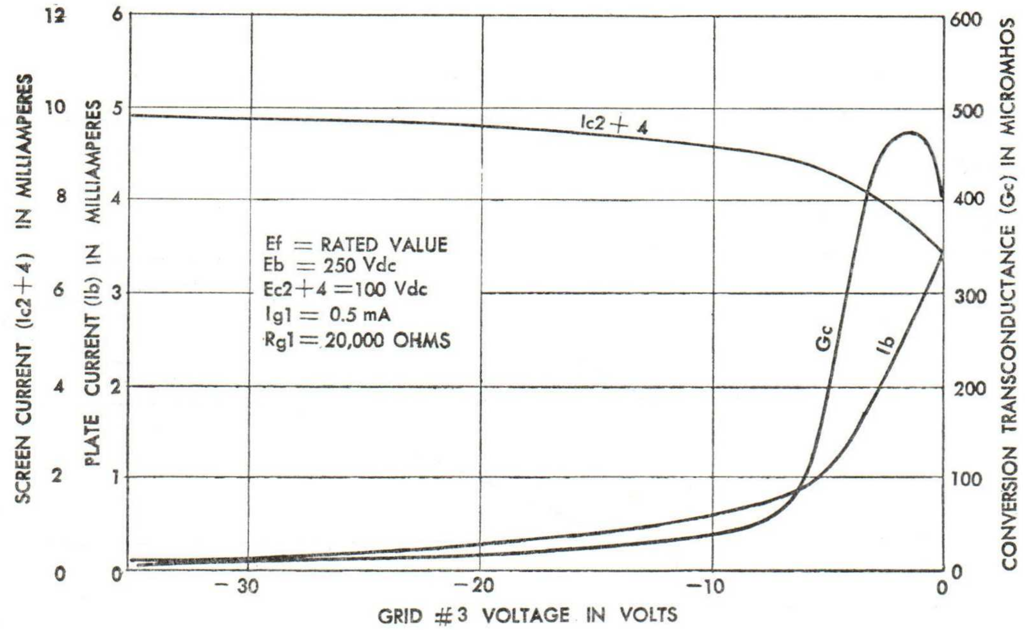


Figure 3-276. Typical Static Plate and Conversion Behavior at Eb = 250 Vdc of Jan-5750/6BE6W.



Fgure 3-277. Typical Transfer Behavior of JAN-5750/6BE6W at Eb = 250 Vdc.

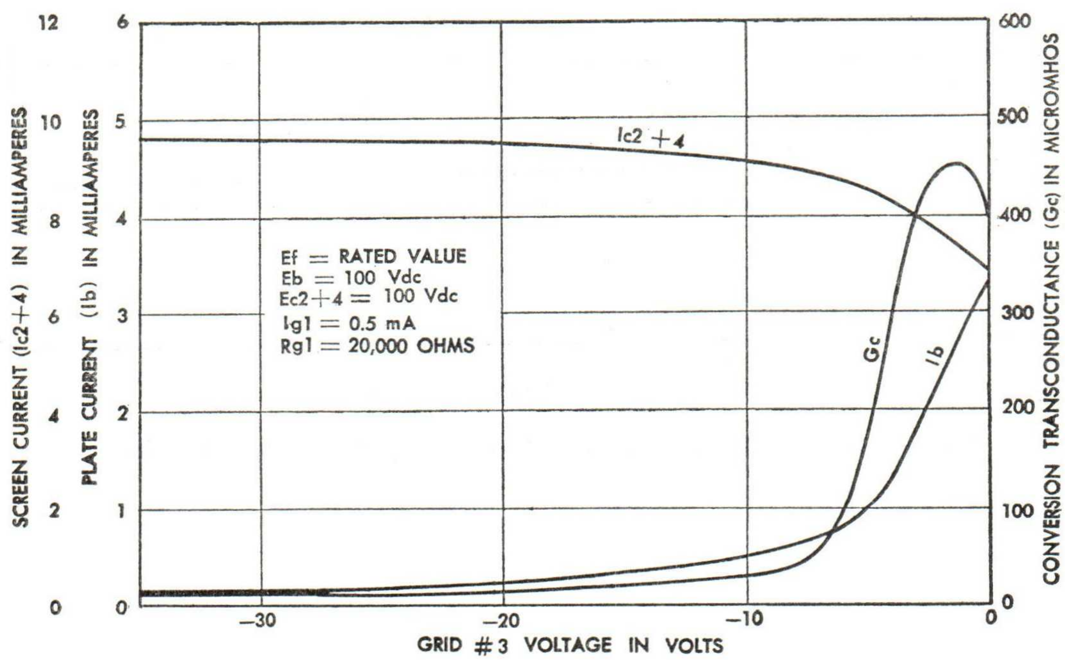


Figure 3-278. Typical Transfer Behavior of JAN-5750/6BE6W at Eb = 100 Vdc.

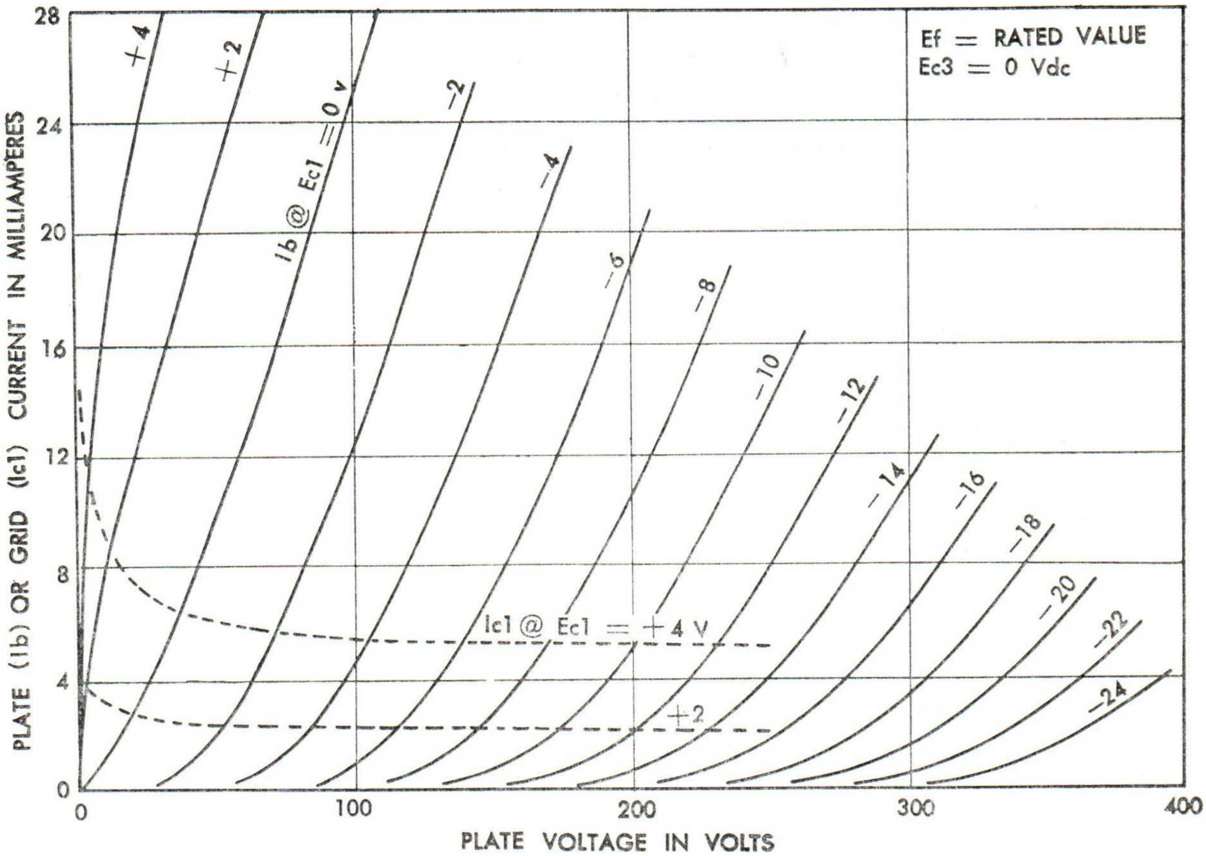


Figure 3-279. Typical Behavior of the Oscillator Section of JAN-5650/6BE6W; P tied to Ec2 & 4.

SECTION
TUBE TYPE JAN-5751

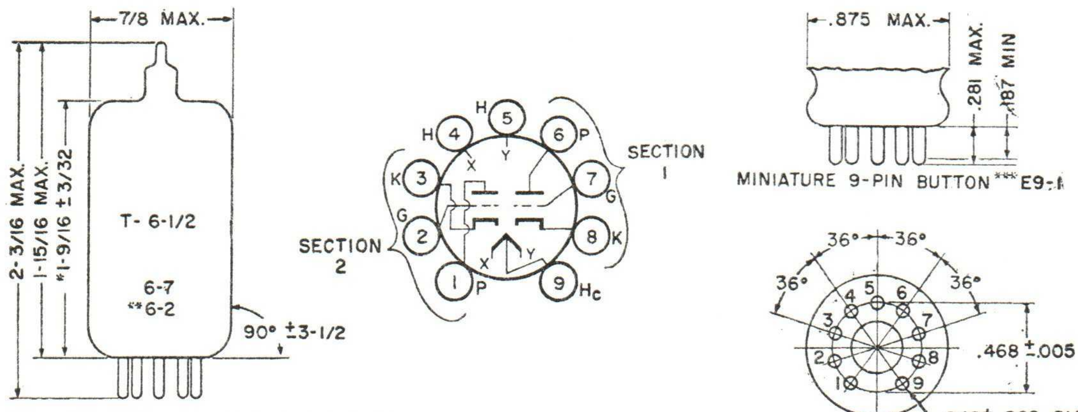
DESCRIPTION.

The JAN-5751 [1] is a 9 pin, miniature, high Mu (70), twin triode having separate cathode connections. The heater may be connected for either series or paralll opration.

ELECTRICAL. Th electrical Characteristics are as follows:

Heater Voltage	12.6 or 6.3 V
Heater Current, Design Center	175 mA
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



***MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.**

**** REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952**

ALL DIMENSIONS IN INCHES

*****REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953**

Figure 3-280. Outline Drawing and Base Diagram of Tube Type JAN-5751.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	*6.3 ± 10% or 12.6 V ± 10%
Plate Voltage	330 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage, Maximum	0 Vdc
Control Grid Voltage, Minimum	—50 Vdc
Heater-Cathode Voltage	100 v
Plate Dissipation (per plate)	0.8 W
*Bulb Temperature	165° C
*Altitude Rating	10,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/10 dated 13 January 1953.

* No test of operation at this rating exists in the specification.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	12.6 V
Plate Voltage, Eb	250 Vdc
Control Grid Voltage, Ec1	—3 Vdc
Heater Current, If	175 mA
Plate Current, Ib	1.0 mAdc
Transconductance, Sm	1200 umhos
Amplification Factor, Mu	70

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/10 dated 13 January 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		160	190	160	190	mA
Transconductance (1)	Sm		900	1600	...	...	umhos
Amplification Factor	Mu		55	85	...	...	...
Plate Current (1)	Ib		0.4	1.8	...	...	mAdc
Plate Current (1) difference between sections	Ib		...	0.6	...	...	mAdc
Capacitance	Cgp	Ef = 0	1.1	1.7	...	...	uuf
(Without Shield)	Cin	Ef = 0	1.1	1.7	...	...	uuf
Section 1:	Cout	Ef = 0	0.23	0.69	...	...	uuf
Section 2:	Cout	Ef = 0	0.19	0.53	...	...	uuf
Grid Current	Ic	R = 1.0 Meg	...	—0.4	...	—0.4	uAdc
Heater-Cathode Leakage							
	Ihk	Ehk = +100 Vdc	...	10	...	10	uAdc
	Ihk	Ehk = -100 Vdc	...	—10	...	—10	uAdc
Insulation of Electrodes							
	R(g-all)	Eg-all = —100 dc	500	...	250	...	Meg
	R(p-all)	Ep-all = —300 Vdc	500	...	250	...	Meg
AC Amplification	Ep	Eb = 100 Vdc; Ec = 0 Esig — 0.2 Vac Rp = 0.5 Meg Rg = 10 Meg	7.5	...	6.5	...	Vac

APPLICATION OF JAN–5751

The chart below shows the permissible operating area for JAN–5751 as defined by the ratings in MIL–E–1/10 dated 13 January 1953. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2.

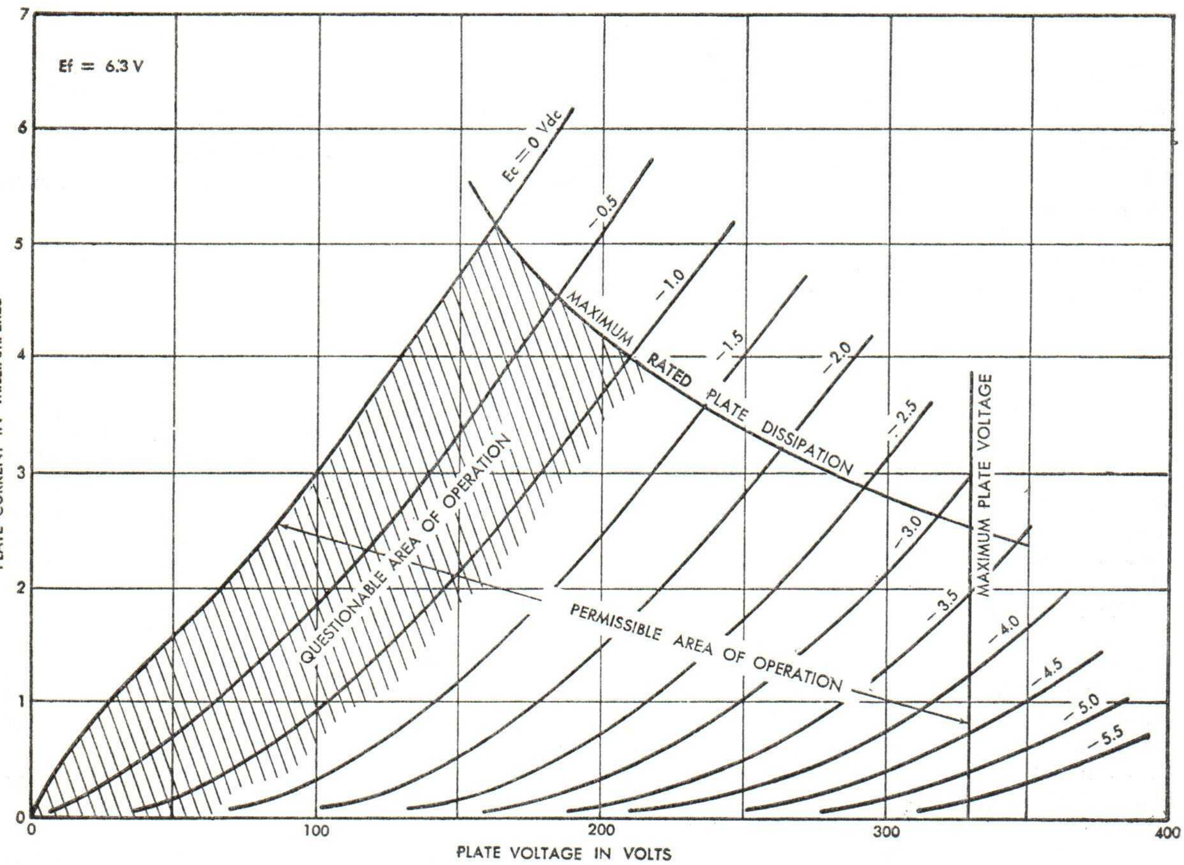


Figure 3-281. Typical Static-Plate Characteristics of JAN-5751; Permissible Area of Operation.

The following table lists general considerations for application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
  High, 3.1.5
  Low, 3.1.5
  AC Operation, 1.3.3, 3.1.5
  28 Volt, 3.1.5
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.1.2
  Cathode, 2.1.1, 3.1.5
  Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes 1.3.6
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL CONSIDERATIONS

In addition to the considerations noted above, PAN-5741 as reflected in Specification MIL-E-1/10 provides limited assurance of operation in the low plate-voltage, low plate-current region by an acceptance test initially and on life for ac amplification using grid leak bias, 100 volt plate supply, and 0.5 megohm plate load resistance. Any operation in this region other than that described above must be questioned, however, considering the variable effects that are manifested in the low-current and zero-bias regions.

VARIABILITY OF JAN-5751 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5751 as defined by MIL-E-1/10 dated 13 January 1953.

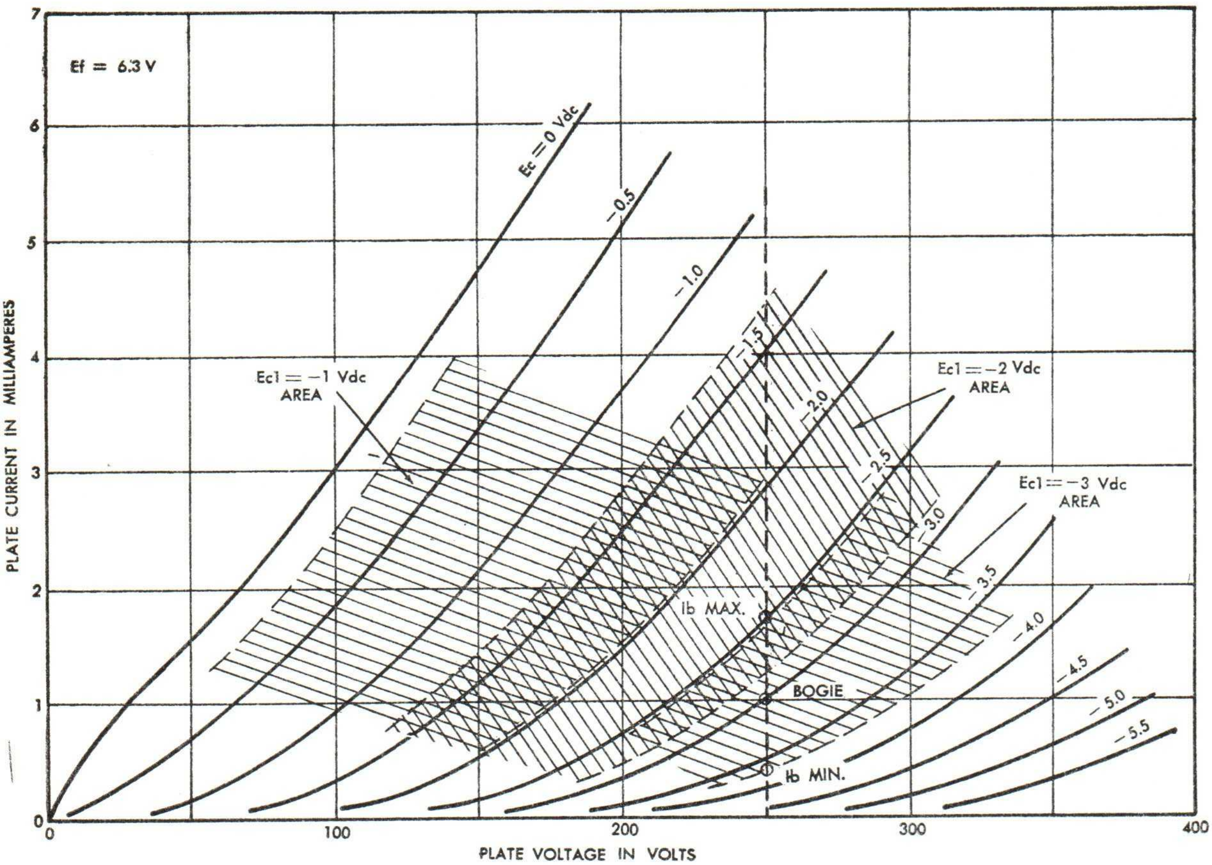


Figure 3-282. Limit Behavior Static-Plate of JAN-5751.

The chart below presents the limit behavior of plate transfer data for JAN-5751 as defined by MIL-E-1/10 dated 13 January 1953.

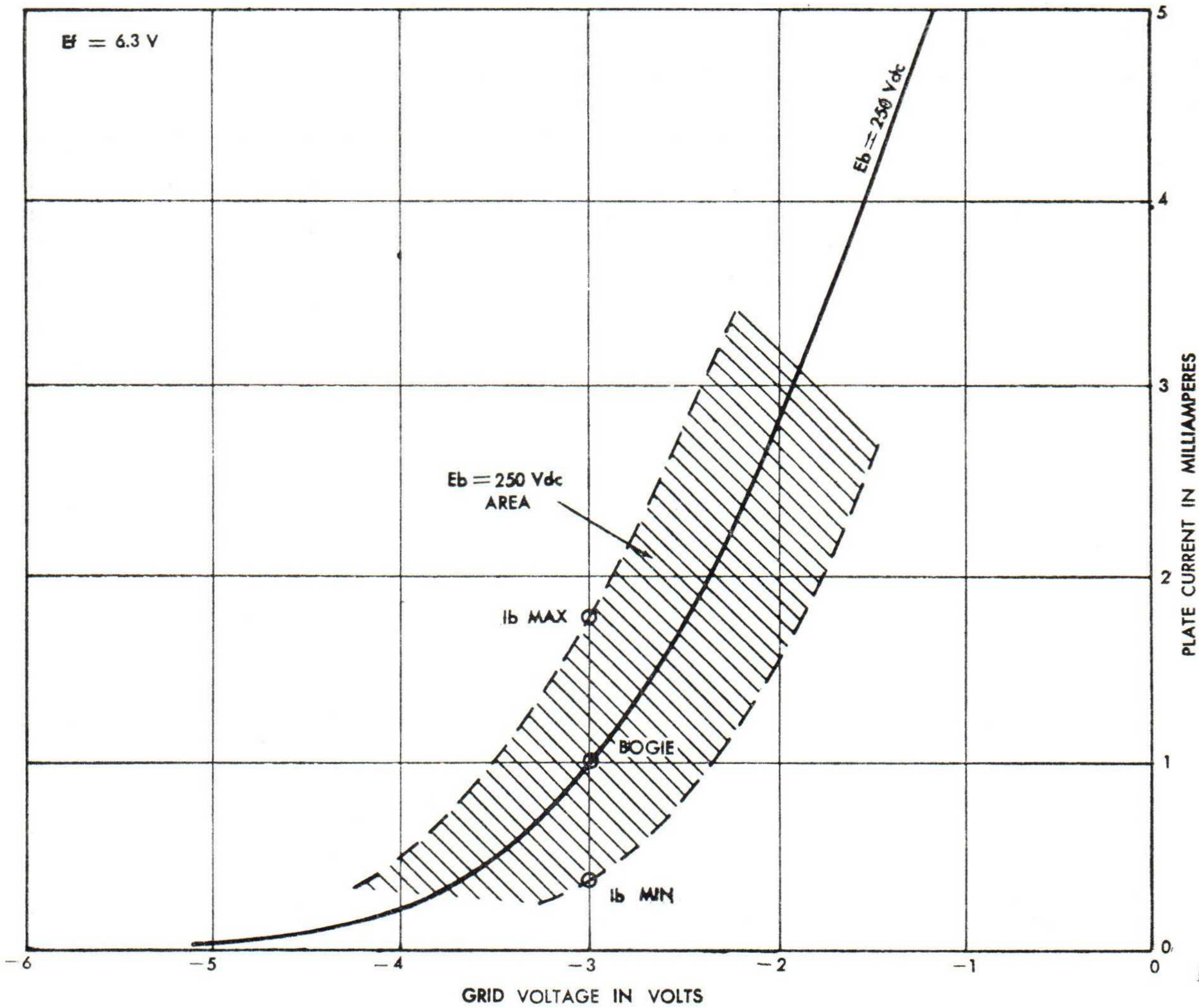


Figure 3-283. Limit Behavior of Transfer Data for JAN-5751.

DESIGN CENTER CHARACTERISTICS OF JAN–5751

These typical curves have been obtained from data published from the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN–5751.

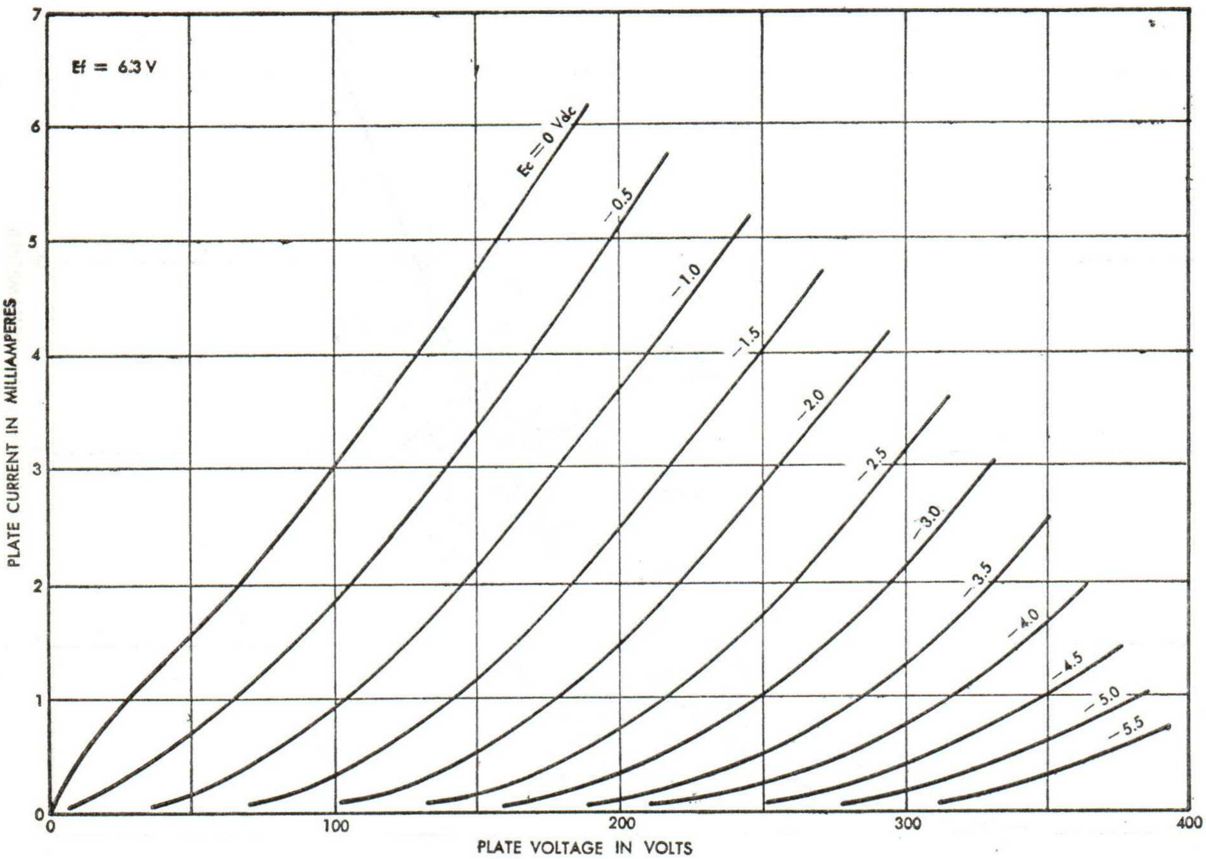


Figure 3-284. Typical Static Plate Characteristics of JAN-5751.

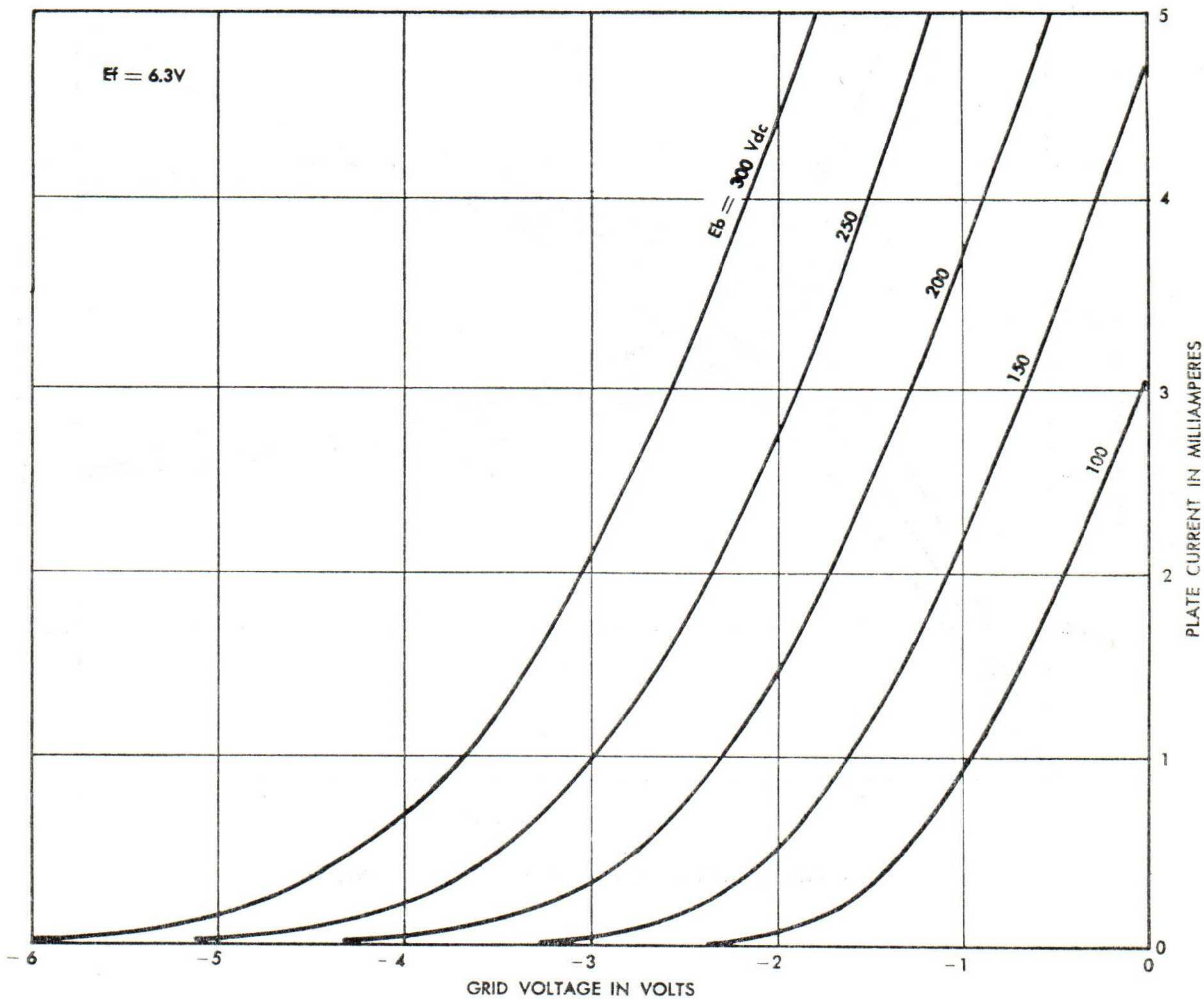


Figure 3-285. Typical Transfer Characteristics for JAN-5751.

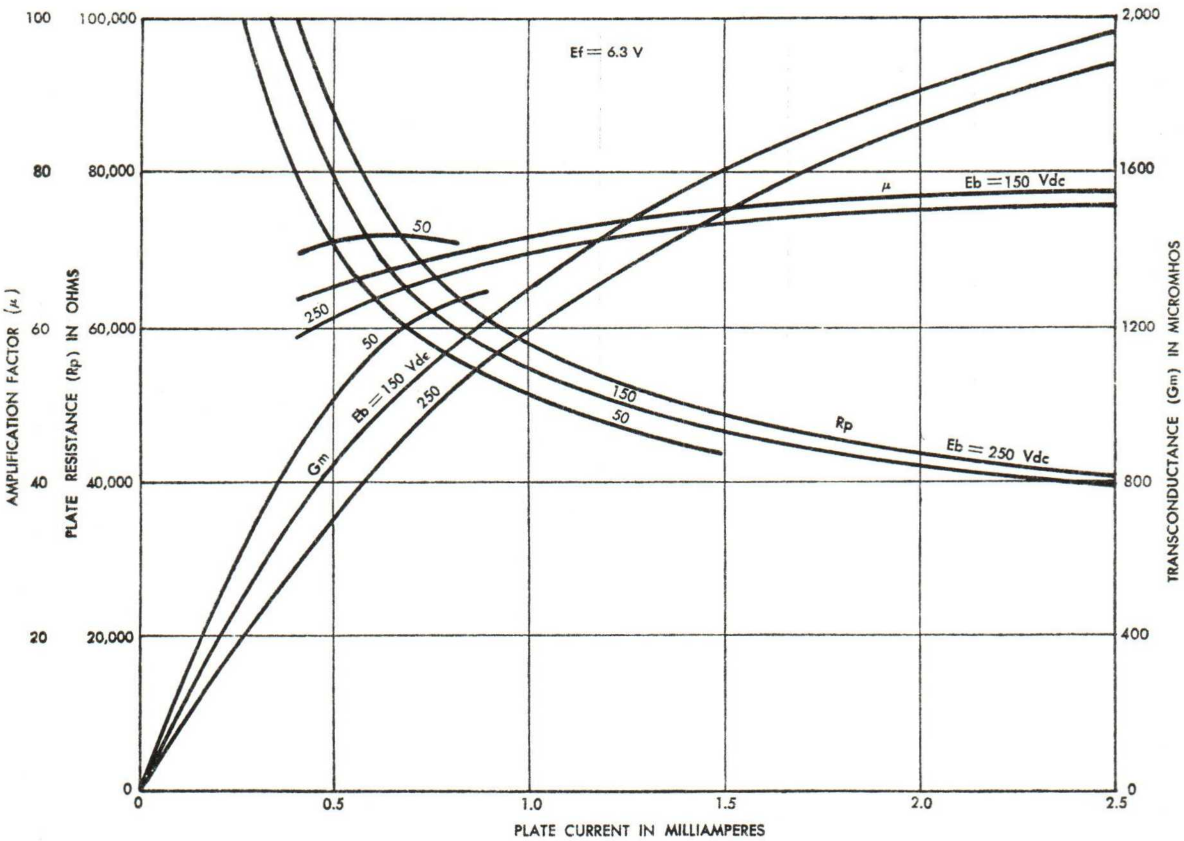


Figure 3-286. Typical Sm, Mu, and rp Characteristics for JAN-5751.

SECTION
TUBE TYPE JAN-5784WA

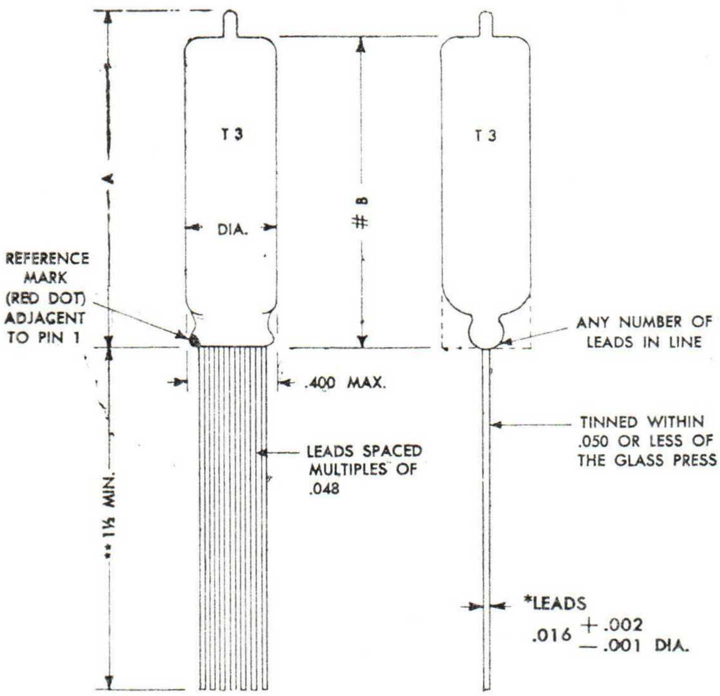
DESCRIPTION.

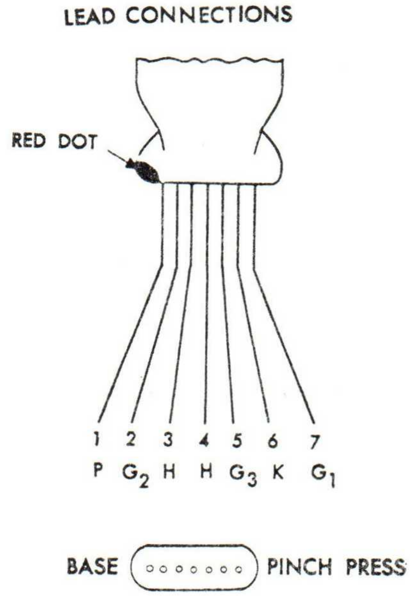
The JAN-5784WA [1] is a flat-press, seven lead subminiature, dualcontrol, pentode having a design center transconductance value of 3200 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current .... 183 to 217 mA
Cathode .... *Coated Unipotential*

MOUNTING. Any type of mounting is adequate.





DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±		
			C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-287. Outline Drawing and Base Diagram of Jan-5784WA.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3 V ± 0.6 V
Plate Voltage .... 200 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Screen Voltage .... 155 Vdc
Suppressor Grid Voltage 30.Vdc

[1] The values and specification comments presented in this section are related to MIL-E-1/88C dated 25 July 1956.

*Plate Dissipation .... 0.80 W
*Screen Dissipation .... ±0.85 W
Heater-Cathode Voltage .... 200 V
*Cathode Current, Maximum .... 20 mAdc
*Cathode Current, Minimum .... 0.5 mAdc
*Bulb Temperature .... 265° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 120 Vdc
Control Grid Voltage, Ec1 .... —2.0 Vdc
Screen Grid Voltage, Ec2 .... 120 Vdc
Suppressor Grid Voltage, Ec3 .... 0 Vdc
Heater-Cathode Voltage .... 100 Vdc
Control Grid Resistance .... 1.0 Meg
Plate Current, Ib .... 5.2 mAdc
Transconductance, Sm .... 3200 umhos

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/88C dated 25 July 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		183	217	183	217	mA
Transconductance (1)	Sm		2500	4500	...	...	umhos
Change in individual Transconductance (2)	Δ Sm/t		...	...	...	...	%
	Δ Sm/Ef	Ef = 5.7 V	...	15	...	25	%
Plate Current (1)	Ib		2.5	9.0	...	...	mAdc
Plate Current (2)	Ib	Ec3 = —15 Vdc	...	20	...	...	uAdc
Screen Grid Current	Ic2		0	7.0	...	...	mAdc
Capacitance	Cg1p	Ef = 0	...	0.030	...	...	uuf
(Shielded as	Cin	Ef = 0	3.5	5.5	...	...	uuf
Specified)	Cout	Ef = 0	2.8	4.4	...	...	uuf
Grid Current (1)	Ic		0	—0.1	0	—0.9	uAdc
Heater-Cathode Leakage	Ihk	Ehk = 100 Vdc	...	10	...	20	uAdc
	Ihk	Ehk = —100 Vdc	...	—10	...	—20	uAdc
Insulation of Electrodes	R(g-all)	Eg1-all = —100 Vdc	100	...	50	...	Meg
	R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg
	R(g3-all)	Eg3-all = —100 Vdc	100	...	50	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.5.8
Heater-Cathode, 1.3.7
Plate:
High, 3.2.9
Low, 3.5.2, 3.5.6
28 Volt, 3.5.8
AC Operation, 1.3.3, 3.2.9
Screen Grid:
Supply, 3.2.7
Protection, 3.5.8
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.2.7, 3.5.7
Cathode, 2.1.1, 3.5.8
Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.5.8
Contact Potential, 1.3.1, 3.5.7, 3.5.8

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.5.8
Screen Grid Series, 3.5.2, 3.2.9
Cathode Interface, 1.3.10, 3.5.8
Cathode, 1.3.7, 2.1.1, 3.5.8

Temperature

Bulb and Environmental, 3.5.3

Current

Cathode, 1.3.10, 3.5.5, 3.5.8
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.5.7
Screen Grid, 3.5.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.5.7
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.5.3
Screen Grid, 2.1, 3.5.2, 3.5.6

Miscellaneous

Pulse Operation, 3.5.8
Shielding, 3.5.3
Intermittent Operation, 3.5.8
Triode Connection, 3.5.8
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-5784WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

Figure 3-289 below presents the limit behavior of static plate characteristics for JAN–5784WA as defined by MIL–E–1/88C dated 25 July 1956.

Figure 3-290 below presents the limit behavior of Static Screen Grid Characteristics for JAN–5784WA.

Figure 3-291 below presents the limit behavior of plate transfer data for JAN–5784WA as defined by MIL–E–1/88A dated 28 October 1953.

Figure 3-292 below presents the limit behavior of Screen Grid Transfer Data for JAN–5784WA.

APPLICATION OF JAN-5784WA

The chart below shows the permissible operating area for JAN-5784WA as defined by the ratings in MIL-E-1/88C dated 25 July 1956. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2 through 3.2.7.

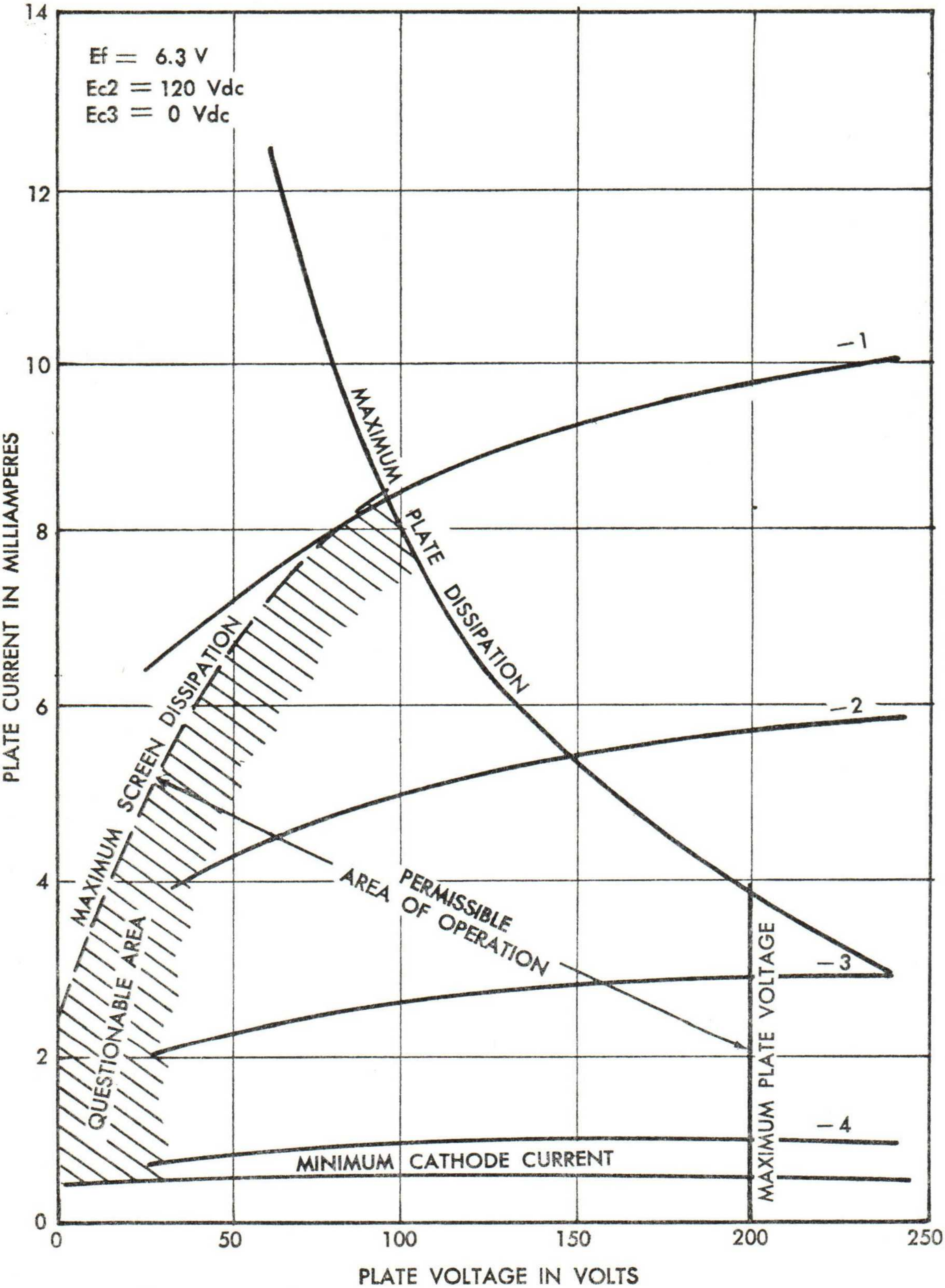


Figure 3-288. Typical Static Characteristics of JAN-5784WA; Permissible Area of Operation.

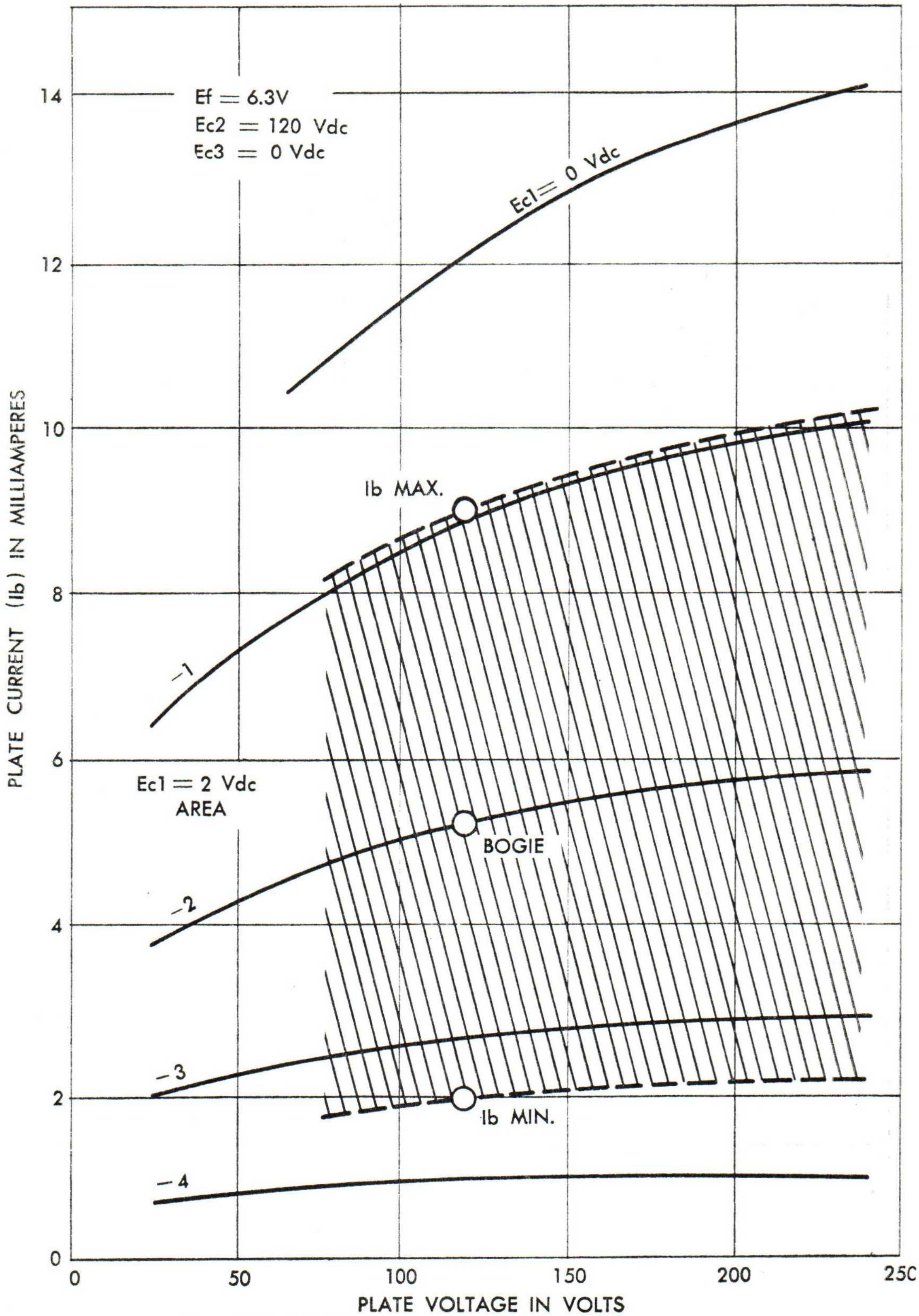


Figure 3-289. Limit Plate Characteristics of JAN-5748WA; Variability of Ib.

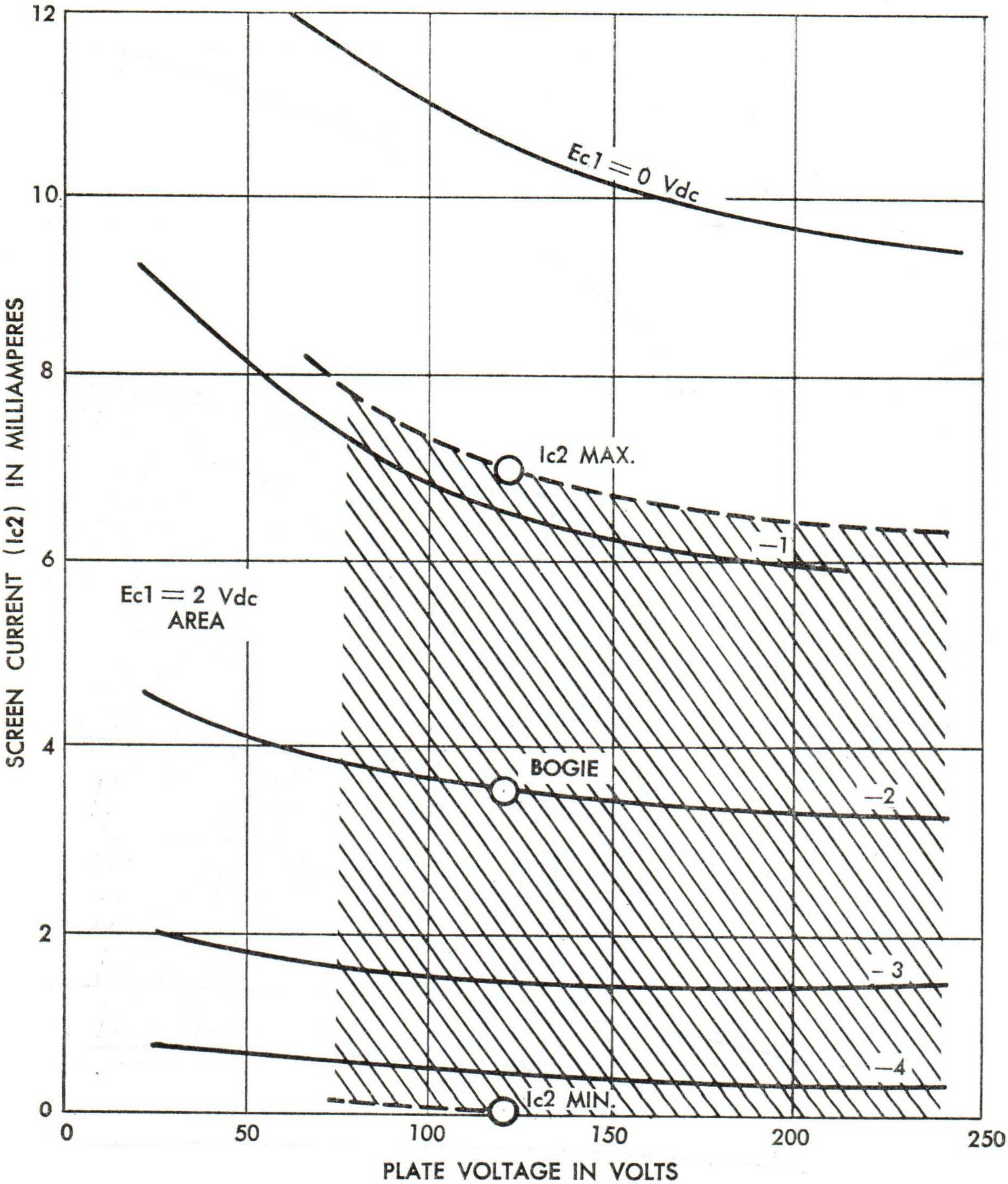


Figure 3-290. Limit Plate Characteristics of JAN-5784WA; Variability of Ic2.

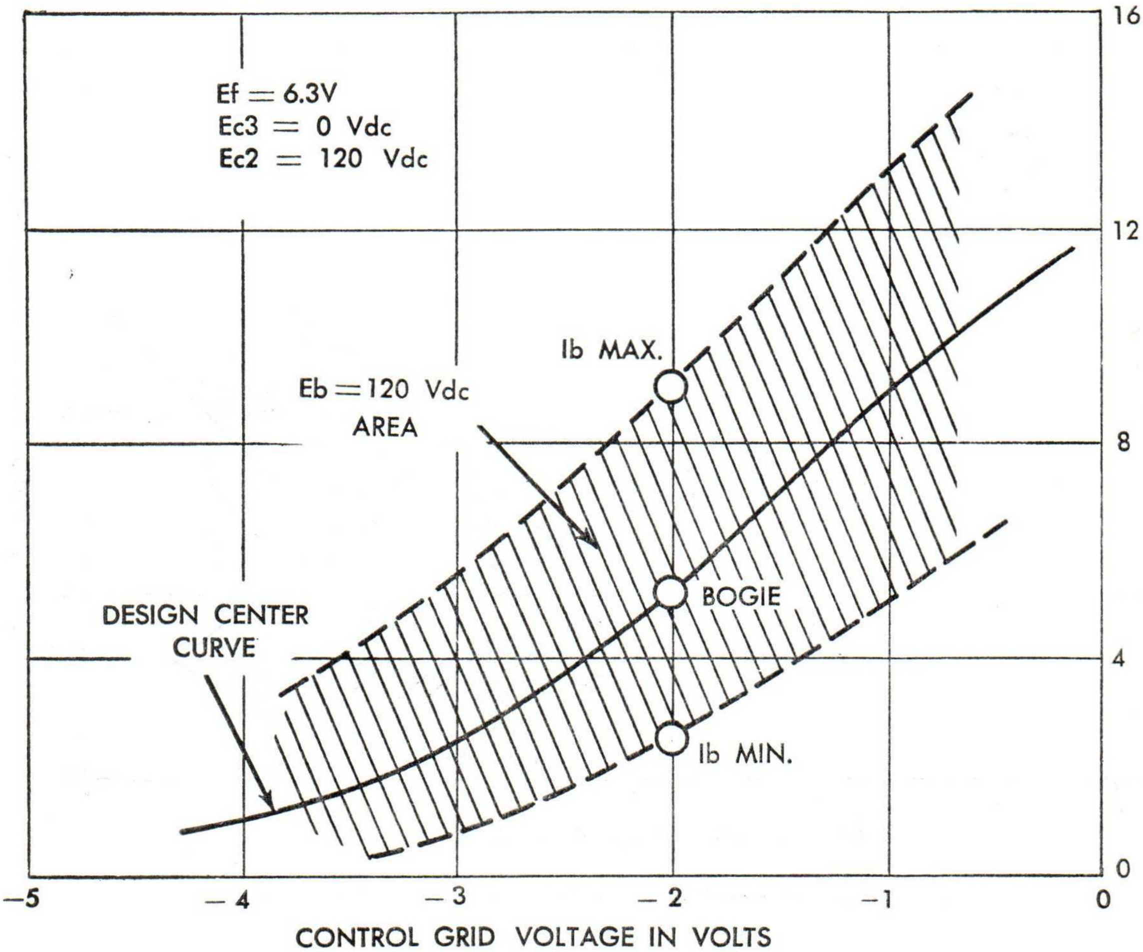


Figure 3-291. Limit Transfer Characteristics of Tube Type JAN-5784WA; Variability of Ib.

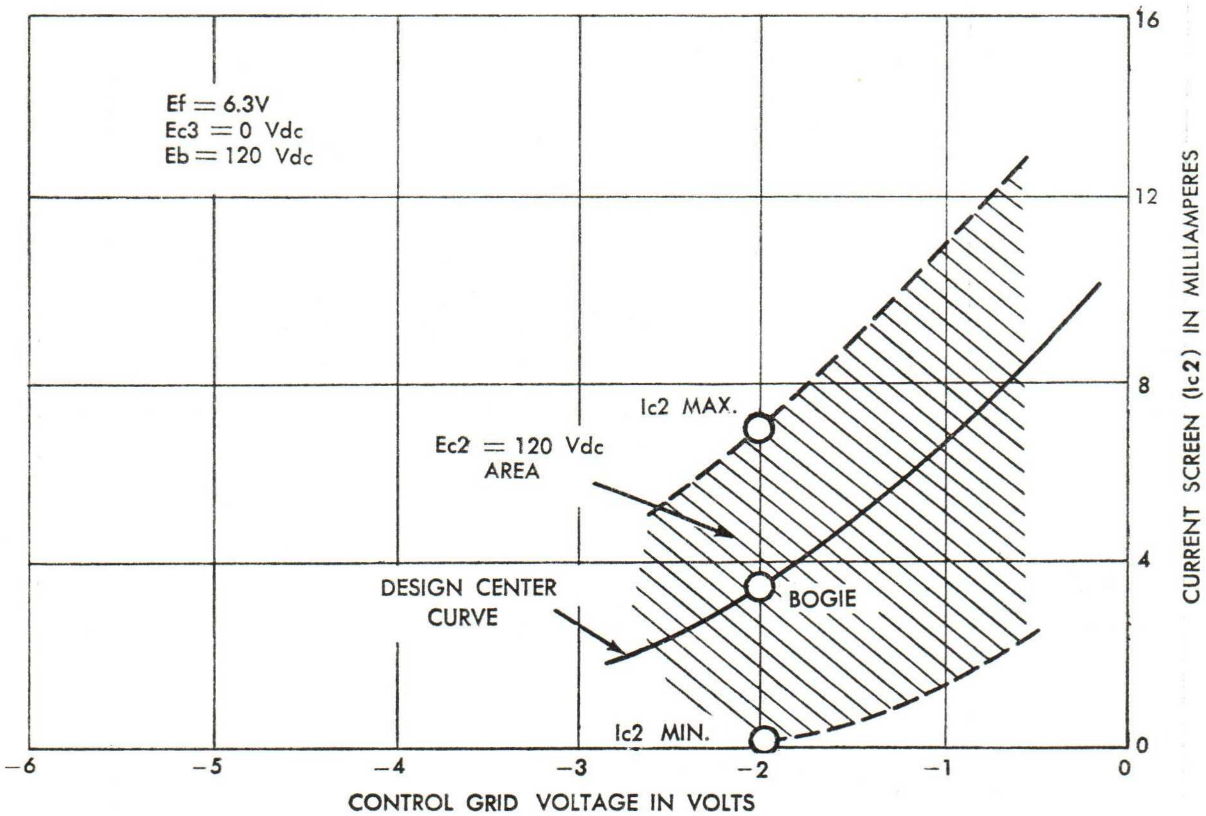


Figure 3-292. Limit Transfer Data for Tube Type JAN-5784WA; Variability of Ic2.

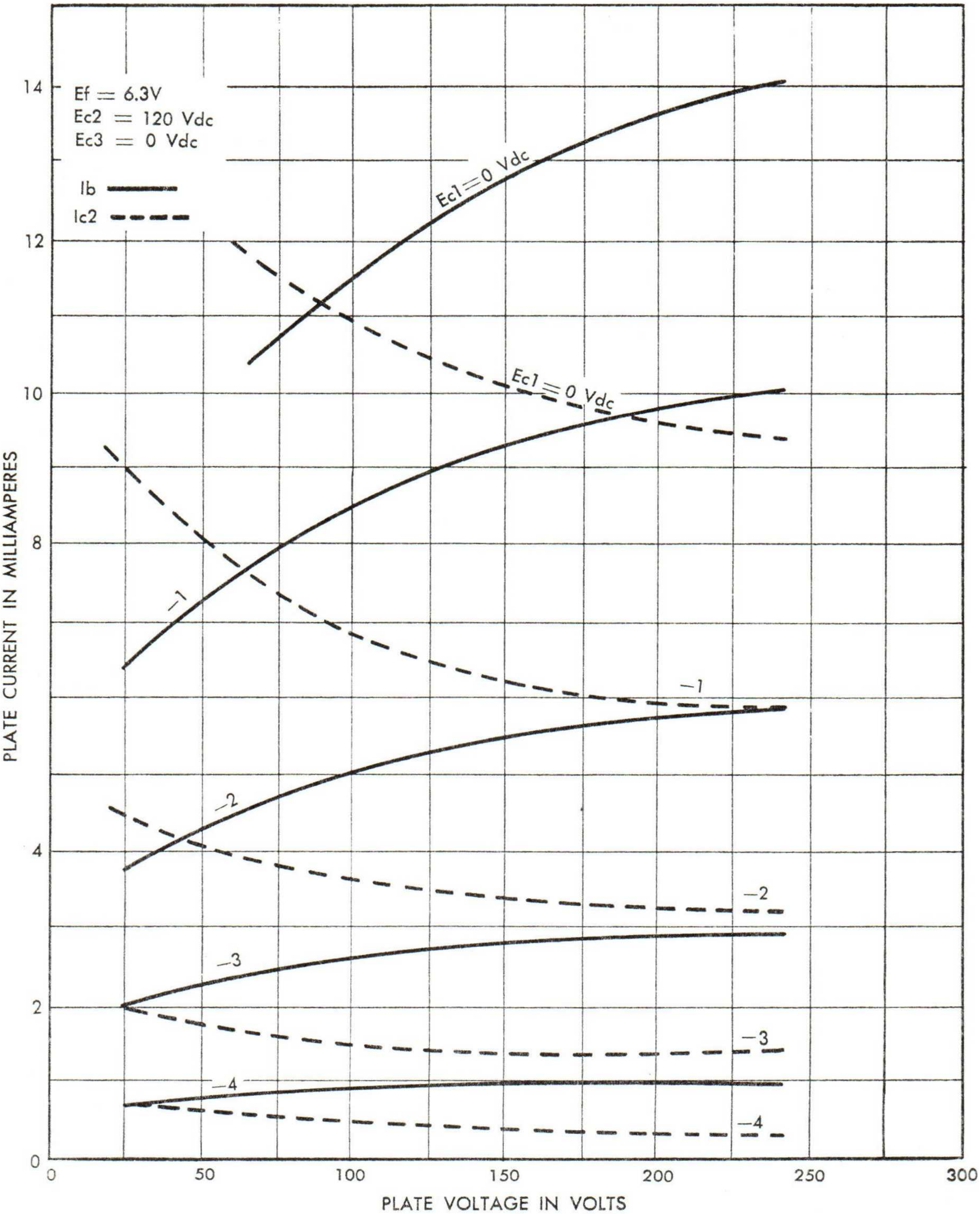


Figure 3-293. Typical Static Plate Characteristics of JAN-5784WA.

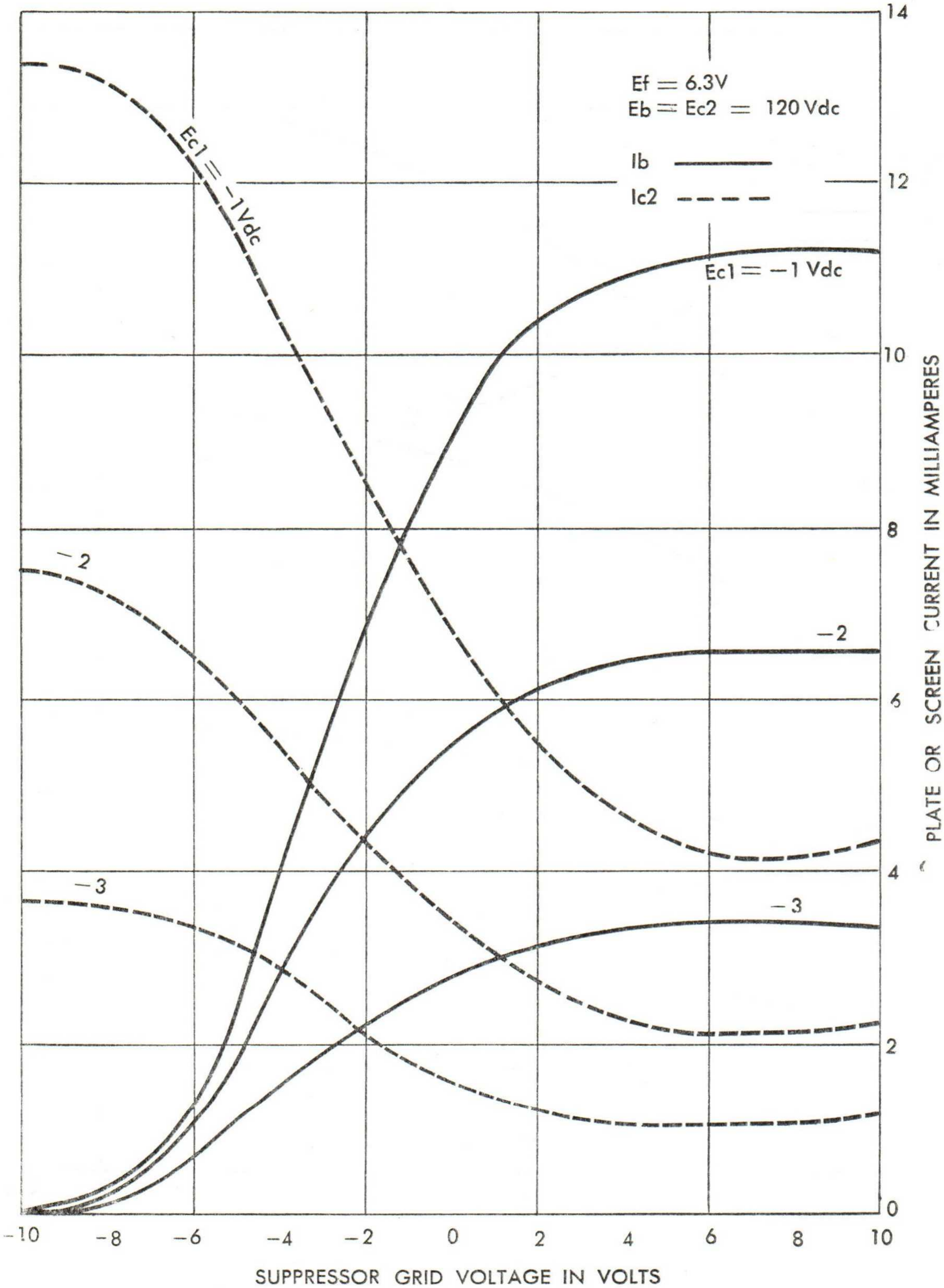


Figure 3-294. Typical Suppressor Transfer Characteristics of JAN-5784WA.

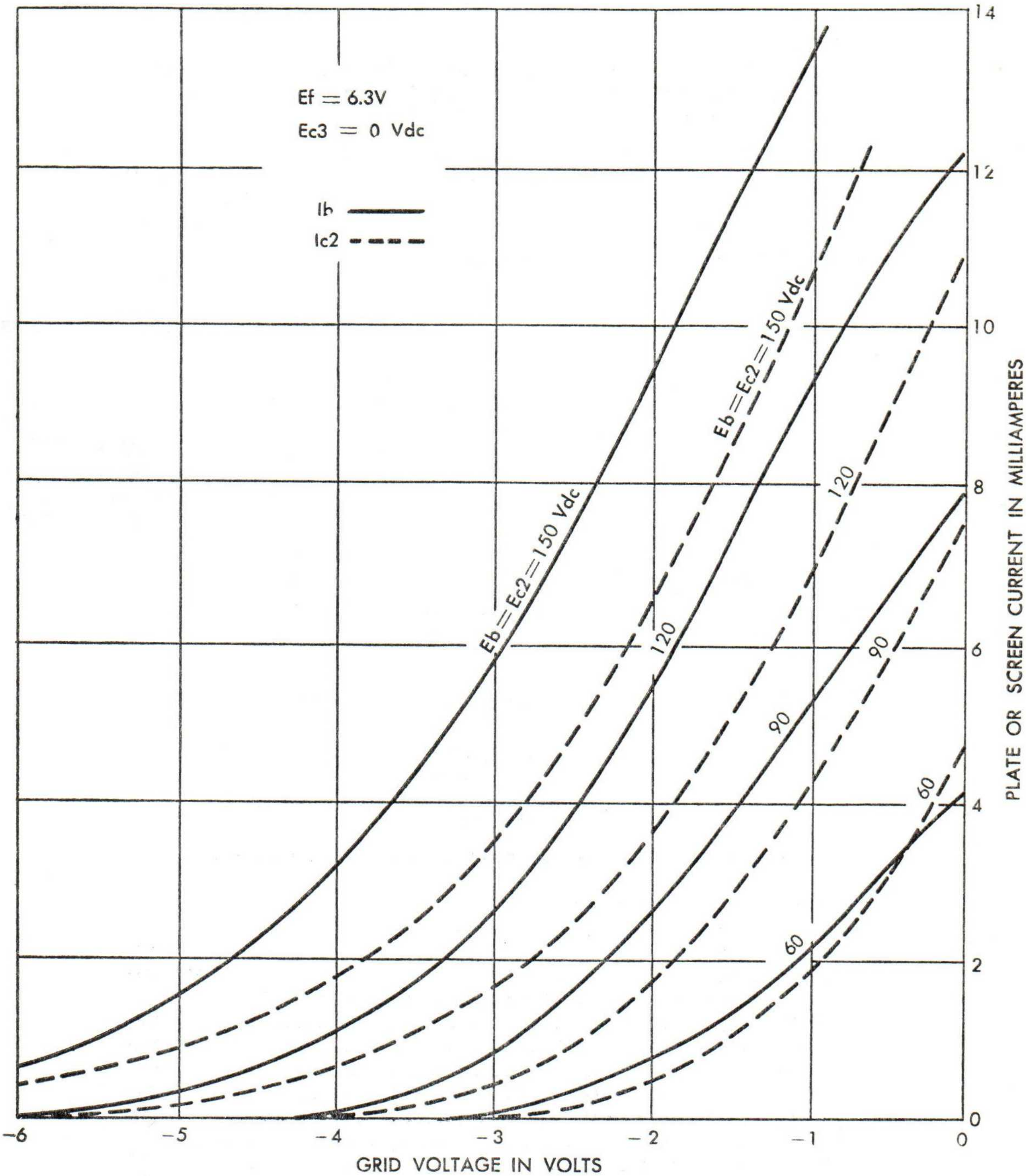


Figure 3-295. Typical Transfer Characteristics of JAN-5784WA.

SECTION
TUBE TYPE JAN–5814A

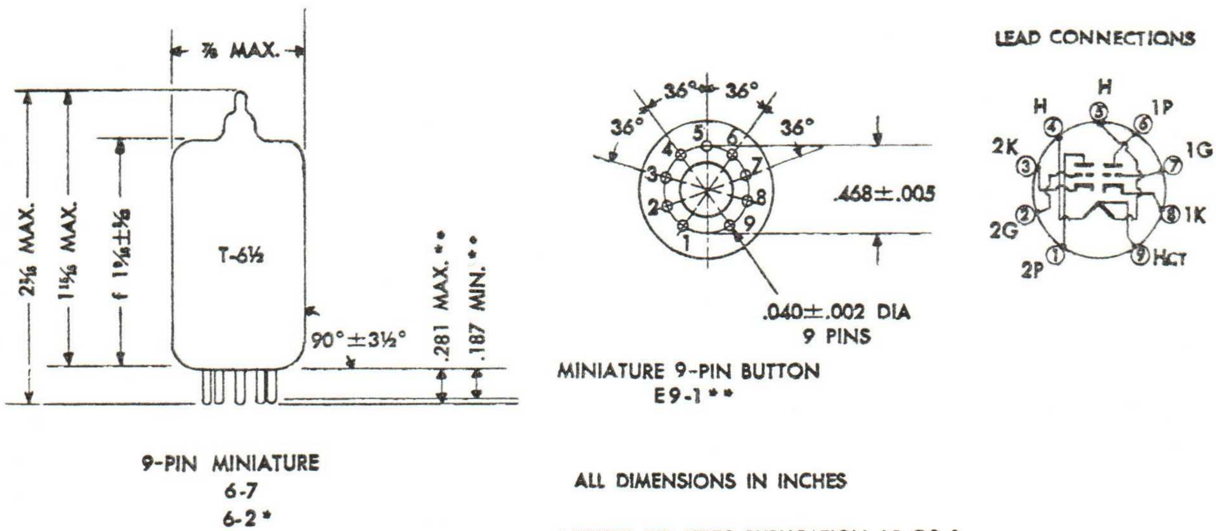
DESCRIPTION.

The JAN–5814A [1] is a 9 pin miniature medium-mu twin triode having separate cathode connections. The heater may be connected for either series or parallel operation.

ELECTRICAL. The electrical characteristics are as follows:

- Heater Voltage .... 12.6 or 6.3 V
- Heater Current, Design Center .... 175 or 350 mA
- Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



ALL DIMENSIONS IN INCHES

* REFERS TO JETEC PUBLICATION J5-G2-1, JANUARY 1949

** REFERS TO JETEC PUBLICATION JO-G3-1, FEBRUARY 1949

Figure 3-296. Outline Drawing and Base Diagram of Tube Type JAN-5814A

RATINGS, ABSOLUTE SYSTEM:

The absolute system ratings are as follows:

- Heater Voltage .... 6.3 ± .6 or 12.6 ± 1.3 V
- *Plate Voltage .... 330 Vdc
  Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*
- Grid Voltage, Maximum .... 0 Vdc
- *Grid Voltage, Minimum .... —55 Vdc
- Heater-Cathode Voltage .... 100 v
- Grid Series Resistance (per Grid) .... 0.5 Meg
- *Cathode Current (per cathode) .... 22 mA
- *Grid Current (per grid) .... 5 mA
- Plate Dissipation (per Plate) .... 3.0 W
- Bulb Temperature .... 165°C
- Altitude Rating .... 60,000 ft

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/12A dated 28 December 1955.

TEST CONDITIONS AND DESIGN CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	12.6 V
Plate Voltage, Eb	250 Vdc
Grid Voltage, Ec	—8.5 Vdc
Heater-Cathode Voltage, Ehk	0V
Heater Current, Ia	175 mA
Plate Current, Ib	10.5 mA
Transconductance, Sm	2200 umhos
Amplification Factor, U	17

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/12A dated 23 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		160	190	160	193	mA
Transconductance (1)	Sml		1750	2650	...	...	umhos
	$\frac{\Delta Sml}{t}$		...	...	...	15	%
Transconductance (2)	$\frac{\Delta Sm}{Ef}$		...	15	...	15	%
Change in Average	$\frac{Avg\ \Delta Sm}{t}$		...	...	...	10	%
Amplification Factor	Mu		15.5	18.5	...	...	
Transconductance (3)	Sm	Eb = 100 Vdc; Ec = 0	2500	4000	...	...	umhos
Plate Current (1)	Ib.		6.5	14.5	...	...	mAdc
Plate Current (2)	Ib	Ec = 30 Vdc Rp = 0.1 Meg	...	20	...	...	uAdc
Plate Current (3)	Ib	Ec = —18 Vdc	5	...	...	...	uAdc
Plate Current (1) difference between sections	Ib		...	3.5	...	...	mAdc
Capacitance (no shield)	Cgp	Ef = 0	1.20	1.80	...	...	uuf
	Cin	Ef = 0	1.25	1.95	...	...	uuf
	Cout1	Ef = 0	0.30	0.70	...	...	uuf
	Cout2	Ef = 0	0.20	0.60	...	...	uuf
Grid Current	Ic	Rg = 0.5 Meg	0	—0.5	0	—0.5	uAdc
Grid Emission	Isc	Ef = 15.0 V Ec = —30 Vdc Rg = 0.5 Meg	...	—1.5	...	...	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	7	...	7	uAdc
	Ihk	Ehk = —100 Vdc	...	—7	...	—7	uAdc

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Insulation of Electrodes	Rg-all	Eg-all = —100 Vdc	500	...	250	...	Meg
	Rp-all	Ep-all = 300 Vdc	500	...	250	...	Meg

APPLICATION OF JAN-5814A

The chart below shows the permissible operating area for JAN-5814A as defined by the ratings in MIL-E-1/12a dated 23 December 1955. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.6.

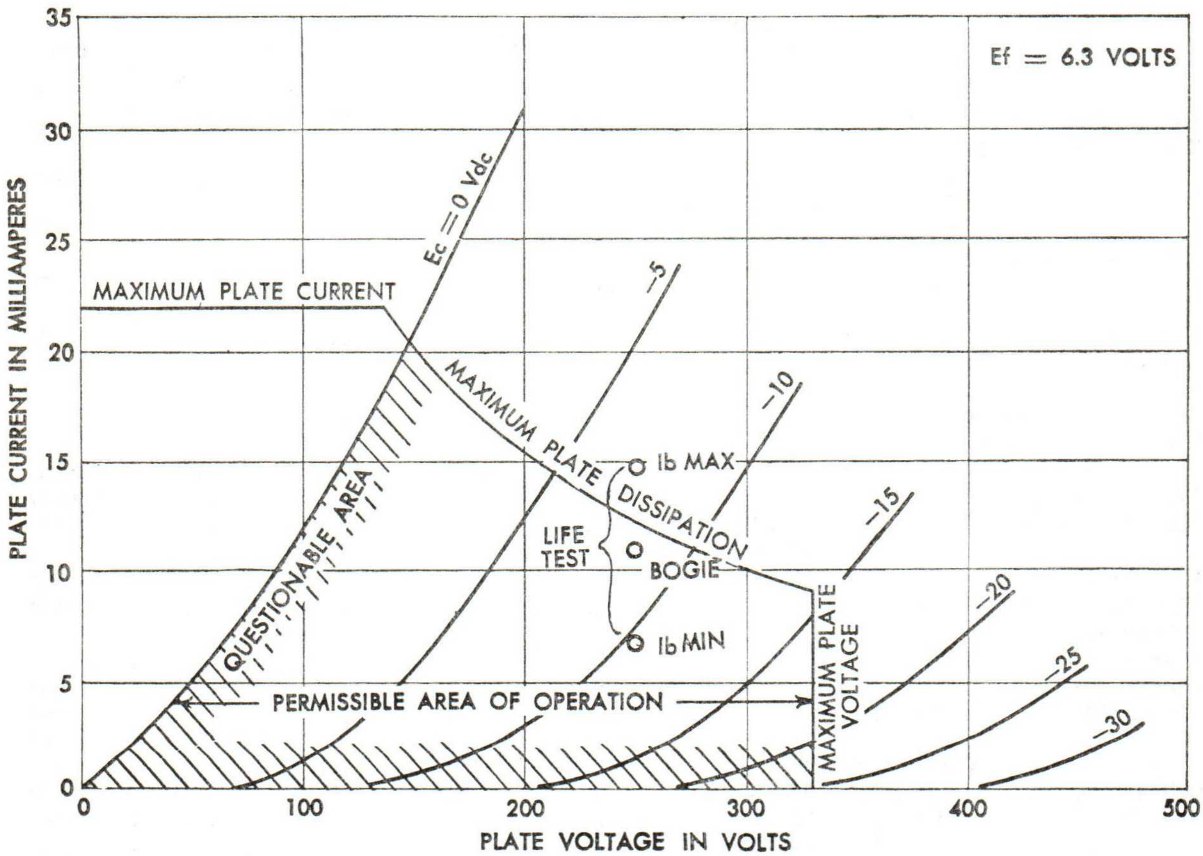


Figure 3-297. Typical Plate Characteristics for JAN-5814A; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8

Tempearture

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN-5814A CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

Figures 3–298 and 3–299 below present the limit behavior of static plate and transfer characteristics for JAN–5814A as defined by MIL–E–1/12A dated 23 December 1955.

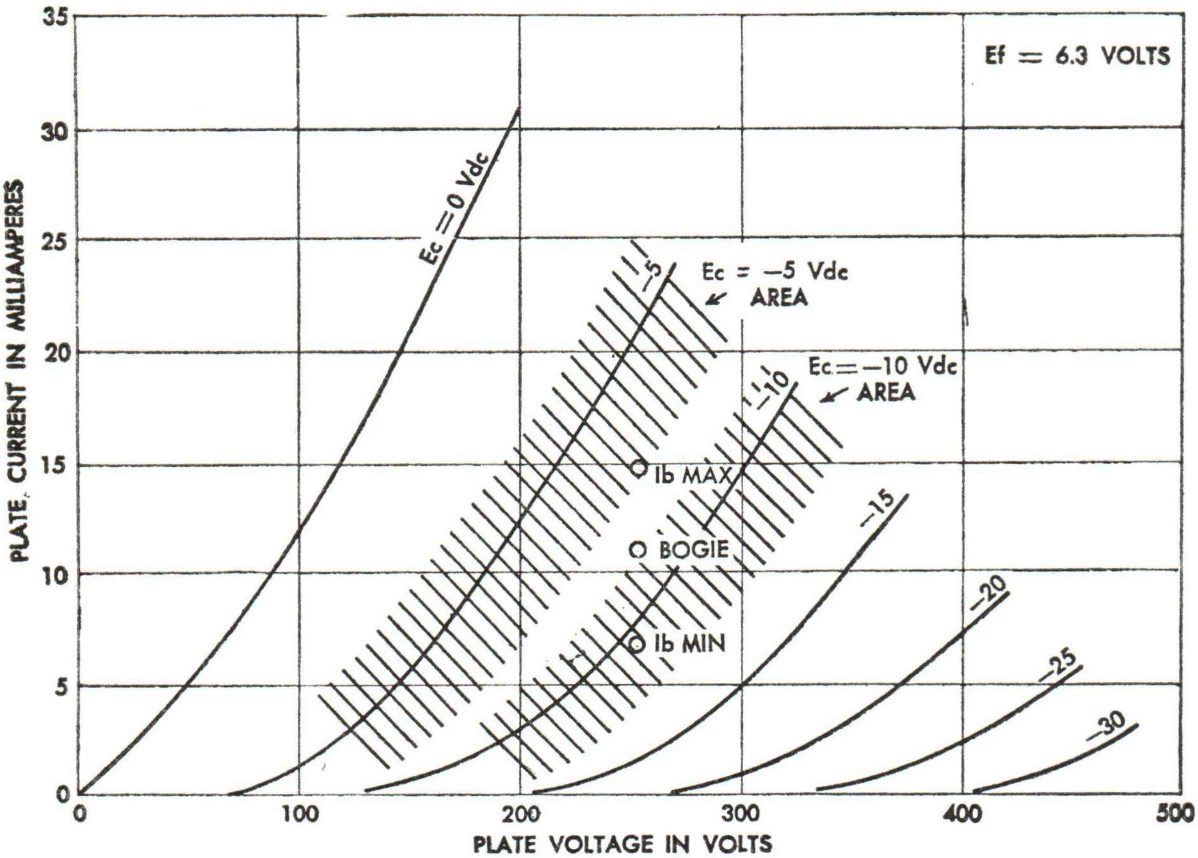


Figure 3-298. Limit Plate Characteristics for JAN 5814A; Variability of 1b.

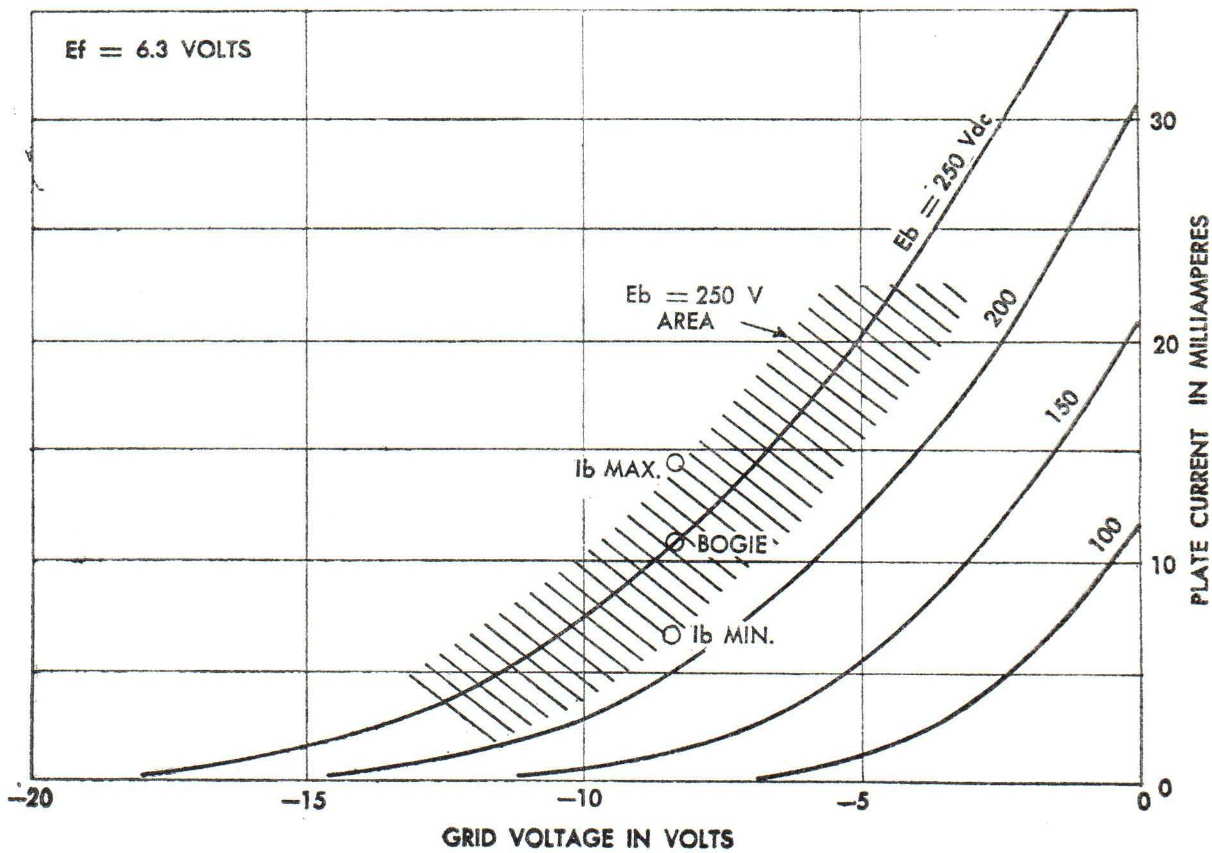


Figure 3-299. Limit Transfer Characteristics for JAN 5814A.

DESIGN CENTER CHARACTERISTICS OF JAN-5814A

The following typical curves have been obtained from current data being published by the original RETMA registrant of this type.

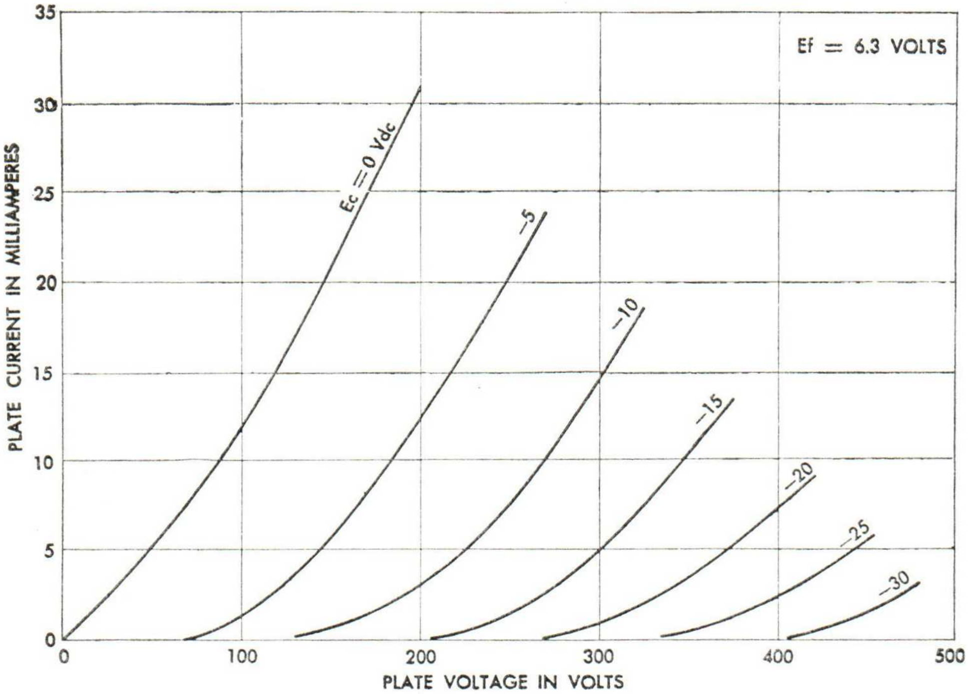


Figure 3-300. Typical Plate Characteristics for JAN-5814A.

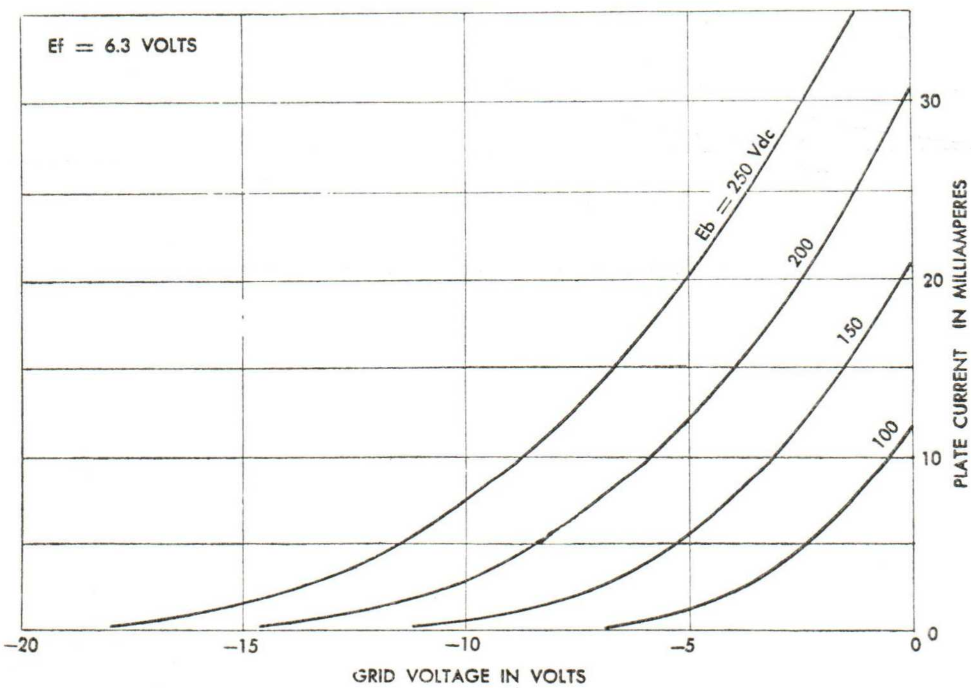


Figure 3-301. Typical Transfer Characteristics for JAN-5814A

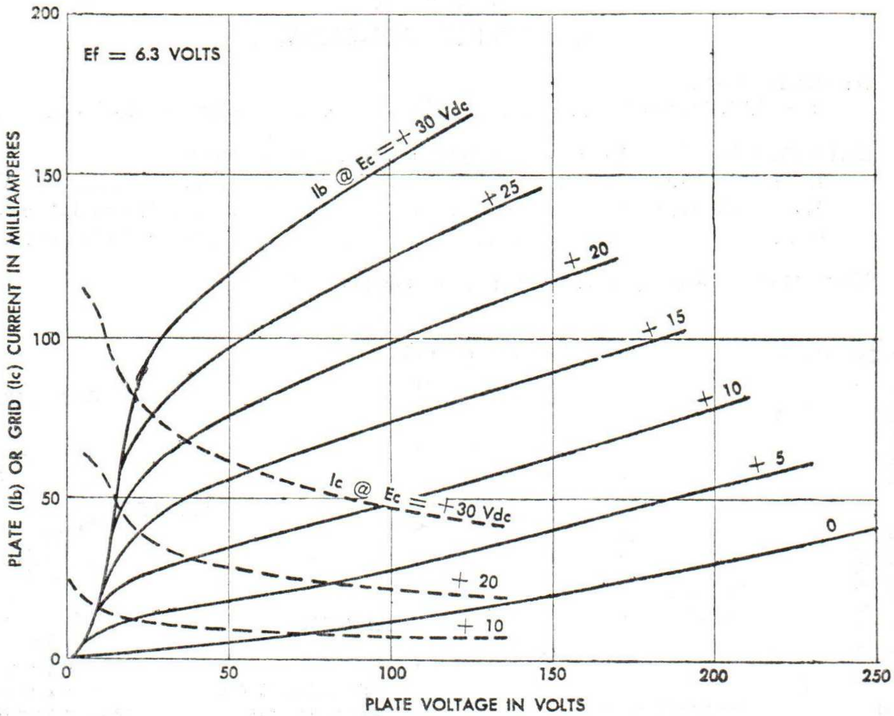


Figure 3-302. Typical Plate and Grid Characteristics for JAN-5814A.

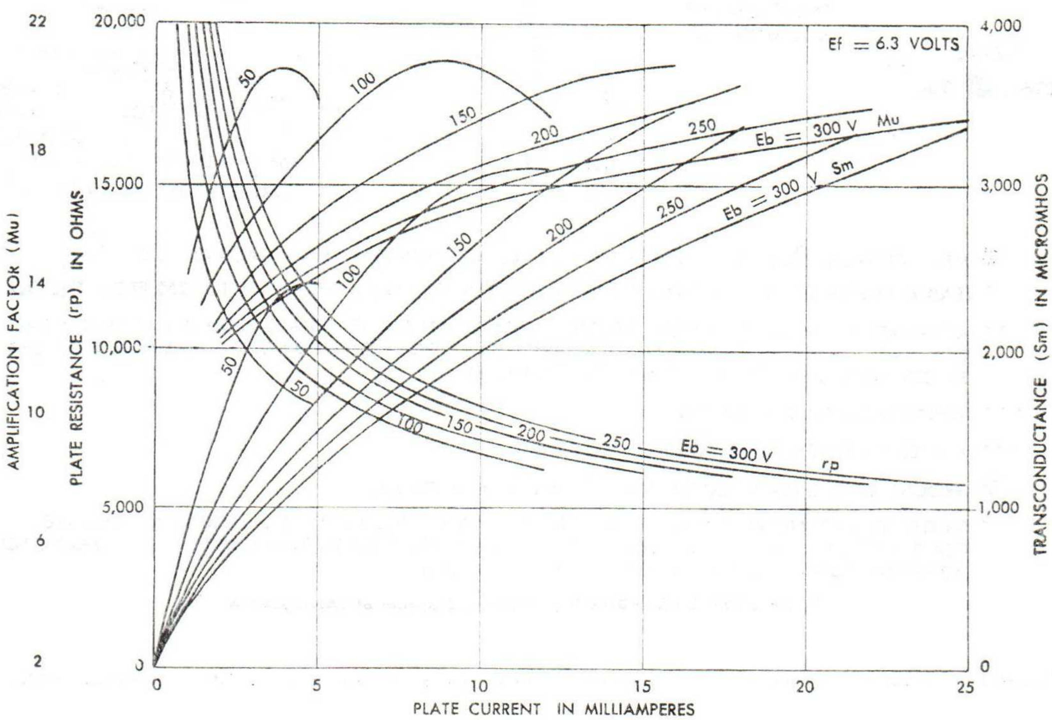


Figure 3-303. Typical Sm, Mu and rp Characteristics for JAN-5814A.

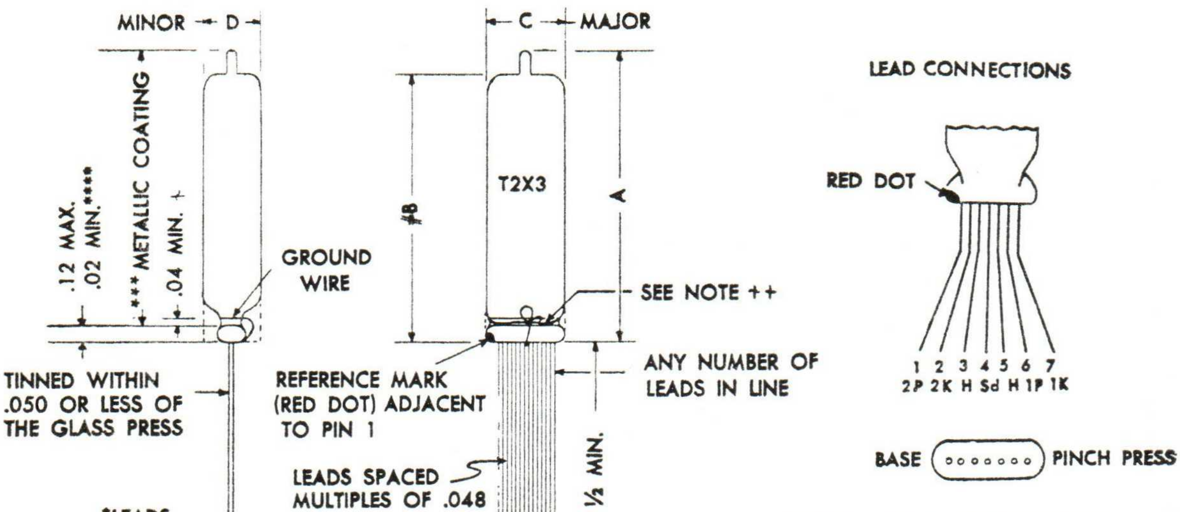
SECTION
TUBE TYPE JAN–5829WA

DESCRIPTION.
The JAN-5829WA [1] is a 7-lead, pinch-press, subminiature, double diode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 138 to 162 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.400	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

*** WHEN SPECIFIED ON THE TSS

**** APPLIES TO PINCH PRESS TYPES ONLY (.02 MIN.)

‡ GROUND LEAD OVERLAPPED BY SHIELD BY A MINIMUM OF .04

‡‡ SHIELD TO GROUND WIRE MAY BE FROM EITHER SIDE OF THE MAJOR DIMENSION. ALTERNATIVE CONSTRUCTION: UNUSED OR EXTRA RANDOM LEAD IN PRESS OR BUTTON MAY BE FOLDED BACK AND WRAPPED AROUND BULB TO MAKE CONTACT WITH SHIELD.

Figure 3-304. Outline Drawing and Base Diagram of JAN-5829WA.

[1] The values and specification comments presented in this section are related to MIL–E–1/292 dated 23 December 1955.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage	6.3 ± 0.3 V
Plate Supply Voltage (per plate)	130 Vac
Peak Inverse Plate Voltage (per plate)	360 v
Heater-Cathode Voltage	360 v
Steady State Peak Plate Current (per plate)	33 mA
Output Current (per plate)	5.5 mAdc
Transient Peak Plate Current (per plate)	175 mA
*Bulb Temperature	220° C
*Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Supply Voltage (per plate), Epp	117 Vac
Heater-Cathode Voltage	0 V
Load Resistance (Unity Power Factor), RL	14,000 ohms
Load Capacitance, CL	8 uf

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/292A dated 23 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		138	162	135	165	mA
Plate Current	Ib	Ebb = 0; Rp = 40,000	2	20	...	...	uAdc
Difference between sections	ΔIb		...	5	...	...	uAdc
Operation	Io	See Note Below	9.0	...	7.0	...	mAdc
Emission	Is	Eb = 6.5 Vdc	15	...	...	...	mAdc
Capacitance (Without Shield)	Cp-p	Ef = 0	0.06	0.12	...	...	uuf
Cp1 — h+k1+sd (except p2)	Cp1–all	Ef = 0	1.9	3.5	...	...	uuf
Cp2 — h+k2+sd except p1)	Cp2–all	Ef = 0	1.7	3.3	...	...	uuf
Ck1 — h+p1+sd	Ck1–all	Ef = 0	2.4	4.2	...	...	uuf
Ck2 — h+p2+sd	Ck2–all	Ef = 0	2.8	4.6	...	...	uuf
	Ck1–h	Ef = 0	1.1	2.2	...	...	uuf
	Ck2–h	Ef = 0	1.3	2.5	...	...	uuf
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	10	0	20	uAdc
	Ihk	Ehk = —100 Vdc	...	—10	0	—20	uAdc
Insulation of Electrodes	R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg

Note: In a full wave vircuit, adjust Zp (per plate) so that a tube having Etd = 5.5 Vdc at 15 mAdc (per plate) gives an Io = 10 mAdc. The minimum peak current shall be 25 ma.

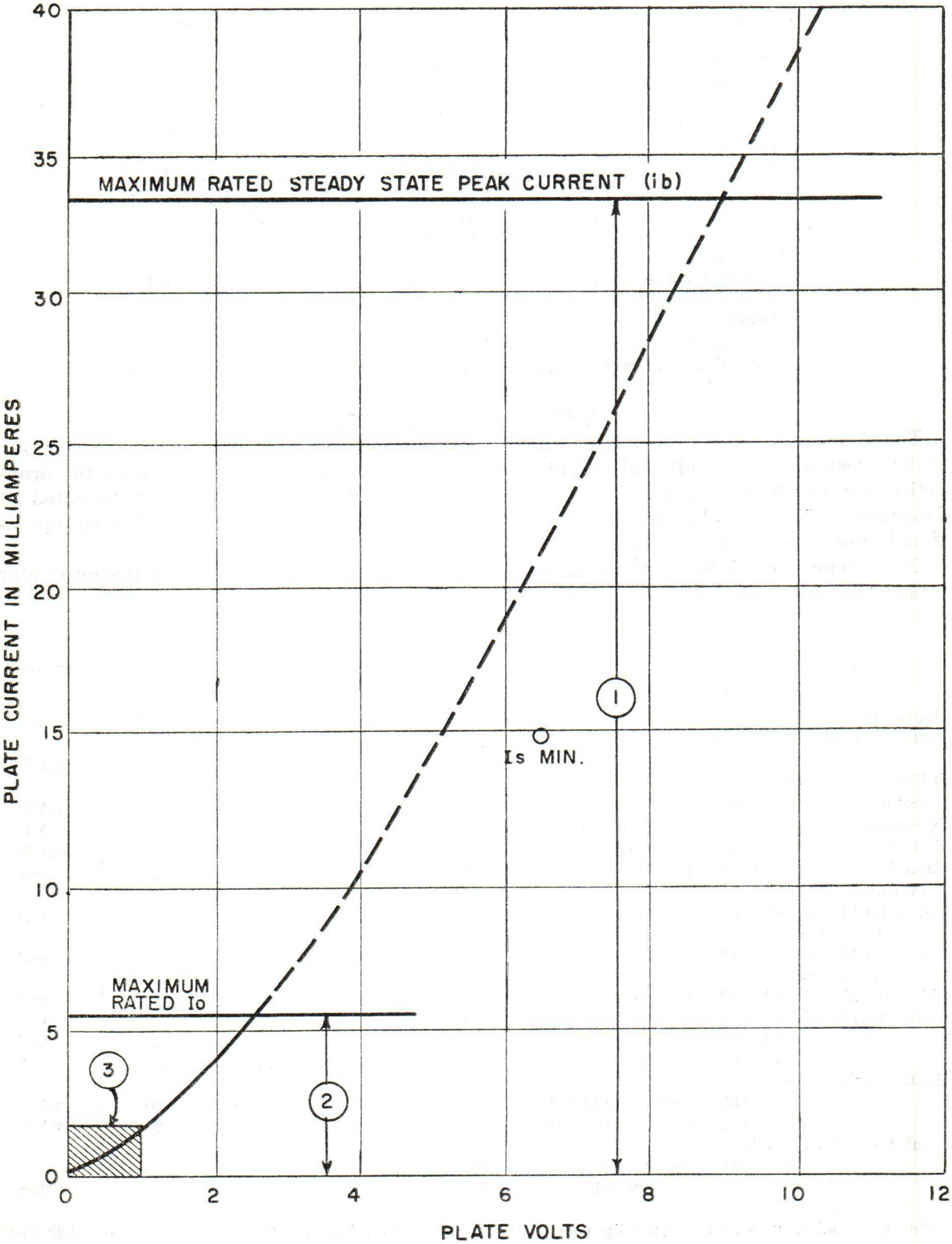


Figure 3-305. Chart A — JAN-5829WA; Permissible Limits of Operation.

APPLICATION OF THE JAN-5829WA

Signal Rectifier Service: In the application of JAN-5829WA in signal rectifier service, Chart "A" relates boundaries of permissible operation and the questionable area of operation, to the plate characteristic.

Limit (1) is based on the maximum rated steady peak current (Ib/p) of 33 milliamperes. Limit (2) is based on the maximum rated dc output per plate (Io/p) of 5.5 milliamperes.

Permissible steady state peak plate current is limited to 33 milliamperes per plate, to define boundary (1), and dc output current is limited to 5.5 milliamperes per plate, to define boundary (2). Area (3) is defined as questionable from the standpoint of uniformity and stability of plate current in low-level signal rectifier applications. Although the specification enforces a control on plate current balance between the two sections to within 5 microamperes under MIL-E-1 test conditions, there is little assurance of such balance under conditions of heater operation differing from test conditions. Reference should be made to Section 1.3.1 for a review of the behavior of initial electron velocity and contact potential in tubes in general, where the control gird currents discussed are equivalent to plate currents in signal diode application.

Supply Voltage Rectifier Service: Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN-5829WA must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

Figure 3-306. *Rating Chart I* is based on maximum rated peak inverse voltage per plate (exp) of 360 volts and maximum rated dc output current per plate (Io/p) of 5.5 milliamperes. Point C corresponds to the occurrence of these two ratings permissible under choke-input filter conditions. Point E is based on life test conditions. The area CDE is limited to choke-input filter application.

Figure 3-307. *Rating Chart II* for capacitor input filter applications is based on maximum rated dc output current per plate (Io/p) and maximum rated steady state peak plate current (Ib) of 33 milliamperes per plate. Rectification efficiency must not exceed 0.67 under conditions of maximum rated dc output current.

Figure 3-308. *Rating Chart III* for capacitor input filter is based on maximum rated surge current (i surge) of 175 milliamperes per plate. Minimum permissible series resistance (Rs) is approximately 900 ohms per plate under conditions of maximum permissible supply voltage per plate.

Other Considerations:

Heater Voltage: See paragraph 3.4.3.

Low Electrode Current: See paragraph 3.4.3.

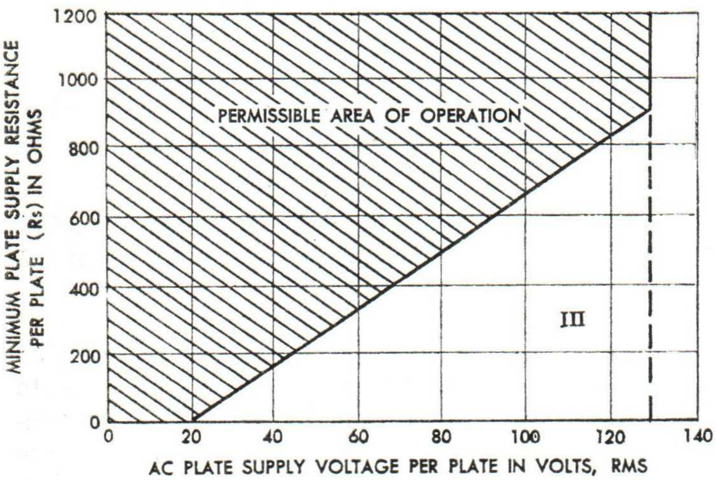


Figure 3-308.

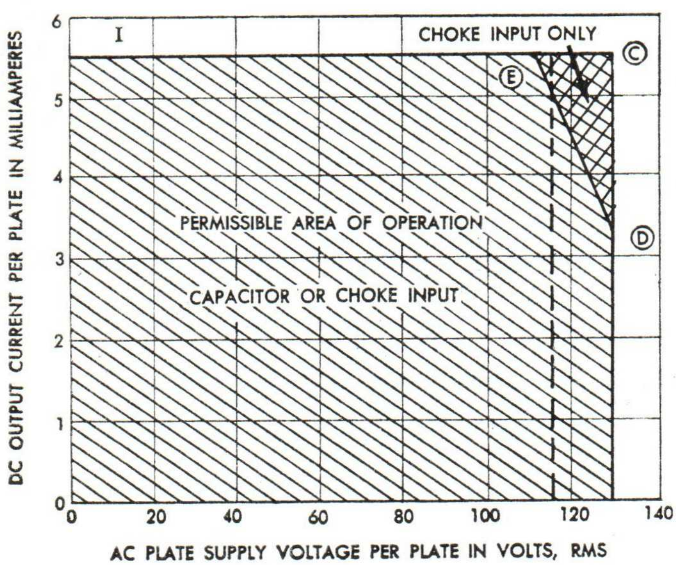


Figure 3-306.

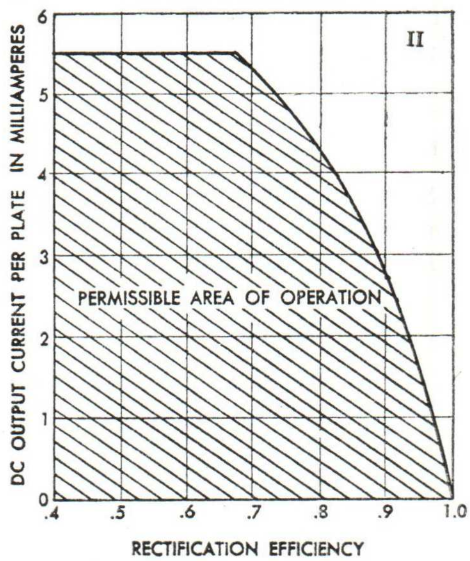


Figure 3-307.

AVERAGE CHARACTERISTICS OF JAN-5829WA

The chart below presents the Static Plate Characteristic of JAN-5829WA, reproduced from data published by the original **RETMA** registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

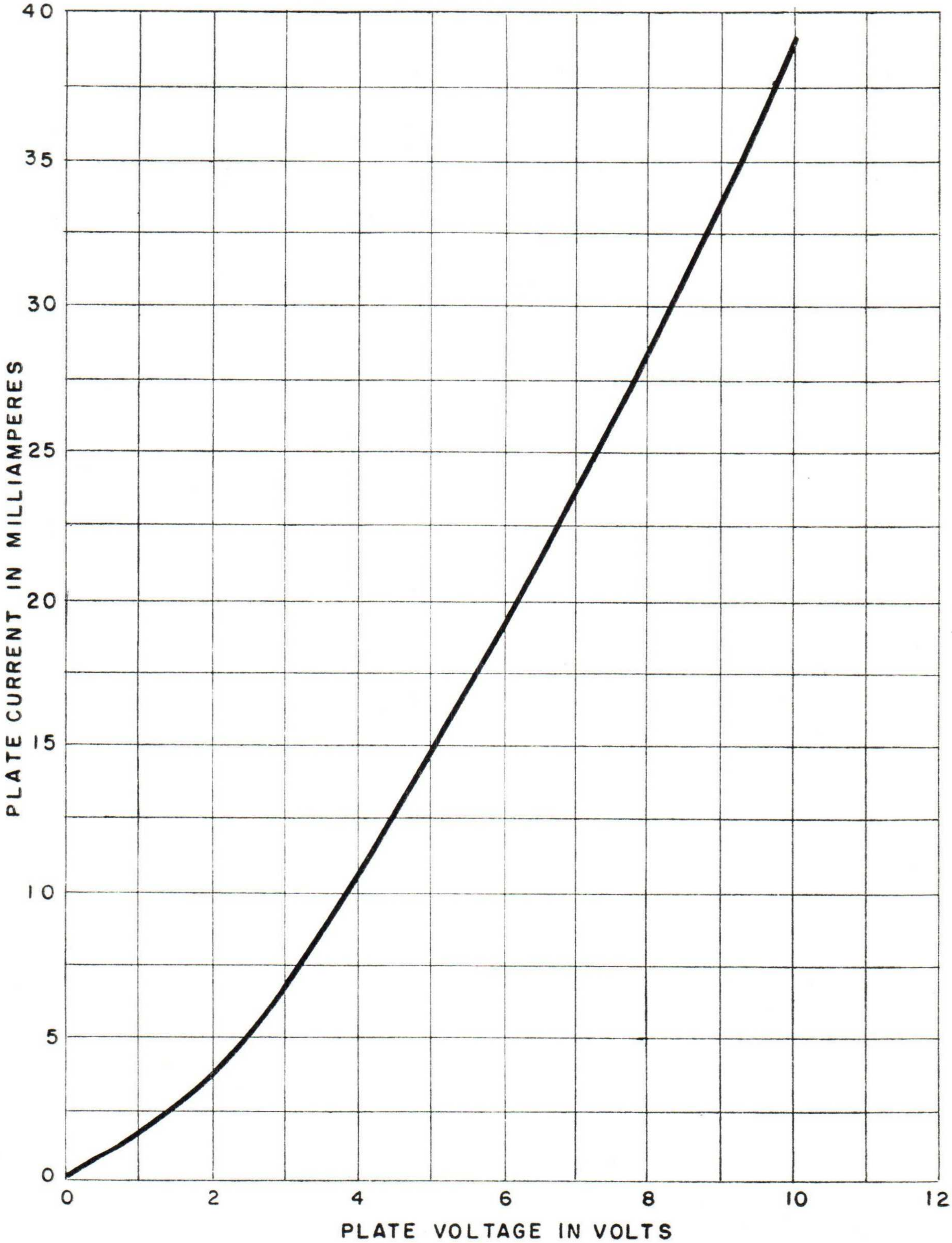


Figure 3-309. Typical Plate Characteristics of JAN-5829WA.

SECTION
TUBE TYPE JAN-5840

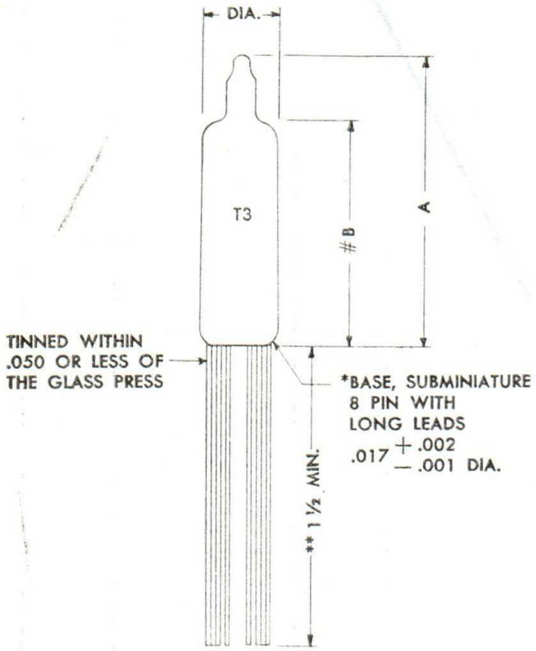
DESCRIPTION.

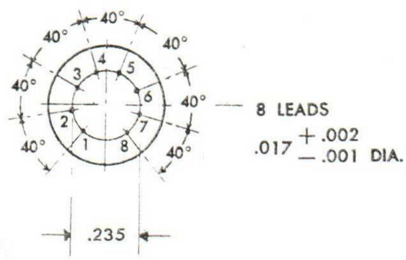
The JAN-5840 [1] is an 8 lead, button base, subminiature, sharp cutoff pentode having a design center transconductance of 5000 micromhos. The JAN-5840 is similar in plate characteristics to JAN-5702WA and the miniature type JAN-5654/6AK5W.

ELECTRICAL. The electrical characteristics are as follows:

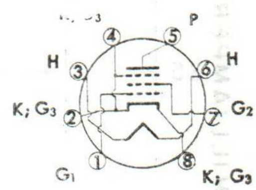
Heater Voltage .... 6.3 V
Heater Current, Design Center .... 150 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.





LEAD CONNECTIONS



DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±		
			C MAX	D MAX
1.500	1.300	.100	.400	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-310. Outline Drawing and Base Diagram of JAN-5840.

RATINGS, ABSOLUTE SYSTEM

The asolute system ratings are as follows:

Heater Voltage .... 6.3 V ± .3 V
Plate Voltage .... 165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Control Grid Voltage, Maximum .... 0 Vdc
Control Grid Voltage, Minimum .... —55 Vdc
*Screen Grid Voltage .... 155 Vdc

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-140/B dated 5 August 1955.

*Suppressor Grid Voltage	22 Vdc
Heater-Cathode Voltage	200 v
Control Grid Series Resistance	1.1 Meg
**Cathode Current, Maximum	16.5 mAdc
Plate Dissipation	0.80 W
Screen Grid Dissipation	0.35 W
Bulb Temperature	+220° C
Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	100 Vdc
Screen Grid Voltage, Ec2	100 Vdc
Suppressor Grid Voltage, Ec3	0 Vdc
Cathode Resistance, Rk	150 ohms
Heater Current, If	150 mA
Plate Current, Ib	7.5 mAdc
Transconductance, Sm	5000 umhos

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/140B dated 5 August 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		140	160	138	164	mA
Transconductance (1)	Sm		4200	5800	...	...	.umhos
Change in individual	Δ Sm t		...	...	...	20	%
Plate Resistance	rp		0.175	...	...	...	Meg
Plate Current (1)	Ib		5.5	9.5	...	...	mAdc
Screen Grid Current	Ic2		1.5	3.3	...	...	mAdc
Capacitance	Cg1-p	Ef = 0	...	0.015	...	...	uuf
(Shielded as	Cin	Ef = 0	3.5	4.9	...	...	uuf
Specified)	Cout	Ef = 0	2.9	3.9	...	...	uuf
Control Grid Current	Ic1	Rg1 = 1.0 Meg	0	—0.3	0	—0.8	uAdc
Heater-Cathode Leakage							
	Ihk	Ehk = +100 Vdc	...	5.0	...	10.0	uAdc
	Ihk	Ehk = —100 Vdc	...	—5.0	...	—10.0	uAdc
Insulation of Electrodes							
	R(g1-all)	Eg1-all = —100 Vdc	100	...	50	...	Meg
	R(p -all)	Ep-all = —300 Vdc	100	...	50	...	Meg

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
High, 3.2.9
Low, 3.2.2, 3.2.6
28 Volt, 3.2.9
AC Operation, 1.3.3, 3.2.9
Screen Grid:
Supply, 3.2.7
Protection, 3.2.9
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
Cathode, 2.1.1, 3.2.9
Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

APPLICATION OF JAN-5840

The chart below shows the permissible operating area for JAN-5840 as defined by the ratings in MIL-E-1/140B dated 5 August 1955. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

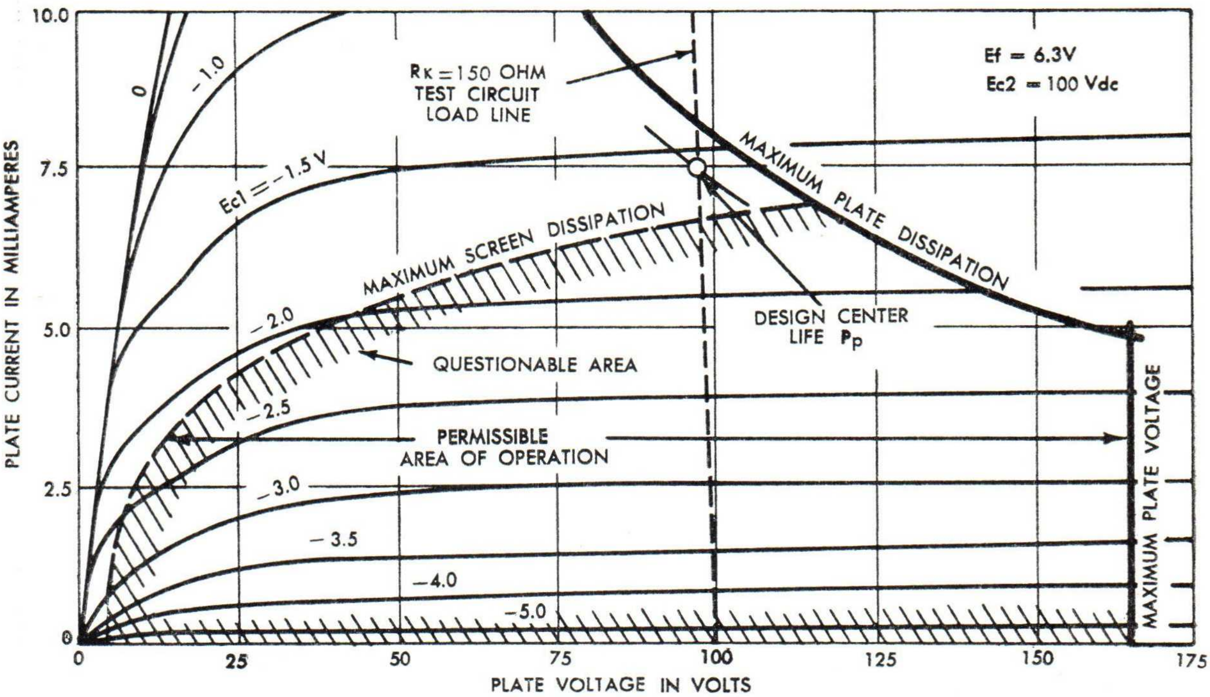


Figure 3-311. Typical Static Plate Characteristics of JAN-5840; Permissible Area of Operation.

VARIABILITY OF JAN-5840 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5840 as defined by MIL-E-1/140B dated 5 August 1955.

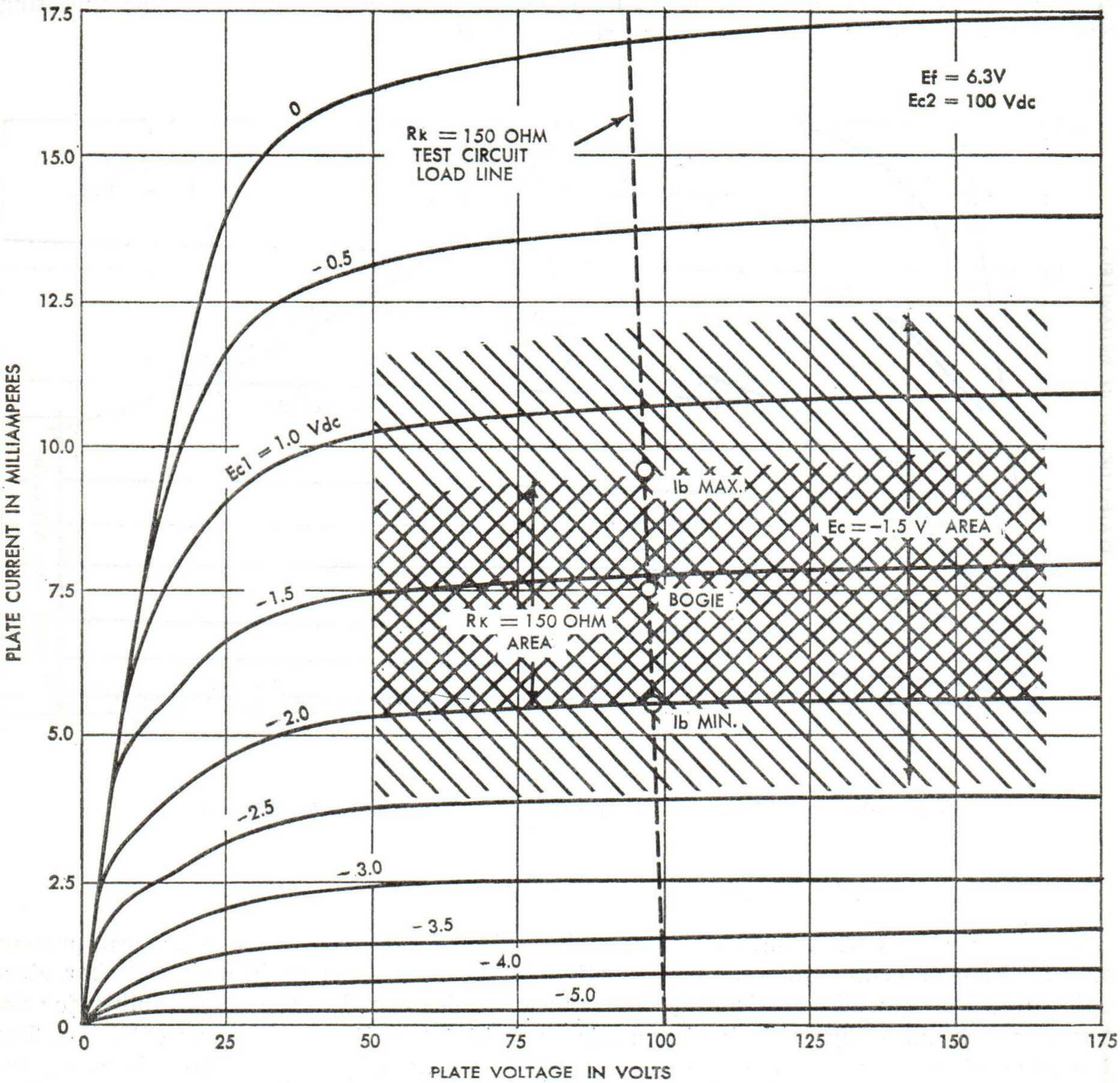


Figure 3-312. Limit Behavior of JAN-5840 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of static screen grid characteristics for JAN–5840.

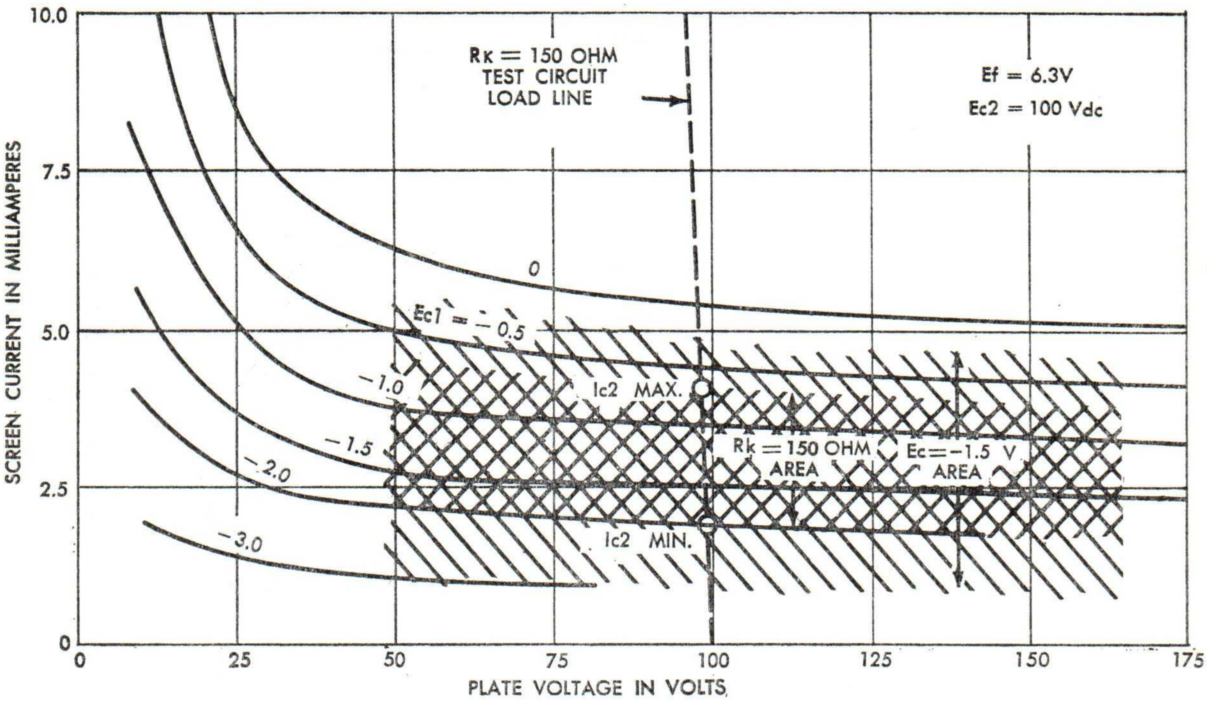


Figure 3-13. Limit Behavior of JAN-5840 Static Plate Data; Variability of Ic2.

The chart below presents the limit behavior of plate transfer data, for JAN–5840 as defined by MIL–E–1/140B dated 5 August 1955.

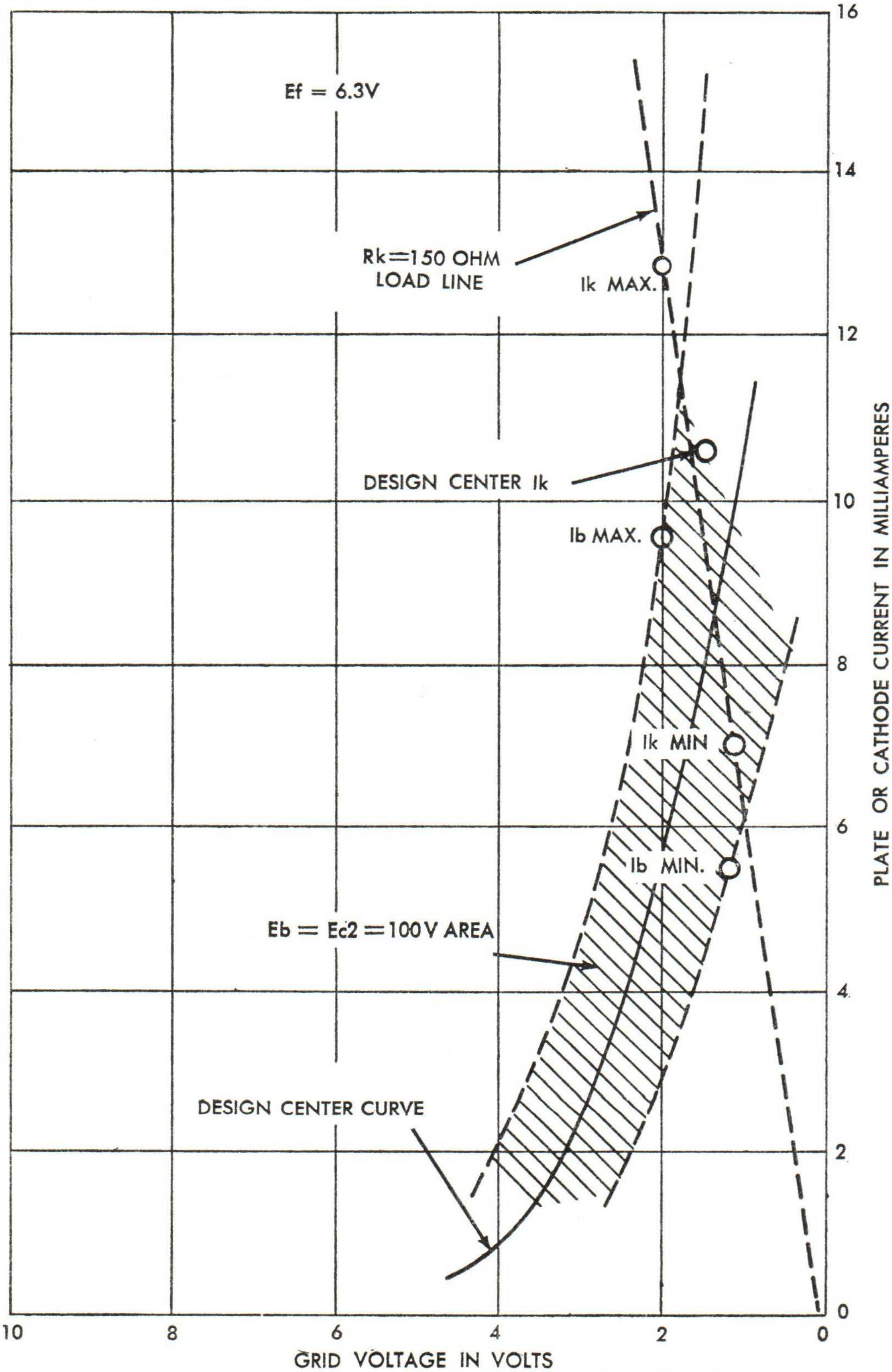


Figure 3-314. Limit Behavior of JAN-5840 Transfer Data; Variability of Ib.

The chart below presents the limit behavior of Screen Grid Transfer Data for JAN-5840.

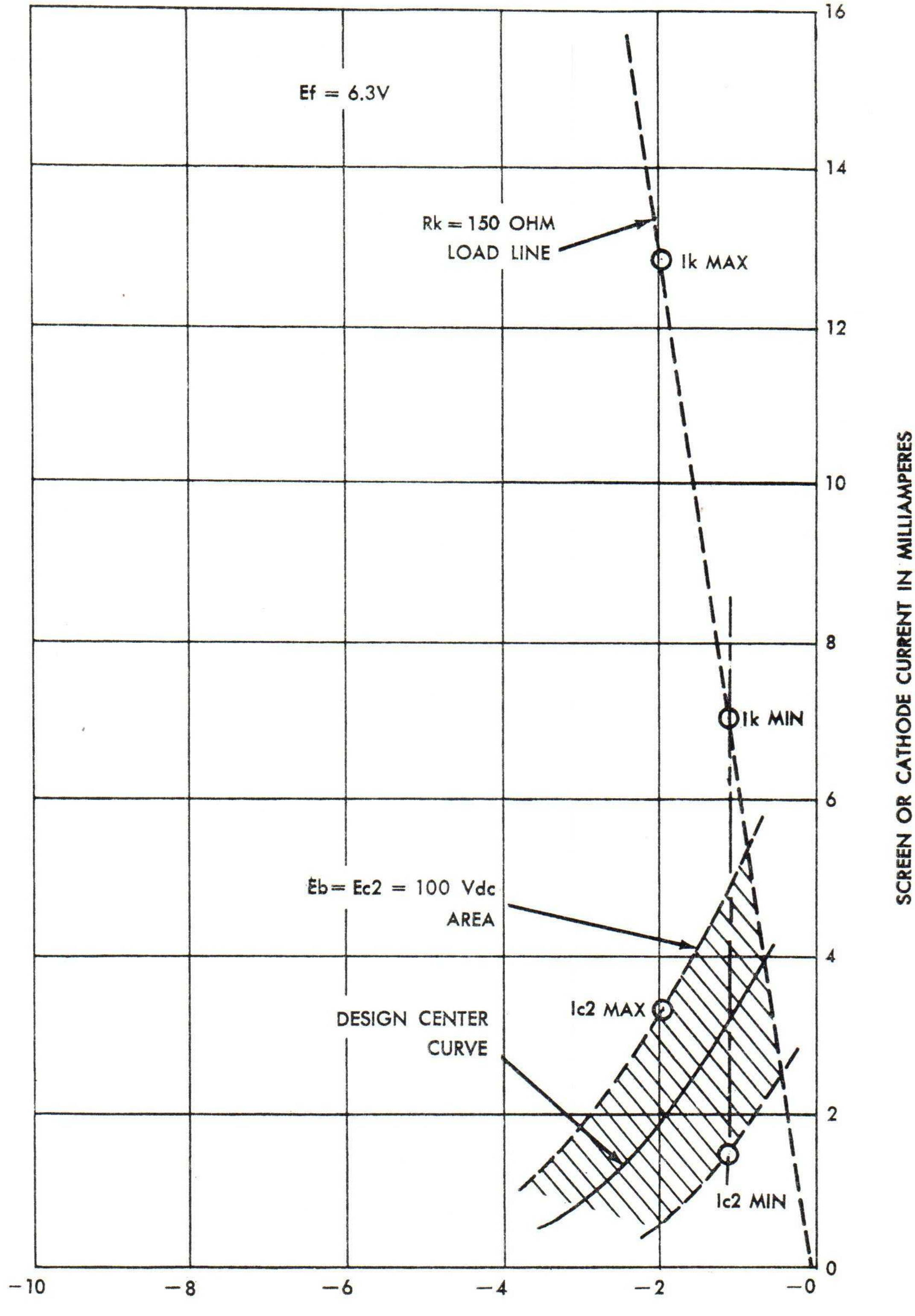


Figure 3-315. Limit Behavior of JAN-5840 Transfer Data; Variability of Ic2.

DESIGN CENTER CHARACTERISTICS OF JAN-5840

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5840.

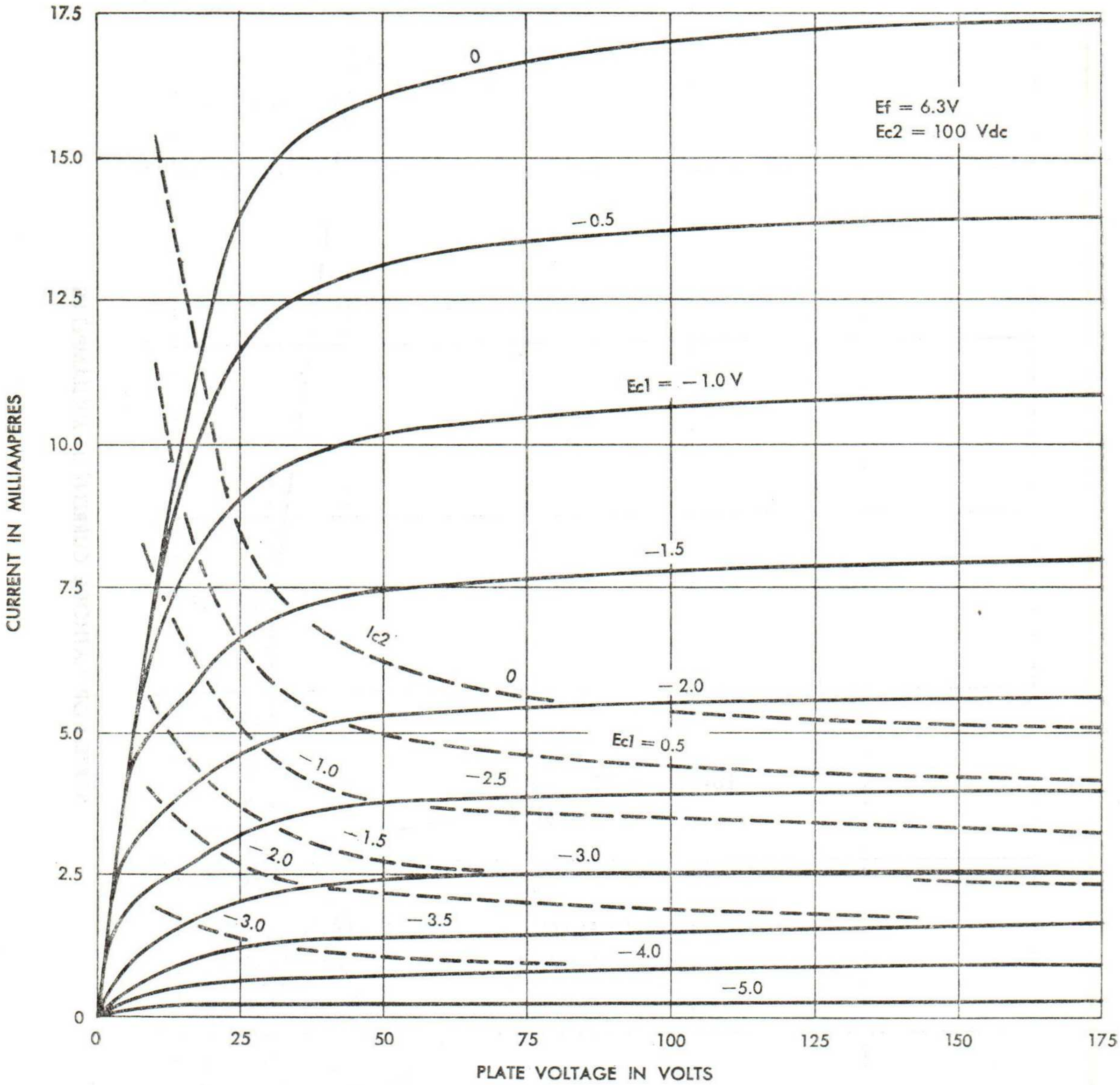


Figure 3-316. Typical Plate Characteristics for JAN-5840.

The chart below presents the Average Plate Transfer Data for JAN-5840.

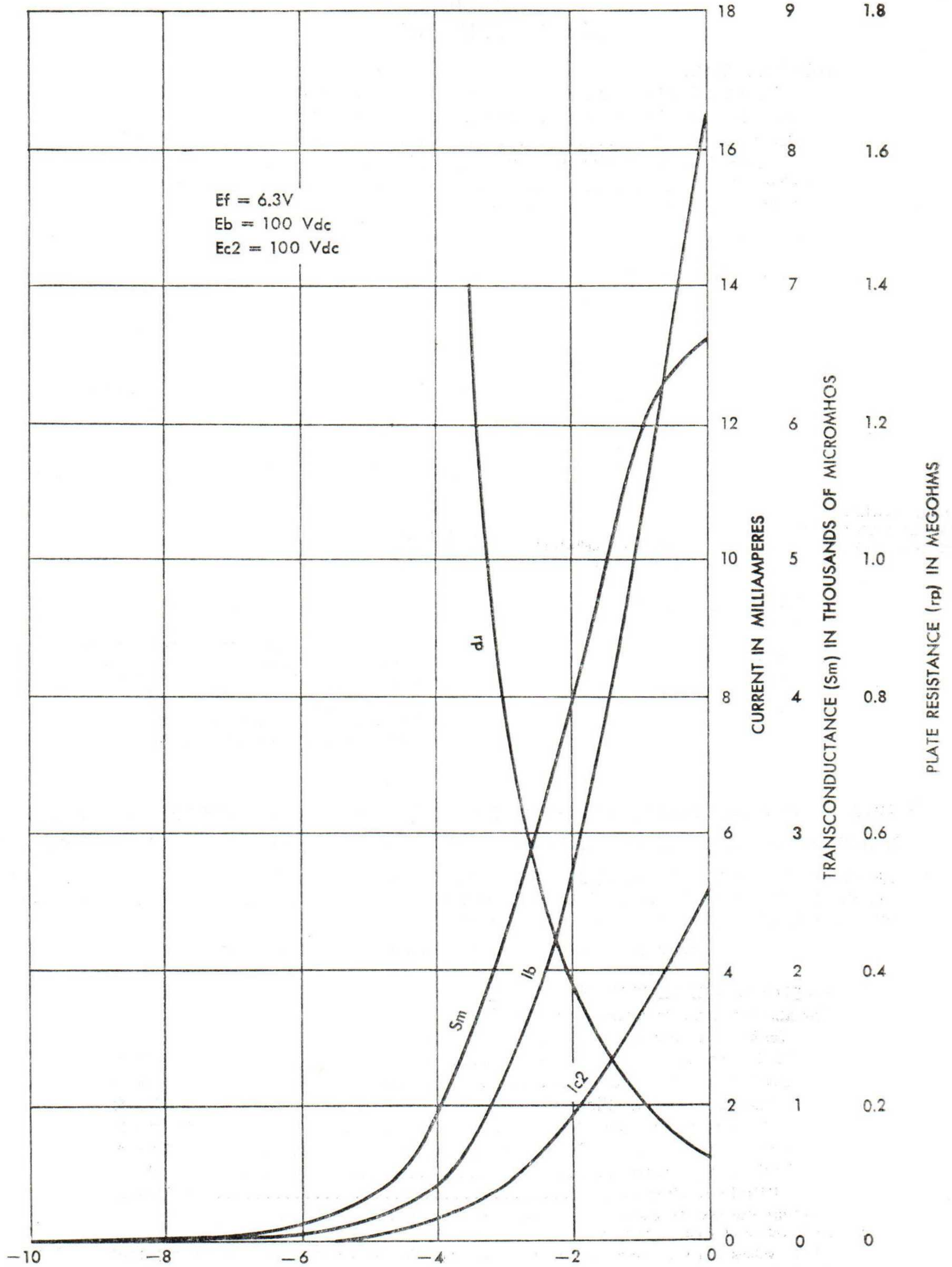


Figure 3-317. Typical Transfer Characteristics of JAN-5840.

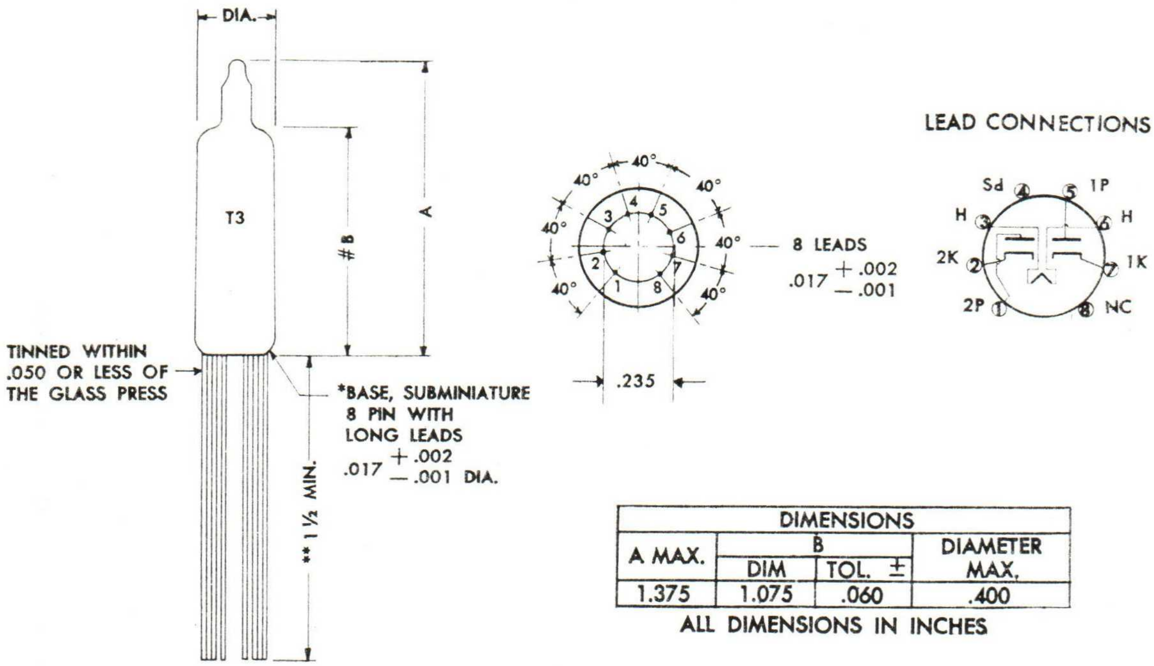
SECTION
TUBE TYPE JAN-5896

DESCRIPTION.
The JAN-5896 [1] is an 8 lead, button base, subminiature, double diode.

ELECTRICAL: The electrical characteristics are as follows:

- Heater Voltage .... 6.3 V
- Heater Current, Design Center .... 300 mA
- **Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.375	1.075	.060	.400

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-318. Outline Drawing and Base Diagram of Tube Type JAN-5896.

RATINGS, ABSOLUTE SYSTEM
The absolute system ratings are as follows:

- Heater Voltage .... 6.3 ± .3 V
- Peak Inverse Plate Voltage .... 460 v
- Heater-Cathode Voltage .... 360 v
- Steady State Peak Plate Current (per Plate) .... 60 mA
- Output Current (per Plate) .... 10 mAdc
- Transient Peak Plate Current (per Plate) .... 350 mA
- Bulb Temperature .... + 220° C
- Altitude Rating .... 60,000 ft

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/174C dated 23 June 1955.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Supply Voltage (per Plate), Epp .... 165 Vac
Load Resistance (Unity Power Factor), RL .... 11,000 ohms
Load Capacitance, CL .... 8 uf
Heater Current, If .... 300 mA

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/174C dated 23 June 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		280	320	276	328	mA
Operation	Io	See Note Below	16	...	...	...	mAdc
Change in Individual	Io		...	...	...	14	mAdc
Plate Current	Ib	Ebb = 0; Rp = 40,000 ohms	5.0	25	...	...	uAdc
Difference between sections	Ib		...	5.0	...	...	uAdc
Emission	Is	Eb = 10 Vdc	30	...	...	...	mAdc
Capacitance (Shielded as Specified)	C1p to 2p	Ef = 0	...	0.026	...	...	uuf
	C1p to h+1k+sd	Ef = 0	2.5	3.5	...	...	uuf
	C2p to h+2k+sd	Ef = 0	2.5	3.5	...	...	uuf
	C1k to h+1p+sd	Ef = 0	3.5	4.9	...	...	uuf
	C2k to h+2p+sd	Ef = 0	3.5	4.9	...	...	uuf
Heater-Cathode Leakage	Ihk	Ehk = +360 Vdc	...	40	...	80	uAdc
	Ihk	Ehk = —360 Vdc	...	—40	...	—80	uAdc
Insulation of Electrodes	R(p–all)	Ep-all = —500 Vdc	100	...	25	...	Meg

Note: In a full wave circuit, adjust Zp (per plate) so that a bogie tube gives Io = 18 mAdc. A bogie tube has a tube drop Etd = 10 Vdc at Is = 50 mAdc per plate.

APPLICATION OF THE JAN-5896

Signal Rectifier Service: In the application of JAN-5896 in signal rectifier service, Chart "A" relates boundaries of permissible operation and the questionable area of operation, to the plate characteristics.

Permissible steady state peak plate current is limited to 60 milliamperes per plate, to define boundary (1), and dc output currents is limited to 10 milliamperes per plate to define boundary (2). Area (3) is defined as questionable from the standpoint of uniformity and stability of plate current in low-level signal rectifier applications. Although the specification enforces a control on plate current between the two sections to within 5 microamperes under MIL-E-1 test conditions, there is little assurance of such balance under conditions of heater operation differing from test conditions. Reference should be made to Section 1.3.1 for a review of the behavior of initial electron velocity and contact potential in tubes in general, where control grid currents discussed are equivalent to plate currents in signal diode application.

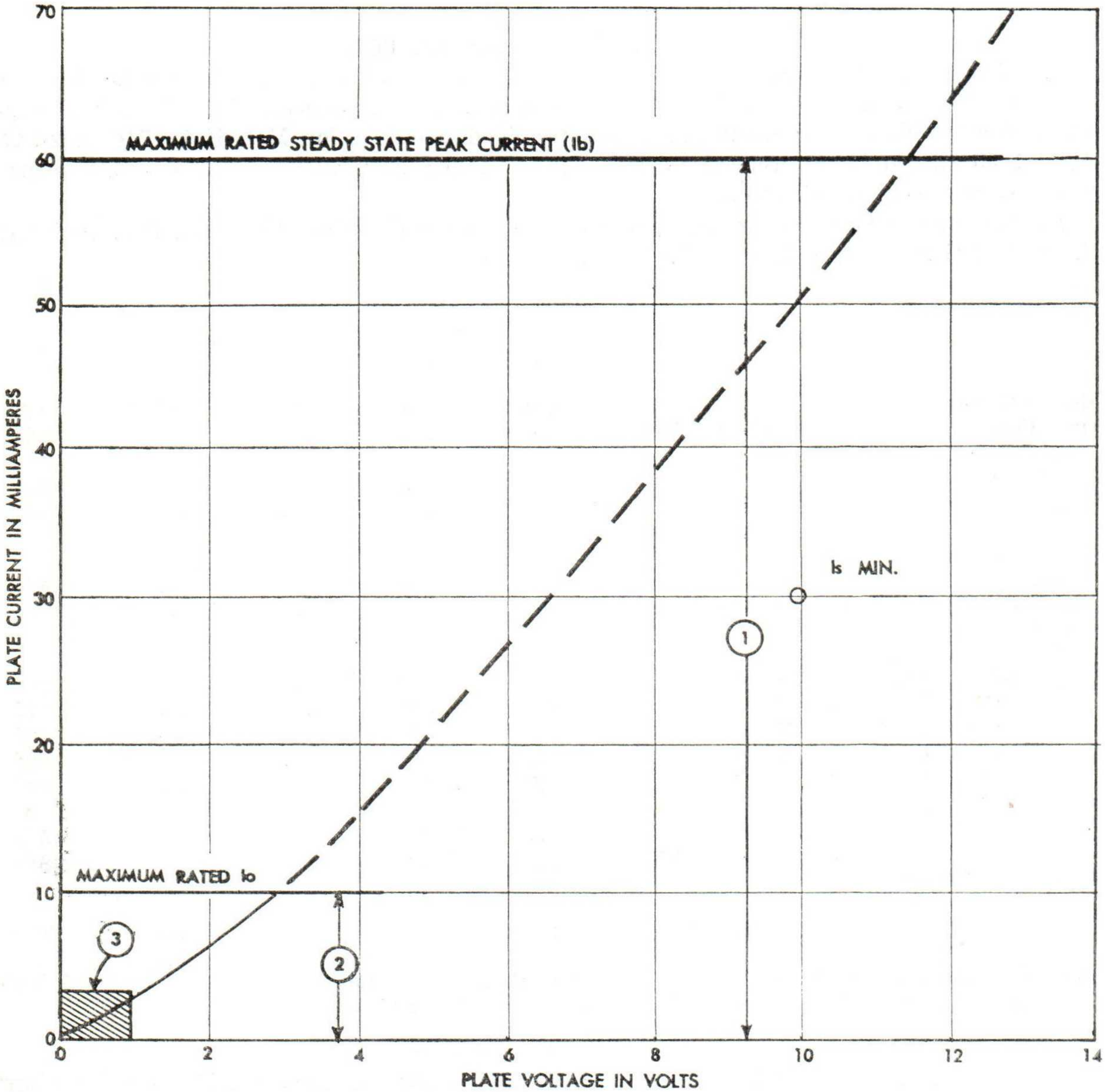


Figure 3-319. Chart A — JAN-5896; Permissible Limits of Operation.

Limit 1 is based on the maximum rated steady-state plate current (Ib) of 60 milliamperes. Limit 2 is based on the maximum rated dc output per plate (Io/p) of 10 milliamperes.

Supply Voltage Rectifier Service: Rating Charts I, II, and III represent areas of permissible operation within which any application of the JAN-5896 must fall. Requirements of all charts must be satisfied simultaneously in capacitor-input filter applications.

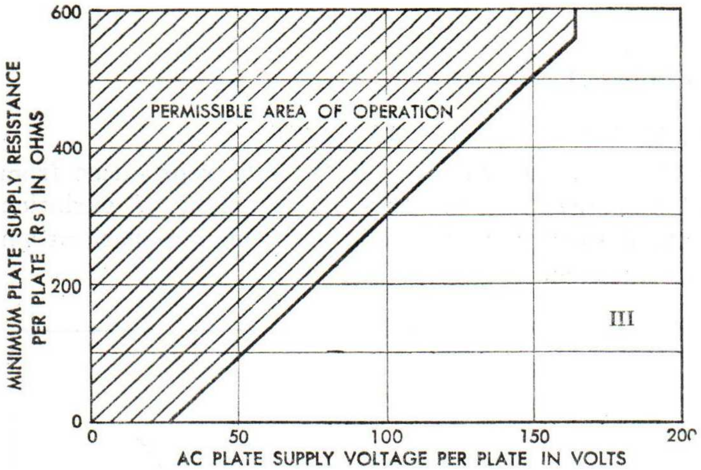


Figure 3-322. Rating Chart III for JAN-5896

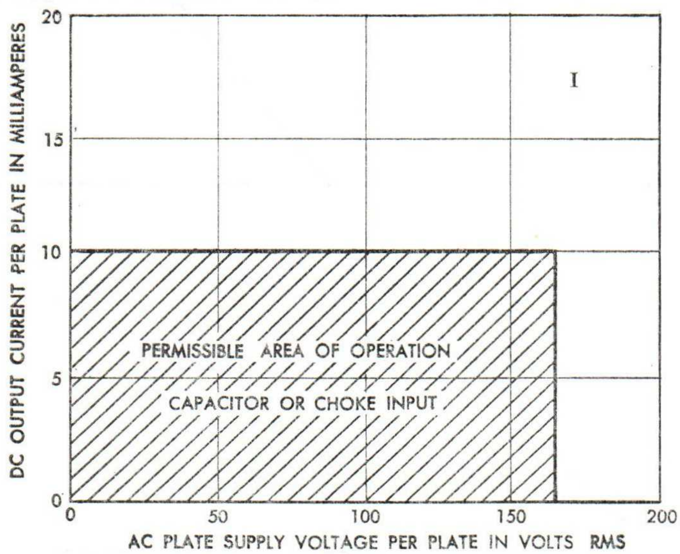


Figure 3-320. Rating Chart I for JAN-5896

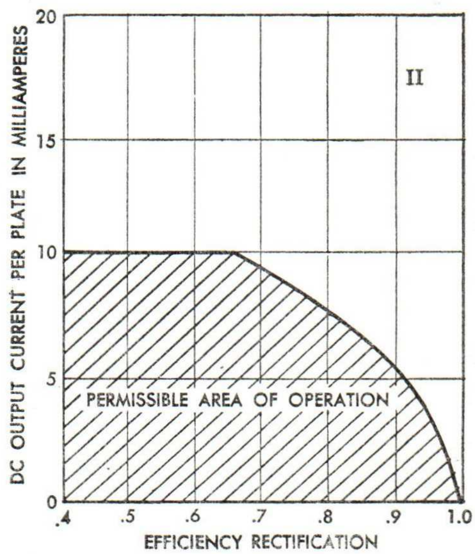


Figure 3-321. Rating Chart II for JAN-5896

Figure 3-320. *Rating Chart* I is based on maximum rated peak inverse voltage per plate (epx) of 460 volts and maximum rated dc output current per plate (Io/p) of 10 milliamperes. Point C corresponds to the simultaneous occurence of these two ratings permissible under capacitor—or choke-input filter conditions.

Figure 3-321. *Rating Chart II* for capacitor input filter applications is based on maximum rated dc output current per plate (Io/p) and maximum rated steady state peak plate current (Ib/p) of 60 milliamperes per plate. Rectification efficiency must not exceed 0.67 under conditions of maximum rated dc output current.

Figure 3-322. *Rating Chart III* for capacitor input filter is based on maximum rated surge current (i surge) of 350 milliamperes per plate. Minimum permissible series resistance (Rs) is approximately 560 ohms per plate under conditions of maximum permissible supply voltage per plate.

Other Considerations:
Heater Voltage: See paragraph 3.4.3.
Low Electrode Current: See paragraph 3.4.3.

AVERAGE CHARACTERISTICS OF JAN-5896

The charts below present the Static Plate Characteristics of JAN-5896, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be derived from the specification which provides only a minimum limit on emission.

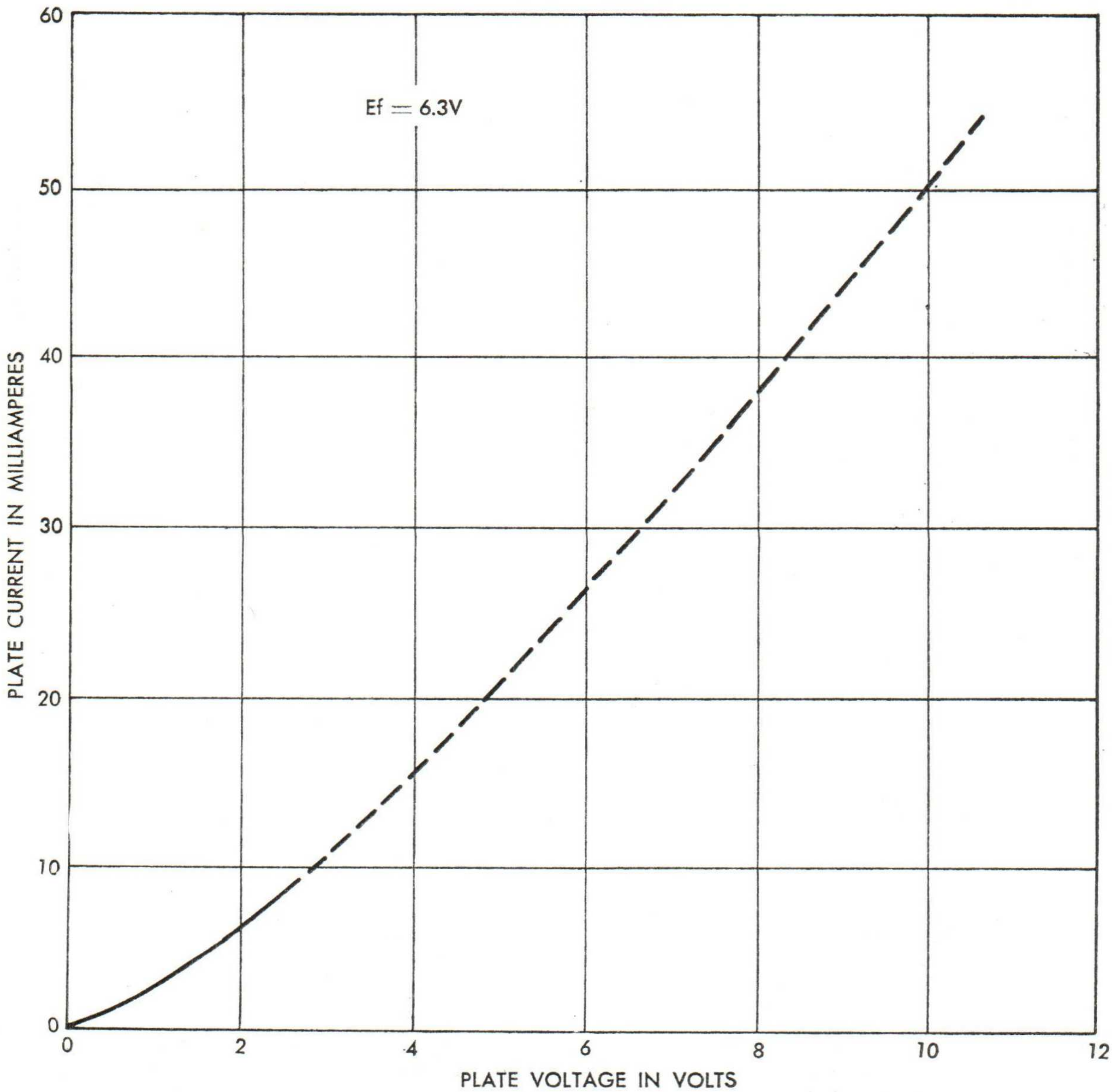


Figure 3-323. Typical Plate Characteristics-Single Section for Jan-5896.

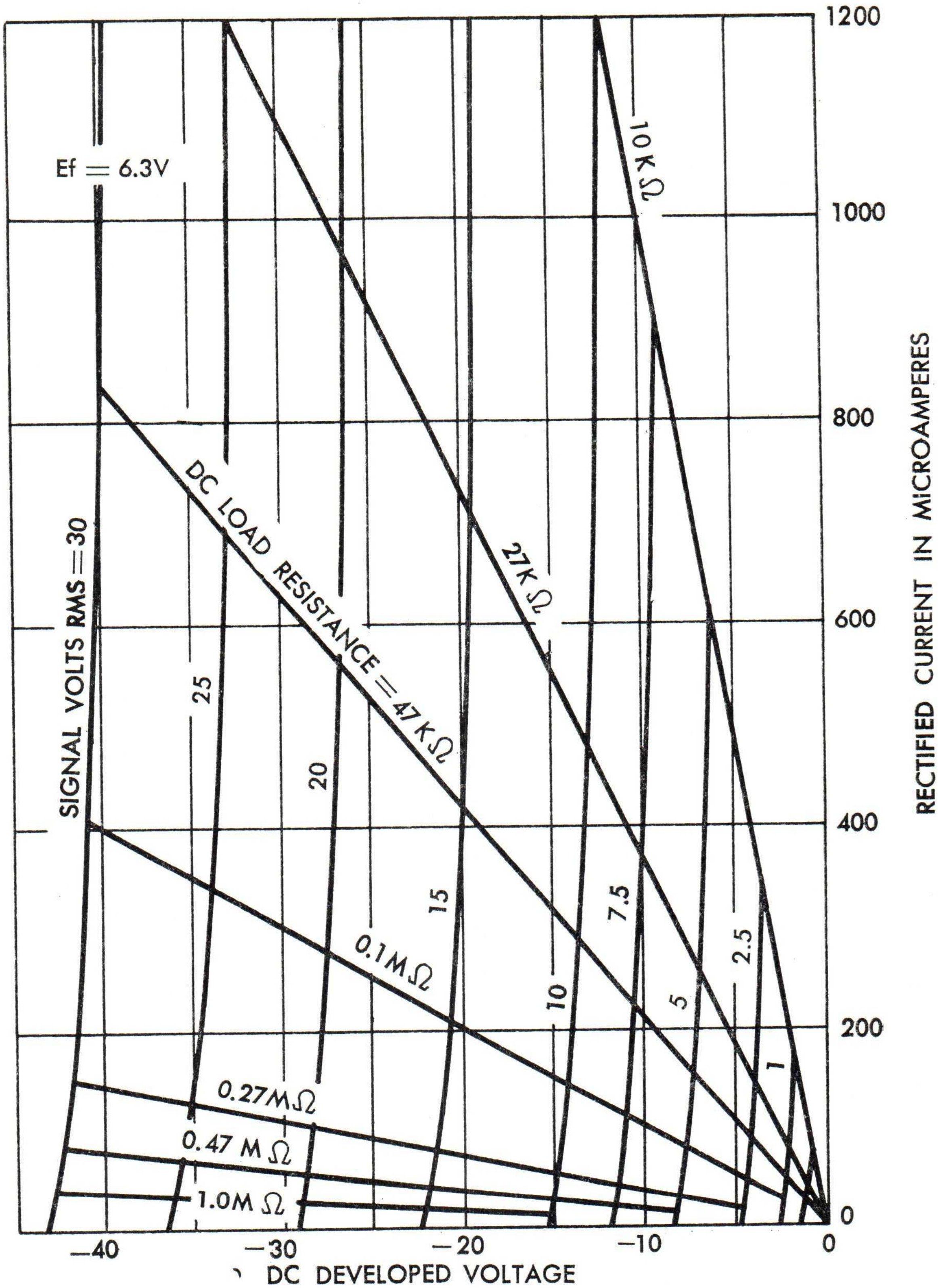


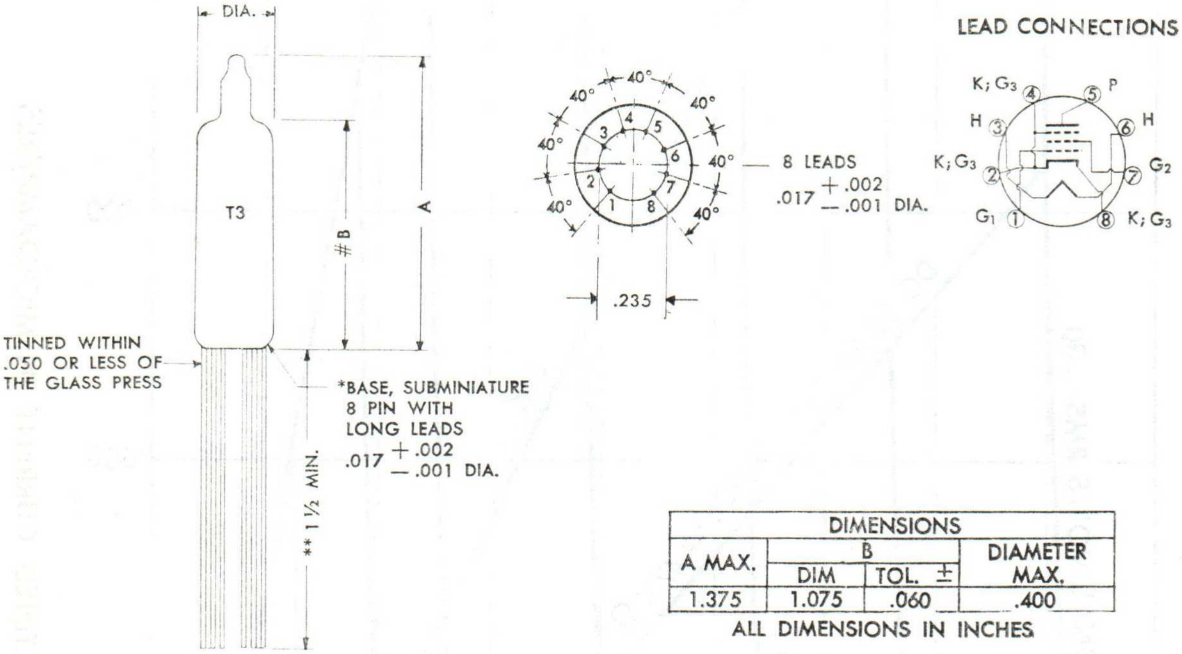
Figure 3-324. Typical Half-Wave Rectification Characteristics for a Single Section of JAN-5896.

SECTION
TUBE TYPE JAN-5899

DESCRIPTION.
The JAN-5899 [1] is an 8 lead, button base, subminiature, semi-remote cutoff pentode having a design center transconductance of 4500 micromhos.
ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 ± .3 V
Heater Current, Design Center .... 150 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.375	1.075	.060	.400

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-325. Outline Drawing and Base Diagram of JAN-5899.

RATINGS, ABSOLUTE SYSTEM.
The absolute system ratings are as follows:

Heater Voltage .... 6.3 + .3 V
Plate Voltage .... 165 Vdc
Reference MIL-E-1C 6.5.1.1 *Plate Voltage*
Control Grid Voltage, Maximum .... 0 Vdc
Control Grid Voltage, Minimum .... —55 Vdc
*Screen Grid Voltage .... 155 Vdc
*Suppressor Grid Voltage .... 22 Vdc
Heater-Cathode Voltage .... 200 v
Control Grid Series Resistance .... 1.1 Meg

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/97C dated 23 June 1955.

**Cathode Current, Maximum .... 16.5 mAdc
Plate Dissipation .... 0.75 W
*Screen Grid Dissipation .... 0.35 W
Bulb Temperature .... 220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 100 Vdc
Screen Grid Voltage, Ec2 .... 100 Vdc
Suppressor Grid Voltage, Ec3 .... 0 Vdc
Heater-Cathode Voltage .... 0 Vdc
Cathode Resistance, Rk .... 120 ohms
Heater Current, If .... 150 mA
Plate Current, Ib .... 7.2 mAdc
Transconductance, Sm .... 4500 umhos
Transconductance, Sm (Ec1 = —14 Vdc, Rk = 0) .... 25 umhos

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/97C dated 23 June 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		140	160	138	164	mA
Transconductance (1)	Sm		3800	5200	...	...	umhos
Change in individual	Δ Sm t		...	...	...	20	%
Transconductance (2)	Δ Sm Ef		...	10	...	15	%
Transconductance (3)	Sm	Ec1 = -14 Vdc; Rk = 0	1.0	75	...	...	umhos
Plate Resistance	rp		0.175	...	...	...	Meg
Plate Current (1)	Ib		5.2	9.2	...	...	mAdc
Screen Grid Current	Ic2		1.0	3.0	...	...	mAdc
Capacitance	Cg1-p	Ef = 0	...	0.015	...	...	uuf
Shielded as	Cin	Ef = 0	3.8	4.8	...	...	uuf
Specified)	Cout	Ef = 0	2.9	3.9	...	...	uuf
Control Grid Current	Ic1	Rg1 = 1.0 Meg	0	—0.3	0	-0.8	uAdc
Heater1Cathode Leakage	Ihk	Ehk = + 100 Vdc	...	5.0	...	10	uAdc
	Ihk	Ehk = — 100 Vdc	...	—5.0	...	—10	uAdc
Insulation of Electrodes	R(g-all)	Eg1-all = — 100 Vdc	100	...	50	...	Meg
	R(p-all)	Ep -all = — 300 Vdc	100	...	50	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

APPLICATION OF JAN-5899

The chart below shows the permissible operating area for JAN-5899 as defined by the ratings in MIL-E-1/97C dated 23 June 1955. A discussion of the permissible operating area for pentodes may be found in paragraphs 3.2.2.

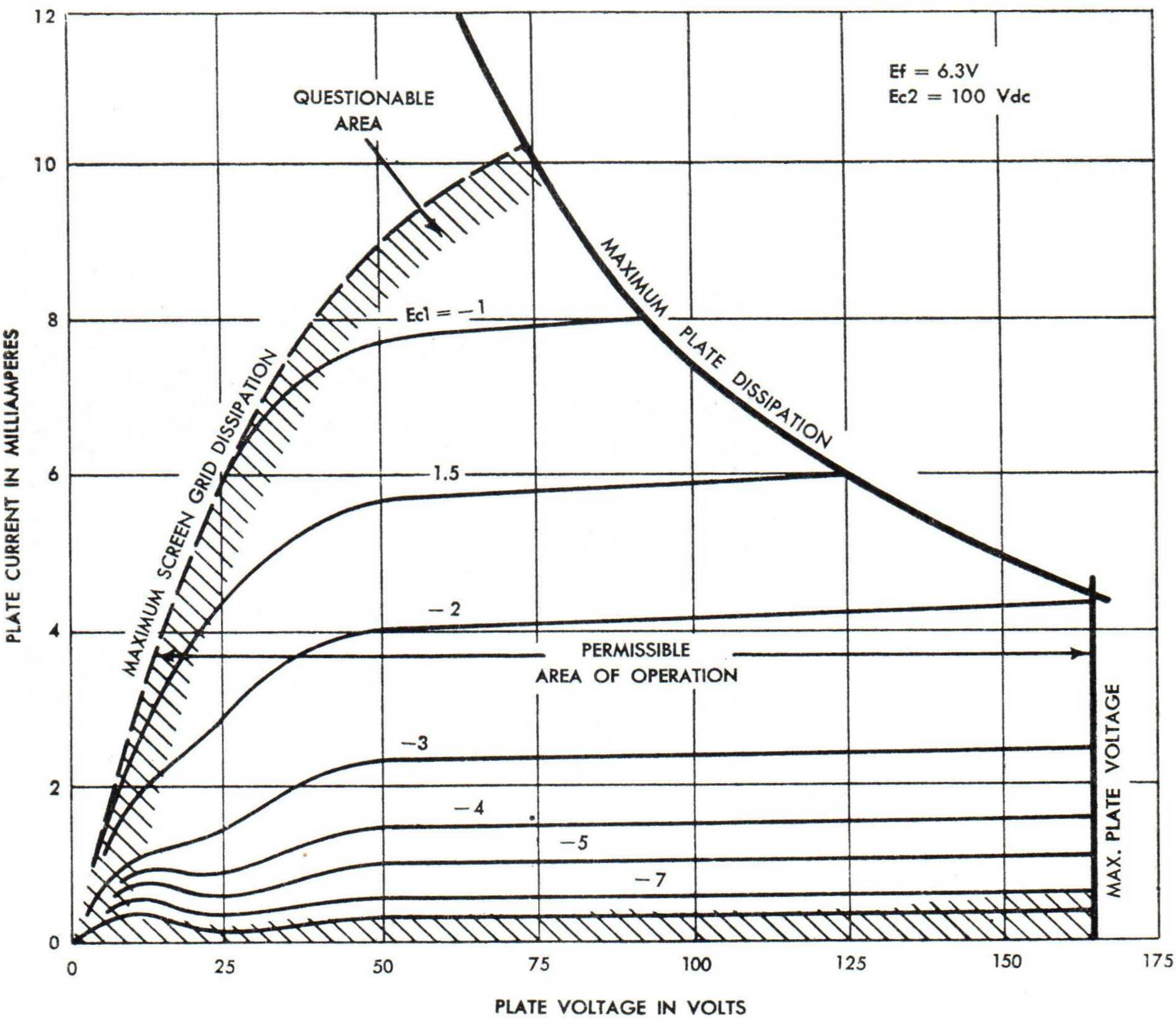


Figure 3-326. Typical Static Plate Characteristics of JAN-5899; Permissible Area of Operation.

VARIABILITY OF JAN-5899 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extend to variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN–5899 as defined by MIL–E–1/97C dated 23 June 1955.

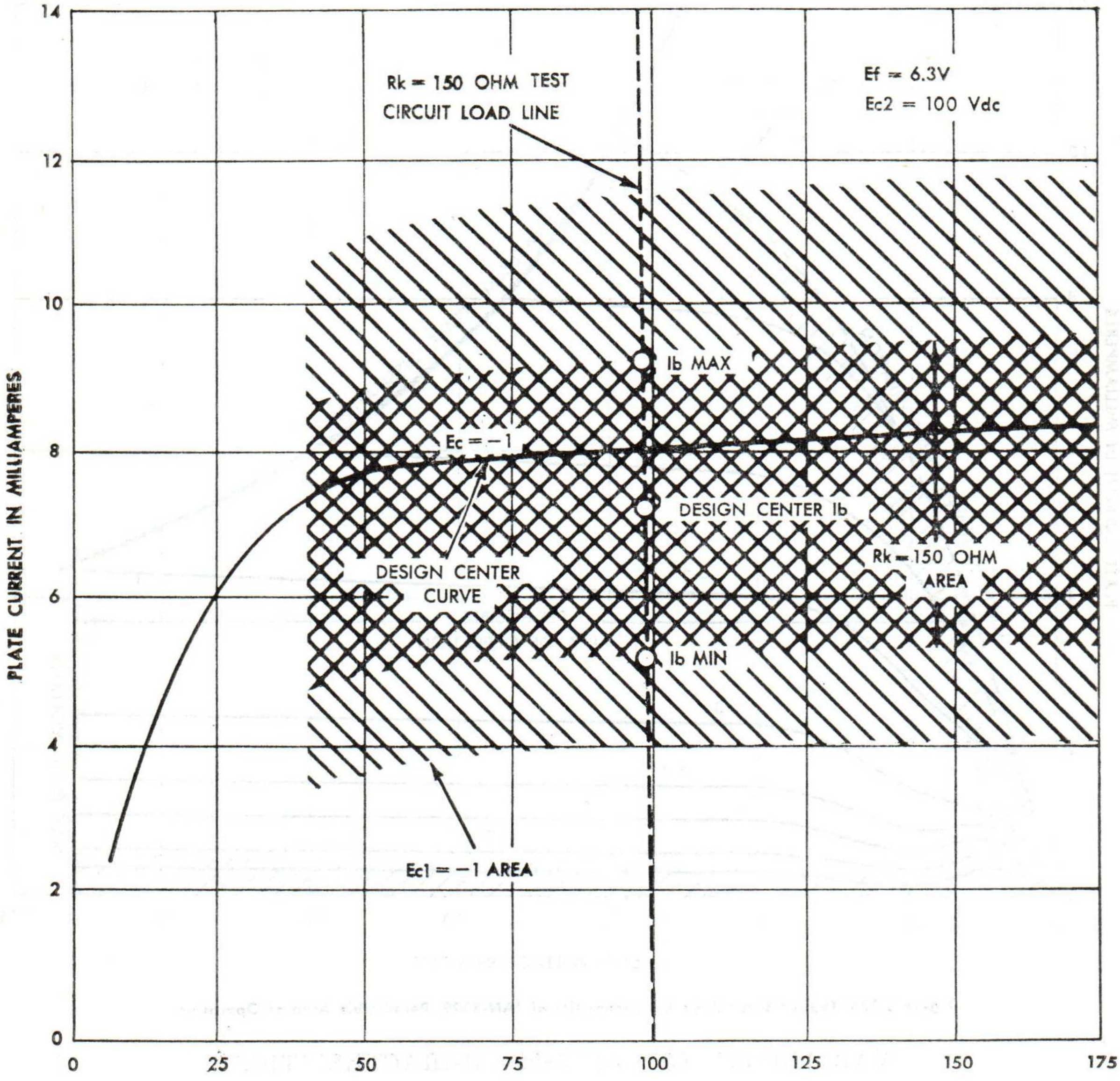


Figure 3-327. Limit Behavior of JAN-5899 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-5899 as defined by MIL-E-1/97C dated 23 June 1955.

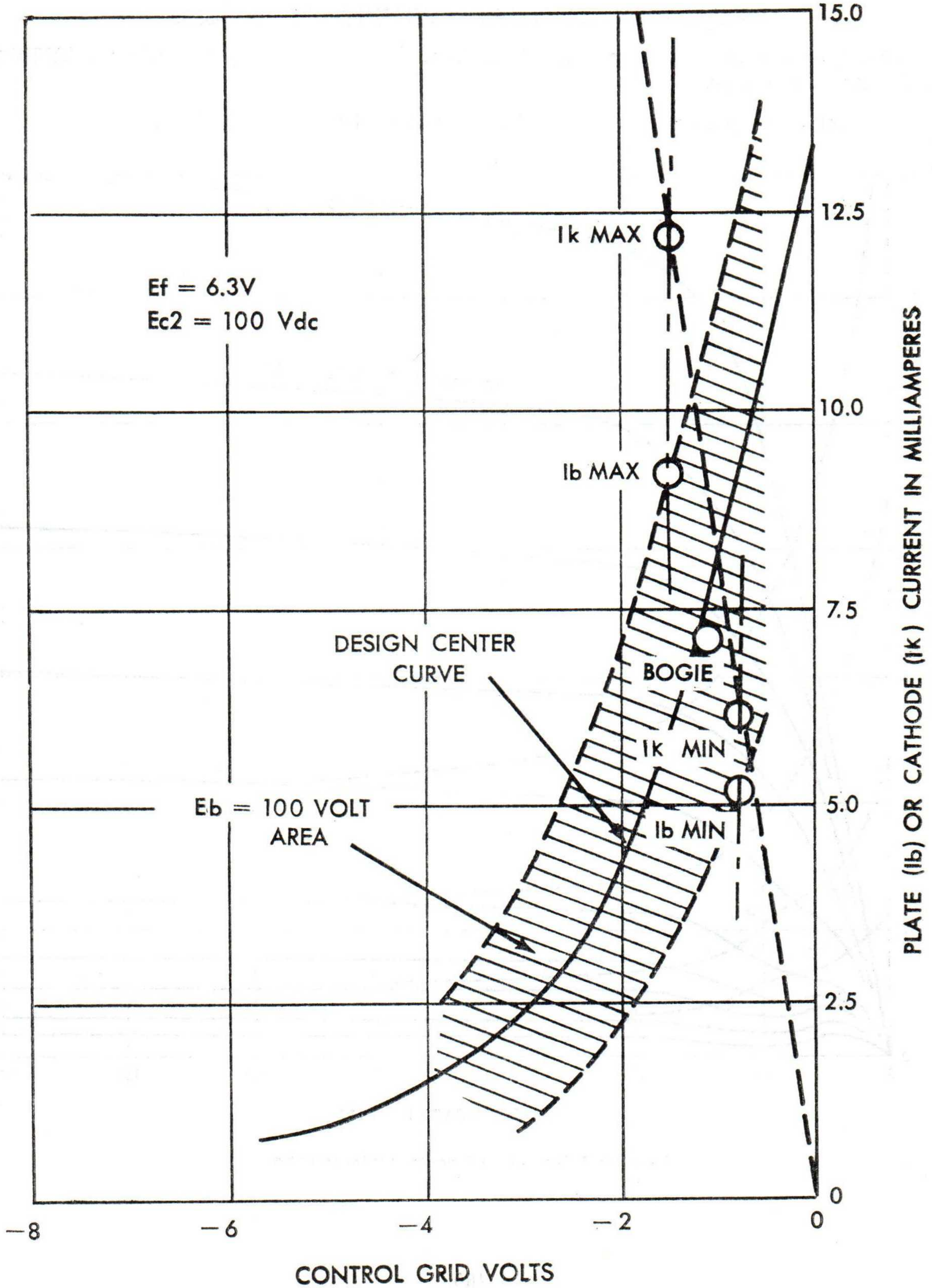


Figure 3-328. Limit Transfer Data for JAN-5899; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-5899

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-5899.

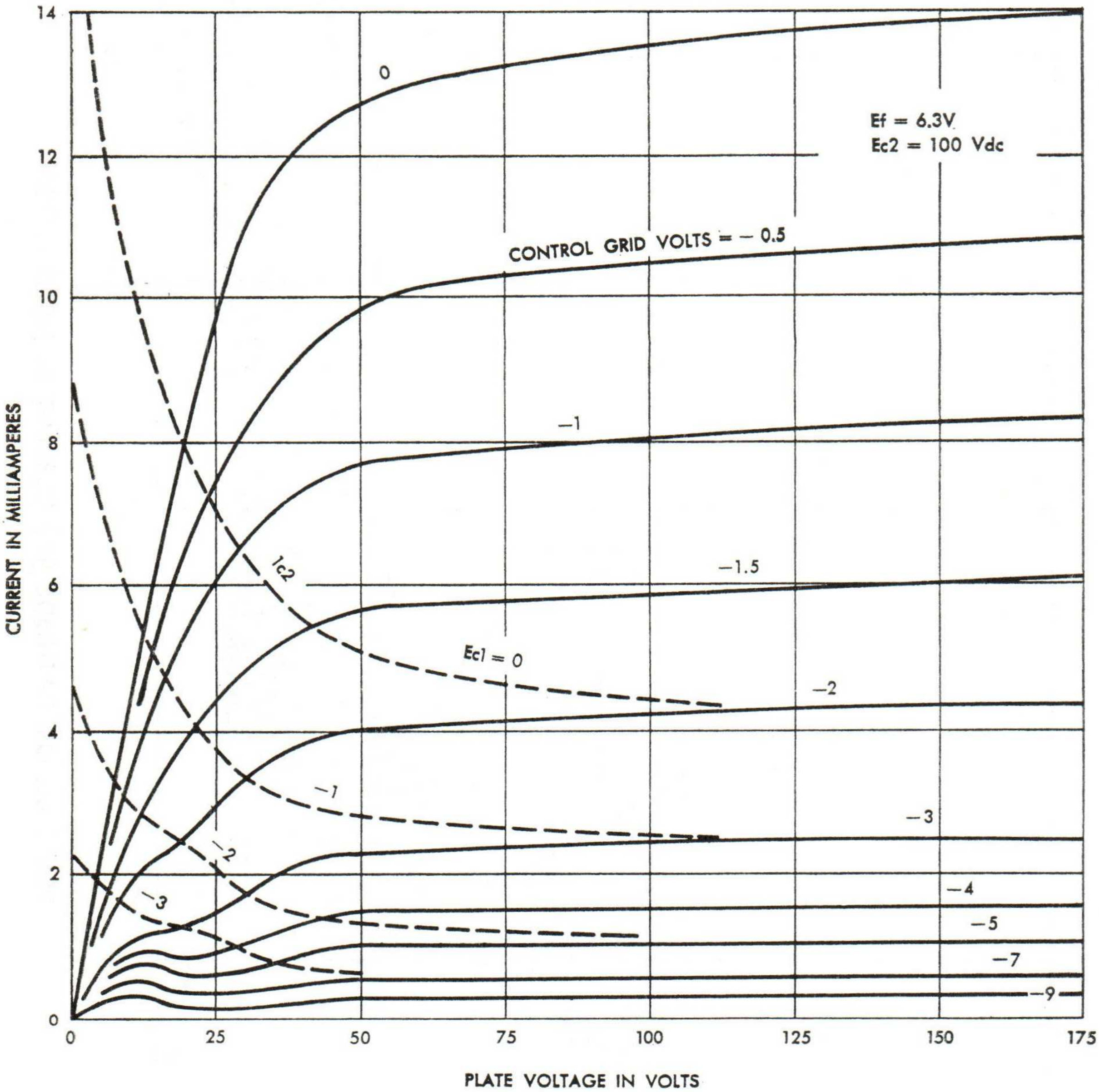


Figure 3-329. Typical Plate Characteristics for JAN-5899.

The chart below presents the Average Plate Transfer Data for JAN-5899.

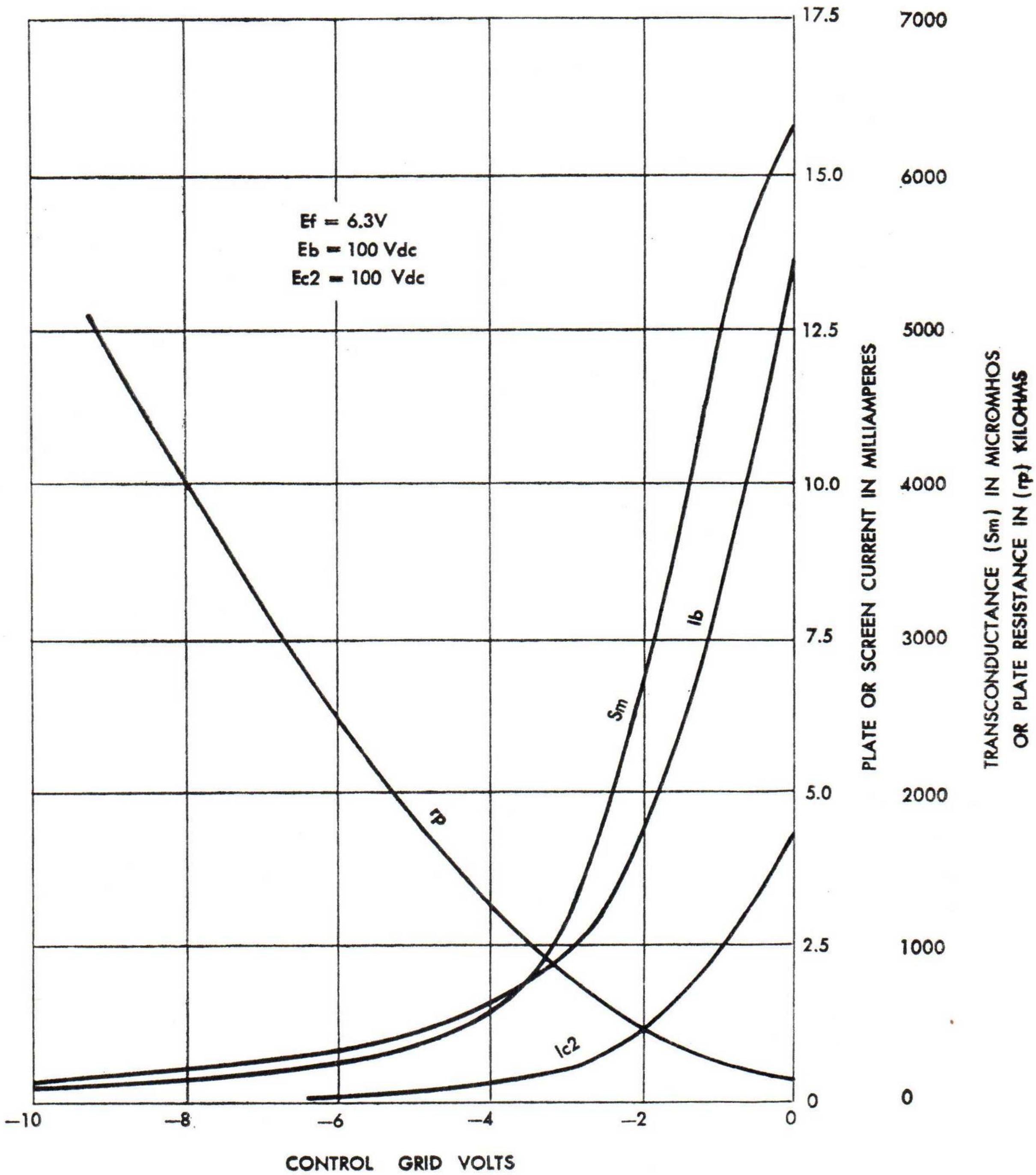


Figure 3-330. Typical Transfer Characteristics of JAN-5899.

SECTION
TUBE TYPE JAN-5902

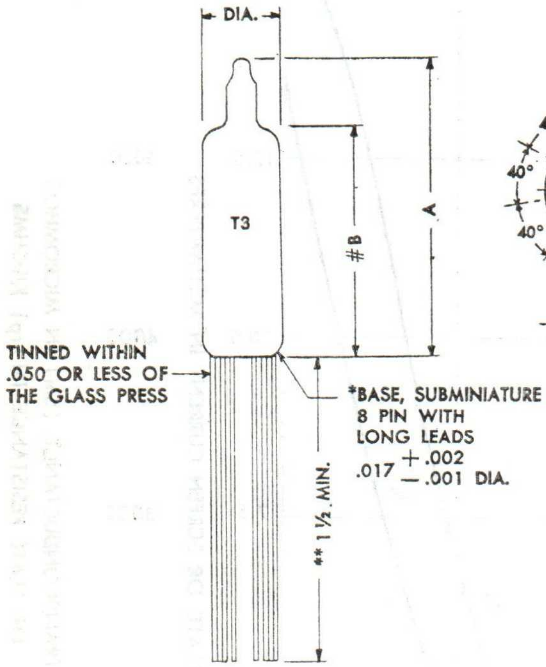
DESCRIPTION.

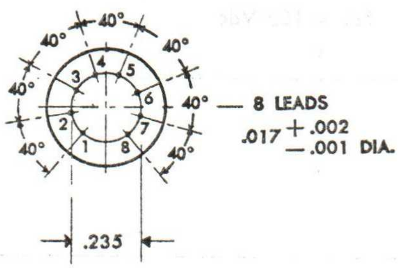
The JAN-5902 [1] is an 8 lead, buttom base, subminiature, beam power pentode having a design center transconductance of 4200 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

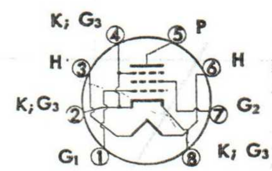
Heater Voltage .... 6.3 V
Heater Current, Design Center .... 450 mA
Cathode .... Coated Unipotential

MOUNTING. Auy type of mounting is adequate.





LEAD CONNECTIONS



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.750	1.450	.060	.400

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-331. Outline Drawing and Base Diagram of JAN-5902.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.3 V
Plate Voltage .... 165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Control Grid Voltage, Maximum .... 0 Vdc
Control Grid Voltage, Minimum .... —55 Vdc
*Screen Grid Voltage .... 155 Vdc
Heater-Cathode Voltage .... 200 V
Control Grid Series Resistance .... 0.55 Meg

* No test at this rating exists in the specification.

[1] The values and specification comments presented in this section are related to MIL-E-1/175C dated 14 May 1956.

**Cathode Current, Maximum .... 50 mAdc
Plate Dissipation .... 3.7 W
Screen Grid Dissipation .... 0.4 W
Bulb Temperature .... +220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 110 Vdc
Screen Grid Voltage, Ec2 .... 110 Vdc
Cathode Resistance, Rk .... 270 ohms
Heater Current, If .... 450 mA
Plate Current, Ib .... 30.0 mAdc
Transconductance, Sm .... 4200 umhos

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current paproaching the maximum.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/175C dated 14 May 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		420	480	414	492	mA
Transconductance (1)	Sm		3500	4900	...	...	umhos
Plate Resistance	rp		0.01	...	...	...	Meg
Plate Current (1)	Ib		23.0	37.0	...	...	mAdc
Screen Grid Current	Ic2		0	4.0	...	...	mAdc
Power Output	Po	Esig = 6.4 Vac Rp = 3000	0.75	...	...	...	W
Change in individual	ΔPo t	Esig = 6.4 Vac Rp = 3000	...	...	...	20	%
Average Change	Avg ΔPo t		...	...	...	15	%
Change with Ef	Po Ef	Ef = 5.7	...	15	...	15	%
Capacitance	Cgp	Ef = 0	...	0.20	...	...	uuf
(shielded as	Cin	Ef = 0	5.5	7.5	...	...	uuf
specified)	Cout	Ef = 0	6.5	8.5	...	...	uuf
Control Grid Current	Ic1	Rg = 1.0 Meg	0	—1.0	0	—2.0	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	15	...	60	uAdc
	Ihk	Ehk = —100 Vdc	...	—15	...	—60	uAdc
Insulation of Electrodes	R(g1-all)	Eg1-all = —100 Vdc	50	...	25	...	Meg
	R(p -all)	Ep -all = —300 Vdc	50	...	25	...	Meg

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 32.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

APPLICATION OF JAN-5902

The chart below shows the permissible operating area for JAN-5902 as defined by the ratings in MIL-E-1/175C dated 14 May 1956. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

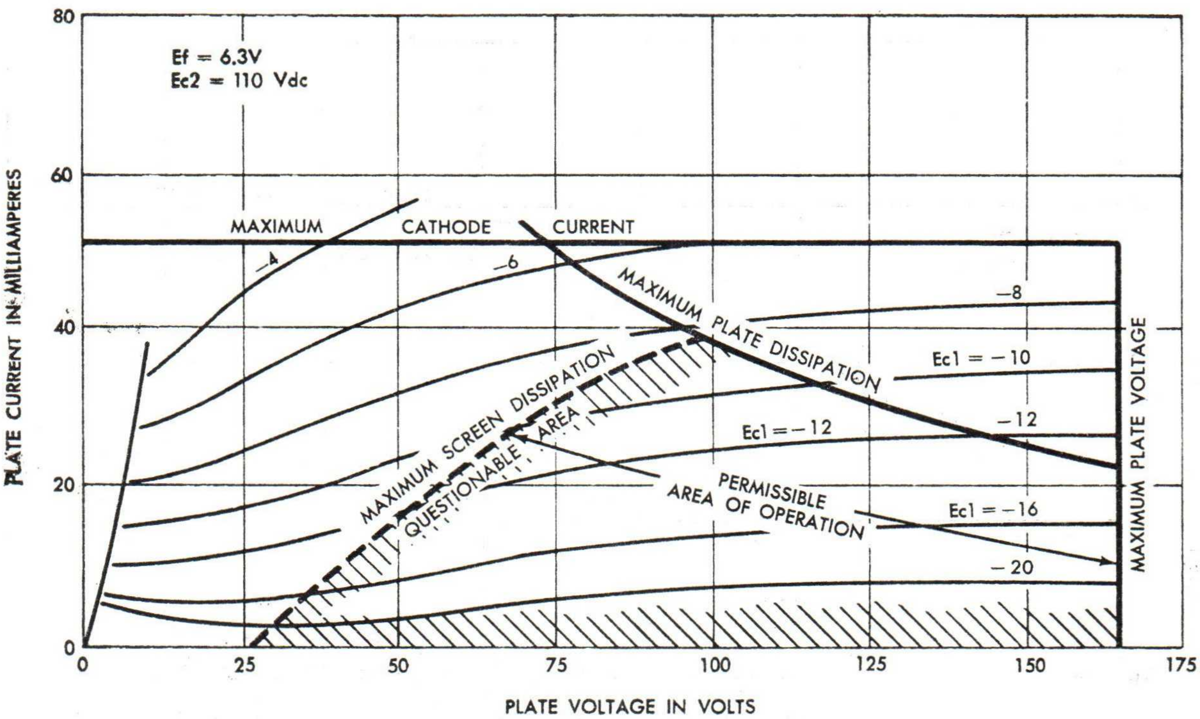


Figure 3-332. Typical Static Plate Characteristics of JAN-5902; Permissibile Area of Operation.

SPECIAL OPERATING CONDITIONS

Class A power output for this tube is defined by attribute limits and by average shift throughout life. It is also defined during life test at a heater voltage of 5.7 V.

A test for control grid emission is performed at zero hours.

VARIABILITY OF JAN-5902 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-5902 as defined by MIL-E-1/175C dated 14 May 1956.

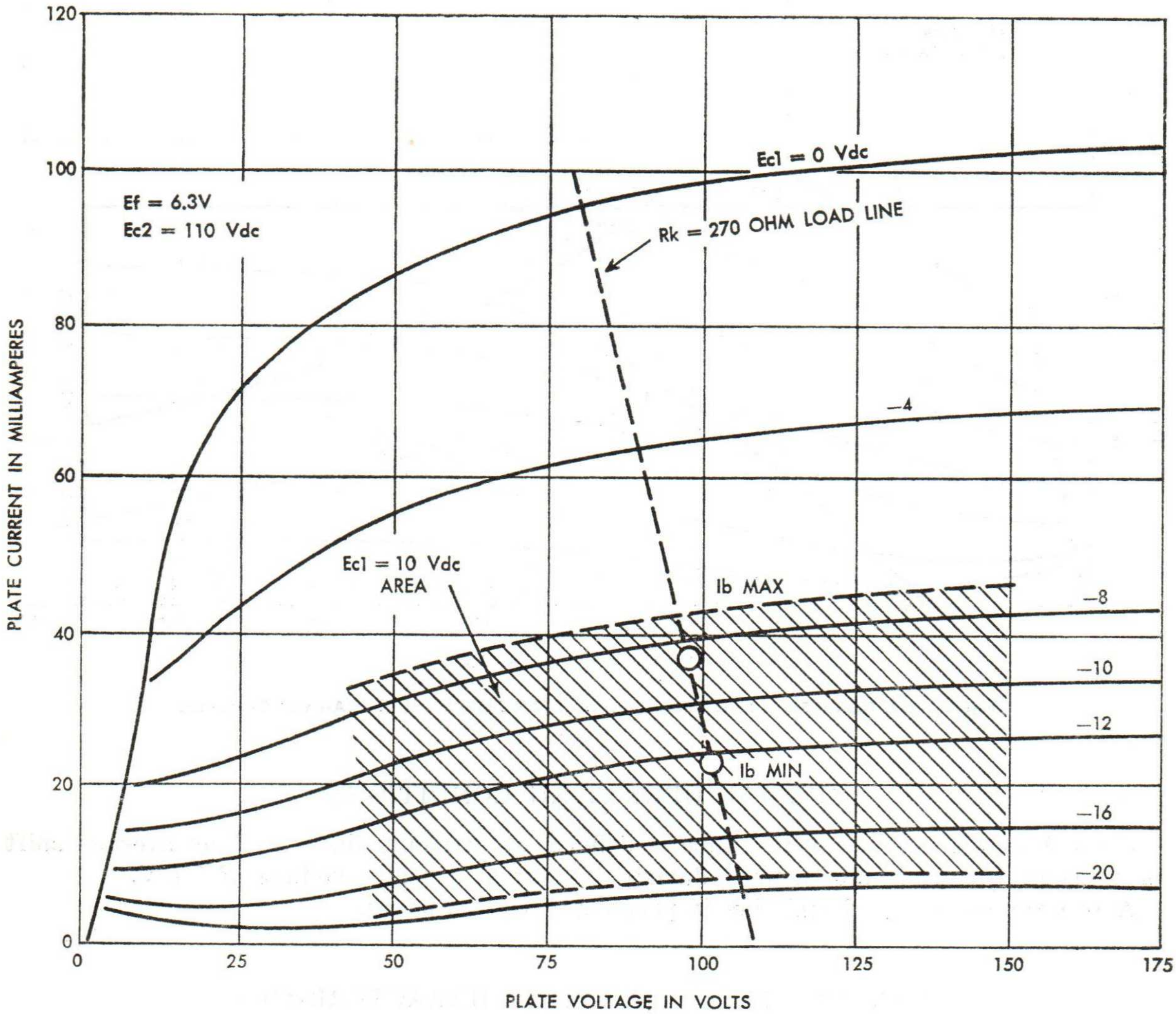


Figure 3-333. Limit Behavior of JAN-5902 Static Plate Data; Variability of Ib

The chart below presents the limit behavior of transfer data for JAN-5902 as defined by MIL-E-1/185C dated 14 May 1956.

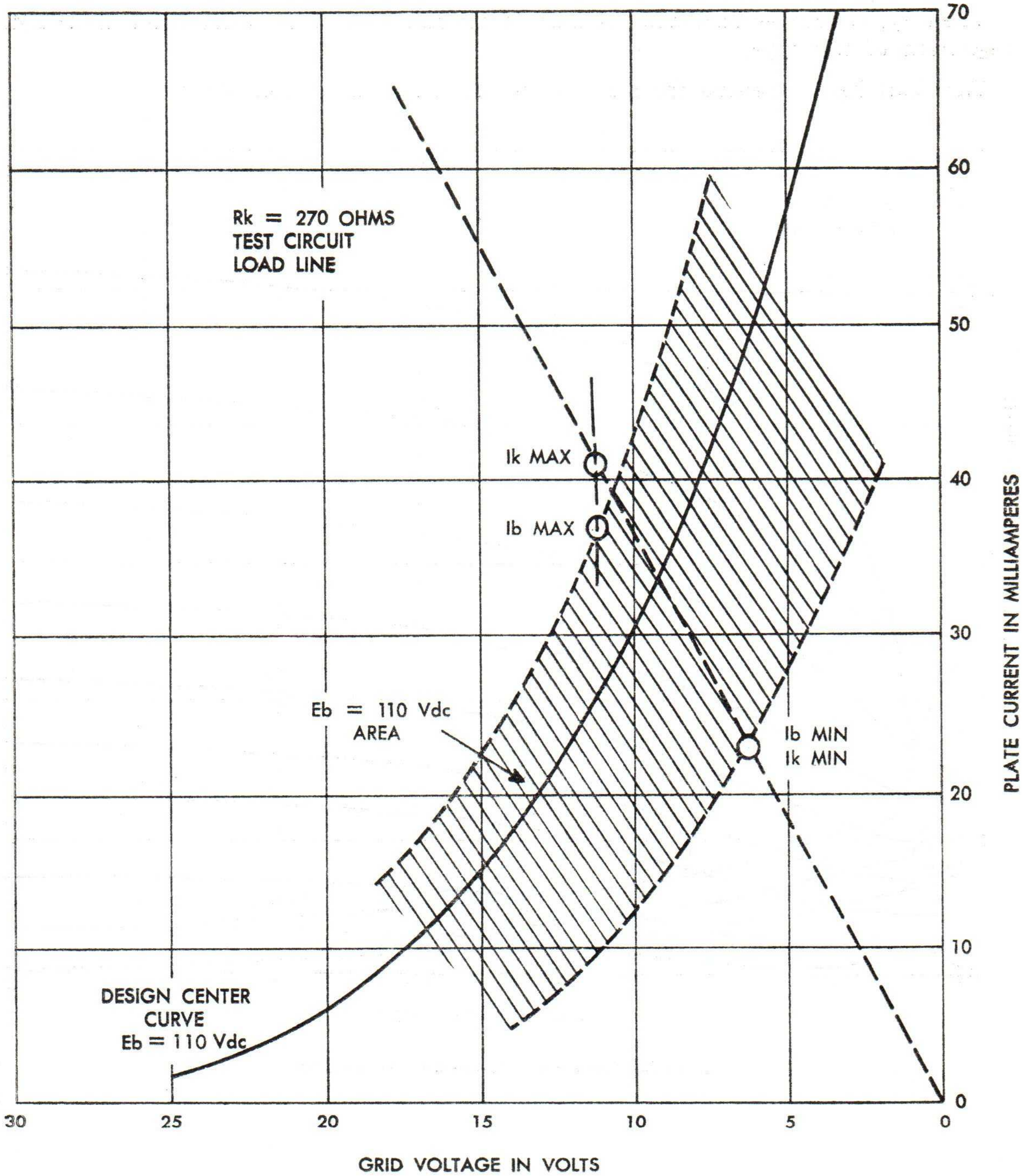


Figure 3-334. Limit Transfer Data on JAN-5902.

DESIGN CENTER CHARACTERISTICS OF JAN–5902

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN–5902.

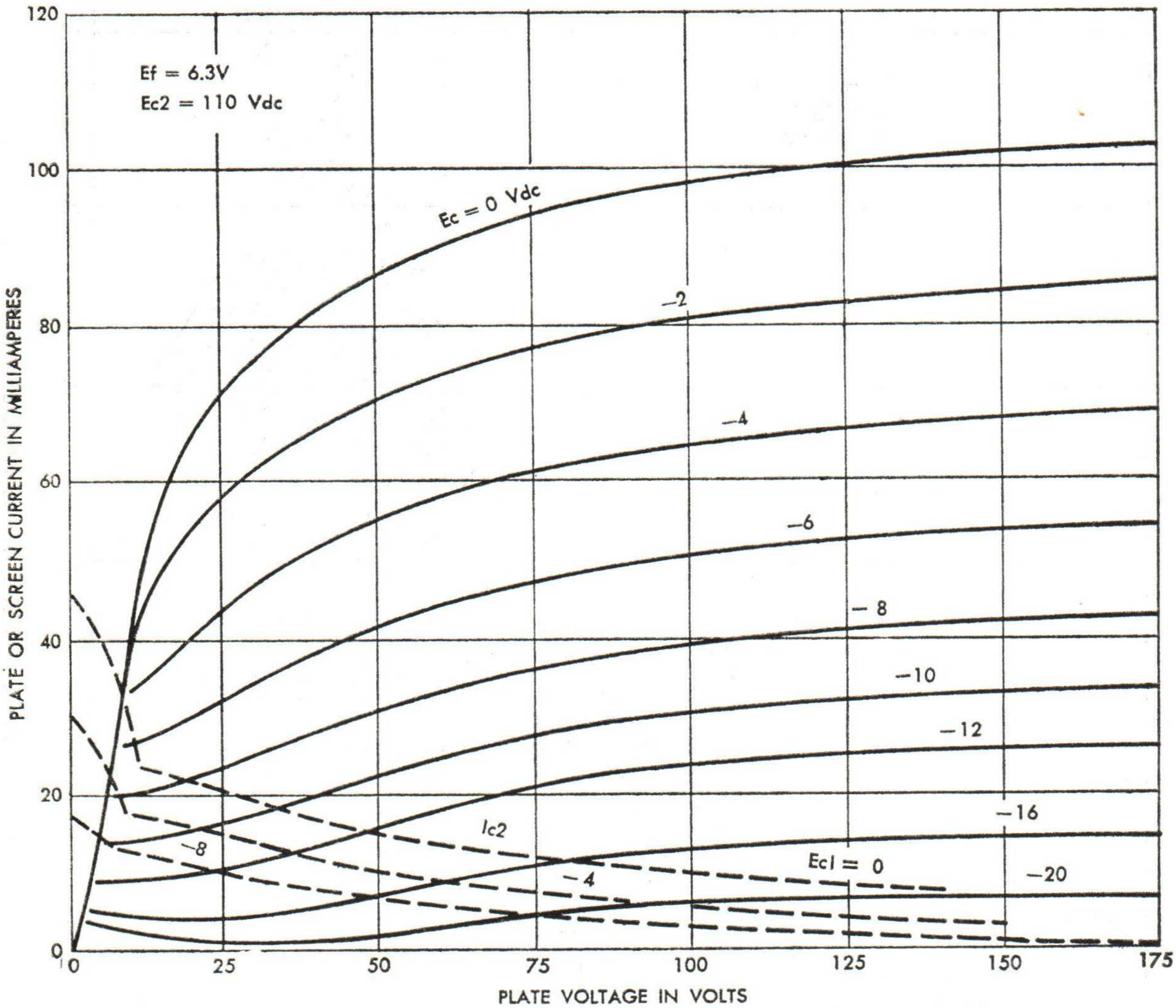


Figure 3-335. Typical Plate Characteristics for JAN-5902.

The chart below presents the Average Plate Transfer Data for JAN-5902.

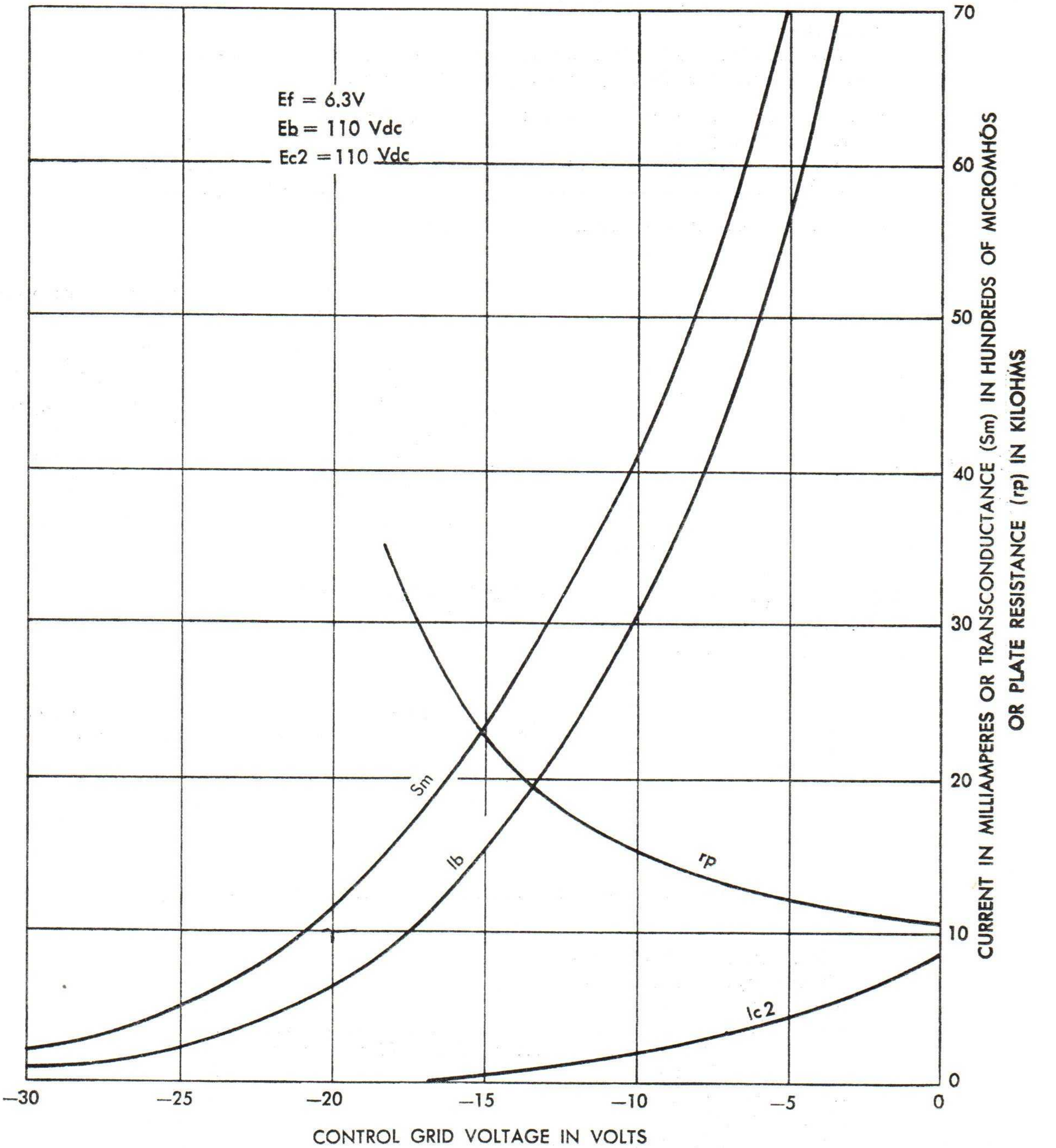


Figure 3-336. Typical Transfer Characteristics of JAN-5902.

SECTION
TUBE TYPE JAN-6005/6AQ5W

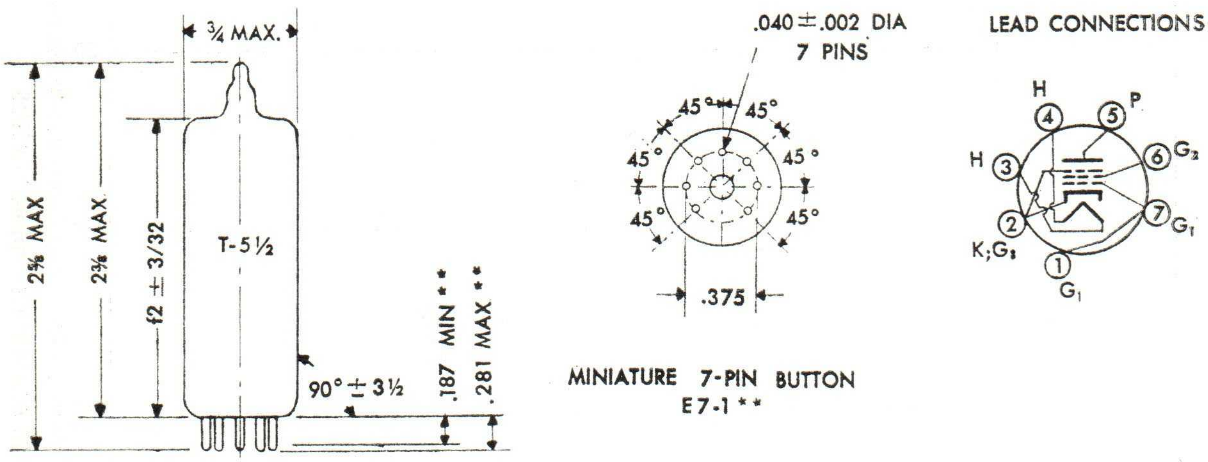
DESCRIPTION.

The JAN-6005/6AQ5W [1] is a 7 pin miniature beam power pentode having a transconductance in the range from 3000 to 5200 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 450 mA
**Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



7 PIN MINIATURE
6-5
5-3 *

* REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952
**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

f MEASURE FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAGE OF 7/16 I.D.

ALL DIMENSIONS IN INCHES

Figure 3-337. Outline Drawing and Base Diagram of Tube Type JAN-6005/6AQ5W.

RATINGS ABSOLUTE SYSTEM

The absolute system rating are as follows:

Heater Voltage .... 6.3 V ± 10%
Plate Voltage ....275 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Screen Grid Voltage .... 275 Vdc
Heater-Cathode Voltage .... ±100 V
Plate Dissipation .... 13.2 W
Screen Grid Dissipation .... 2.2 W

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

[1] The values and specification comments presented in this section are related to MIL-E-1/13A dated 20 May 1953.

*Bulb Temperature .... 225° C
*Altitude .... 10,000 ft

TEST CONDITIONS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 250 Vdc
Control Grid Voltage, Ec1 .... —12.5 Vdc
Screen Grid Voltage, Ec2 .... 250 Vdc
Heater Current, If .... 450 mA
Plate Current, Ib .... 45 mA
Input Capacity, Cin .... 8.3 *uuf*
Output Capacity, Cout .... 7.5 uuf

* No test at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/13A dated 20 May 1953 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current ½	If		410	490	410	490	mA
Plate Current	Ib		33	57	...	..	mAdc
Screen Grid Current	Ic2		...	7.5	...	...	mAdc
Power Output (1)		Esig = 8.8 Vac Rp = 5000	3.4	...	2.3	...	W
Power Output (2)	Po	Esig = 8.8 Vac Rp = 5000 Ef = 5.5 V	3.2	...	...	...	W
Change of Average	Δ Avg Po		...	...	...	17	%
Capacitance	Cglp	Ef = 0	...	0.70	...	...	uuf
(Unshielded)	Cin	Ef = 0	6.6	10.0	...	...	uuf
	Cout	Ef = 0	6.0	9.0	...	...	uuf
Grid Current	Ic1	Rg1 = 0.5 Meg	...	—2.0	...	—4.0	uAdc
Grid Emission	Isc1	Ef = 7.5 V; Ec1 = 50 Vdc; Rg1 = 0.5 Meg	...	—2.0	...	...	uAdc
Heater-Cathode	Ihk	Ehk = 100 Vdc	...	30	...	30	uAdc
Leakage	Ihk	Ehk = —100 Vdc	...	—30	...	—30	uAdc
Insulation of Electrodes							
	Rg1-all	Eg1-all = —100 Vdc	100	...	..	...	Meg
	Rp-all	Ep -all = —300 Vdc	100	...	..	...	Meg

APPLICATION OF JAN-6005/6AQ5W

The chart below shows the permissible operating area for JAN-6005/6AQ5W as defined by the ratings in MIL-E-1/13A dated 20 May 1953. A discussion of the permissible operating area for pentodes may be found in paragraph 3.1.3.

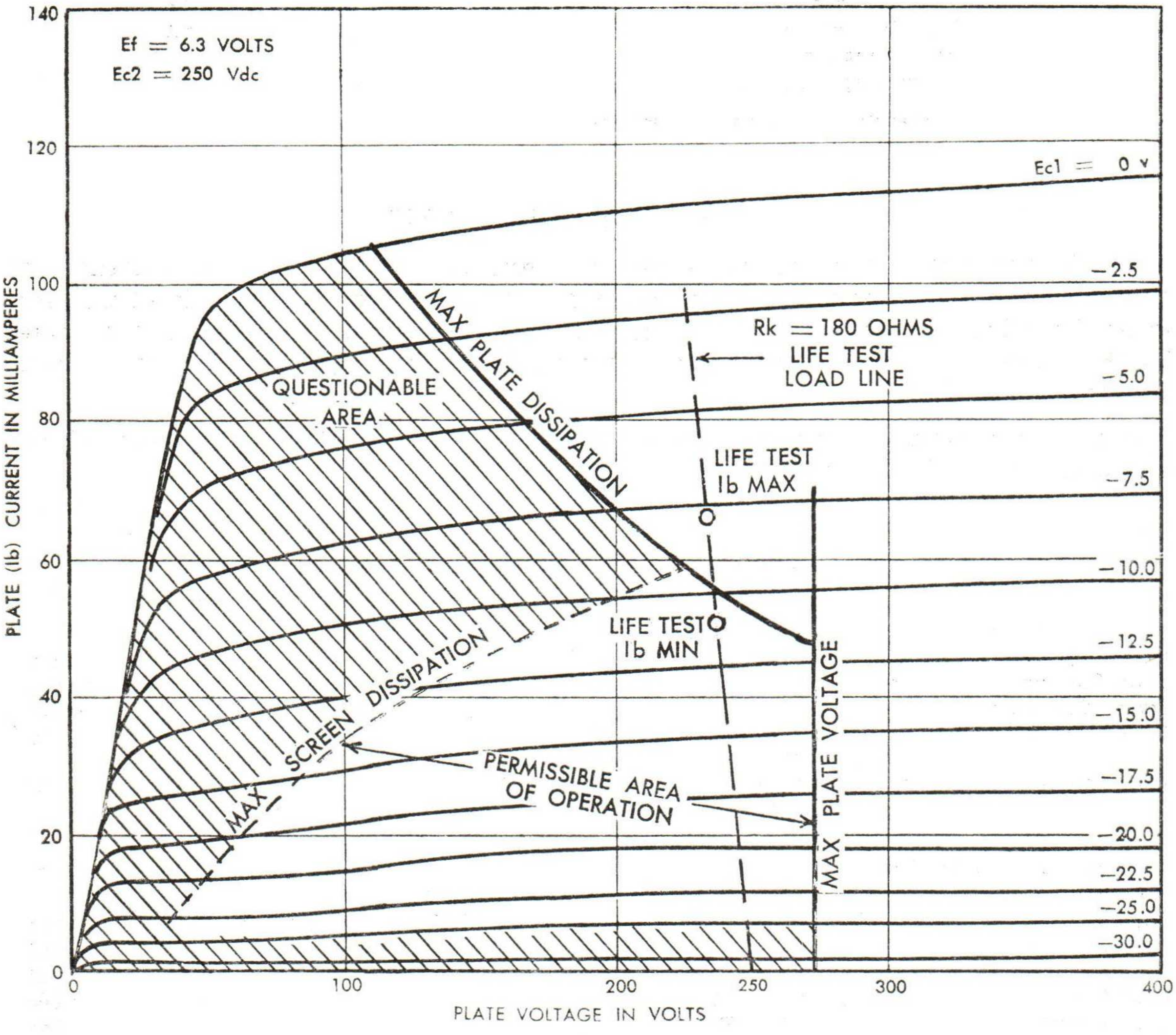


Figure 3-338. Typical Plate Characteristics of JAN-6005/6AQ5W; Permissible Area of Operation.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9
Heater-Cathode, 1.3.7
Plate:
  High, 3.2.9
  Low, 3.2.2, 3.2.6
  28 Volt, 3.2.9
  AC Operation, 1.3.3, 3.2.9
Screen Grid:
  Supply, 3.2.7
  Protection, 3.2.9
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.2.7, 3.2.8
  Cathode, 2.1.1, 3.2.9
  Fixed, 1.3.1, 2.1.1, 3.2.9
Positive Grid Region, 3.2.9
Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9
Screen Grid Series, 3.2.2, 3.2.9
Cathode Interface, 1.3.10, 3.2.9
Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9
Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8
Screen Grid, 3.2.2
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.2.8
Control Grid Emission, 1.3.3
Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3
Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9
Shielding, 3.2.3
Intermittent Operation, 3.2.9
Triode Connection, 3.2.9
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.2.9

VARIABILITY OF JAN-6005/6AQ5W

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The two charts below, Figures 3-339 and 3-340, present the limit behavior of the static plate and transfer characteristics for JAN-6005/6AQ5W as defined by MIL-E-1/13A dated 20 May 1953.

DESIGN CENTER CHARACTERISTICS OF JAN-6005/6AQ5W

Following Figures 3-339 and 3-340, typical curves obtained from data published by the RETMA registrant of the type are furnished as Figures 3-341 through 3-346.

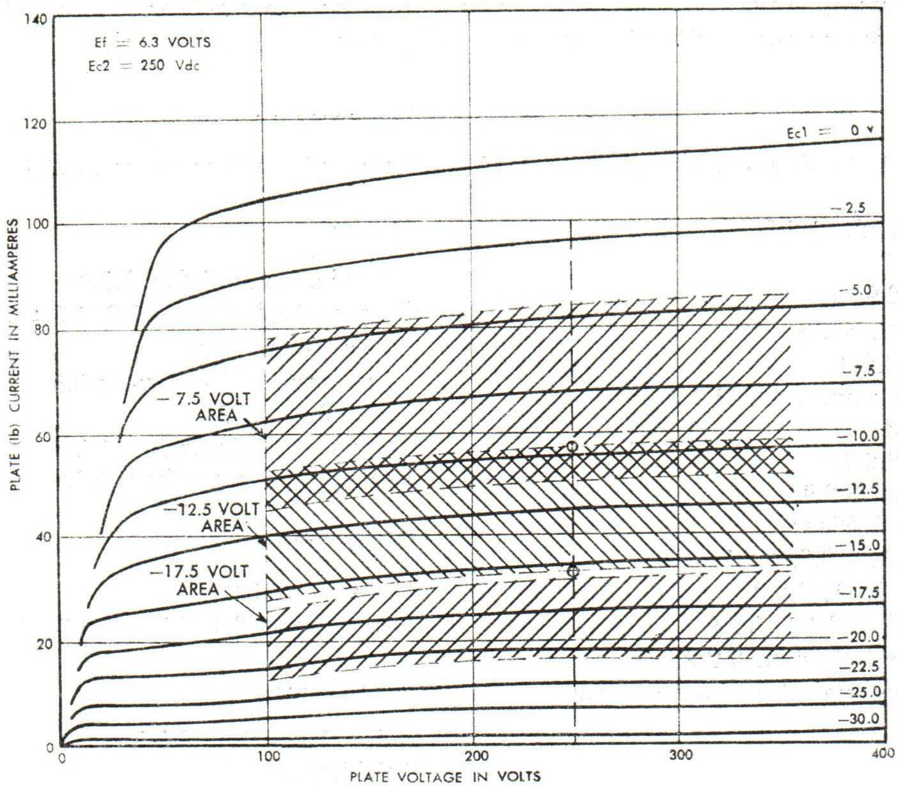


Figure 3-339. Limit Plate Characteristics of JAN-6005/6AQ5W; Variability of Ib.

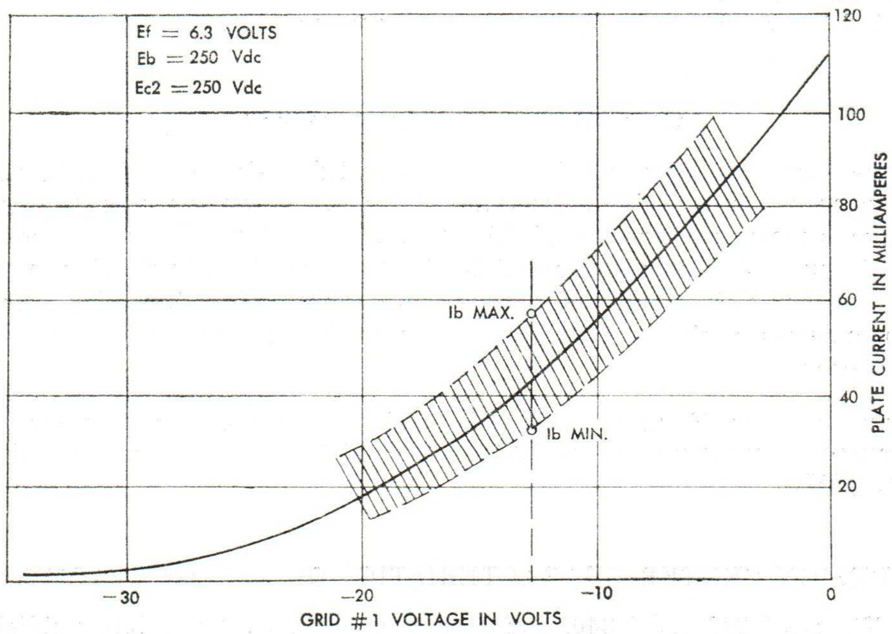


Figure 3-340. Limit Transfer Characteristics of JAN-6005/6AQ5W.

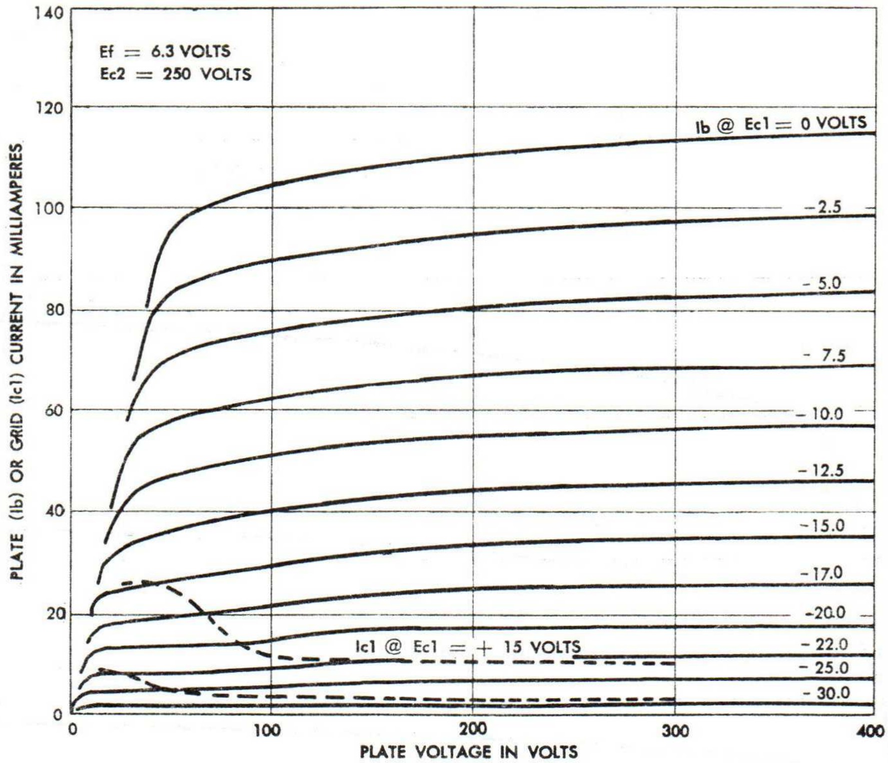


Figure 3-341. Typical Plate Characteristics of JAN-6005/6AQ5W; Negative "Grid" Region.

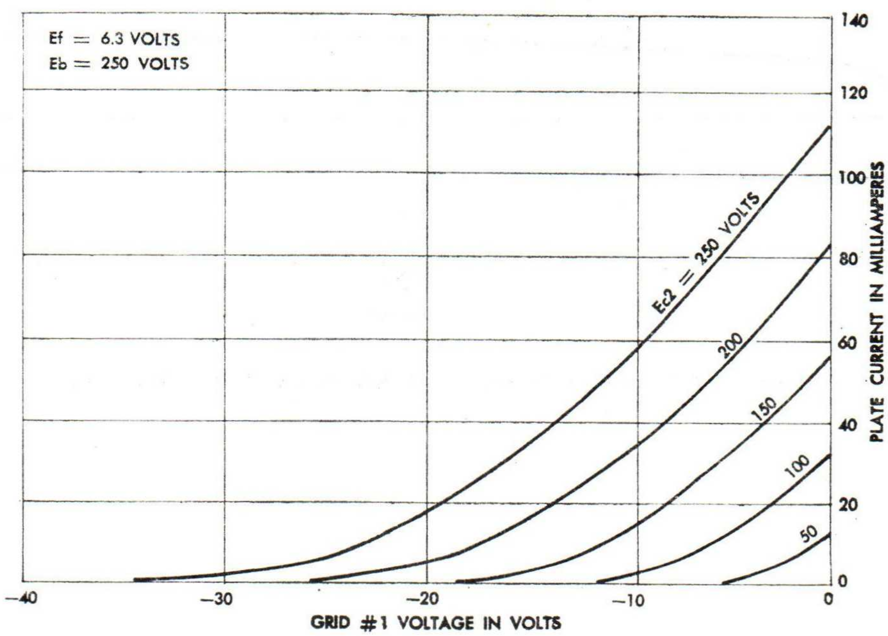


Figure 3-342. Typical Transfer Chracteristics of JAN-6005/6AQ5W.

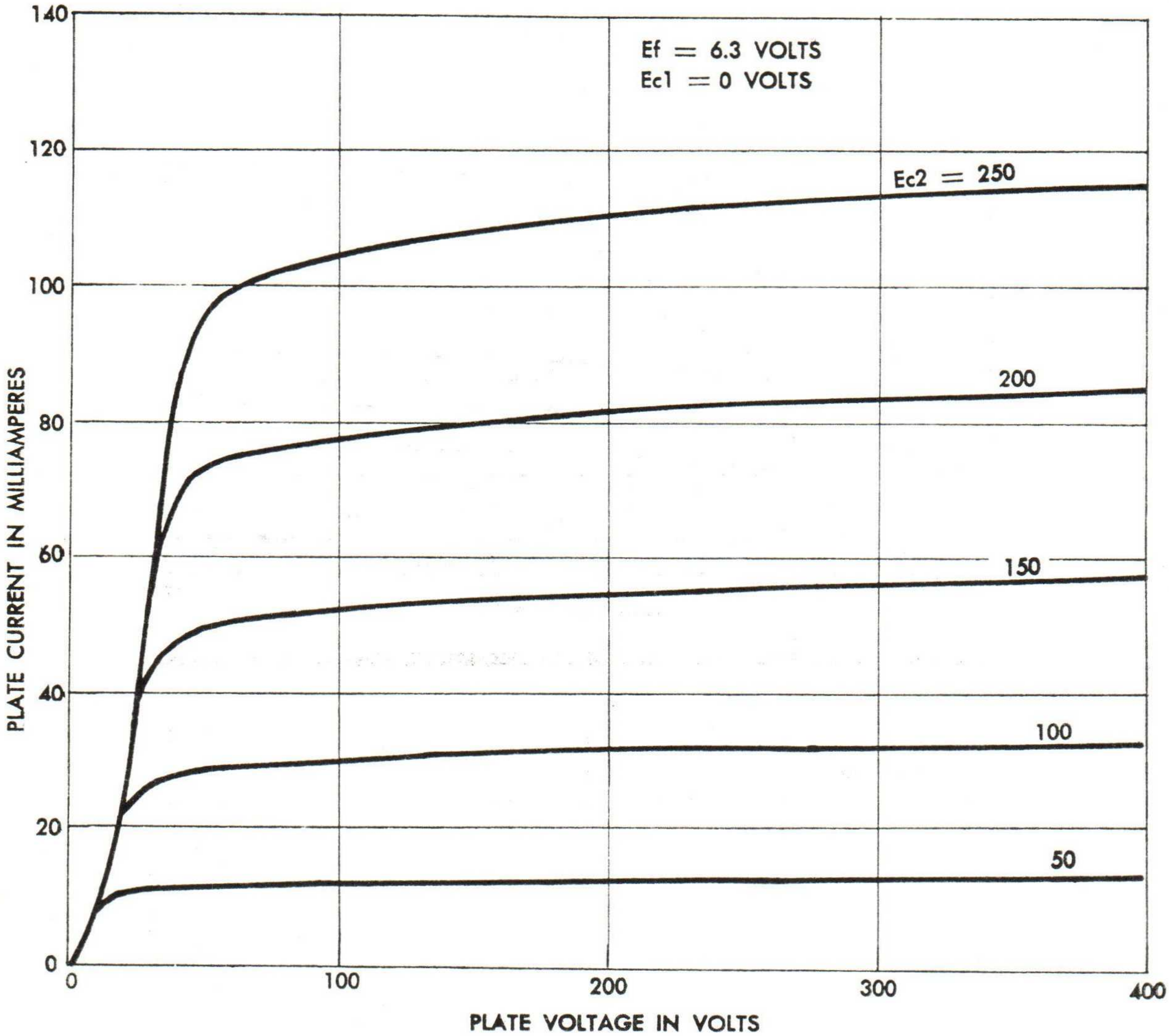


Figure 3-343. Typical Plate Characteristics of JAN-6005/6AQ5W; Variability of Ec2.

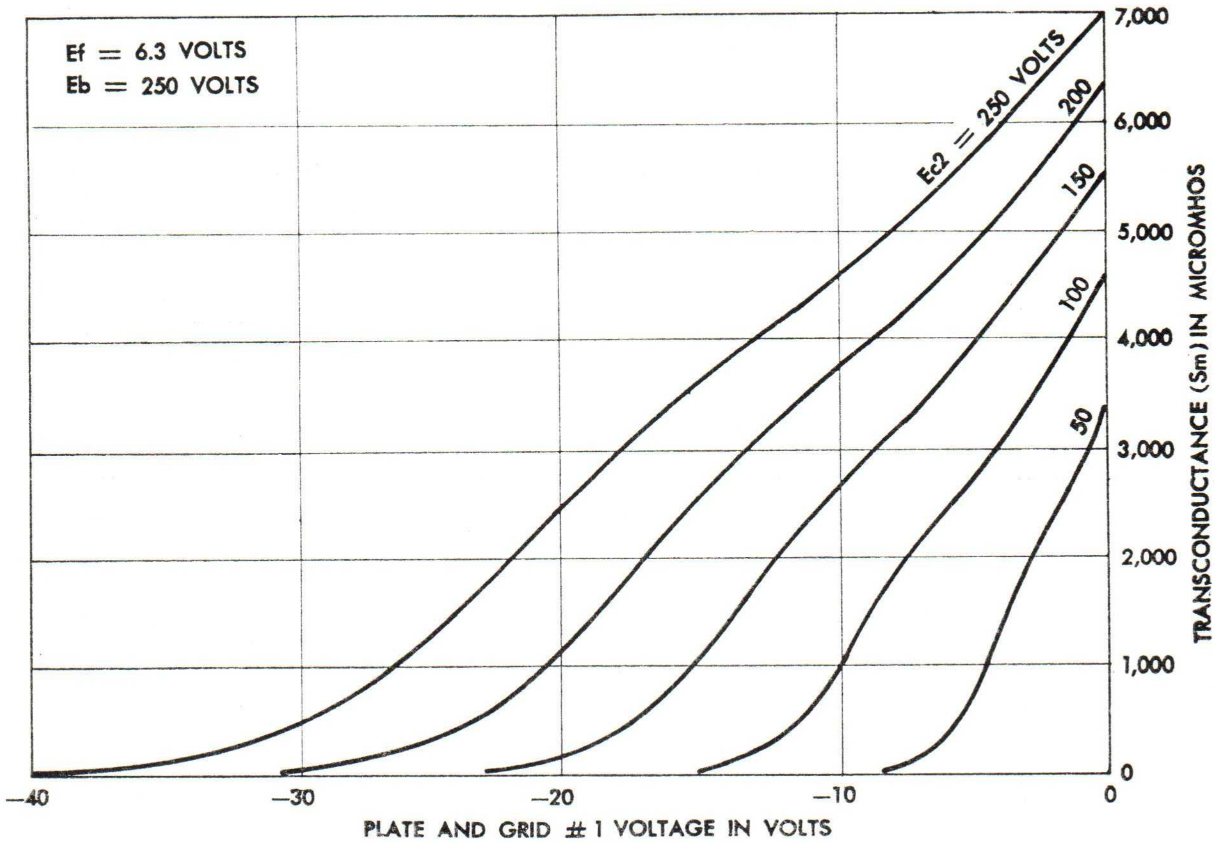


Figure 3-344. Typical Transfer Characteristics of JAN-6005/6AQ5W; Variability of Sm.

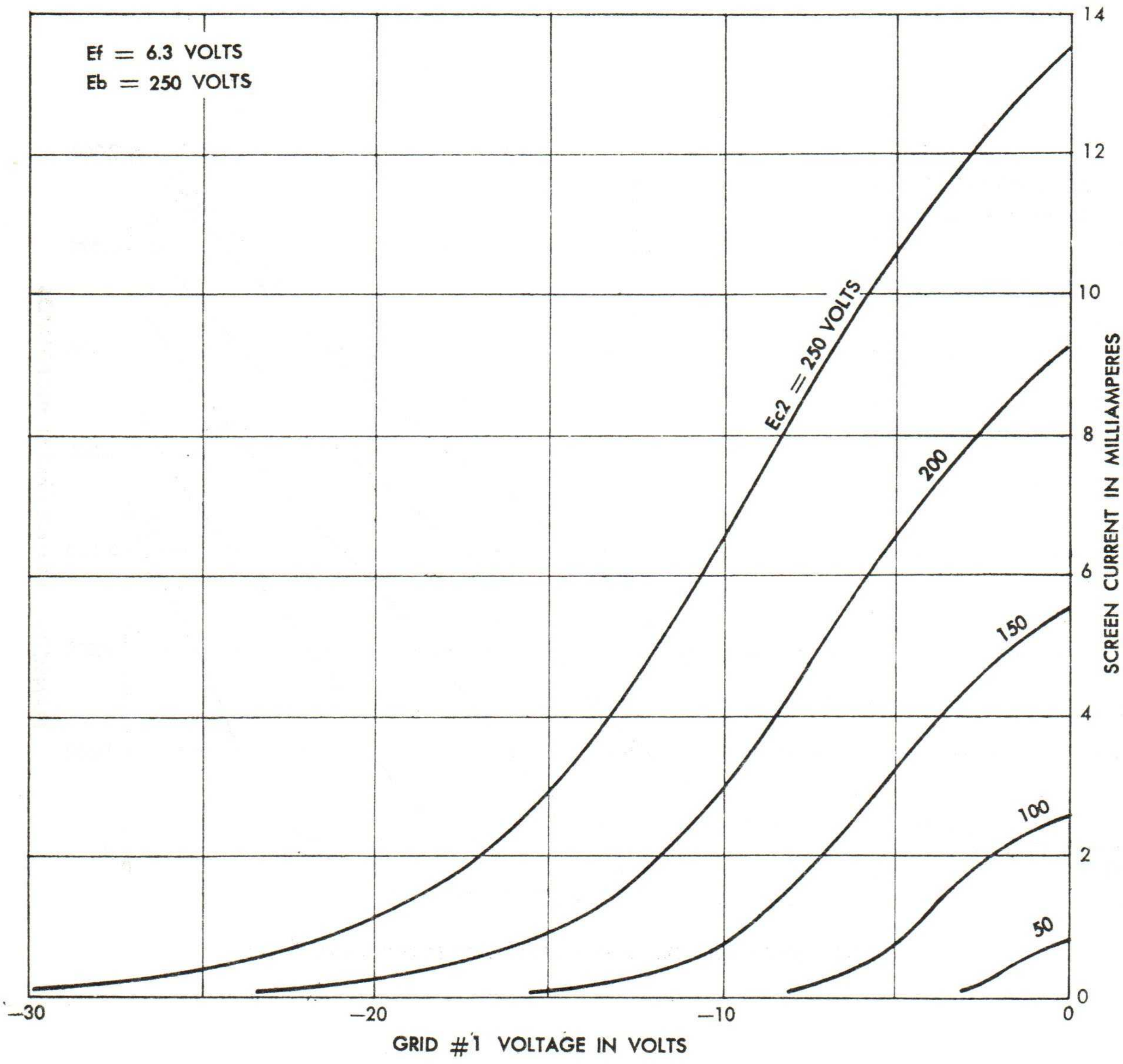


Figure 3-345. Typical Transfer Characteristics of JAN-6005/6AQ5W; Variability of Ic2.

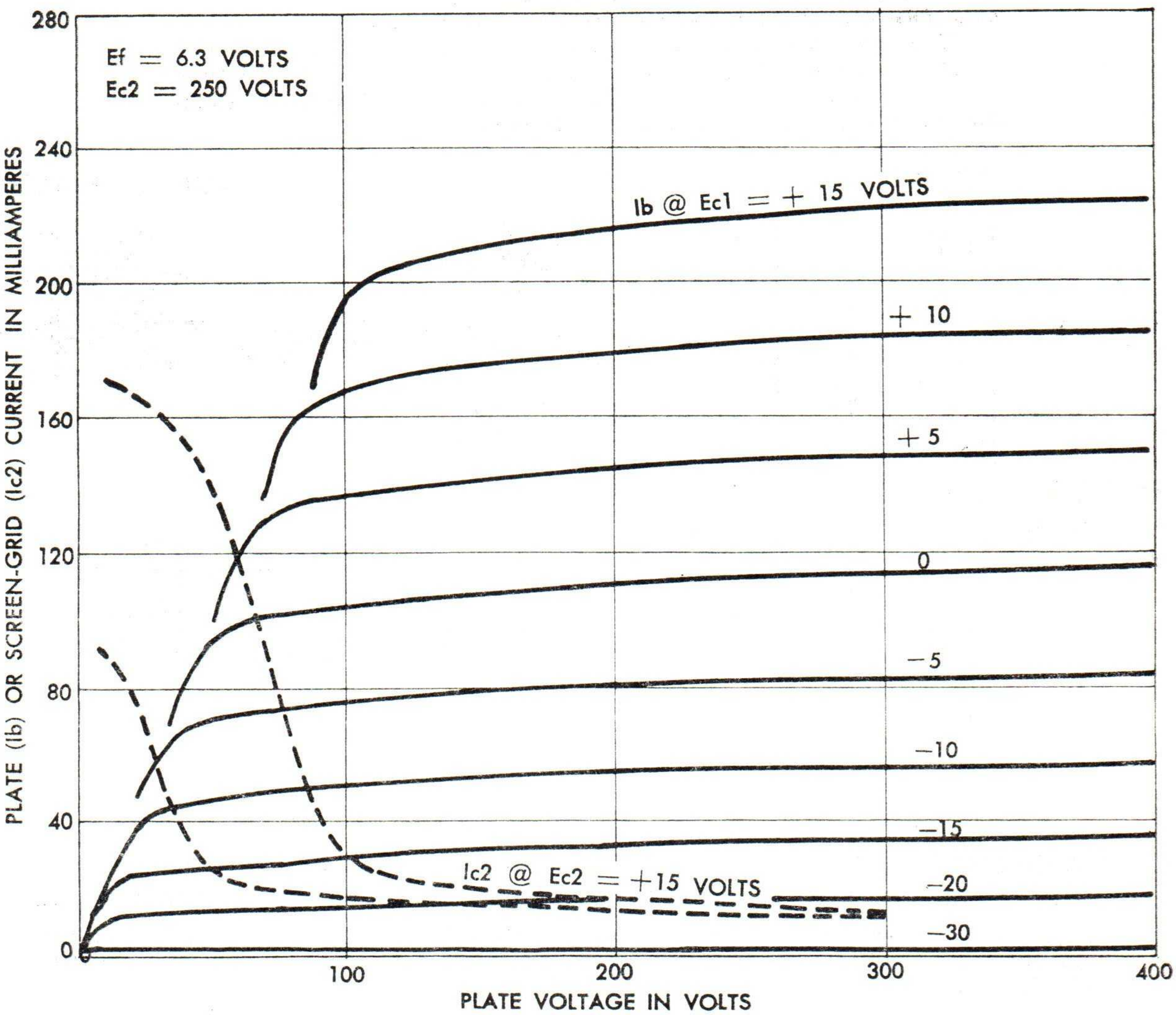


Figure 3-346. Typical Plate and Grid Characteristics of JAN-6005/6AQ5W.

SECTION
TUBE TYPE JAN-6021

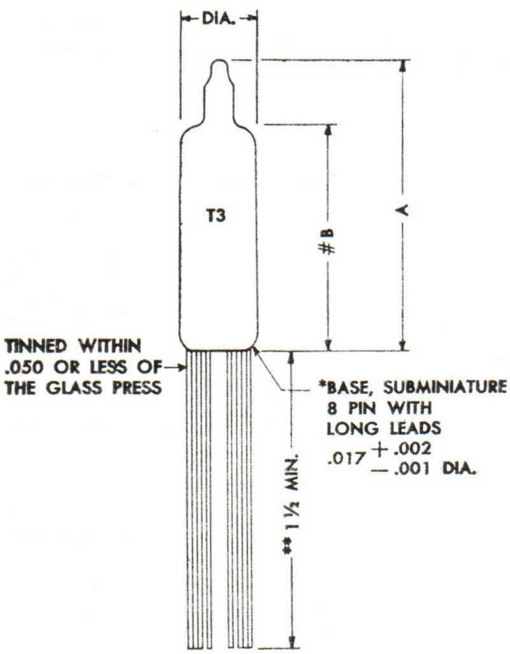
DESCRIPTION.

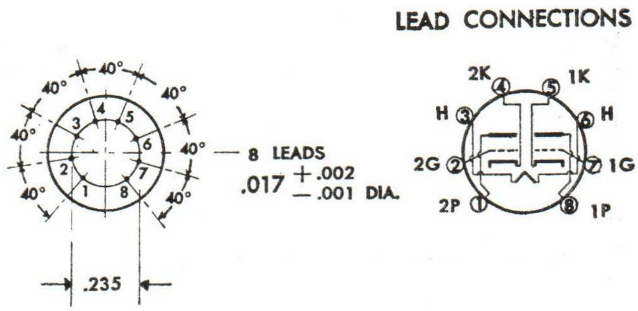
The JAN-6021 [1] is an 8 lead, button base subminiature twin-triode having a design center Mu of 35 and transconductance of 5400. The JAN-6021 is similar in plate characteristics to the miniature type JAN-5670.

ELECTRICAL. The electrical characteristics are as follows:

- Heater Voltage .... 6.3 V
- Heater Current, Design Center .... 300 mA
- Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.





DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.750	1.450	.060	.400

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-347. Outline Drawing and Base Diagram of JAN-6021.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

- Heater Voltage .... 6.3 ± 0.3 V
- Plate Voltage .... 165 Vdc
  - Reference MIL-E-1C 6.5.1.1 *Plate Voltage*
- Grid Voltage, Maximum .... 0 Vdc
- Grid Voltage, Minimum .... —55 Vdc
- Heater-Cathode Voltage .... 200 V
- Grid Series Resistance .... 1.1 Meg

[1] The values and specification comments presented in this section are related to MIL-E-1/188B dated 23 August 1955.

**Plate Current .... 22 mAdc
*Grid Current .... 5.5 mAdc
Plate Dissipation .... 0.7 W
Bulb Temperature .... +220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 100 Vdc
Cathode Resistance, Rk .... 150 ohms
Heater Current, If .... 300 mA
Plate Current, Ib .... 6.5 mAdc
Transconductance, Sm .... 5400 umhos
Amplification Factor, Mu 35

* No test at this rating exists in the specification.

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/188B dated 23 August 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurment conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		280	320	276	328	mA
Transconductance (1)	Sm		4450	6350	...	...	umhos
Change in individual	Δ Sm t		...	...	...	25	%
Transconductance (2)	ΔSm Ef		...	15	...	15	%
Amplification Factor	Mu		30	40	...	...	
Plate Current (1)	Ib		4.5	8.5	...	...	mAdc
Plate Current (1) difference between sections	Ib		...	1.6	...	...	mAdc
Pulse Emission	is	Ef = 6.0 V; E pulse = 50 V tp = 25 u sec; prr = 200 pps	300	...	...	...	ma
Capacitance	Cyp	Ef = 0	1.2	1.8	...	...	uuf
	Cin	Ef = 0	1.8	3.0	...	...	uuf
(Without Shield)							
Section 1-	Cout	Ef = 0	0.20	0.36	...	...	uuf
Section 2-	Cout	Ef = 0	0.22	0.42	...	...	uuf
	Cgg	Ef = 0	...	0.013	...	...	uuf
	Cpp	Ef = 0	...	0.52	...	...	uuf
Grid Current	Ic	Eb = 150 Vdc; Rk = 300 Rg = 1.0 Meg	0	—0.3	0	—0.9	uAdc

Property	Measurement Conditions	Limits				Units
		Initial		Life test		
		Min	Max	Min	Max	
Grid Emission Ic	Ef = 7.5 V; Ec = —7.5 Vdc Eb = 150 Vdc; Rk = 0 Rg = 1.0 Meg	C	—0.5	...	...	uAdc
Heater-Cathode Leakage						
Ihk	Ehk = +100 Vdc	...	5.0	...	10.	uAdc
Ihk	Ehk = —100 Vdc	...	—5.0	...	—10.	uAdc
Insulation of Electrodes						
R(g-all)	Eg-all = —100 Vdc	100	...	50	...	Meg
R(p-all)	Ep-all = —300 Vdc	100	...	50	...	Meg

APPLICATION OF JAN-6021

The chart below shows the permissible op erating area for JAN-6021 as defined by the ratings in MIL-E-1/188B dated 23 August 1955. A discussion of the permissible operating area for triodes may be found in paragr ph 3.1.2.

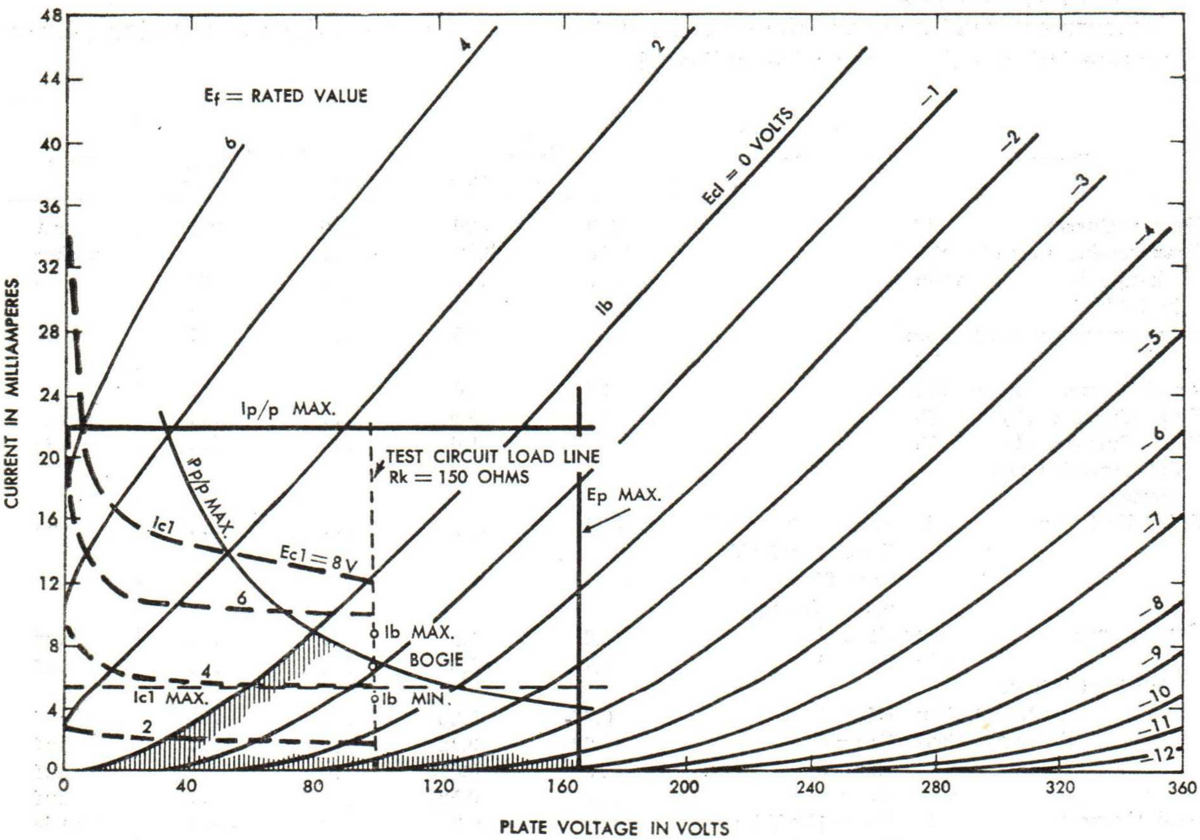


Figure 3-348. Typical Static Characteristics of JAN-6201; Permissible Area of Operation.

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL OPERATING CONSIDERATIONS

In addition to the considerations noted above, JAN–6021 as reflected in Specification MIL–E–1/188B provides additional assurance of pulse operation, initially at least, by an acceptance test requirement of 300 mA minimum peak plate-current with pulse voltage applied.

VARIABILITY OF JAN-6021 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6021 as defined by MIL-E-1/188 dated 23 August 1955.

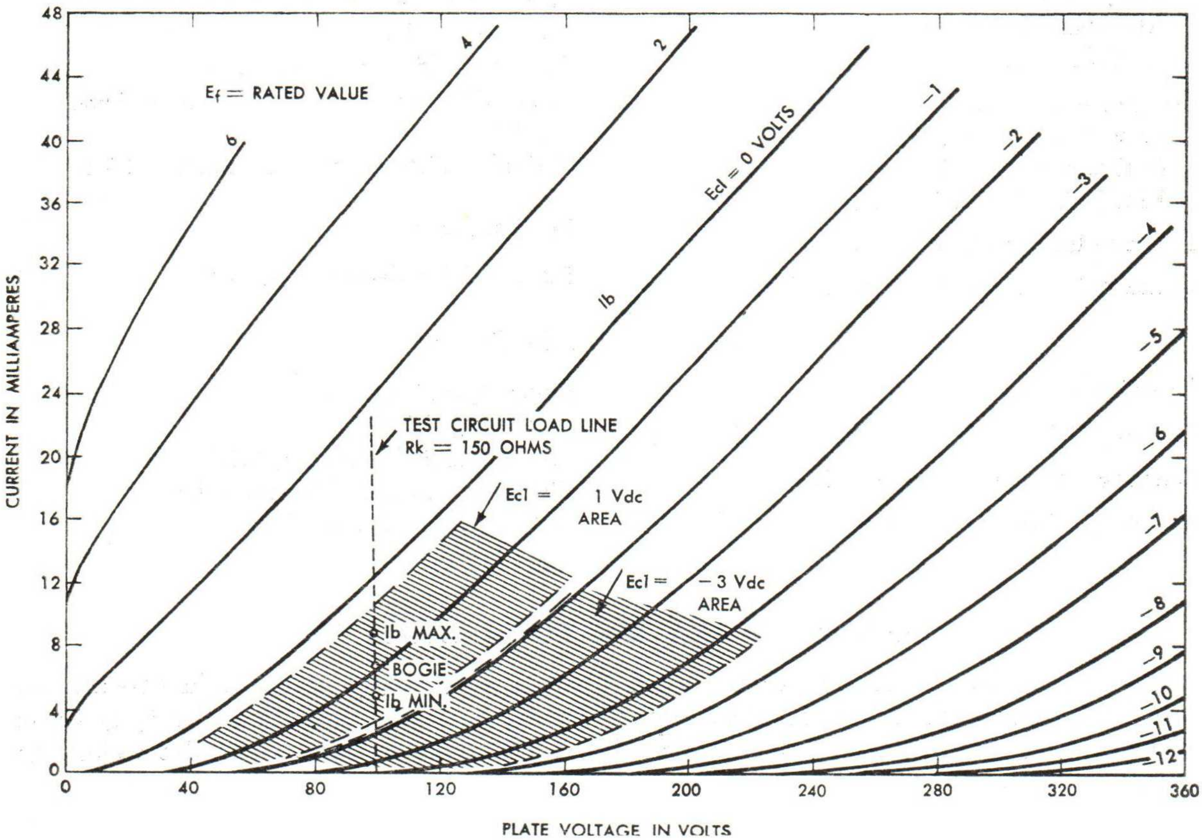


Figure 3-349. iLmit Behavior of JAN-6201 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN-6021 as defined by MIL-E-1/188B dated 23 August 1955.

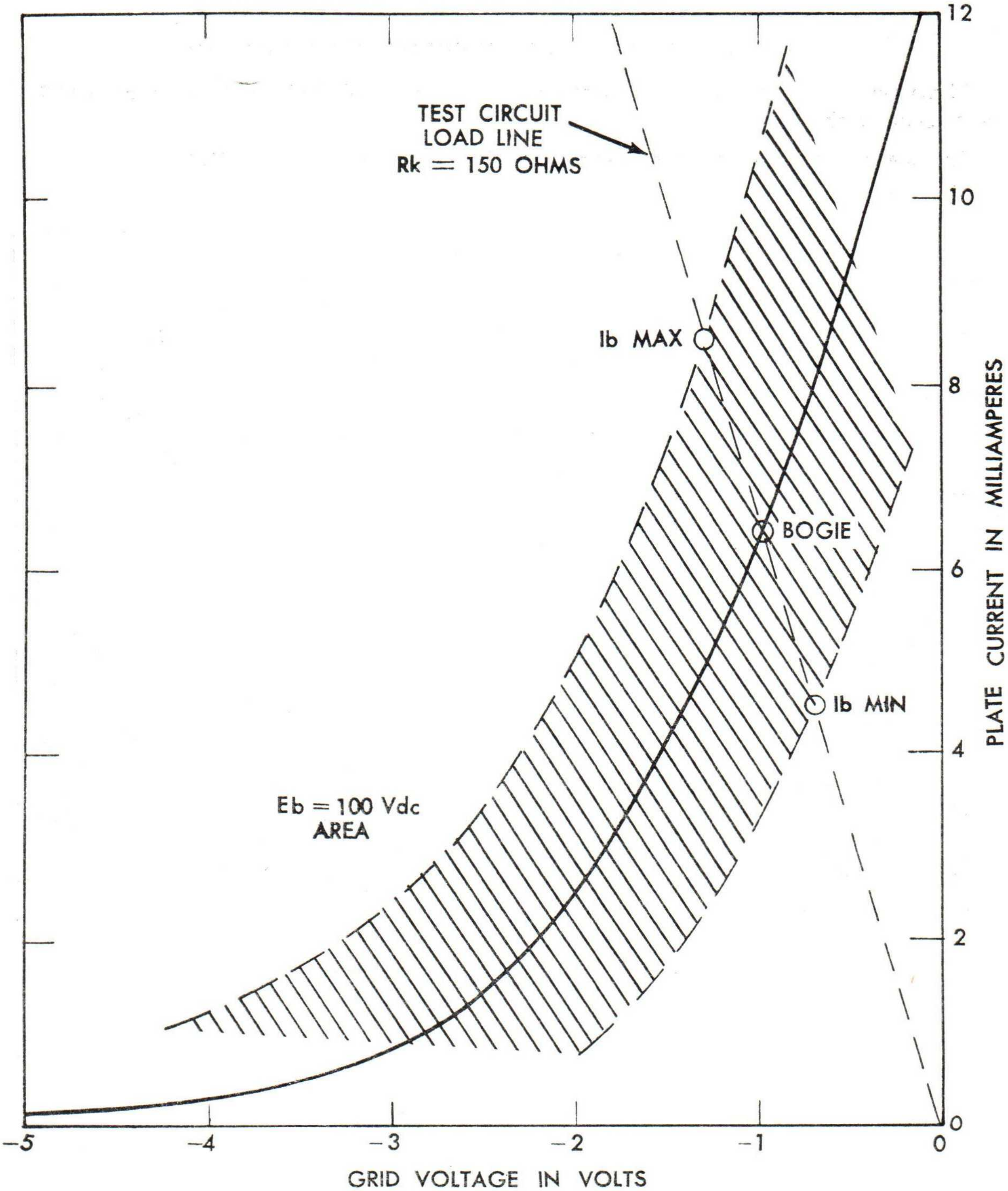


Figure 3-350. Limit Behavior of Transfer Data for JAN-6021.

DESIGN CENTER CHARACTERISTICS OF JAN-6021

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-6021.

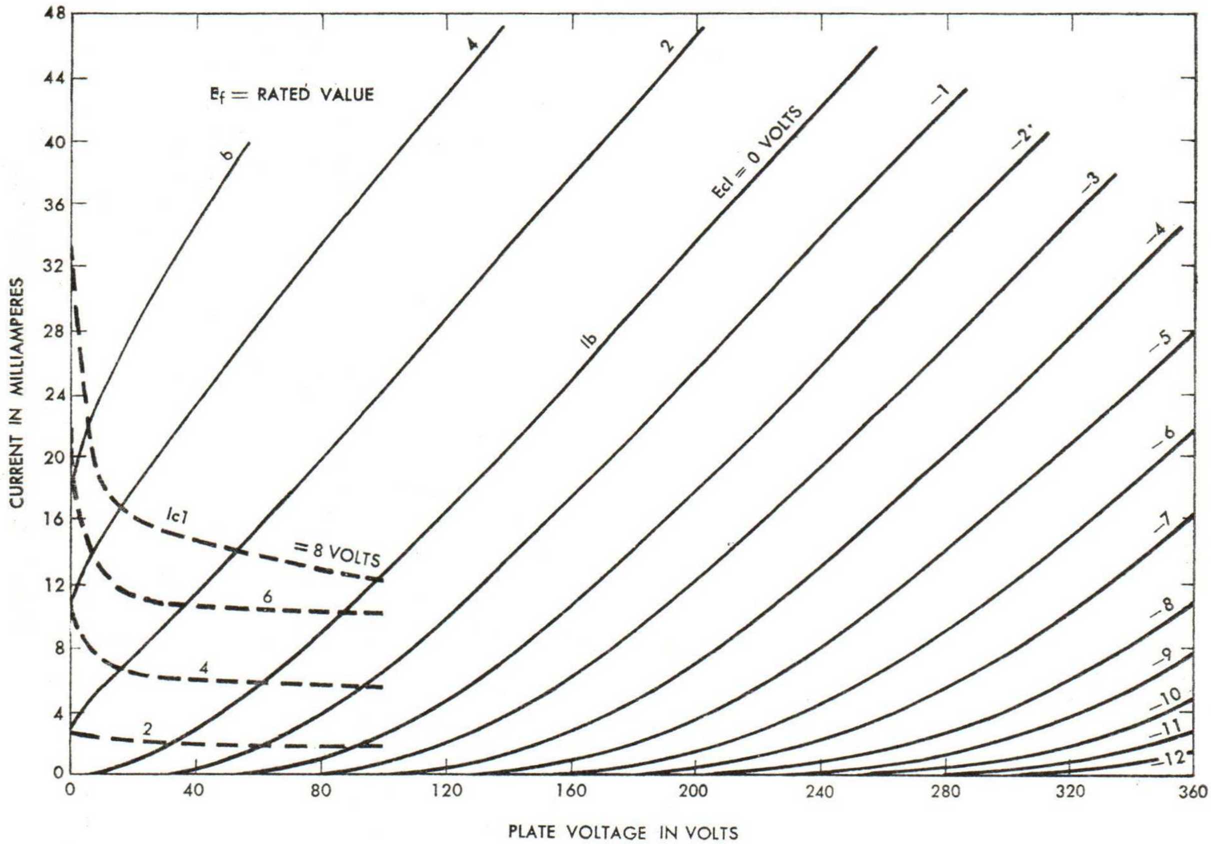


Figure 3-351. Typical Static Characteristics of JAN-6201.

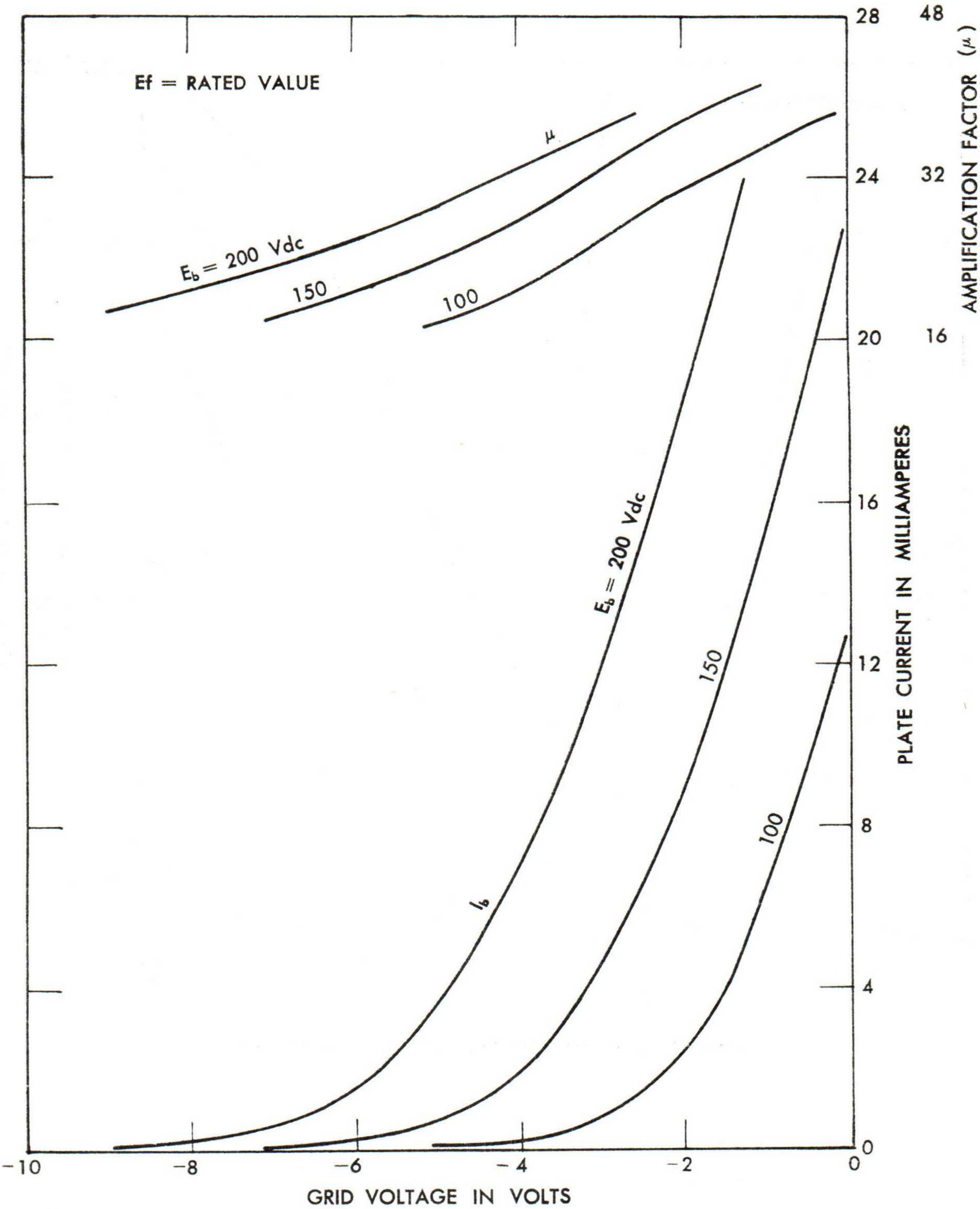


Figure 3-352. Typical Plate Transfer Data for Jan-6021; Variability of Ib and Mu.

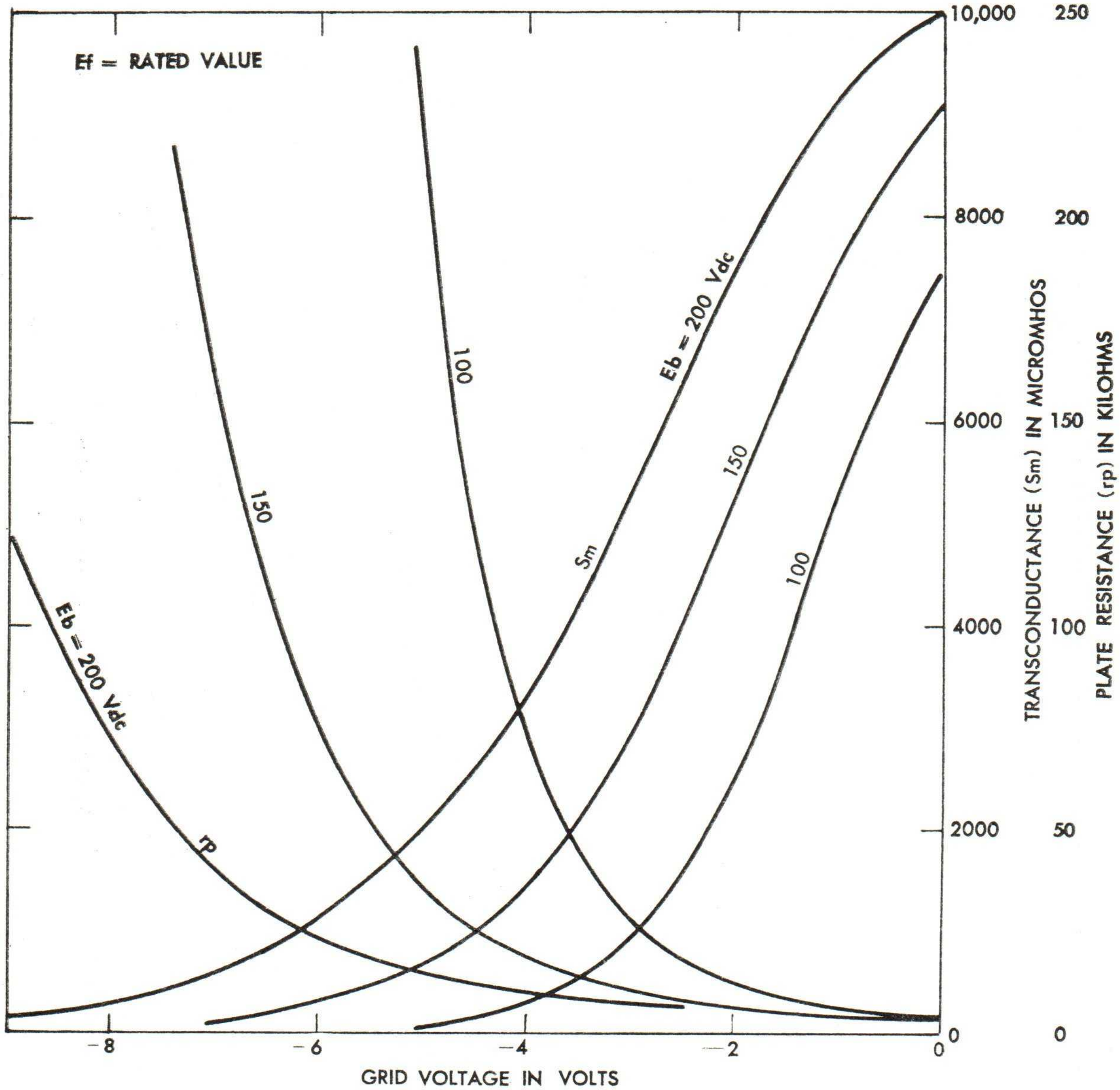


Figure 3-353. Typical Transfer Data for Jan-6021; Variability of Sm and rp.

SECTION
Tube Type JAN-6080WA

DESCRIPTION.
The JAN-6080WA [1] is an 8 pin, octal based low mu, twin power triode.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage, Ac or DC	6.3 V
Heater Current	2.35 to 2.65A
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.

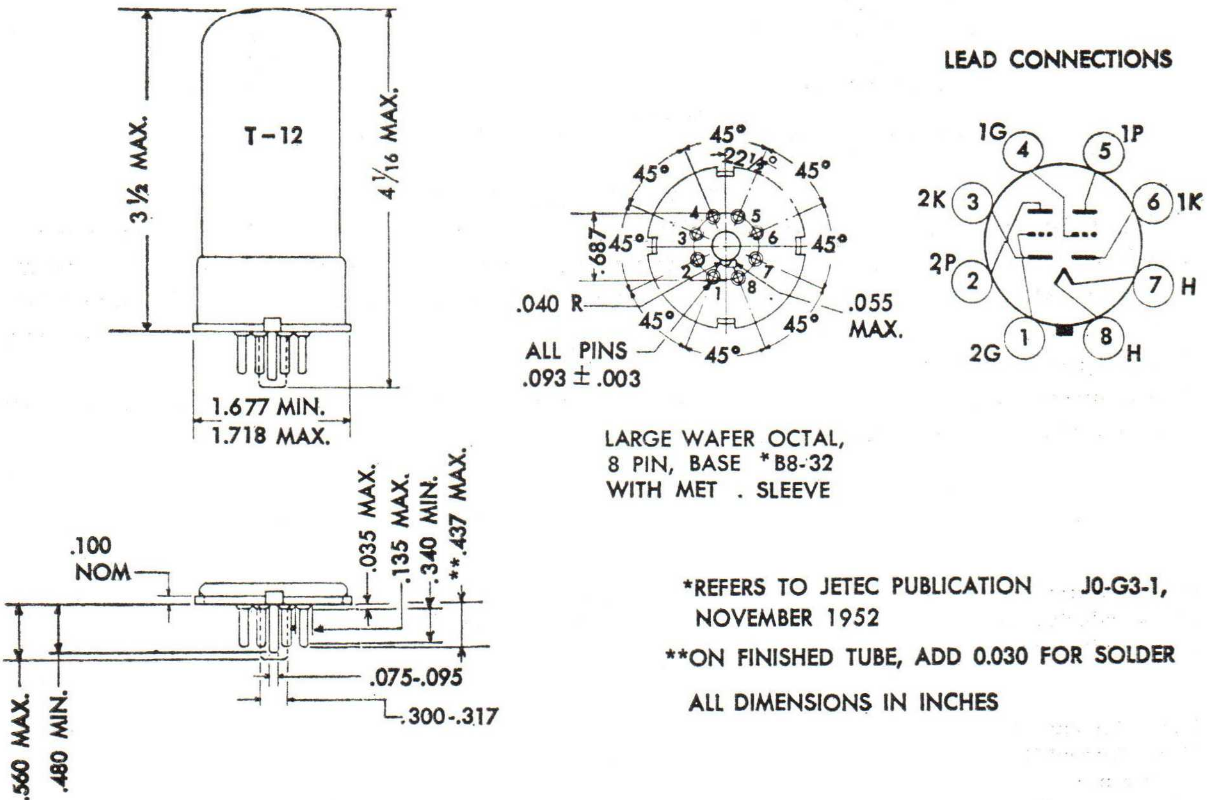


Figure 3-354. Outline Drawing and Base Diagram of Tube Type JAN-6080WA.

RATINGS, ABSOLUTE SYSTEM.
The absolute system ratings are as follows:

Heater Voltage	6.3 ± 0.3 V
Plate Voltage	250 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Control Grid Voltage,	
Maximum	0 Vdc

[1] The values and specification comments presented in this section are related to MIL-E-/510B dated 5 December 1955.

Peak forward anode Voltage .... 3000 v
Heater-cathode Voltage .... ±300 v
Maximum grid circuit Resistance
(a) Cathode bias operation .... 1.0 meg
(b) Fixed bias or a combination of fixed and cathode bias .... 0.1 meg
*Grid current, per grid .... 5.0 mA
Plate Dissipation, per plate .... 13 W
Bulb Temperature .... 230°C
Altitude .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS.

Test conditions and design center characteristics are as follows:
Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 135 Vdc
Cathode Resistance, Rk, per cathode .... 250 ohms
**Plate Current, Ib .... 125 mAdc
Transconductance .... 7000 umhos

* No test at this rating exists in the specification.
**Difficult may be encountered if this tube is operated for long periods of time with very small values of plate current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/510B dated 5 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		2.35	2.65	2.35	2.75	A
Transconductance (1)	Sm		6000	8200	5500	...	umhos
Transconductance (2)	Δ Sm / Ef		...	10	...	10	%
Plate Current (1)	Ib		100	150	...	...	mAdc
Plate Current (1) difference between sections	Ib		...	25	...	...	mAdc
Plate Current (2)	Ib	Eb = 250 Vdc Ec = —200 Vdc	...	10	...	...	mAdc
Insulation	Rg-all	Eg-all = —100 Vdc	200	...	100	...	Meg
of Electrodes	Rp-all	Ep-all = —300 Vdc	200	...	100	...	Meg
Grid Current	Ic	Rg = 1.0 Meg With both units operating, Ic is the sum of I1c and I2c	0	—2.0	0	—10	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	25	...	25	uAdc
	Ihk	Ehk = —100 Vdc	...	—25	...	—25	uAdc

APPLICATION OF JAN-6080WA

The chart below shows the permissible operating area for JAN-6080WA as defined by the ratings in MIL-E-1/510B dated 5 December 1955. A discussion of the permissible operating area for triodes may be found in paragraphs 3.1.2 through 3.1.6.

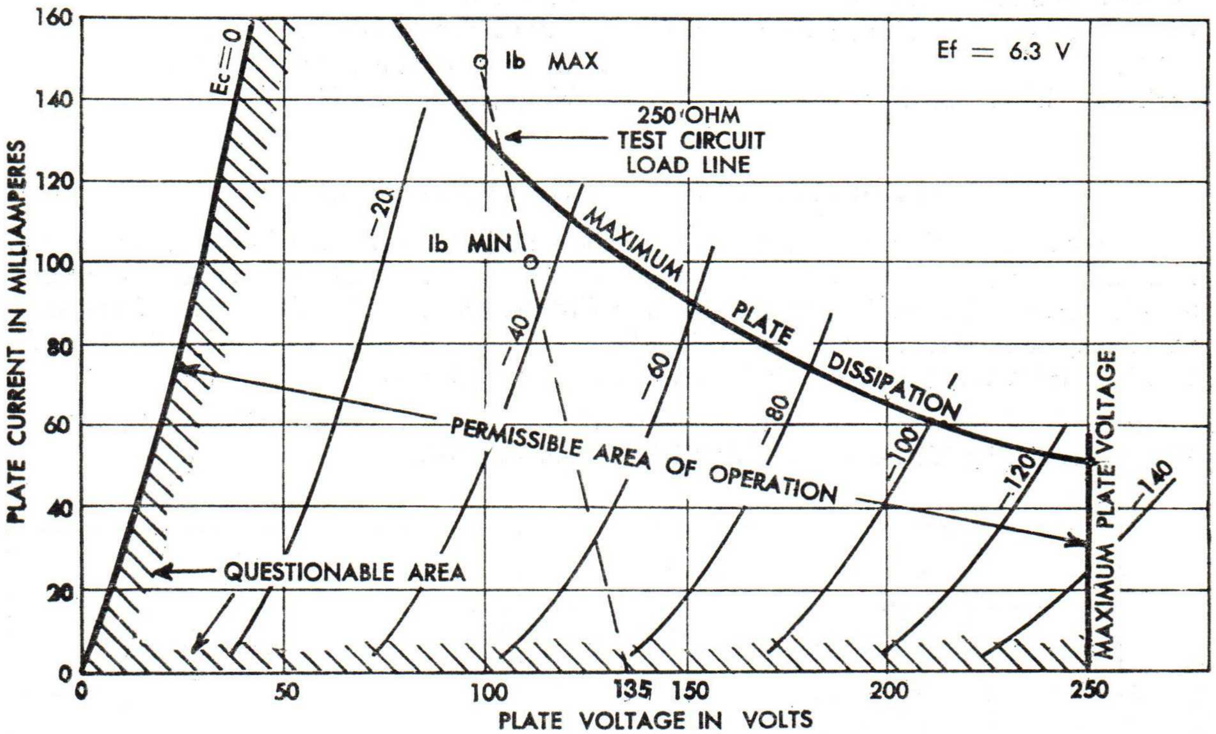


Figure 3-355. Typical Plate Characteristics of JAN-6080WA; Permissible Area of Operation.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
  High, 3.1.5
  Low, 3.1.5
  AC Operation, 1.3.3, 3.1.5
  28 Volt, 3.1.5
Control Grid Bias:
  Low, 1.3.1, 1.3.2, 3.1.2
  Cathode, 2.1.1, 3.1.5
  Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Gross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN–6080WA CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

Figure 3-356 presents the limit behavior of static plate characteristics for JAN–6080–WA as defined by MIL–E–1/510B dated 5 December 1955.

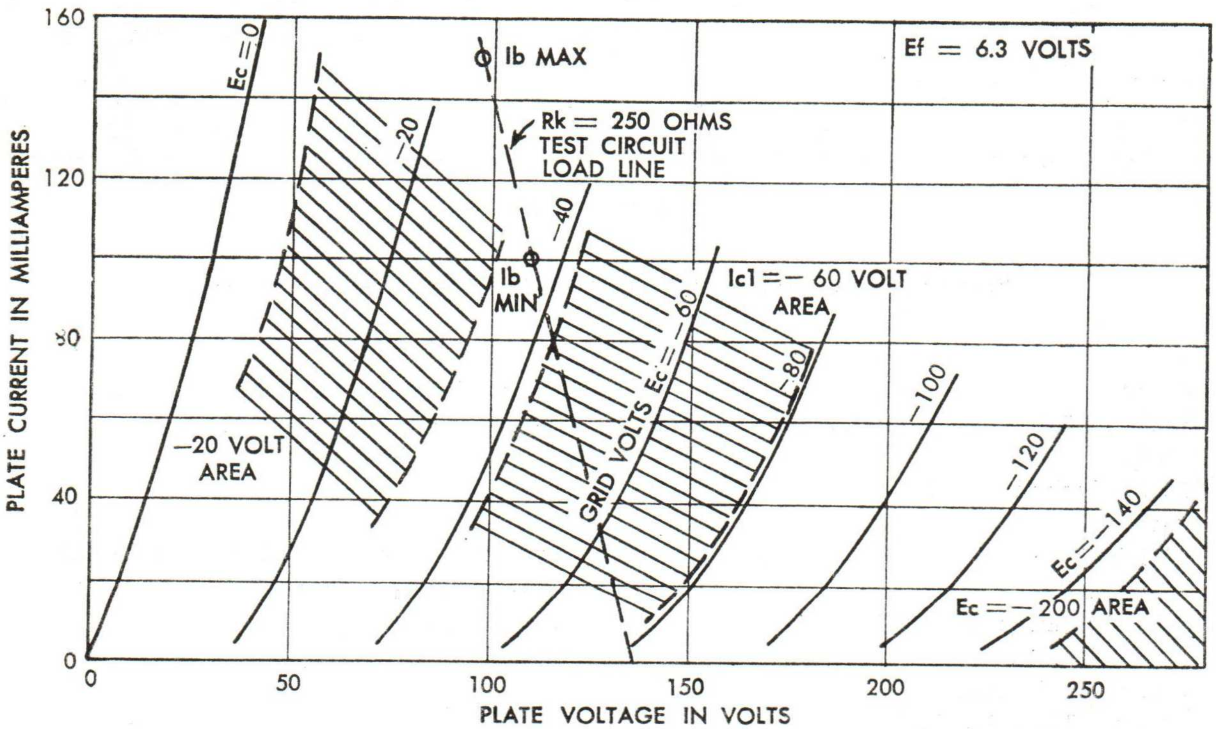


Figure 3-356. Limit Plate Characteristics of JAN-6080WA; Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-6080WA

These typical curves have been obtained from current data being published by the original RETMA registrants of this type.

Figure 3-357 presents the Static Plate Characteristics of JAN-6080WA.

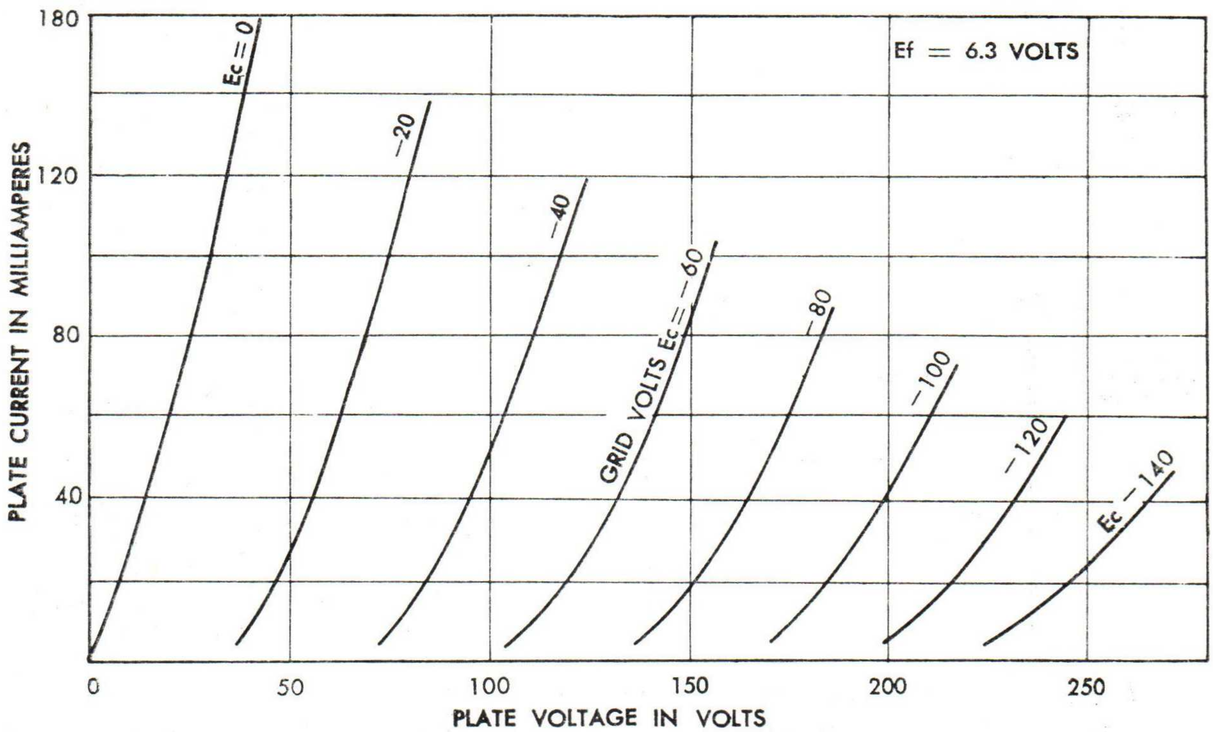


Figure 3-357. Typical Plate Characteristics of JAN-6080WA.

SECTION
TUBE TYPE JAN-6088

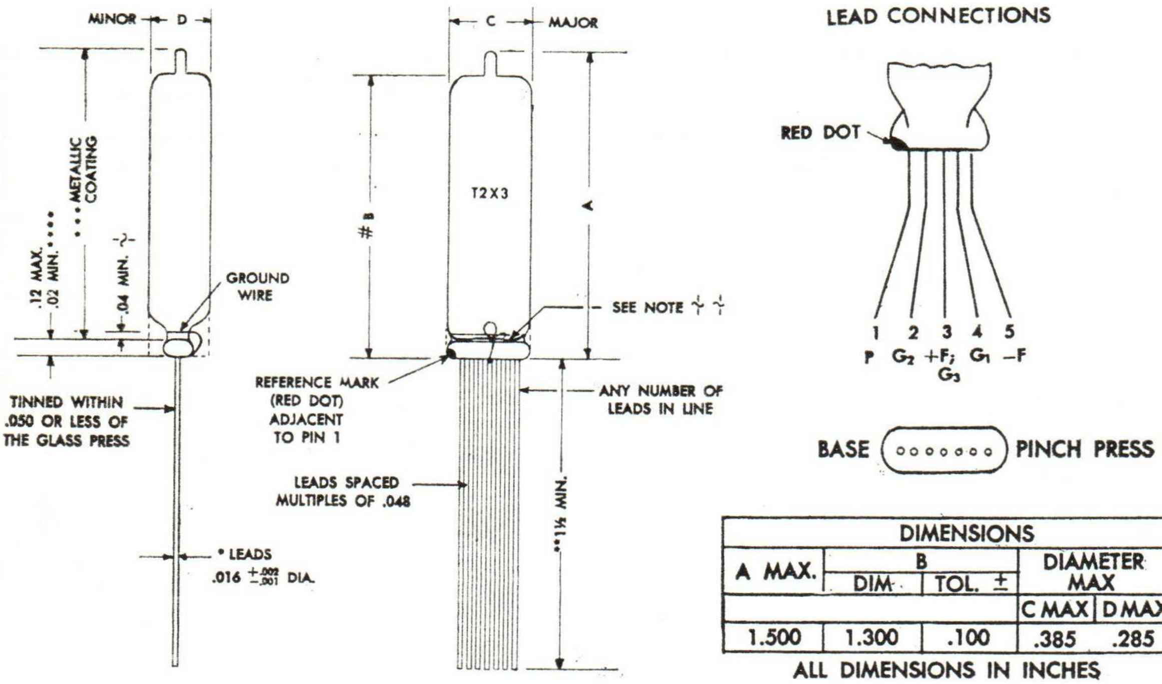
DESCRIPTION.

The JAN-6088 [1] is a 5 lead, flat-press, filamentary, subminiature, power-amplifier pentode having a transconductance in the range, 400 to 720 micromhos.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 1.25 Vdc
Cathode .... Coated Filament

MOUNTING. Any type of mounting is adequate.



DIMENSIONS				
A MAX.	B		DIAMETER MAX	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

*** WHEN SPECIFIED ON THE TSS.

**** APPLIES TO PINCH PRESS TYPES ONLY (.02 MIN.)

† GROUND LEAD OVERLAPPED BY SHIELD BY A MINIMUM OF .04

†† SHIELD TO GROUND WIRE MAY BE FROM EITHER SIDE OF THE MAJOR DIMENSION. ALTERNATIVE CONSTRUCTION: UNUSED OR EXTRA RANDOM LEAD IN PRESS OR BUTTON MAY BE FOLDED BACK AND WRAPPED AROUND BULB TO MAKE CONTACT WITH SHIELD.

Figure 3-358. Outline Drawing and Base Diagram of JAN-6088.

[1] The values and specification comments presented in this section are related to MIL-E-1/694 dated 3 May 1954.

RATINGS ABSOLUTE SYSTEM

The absolute system ratings are as follows:

#Heater Voltage	1.25 Vdc ± 20%
Plate Voltage	67.5 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*	
Screen Grid Voltage	67.5 Vdc
*Cathode Current, Maximum	1.5 mAdc
*Altitude Rating	10,000 ft

TEST CONDITIONS

Test conditions are as follows.

Heater Voltage, Ef	1.25 Vdc
Plate Voltage, Eb	45 Vdc
Control Grid Voltage, Ec1	—1.25 Vdc
Screen Grid Voltage, Ec2	45 Vdc

Concerning this rating, MIL-E-1/694 for JAN-6088 states "Do not use series filament circuits."

* No test of operation at this rating exists in the specification.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/694 dated 3 May 1954 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		17.5	22.5	...	...	mA
Transconductance (1)	Sm		400	720	...	...	umhos
Plate Current (1)	Ib		450	900	...	...	uAdc
Screen Grid Current	Ic2		...	230	...	...	uAdc
Power Output	Po	Esig = 0.9 Vac Rg1 = 5.0 Meg Rp = 0.2 Meg	6.3	...	4.5	...	mW
Control Grid Current	Ic1	Ec1 = —50 Vdc	0	—1.0	...	...	uAdc

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.2.9

Heater-Cathode, 1.3.7

Plate:
- High, 3.2.9
- Low, 3.2.2, 3.2.6
- 28 Volt, 3.2.9
- AC Operation, 1.3.3, 3.2.9

Screen Grid:
- Supply, 3.2.7
- Protection, 3.2.9

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.2.7 3.2.8
- Cathode, 2.1.1, 3.2.9
- Fixed, 1.3.1, 2.1.1, 3.2.9

Positive Grid Region, 3.2.9

Contact Potential, 1.3.1, 3.2.8, 3.2.9

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.2.9

Screen Grid Series, 3.2.2, 3.2.9

Cathode, 1.3.7, 2.1.1, 3.2.9

Temperature

Bulb and Environmental, 3.2.3

Current

Cathode, 1.3.10, 3.2.5, 3.2.9

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.2.8

Screen Grid, 3.2.2

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.2.8

Control Grid Emission, 1.3.3

Thermionic Instability, 1.3.8

Dissipation

Plate, 2.1, 3.2.3

Screen Grid, 2.1, 3.2.3, 3.2.7

Miscellaneous

Pulse Operation, 3.2.9

Shielding, 3.2.3

Intermittent Operation, 3.2.9

Triode Connection, 3.2.9

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.2.9

APPLICATION OF JAN-6088

The chart below shows the permissible operating area for JAN-6088 as defined by the ratings in MIL-E-1/694 dated 3 May 1954. A discussion of the permissible operating area for pentodes may be found in paragraph 3.2.2.

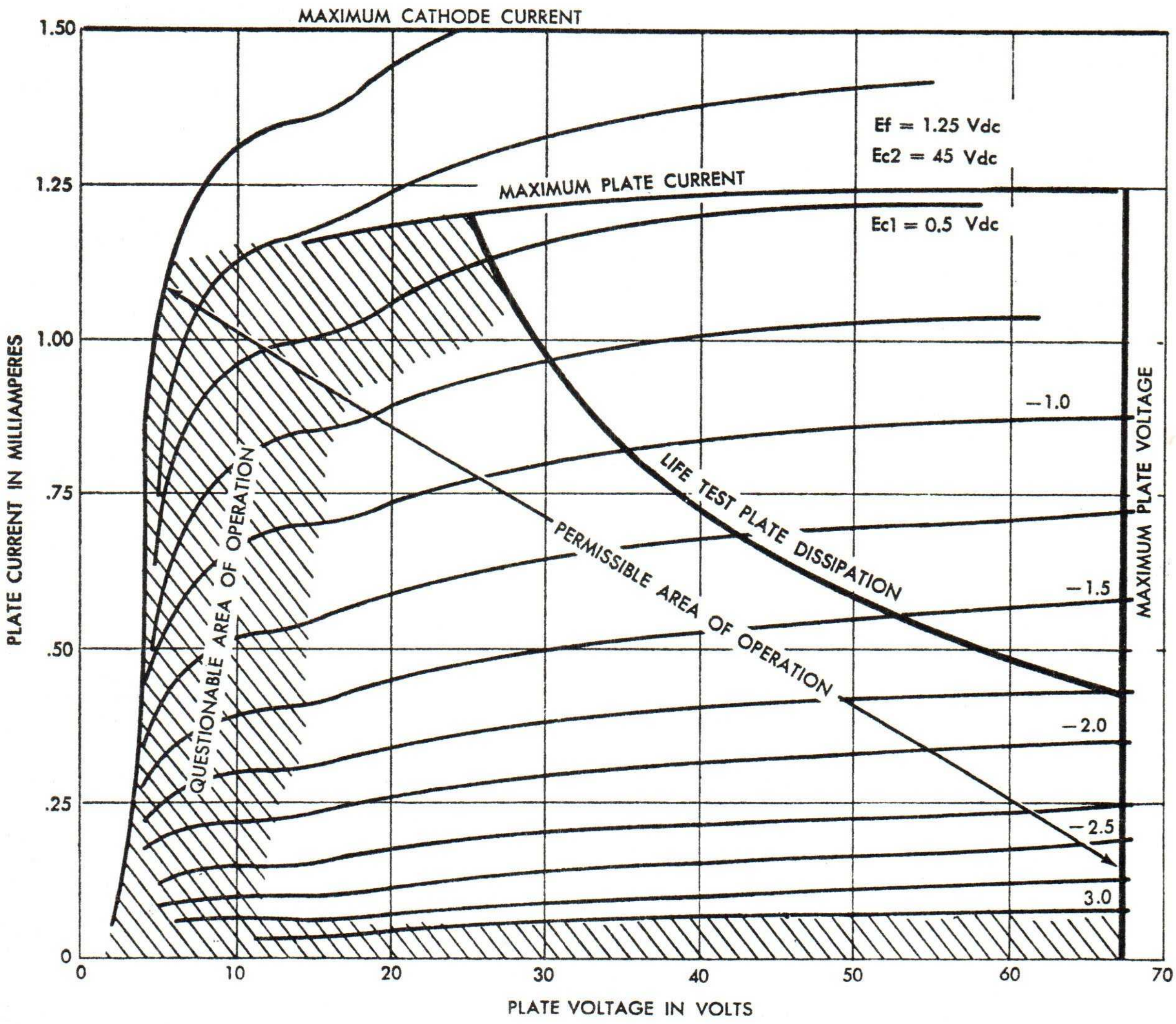


Figure 3-359. Typical Static Plate Characteristics of JAN-6088; Permissible Area of Operation.

SPECIAL OPERATING CONSIDERATIONS

Specification for this type provides some degree of assurance initially and during on life, of satisfactory performance in low-power applications through a power output requirement of 6.3 milliwatts initial and 4.5 milliwatts life test end point, under test condition voltages with a signal voltage of 0.9 volts. Rgl = 5.0 Megohm and Rp 0.2 Megohm.

Specification for this type cautions against its use in series filament circuits.

VARIABILITY OF JAN-6088 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6088 as defined by MIL-E-1/694 dated 3 May 1954.

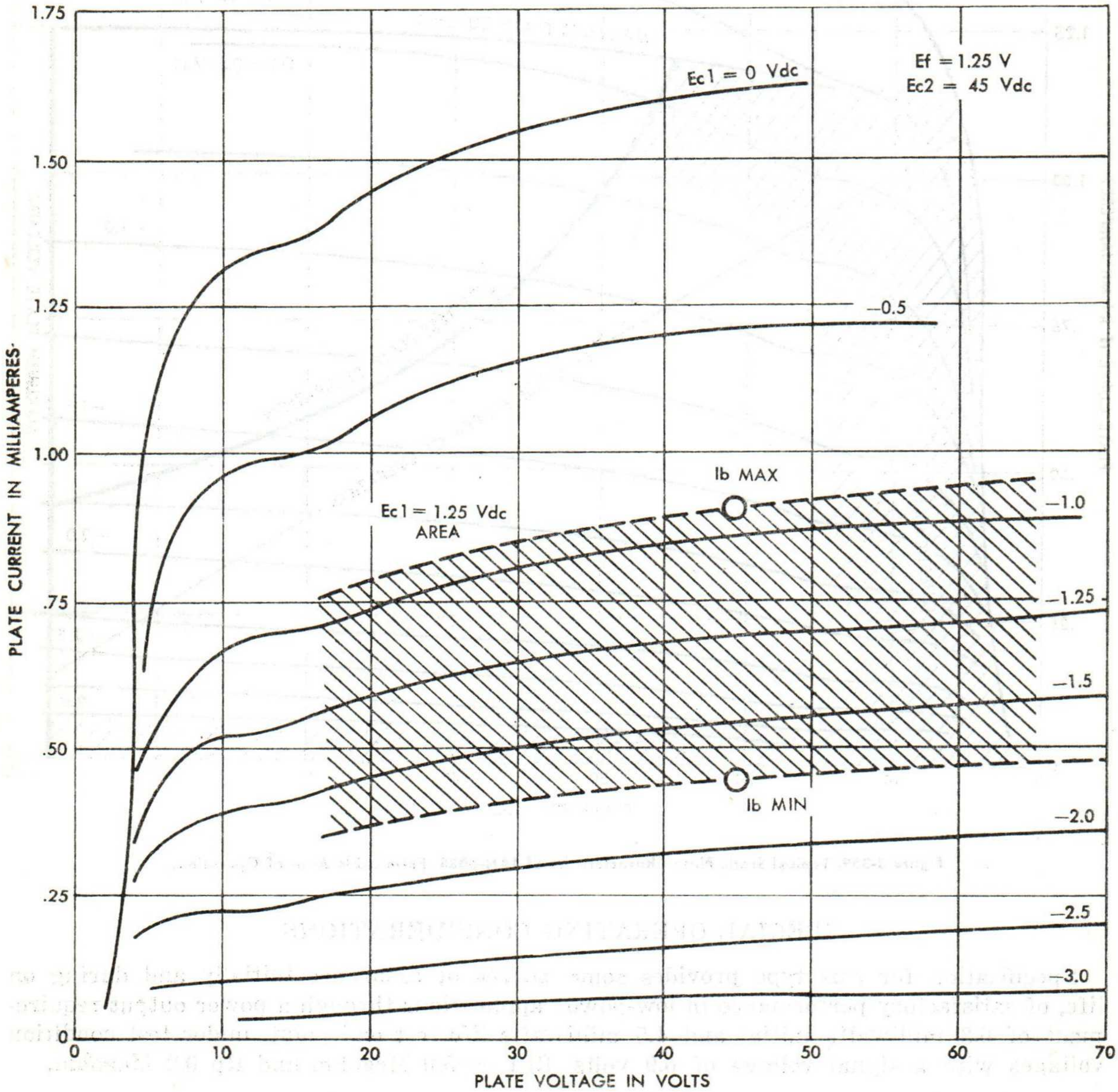


Figure 3-360. Limit Behavior of JAN-6088 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of plate transfer data for JAN–6088 as defined by MIL–E–1/694 dated 3 May 1954.

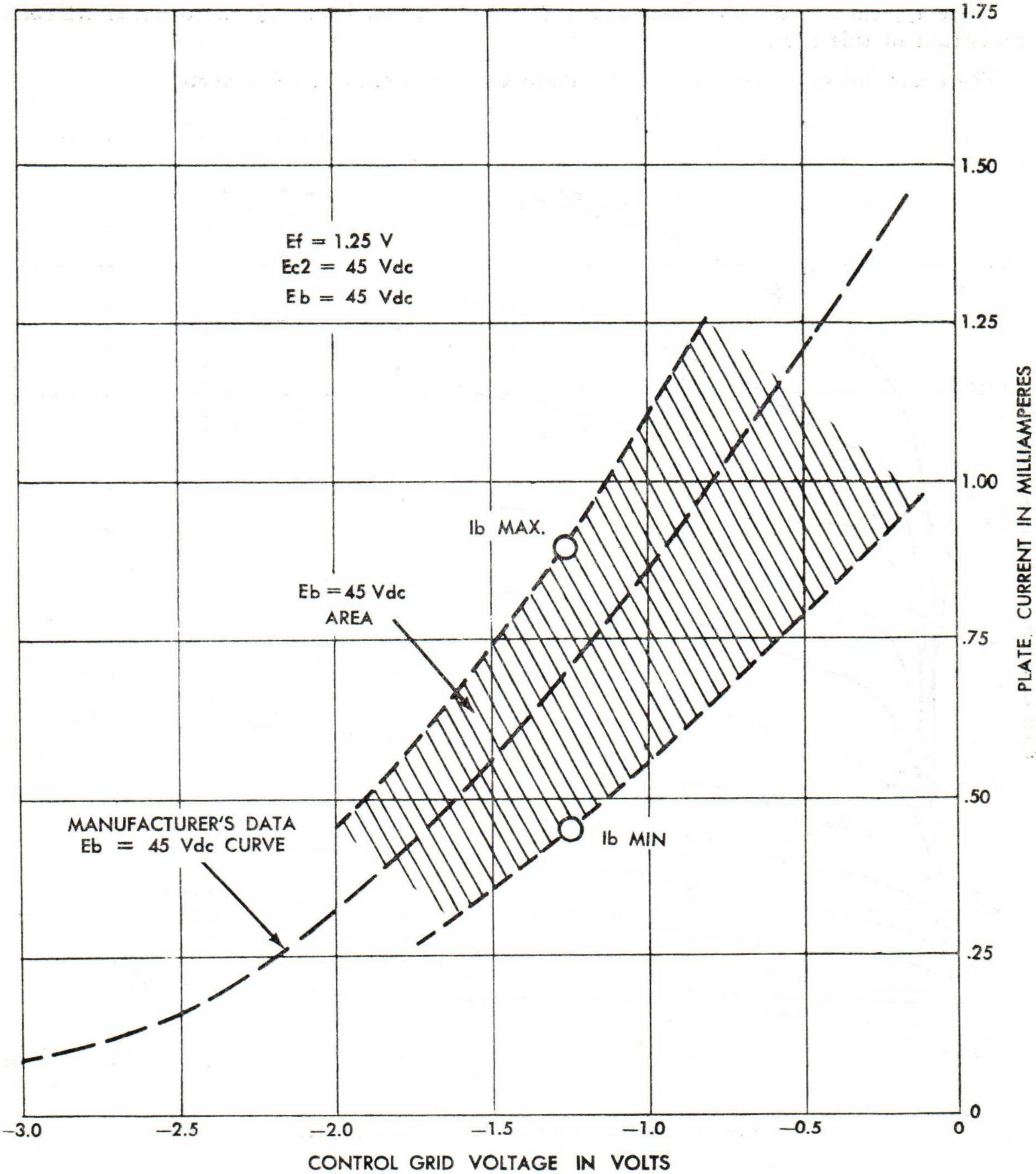


Figure 3-361. Limit Behavior of JAN-6088 Transfer Data; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN-6088

These typical curves have been obtained from data published by the original **RETMA** registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-6088.

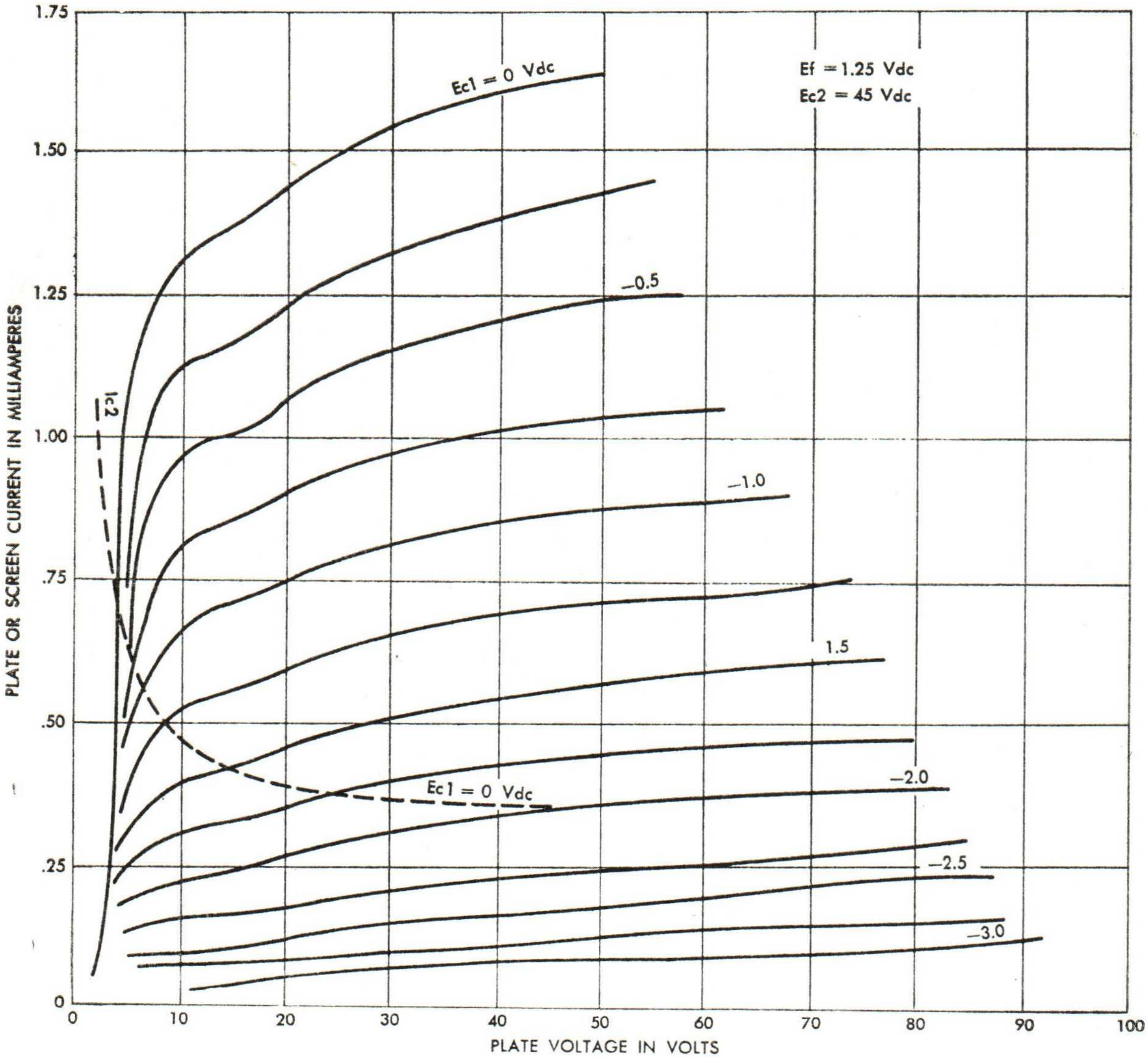


Figure 3-362. Typical Static Plate Characteristics of JAN-6088.

SECTION
TUBE TYPE JAN-6094

DESCRIPTION.

The JAN-6094 is a nine pin miniature beam power pentode in a T 6½ envelope. It is generic to the JAN-6005 and the JAN-6AQ5W.

ELECTRICAL. The electrical characteristics are as follows:

- Heater Voltage .... 6.3 V
- Heater Current .... 560 to 640 mA
- Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.

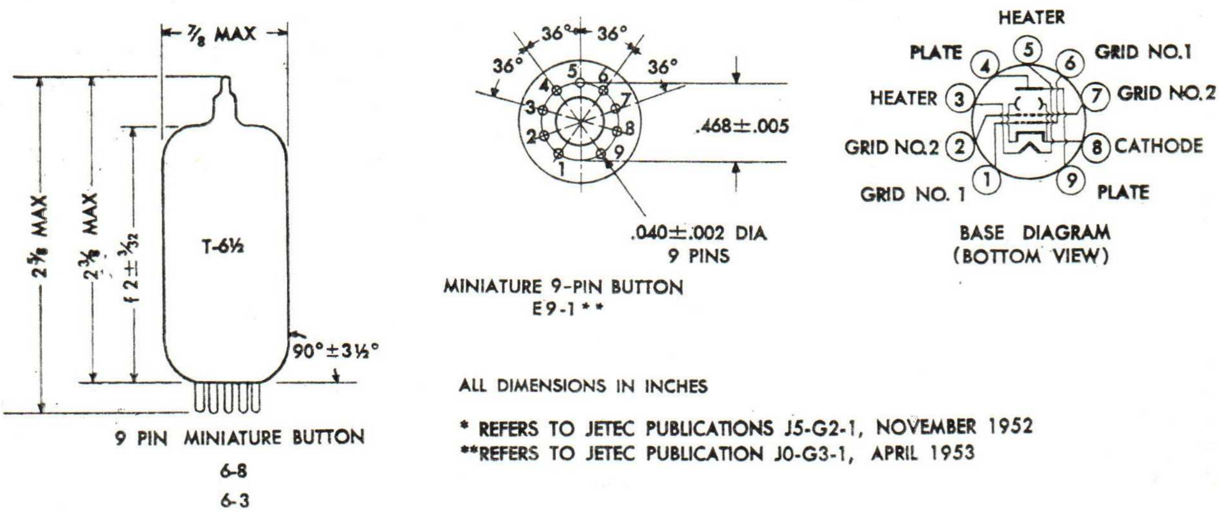


Figure 3-363. Outline Drawing and Base Diagram of JAN-6094.

RATINGS, ABSOLUTE SYSTEM.

The absolute system ratings are as follows:

- Heater Voltage .... 6.3 ± 0.3 V
- Plate Voltage .... 275 Vdc
  - Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
- Control Grid Voltage .... +5.0 Max
  - .... —200 Min
- Screen Grid Voltage .... 275 Vdc
- Heater-Cathode Voltage, peak .... 450 v
- Cathode Current .... 75 mA
- Plate Dissipation .... 12.5 W
- Screen Grid Dissipation .... 2.0 W
- Envelope Temperature .... 300°C
- Altitude .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage	6.3 V
Plate Voltage	250 Vdc
Control Grid Voltage	—12.5 Vdc
Screen Grid Voltage	250 Vdc
Plate Current	45 mA
Transconductance	4100 umhos

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/821B dated 23 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		560	640	550	650	mA
Transconductance (1)	Sm		3000	5200	...	...	umhos
Plate Current (1)	Ib		33	57	...	...	mAdc
Plate Current (2)	Ib	Ec1 = —60 Vdc	...	200	...	...	uAdc
Screen Current	Ic2		0	7.5	...	...	mAdc
Primary Screen	Ic2	Ef2 = 100 Vdc	...	750	...	...	uAdc
Grid Emission		Eb = 0	...	...	...	...	
Power Output (1)	Po	Esig = 8.8 Vac	3.6	...	3.5	15	W
Average Change AugΔ	Po t		...	...	...	...	%
Power Output (2)	Po Ef	RL = 5000 Esig = 8.8 Vac RL = 5000 Ef = 5.7 V	...	15	...	15	%
Capacitance	C1p	Ef = 0	1.3	1.6	...	...	uuf
No Shield	Cin	Ef = 0	7.0	10.0	...	...	uuf
	Cout	Ef = 0	4.0	6.0	...	...	uuf
Grid Current	Ic		0	—0.5	0	-1.0	uAdc
Heater-Cathode Leakage	Ihk	Ehk = +450	...	25	...	20	uAdc
	Ihk	Ehk = —450	...	25	...	20	uAdc
Insulation of Electrodes	Rg-all		100	...	50	...	Meg
	Rp-all		100	...	50	...	Meg

APPLICATION OF JAN-6094

The chart below shows the permissible operating area for JAN-6094 as defined by the ratings in MIL-E-1/821B dated 23 December 1955. A discussion of the permissible operating area for triodes pentodes may be found in paragraphs 3.1.1 and 3.1.2.

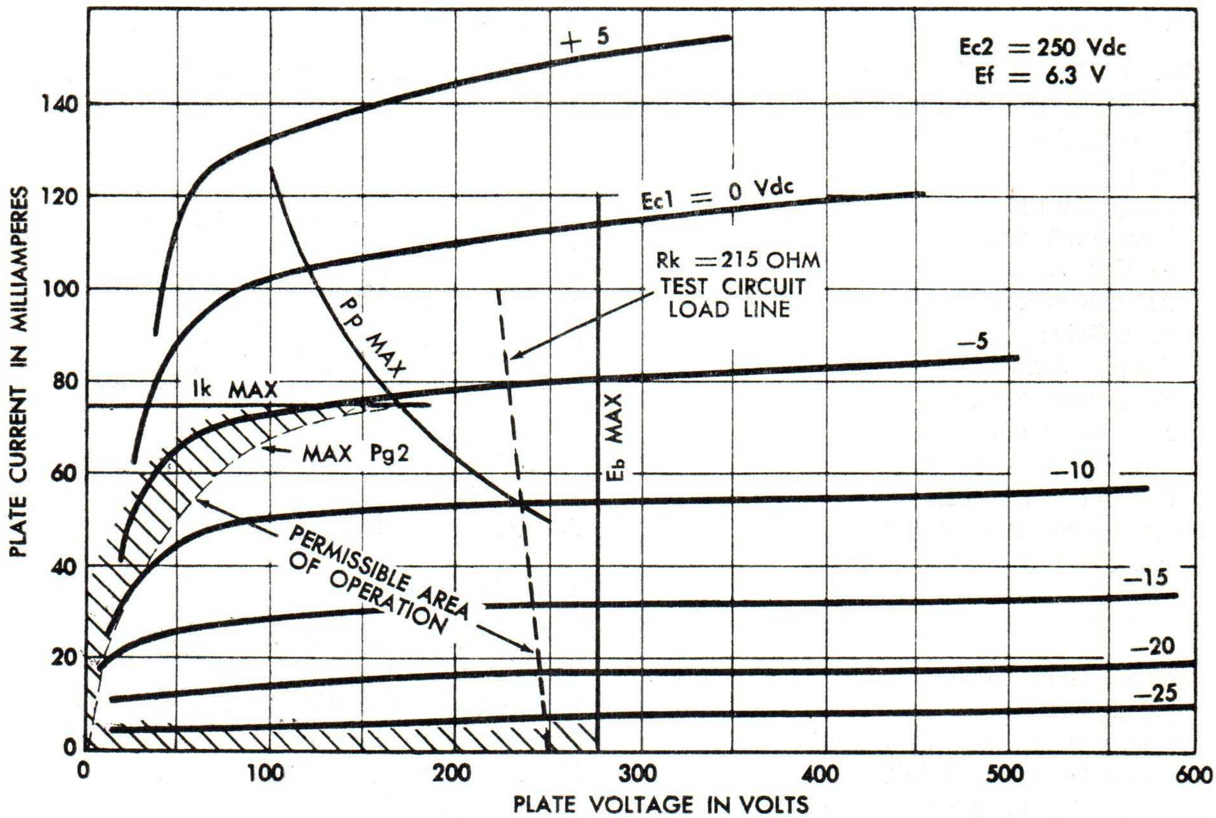


Figure 3-364. Typical Static Plate Characteristics of JAN-6094; Permissible Area of Operation.

SPECIAL CONSIDERATIONS

When using this tube with AC on plate and screen with an inductive load, sufficient unshunted resistance in series with the screen should be used to avoid damage during that portion of the cycle when the plate may be negative to the screen.

A test of primary screen grid emission (see MIL-E-1/821B for details) gives assurance that this tube type will perform adequately in carefully designed AC supply circuitry such as in the power out put stages of servo mechanisms.

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater,1.3.8, 1.3.17, 1.3.22, 1.3.27, 1.3.37, 1.3.51, 1.3.55, 3.2.14
Heater-Cathode, 1.3.30
Plate:
  High, 3.2.12
  Low, 3.2.3, 3.2.7
  28 Volt, 3.2.21
  AC Operation, 1.3.20
Screen Grid:
  Supply, 3.2.8
  Protection, 3.2.22
Control Grid Bias:
  Low, 1.3.4, 1.3.9, 3.2.8, 3.2.9
  Cathode, 2.1.3, 3.2.15
Positive Grid Region, 3.2.19
Contact Potential, 1.3.4, 3.2.9, 3.2.21

Resistance

Control Grid Series, 1.3.9, 1.3.19, 1.3.22, 1.2.23, 3.2.16
Screen Grid Series, 3.2.3, 3.2.17
Cathode Interface, 1.3.50, 3.1.9
Cathode, 1.3.33, 1.3.34, 1.3.35, 2.1.3, 3.2.15

Temperature

Bulb and Environmental, 3.2.4

Current

Cathode, 1.3.50, 3.2.6, 3.2.13
Control Grid, 1.3.4, 1.3.9, 1.3.23, 3.2.9
Screen Grid, 3.2.3
Interelectrode Leakage, 1.3.14
Gas, 1.3.9, 3.2.9
Control Grid Emission, 1.3.18
Cathode, Thermionic Instability, 1.3.37

Dissipation

Plate, 2.1, 3.2.4
Screen Grid, 2.1, 3.2.3, 3.2.8

Miscellaneous

Pulse Operation, 3.2.19
Shielding, 3.2.4
Intermittent Operation, 3.2.13
Triode Connection, 3.2.20
Electron Coupling Effects, 1.3.44
Microphonics, 1.3.56, 3.2.23

VARIABILITY OF JAN-6094 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6094 as defined by MIL-E-1/821B dated 23 December 1955.

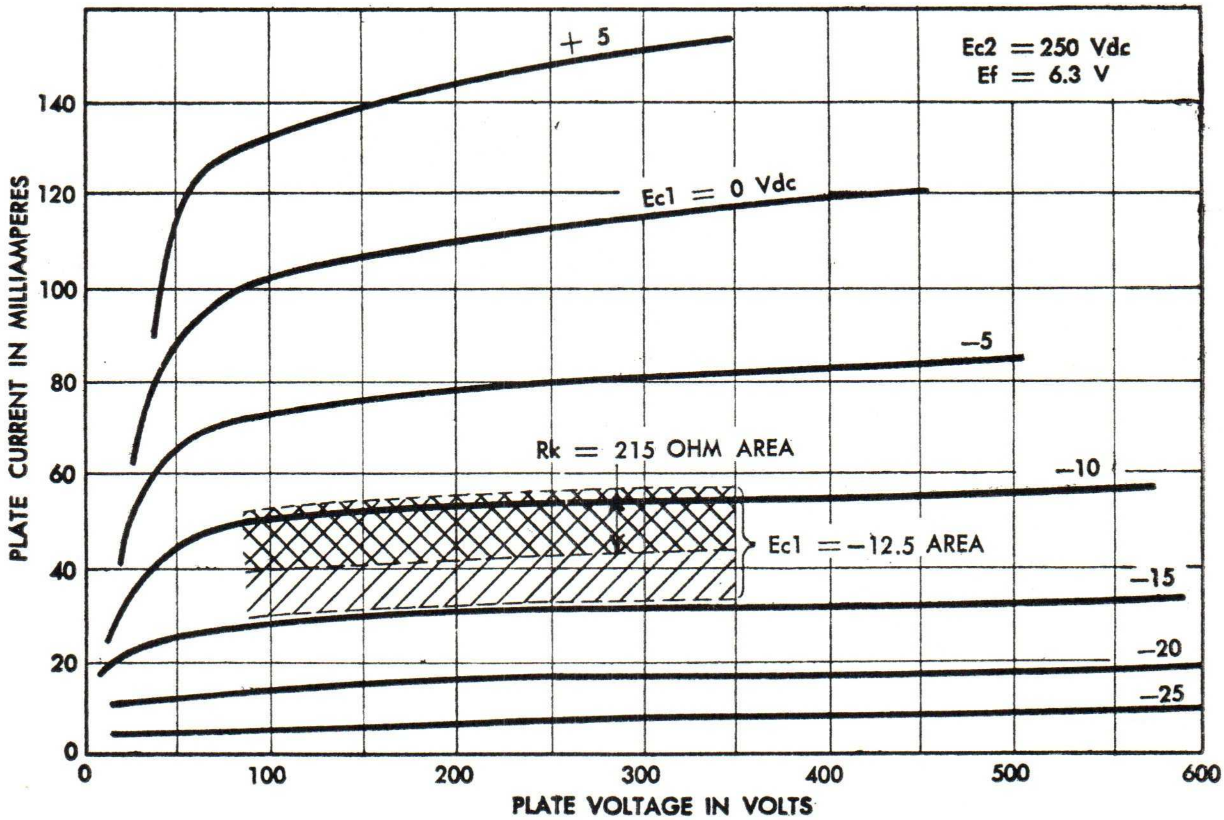


Figure 3-365. Limit Behavior Static Plate Data of JAN-6094; Variability of Ib.

The chart below presents the limit behavior of transfer data for JAN-6094 as defined by MIL-E-1/821B dated 23 December 1955.

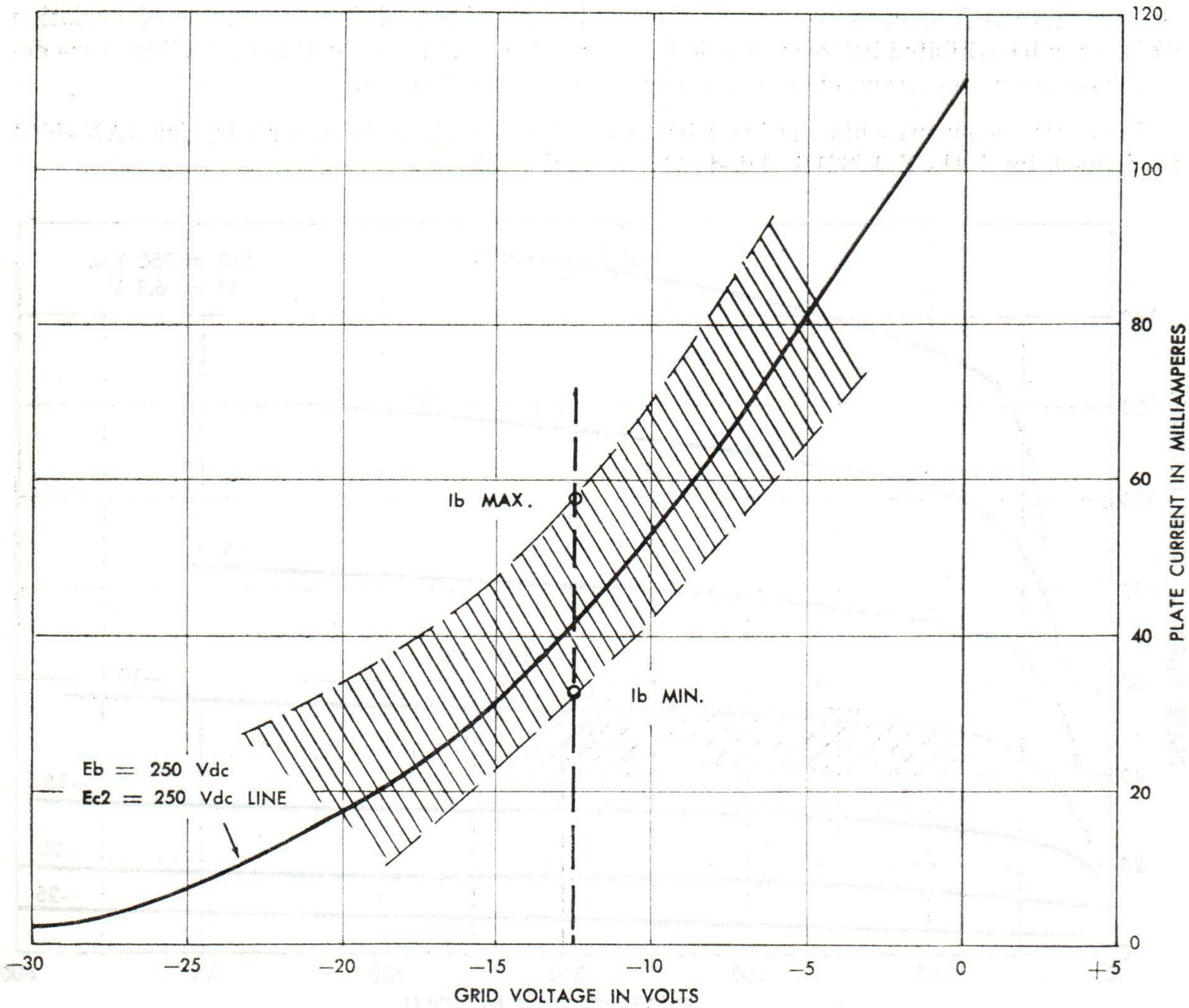


Figure 3-366. Limit Behavior, Transfer Data of JAN-6094; Variability of Ib.

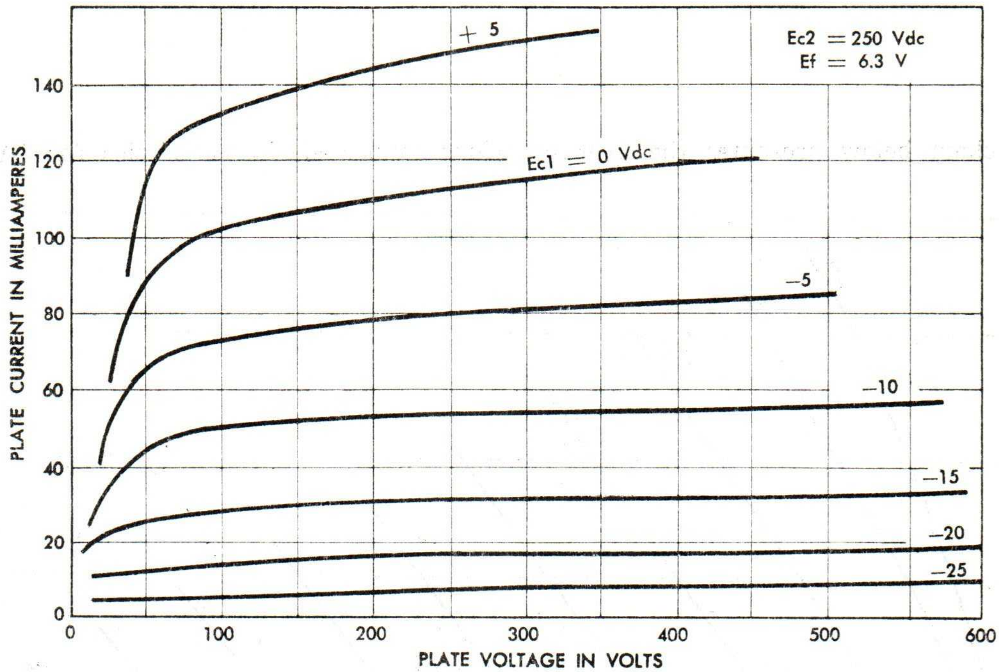


Figure 3-367. Typical Static Plate Characteristics of JAN-6094; Ec2 = 250 Vdc.

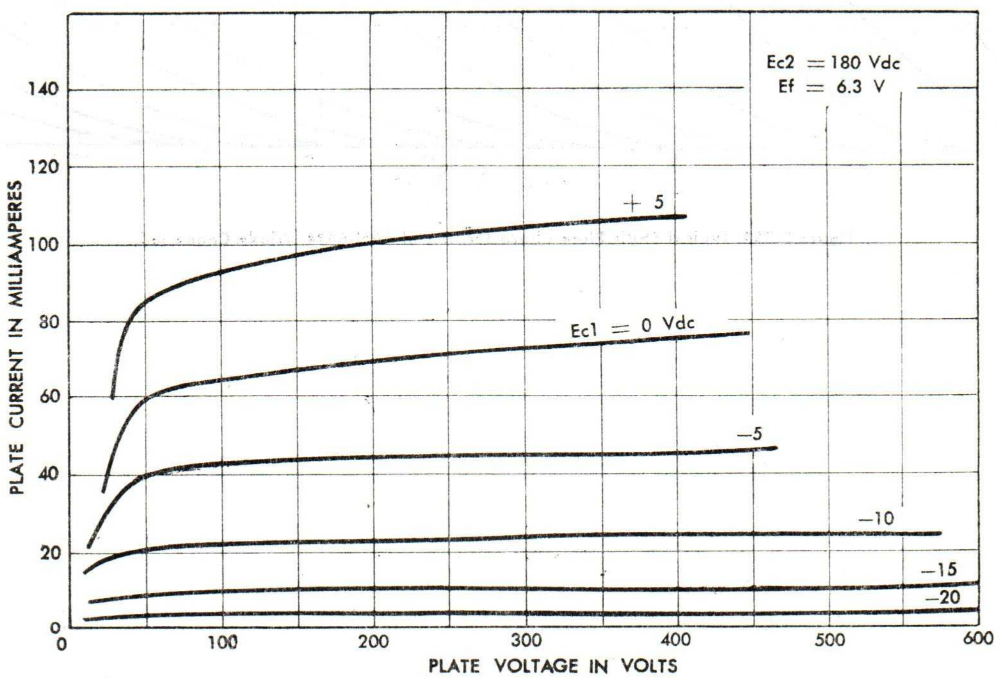


Figure 3-368. Typical Static Plate Characteristics of JAN-6094; Ec2 = 180 Vdc.

The chart below presentes the average triode connected characteristics for JAN-6094.

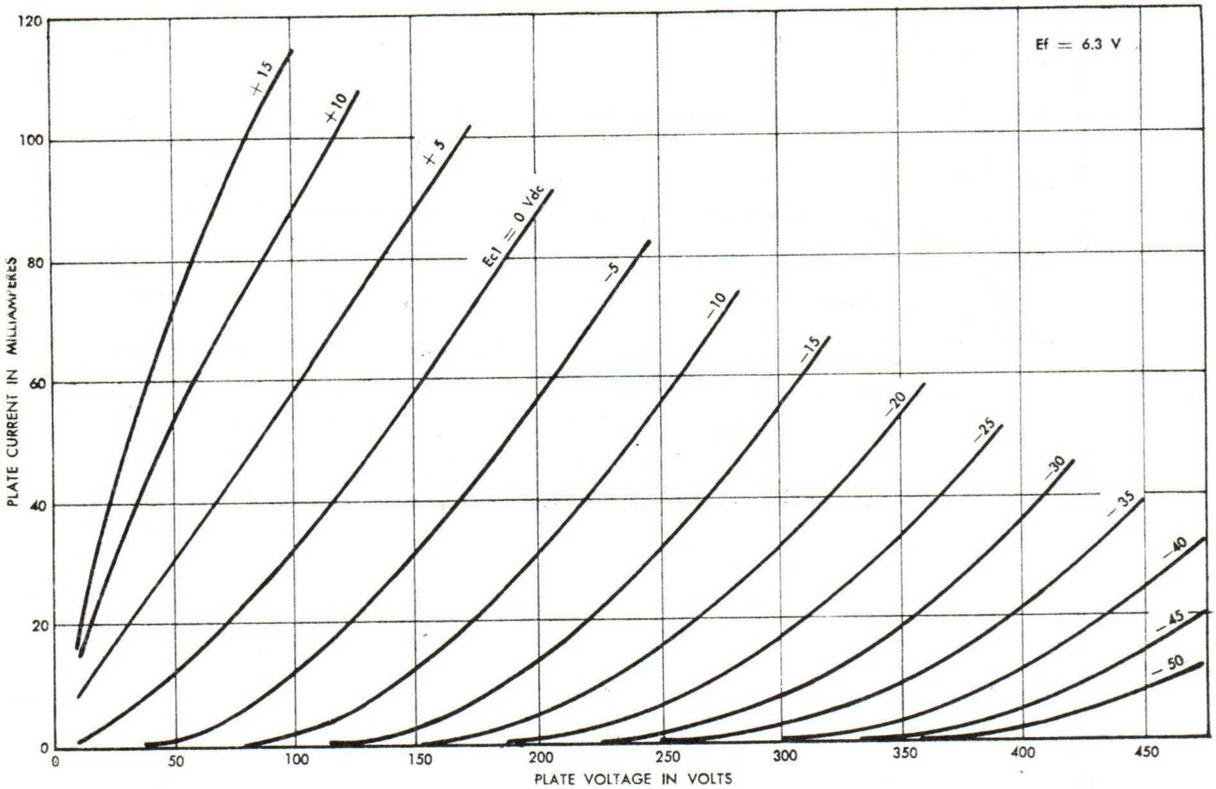


Figure 3-369. Typical Static Plate Characteristics of JAN-6094; Triode Connected.

The charts below present the Typical Transfer Plate Data for JAN–6094.

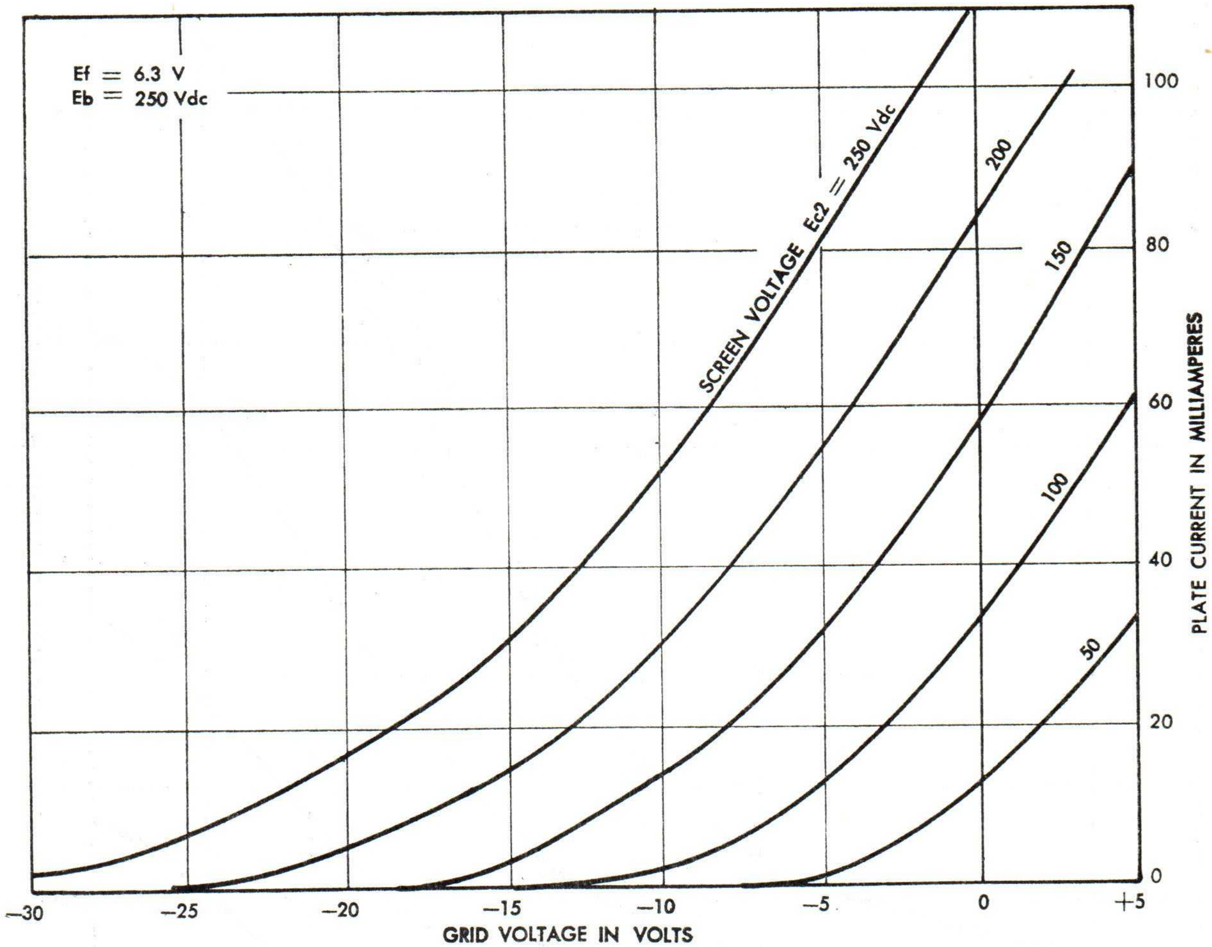


Figure 3-370. Typical Transfer Characteristics of JAN-6094; Variability of Ib.

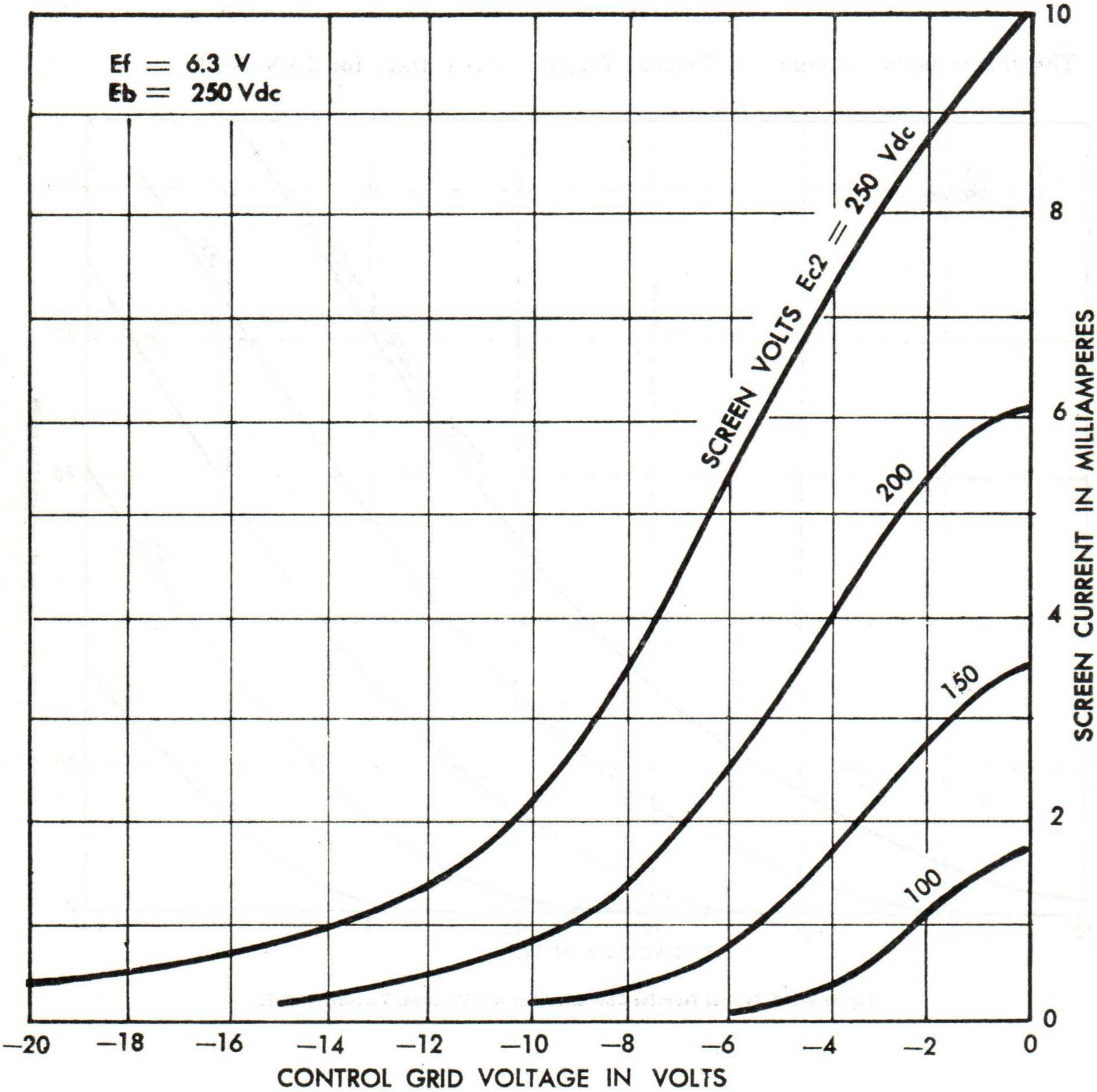


Figure 3-371. Typical Transfer Characteristics of JAN-6094; Variability of Ic2.

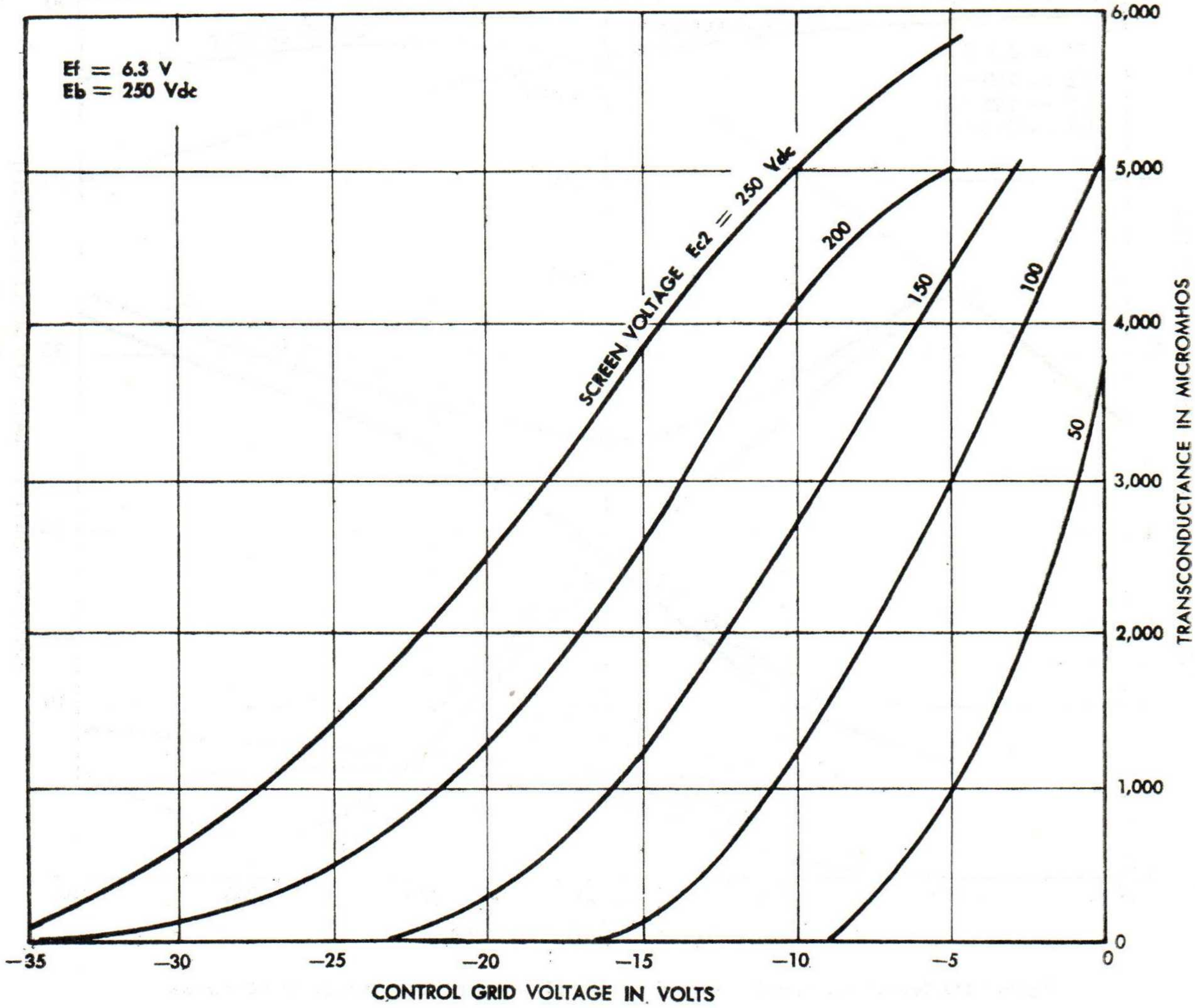


Figure 3-372. Typical Transfer Characteristics of JAN-6094; Variability of Sm.

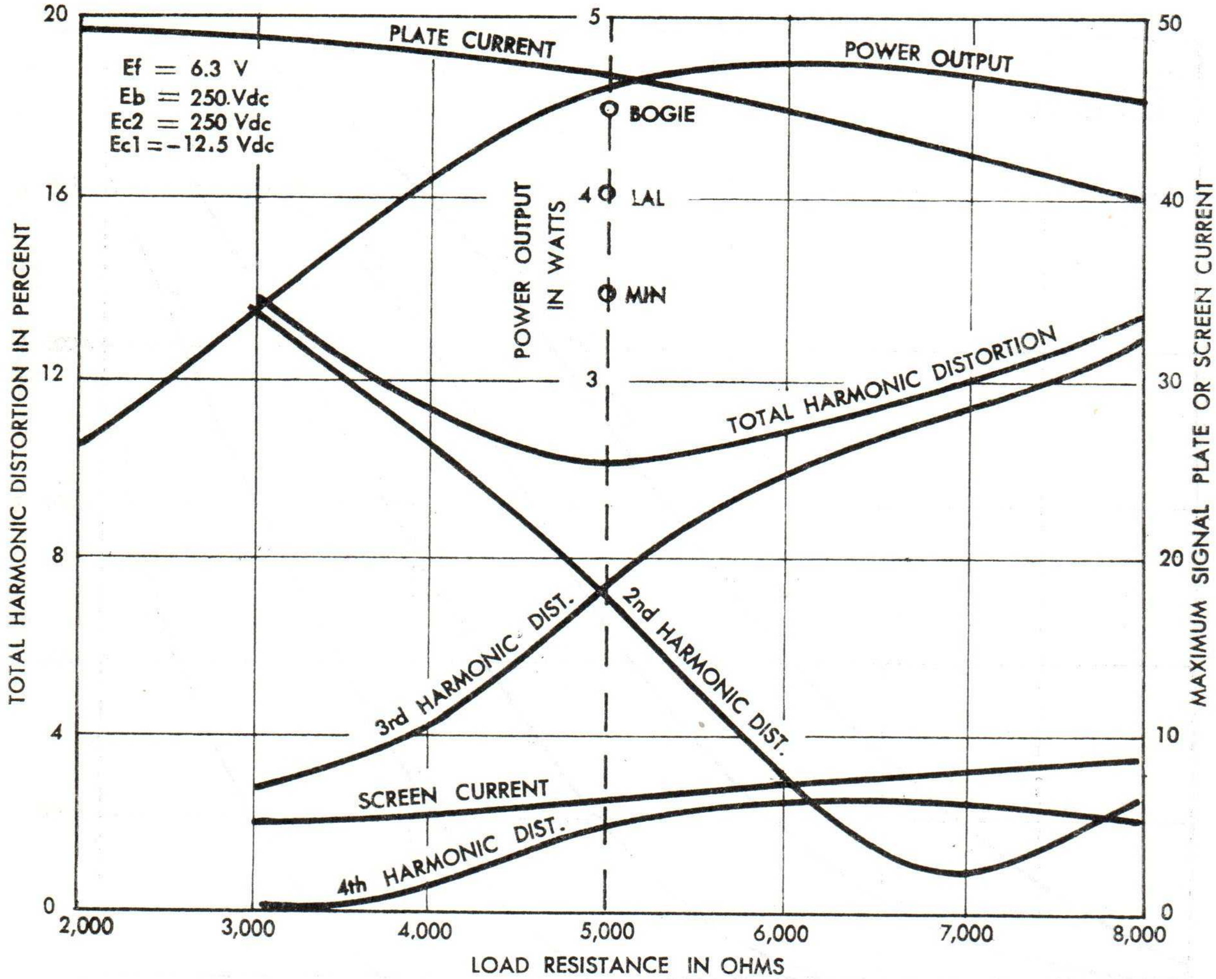
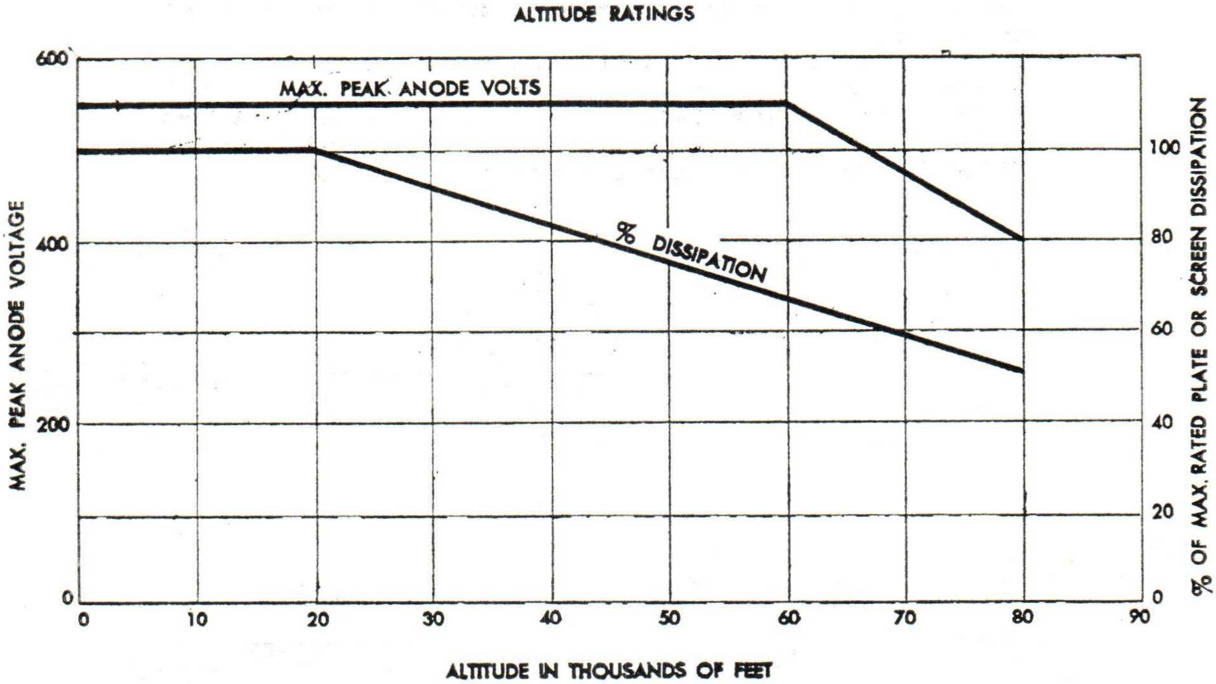


Figure 3-373. Typical Operating Characteristics of JAN-6094; Under MIL-E-1 Dynamic Test Conditions.



THIS CHART IS INCLUDED AS AN ILLUSTRATION OF THE AMOUNT OF DISSIPATION DERATING NECESSARY IN A SPECIFIC APPLICATION TO AVOID EXCEEDING THE MAXIMUM BULB TEMPERATURE. EACH APPLICATION SHOULD BE CHECKED TO DETERMINE THAT THE MAXIMUM BULB TEMPERATURE IS NOT EXCEEDED. EITHER DERATING OR COOLING OR BOTH MAY BE NECESSARY.

CRITERIA FOR DERATING FOLLOWS:

1. VOLTAGE DERATING — TO KEEP BELOW BASE PIN ARC OVER POINT.
2. DISSIPATING DERATING — TO KEEP BULB TEMPERATURE BELOW MAXIMUM RATING.

Figure 3-374. Altitude Derating Chart for JAN-6094.

SECTION
TUBE TYPE JAN-6111

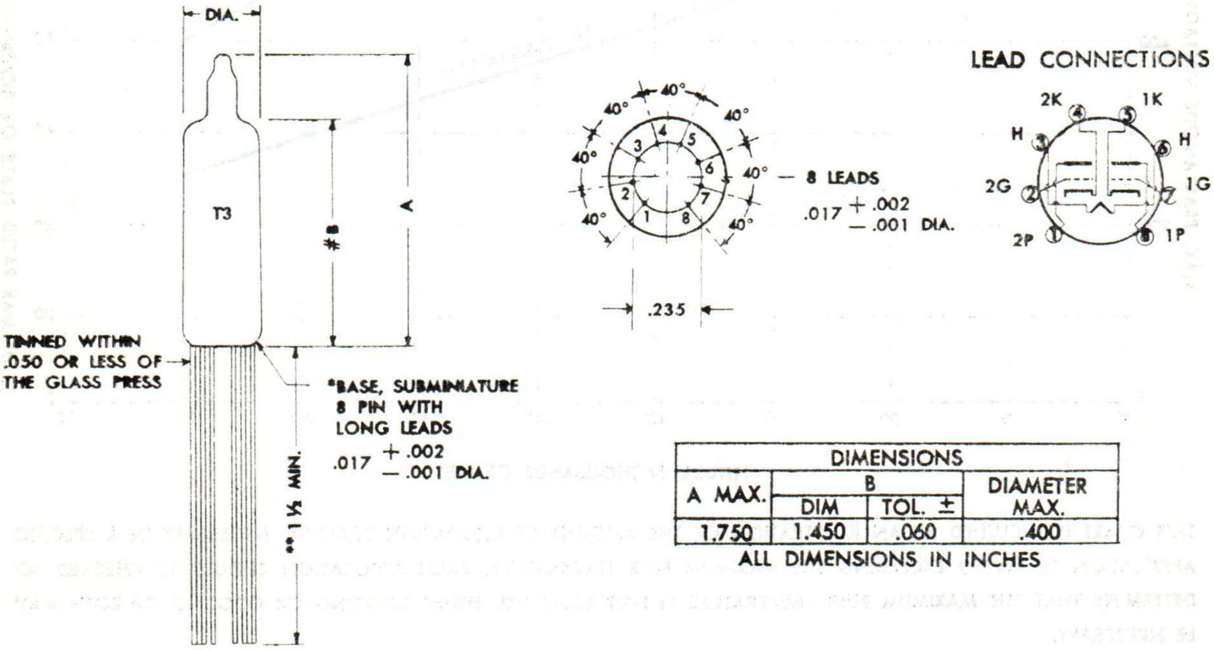
DESCRIPTION,

The JAN-6111[1] is an 8 lead, button-base, subminiature twin triode having a design center amplification factor at 20, and transconductance of 5000. This type has been used successfully in a variety of amplifier applications, including pulse circuits.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 300 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS			
A MAX.	B		DIAMETER MAX.
	DIM	TOL. ±	
1.750	1.450	.060	.400

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-375. Outline Drawing and Base Diagram of JAN-6111.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.3V
Plate Voltage, Maximum .... 165 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Grid Voltage, Maximum .... 0 Vdc
Grid Voltage, Minimum .... —55 Vdc
Heater-Cathode Voltage .... 200 V
Grid Series Resistance .... 1.1 meg

[1] The values and specification comments presented in this section are related to MIL-E-1/189B dated 23 August 1955.

**Plate Current .... .22 mAdc
*Grid Current .... 5.5 mAdc
Plate Dissipation .... 0.95 W
Bulb Temperature .... +220° C
Altitude Rating .... 60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Voltage, Eb .... 100 Vdc
Cathode Resistance .... 220 ohms
Plate Current, Ib .... 8.5 mAdc
Transconductance, Sm .... 5000 umhos
Amplification Factor, Mu 20

* No test of operation at this rating exists in the specification.
** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/189B dated 23 August 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		280	320	276	328	mA
Transconductance (1)	Sm		4100	5900	...	...	umhos
Change in individual	ΔSm t		...	...	...	20	%
Transconductance (2)	Sm Δ Ef		...	15	...	15	%
Amplification Factor	Mu		17	23	...	...	%
Plate Current (1)	Ib		6.0	11.0	...	...	mAdc
Plate Current (2)	Ib	Ec = —9.0 Vdc Rk = O ohms	...	100	...	...	uAdc
Plate Current (1) difference between sections	Ib		...	2.0	...	...	mAdc
Pulse Emission	is	Ef = 6.0 V; e pulse = 50 V tp = 25u sec; prr = 200 pps	200	...	...	...	ma
Capacitance (No shield)							
Cgp/section		Ef = 0	1.2	1.8	...	...	uuf
Cin/section		Ef = 0	1.4	2.4	...	...	uuf
Cout section 1		Ef = 0	0.20	0.36	...	...	uuf
Cout section 2		Ef = 0	0.22	0.42	...	...	uuf
Cgg		Ef = 0	...	0.011	...	...	uuf
Cpp		Ef = 0	...	0.50	...	...	uuf
Grid Current	Ic	Rg = 1.0 Meg	0	—0.3	0	—0.9	uAdc

Property	Measurement Conditions	Limits				Units
		Initial		Life test		
		Min	Max	Min	Max	
Grid Emission Ic	Ef = 7.5 Vdc Ec = —9.0 Vdc Rk = 0; Rg = 1.0 Meg	0	—0.5	...	...	uAdc
Heater-Cathode Leakage						
Ihk	Ehk = +100 Vdc	...	5.0	...	10.0	uAdc
Ihk	Ehk = —100 Vdc	...	—5.0	...	—10.0	uAdc
Insulation of Electrodes						
R(g-all)	g-all; Eg = —100 Vdc	100	...	50	...	Meg
R(p-all)	p-all; Ep = —300 Vdc	100	...	50	...	Meg

APPLICATION OF JAN-6111

The chart below shows the permissible operating area for JAN-6111 as defined by the ratings in MIL-E-1/189B dated 23 August 1955. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2.

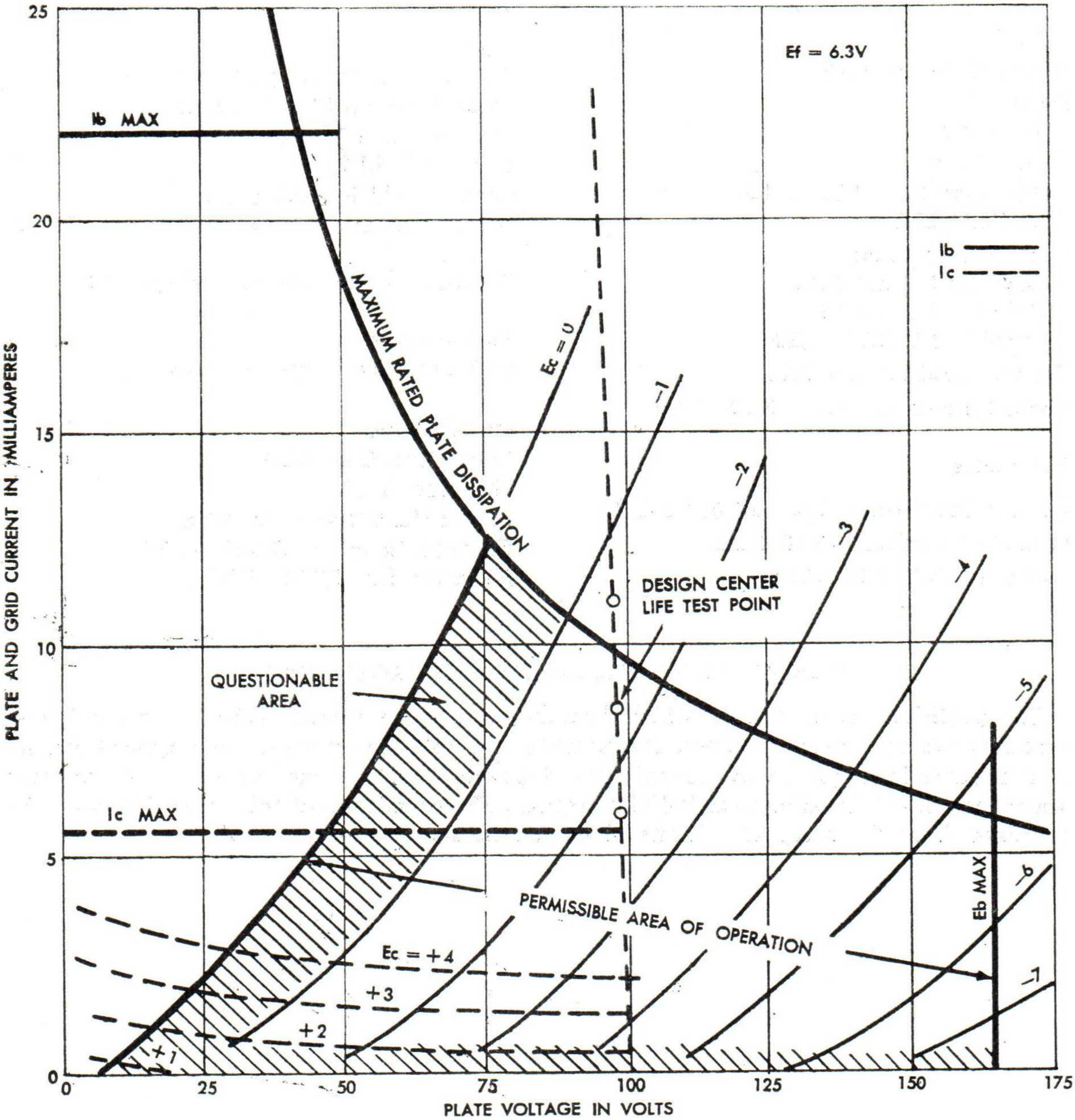


Figure 3-376. Typical Characteristics of JAN-6111; Permissible Area of Operation.

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2

Plate, Low, 1.3.10, 3.1.3, 3.1.5

Interelectrode Leakage, 1.3.5

Gas, 1.3.2, 3.1.2

Control Grid Emission, 1.3.3

Cross Currents in Multistructure Tubes, 1.3.6

Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5

Shielding, 3.1.4

Intermittent Operation, 3.1.5

Electron Coupling Effects, 1.3.9

Microphonics, 1.3.11, 3.1.5

VARIABILITY OF JAN-6111 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN-6111 as defined by MIL–E–1/189B dated 23 August 1955.

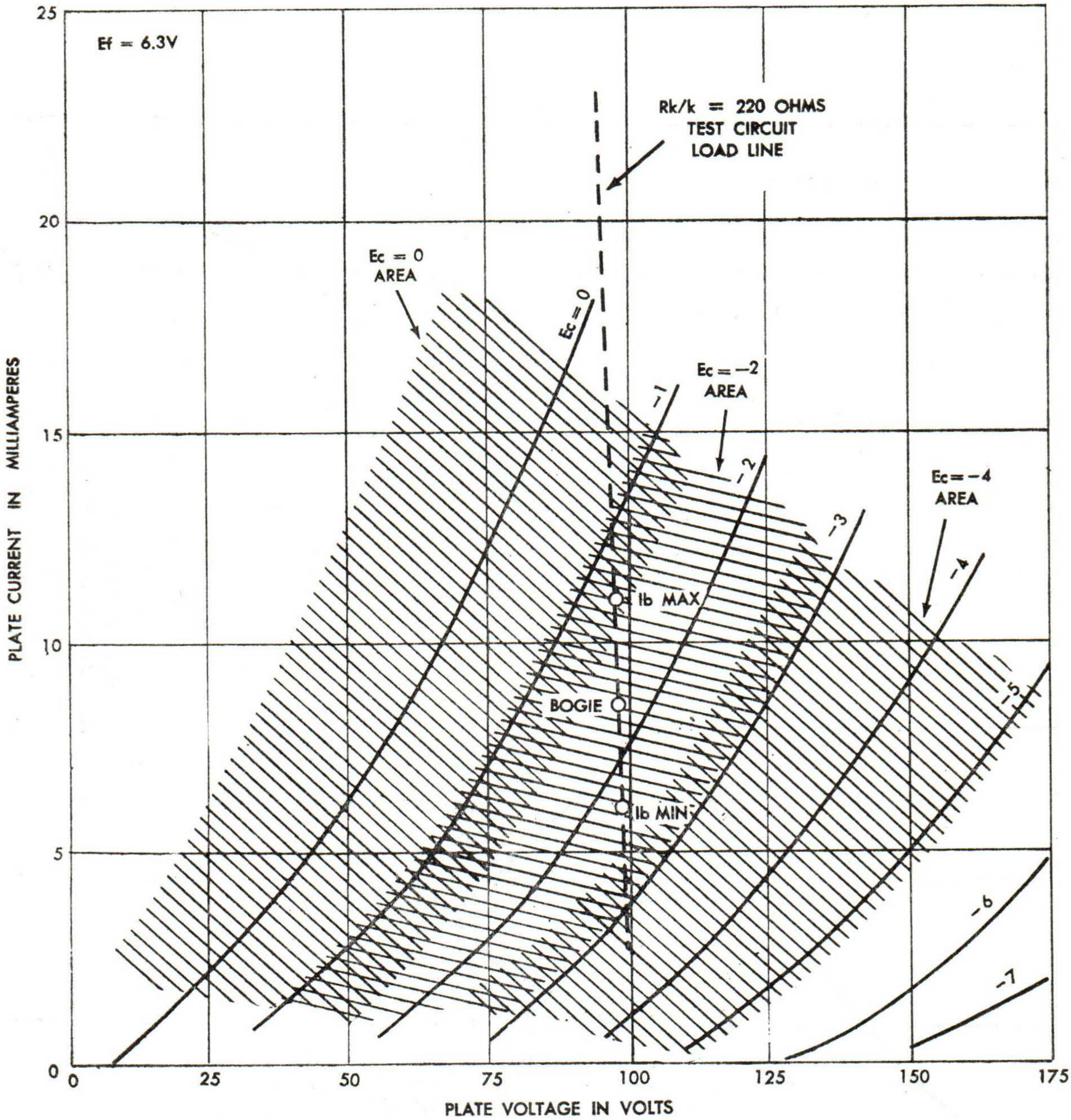


Figure 3-377. Limit Behavior of JAN-6111 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of transfer data for JAN–6111 as defined by MIL–E–1/189B dated 23 August 1955.

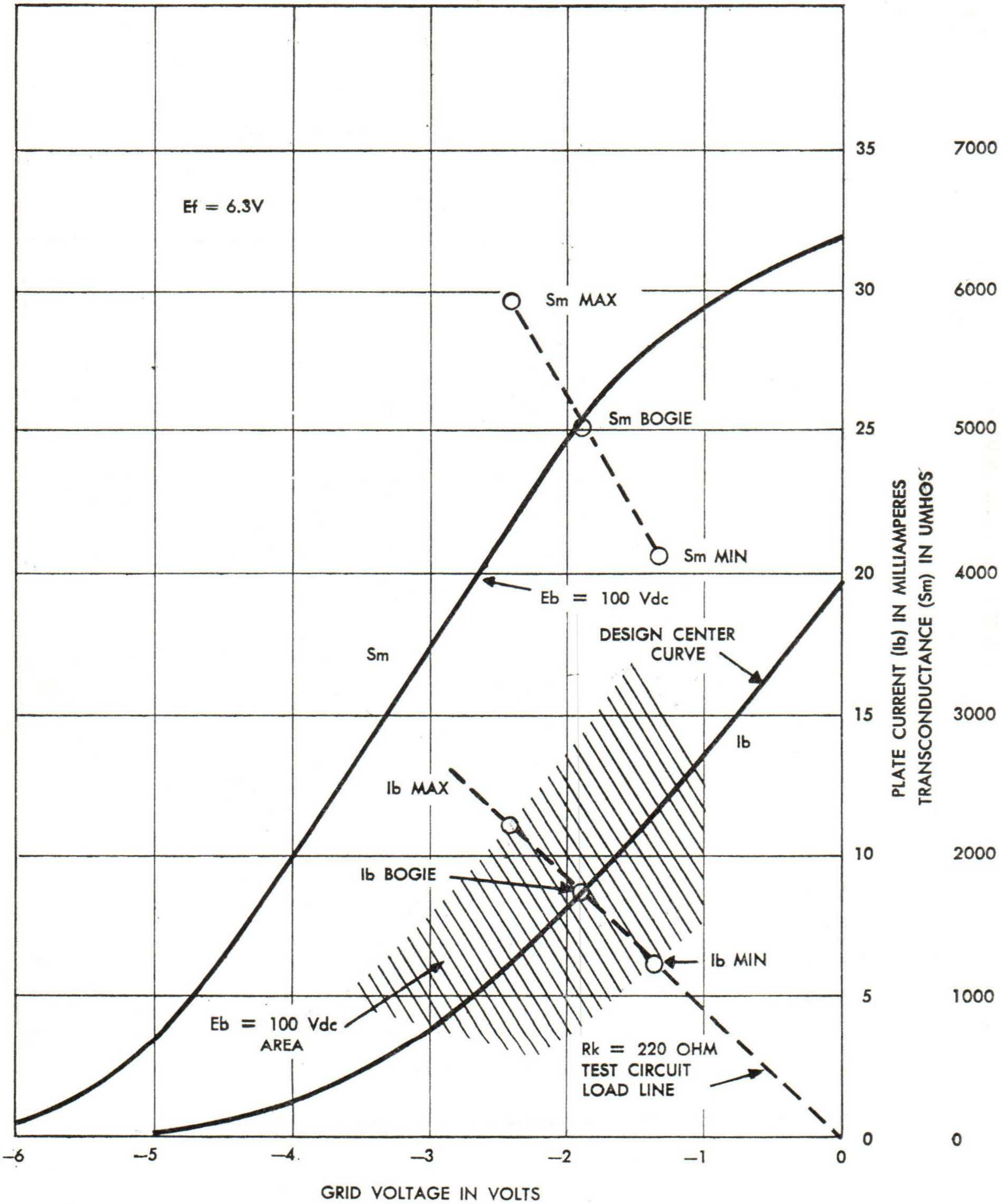


Figure 3-378. Limit Behavior of JAN-6111 Transfer Data; Variability of Ib and Sm.

DESIGN CENTER CHARACTERISTICS OF JAN-6111

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-6111.

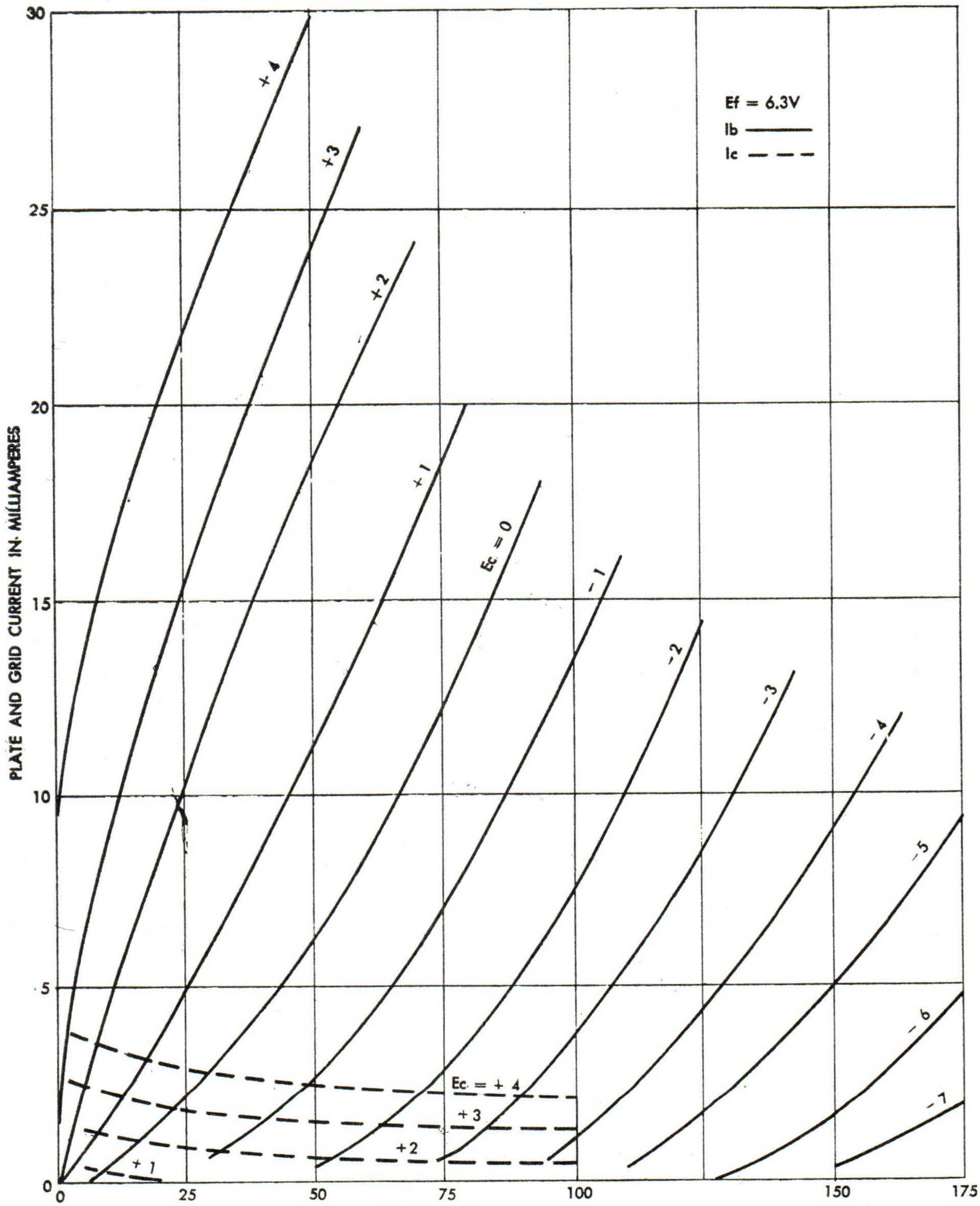


Figure 3-379. Typical Static Plate Characteristics of JAN-6111.

The chart below presents the Average Plate Transfer Data for JAN-6111.

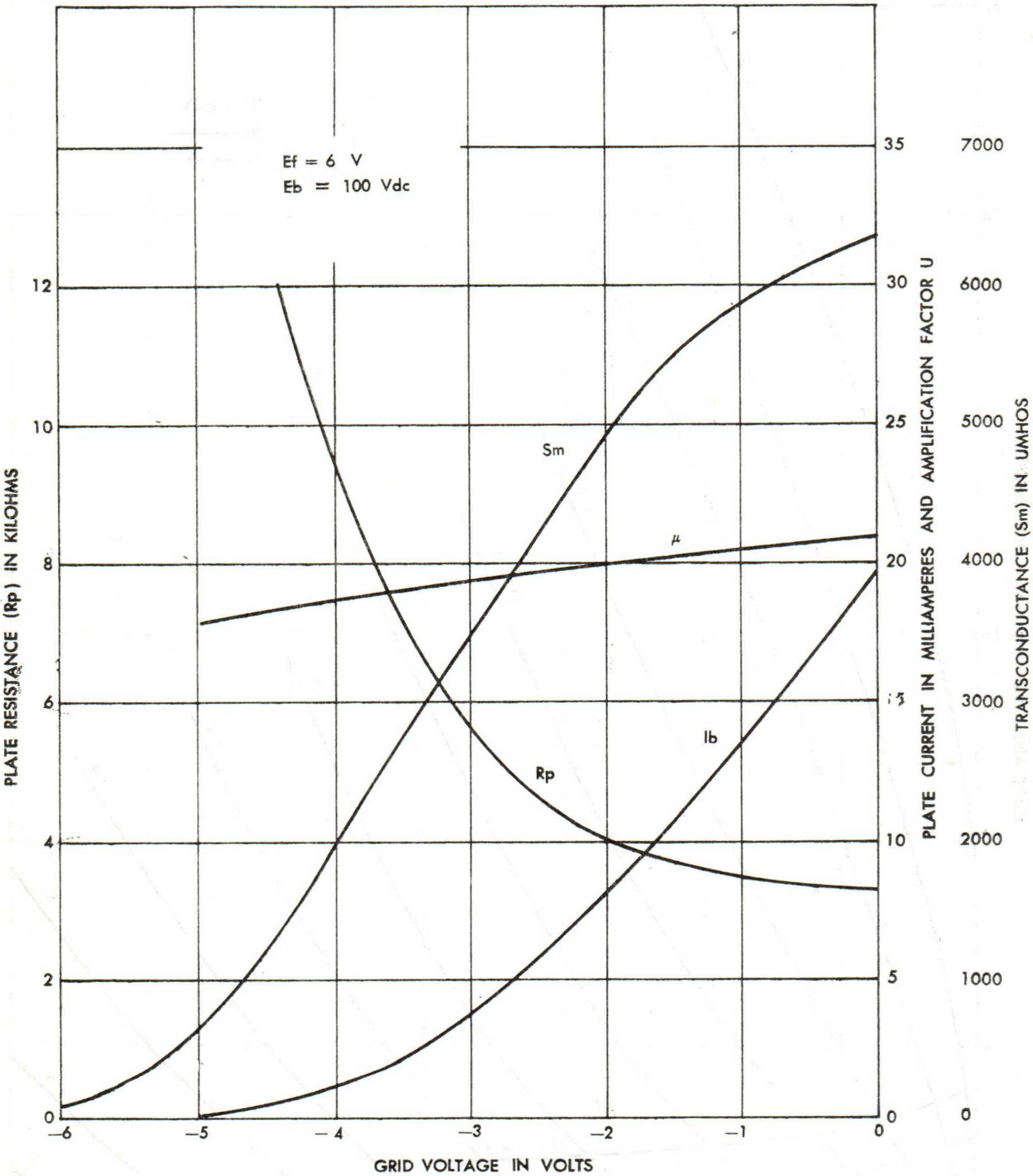


Figure 3-380. Typical Transfer Characteristics of JAN-6111.

SECTION
TUBE TYPE JAN–6112

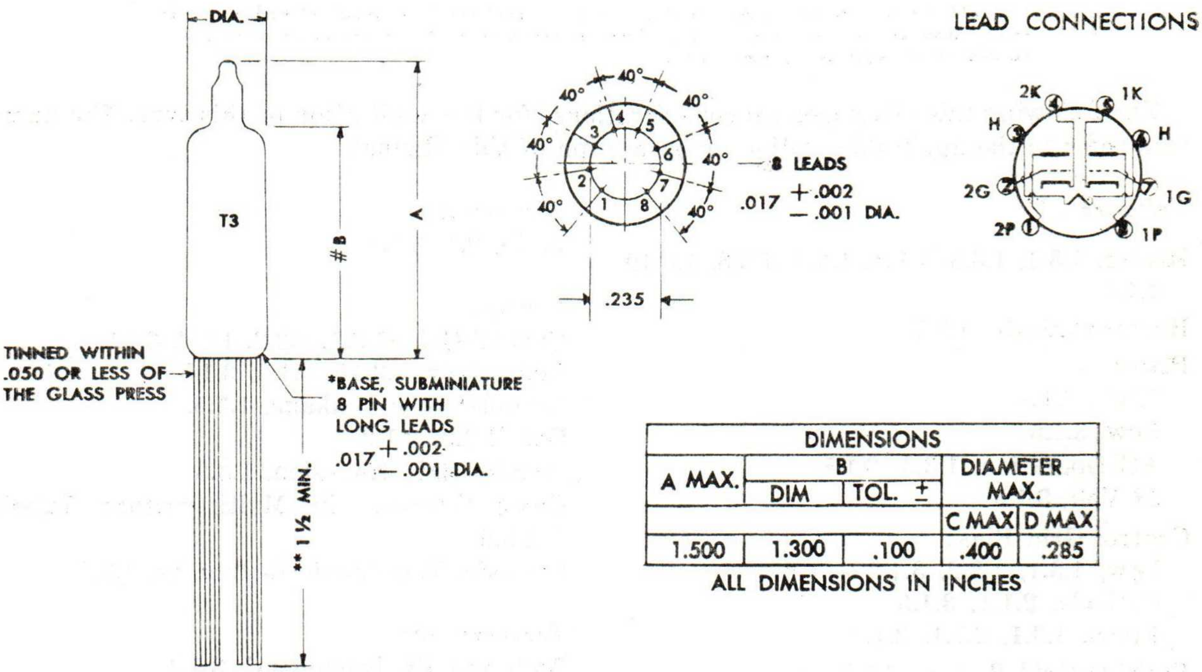
DESCRIPTION.

The JAN–6112 [1] is an 8-lead, button base subminiature twin triode having a design center transconductance of 1800 micromhos and a Mu in the range from 60 to 80. The JAN–6112 has performed satisfactorily in audiofrequency amplifier and phase inverter service.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage .... 6.3 V
Heater Current, Design Center .... 300 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.



DIMENSIONS				
A MAX.	B		DIAMETER MAX.	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.400	.285

ALL DIMENSIONS IN INCHES

\# MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-381. Outline Drawing and Base Diagram of JAN-6112.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.3 V
Plate Voltage .... 165 Vdc
Reference MIL–E–1C Section 6.5.1.1 *Plate Voltage*
Grid Voltage, Maximum .... 0 Vdc
Grid Voltage, Minimum .... —55 Vdc
Heater-Cathode Voltage .... 200 V
Grid Series Resistance .... 1.1 Meg

[1] The values and specification comments presented in this section are related to MIL-E-1/190C dated 14 May 1956.

**Plate Current	3.3 mAdc
Plate Dissipation	0.30 W
Bulb Temperature	+220° C
Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	100 Vdc
Heater-Cathode Voltage, Ehk	0 V
Cathode Resistance,Rk/k	1500 ohms
Heater Current, If	300 mA
Transconductance, Sm	1800 umhos

** Difficulty may be encountered if this tube is operated for long periods of time with very small values of cathode current. No specification assurance of life exists under conditions of cathode current approaching the maximum.

The following table lists general considerations for the application of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5
Heater-Cathode, 1.3.7
Plate:
High, 3.1.5
Low, 3.1.5
AC Operation, 1.3.3, 3.1.5
28 Volt, 3.1.5
Control Grid Bias:
Low, 1.3.1, 1.3.2, 3.1.2
Cathode, 2.1.1, 3.1.5
Fixed, 1.3.1, 2.1.1, 3.1.3
Positive Grid Region, 3.1.5
Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5
Cathode Interface, 1.3.10, 3.1.5
Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cross Currents in Multistructure Tubes, 1.3.6
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL–E–1/190C dated 14 May 1956 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		280	320	276	328	mA
Transconductance (1)	Sm		1500	2100	...	...	umhos
Change in individual	Δ Sm t		...	...	...	25	%
Transconductance (2) Change with Ef	Δ Sm Ef	Ef = 5,.7 V	...	15	...	15	%
Amplification Factor	Mu		60	80	...	...	...
AC Amplification	Ep	Ebb = 100 Vdc; Ecc = 0 Esig = 0.2 Vac; Rk = 0	8.0	...	...	...	Vac
Plate Current (1)	Ib		.50	1.10	...	...	mAdc
Plate Current (2)	Ib	Ec = —2.8 Vdc, Rk = 0	...	50	...	...	uAdc
Capacitance	Cgp	Ef = 0	0.8	1.20	...	...	uuf
(Without shield)	Cin	Ef = 0	1.30	2.10	...	...	uuf
Section 1	Cout	Ef = 0	0.16	0.30	...	...	uuf
Section 2	Cout	Ef = 0	0.21	0.35	...	...	uuf
	Cgg	Ef = 0	...	0.014	...	...	uuf
	Cpp	Ef = 0	...	0.80	...	...	uuf
Grid Current	Ic	Eb = 150 Vdc; Ec = 0 Rk = 820; Rg = 1.0 Meg	0	—0.3	0	—0.9	uAdc
Grid Emission	Ic	Ef = 7.5 V; Ec = —4.0 Vdc Ef = 150 Vdc, Rk = 0 Rg = 1.0 Meg	0	—0.5	...	...	uAdc uAdc
Heater-Cathode Leakage	Ihk	Ehk = +100 Vdc	...	5.0	...	10.	uAdc
	Ihk	Ehk = —100 Vdc	...	—5.0	...	—10.	uAdc
Insulation of Electrodes	R(g–all)	Eg–all = —300 Vdc	100	...	50	...	Meg
	R(p–all)	Ep–all = —100 Vdc	100	...	50	...	Meg

APPLICATION OF JAN–6112

The chart below shows the permissible operation area for JAN–6112 as defined by the ratings in MIL–E–1/190C dated 14 May 1956. A discussion of the permissible operating area for triodes may be found in paragraph 3.1.2.

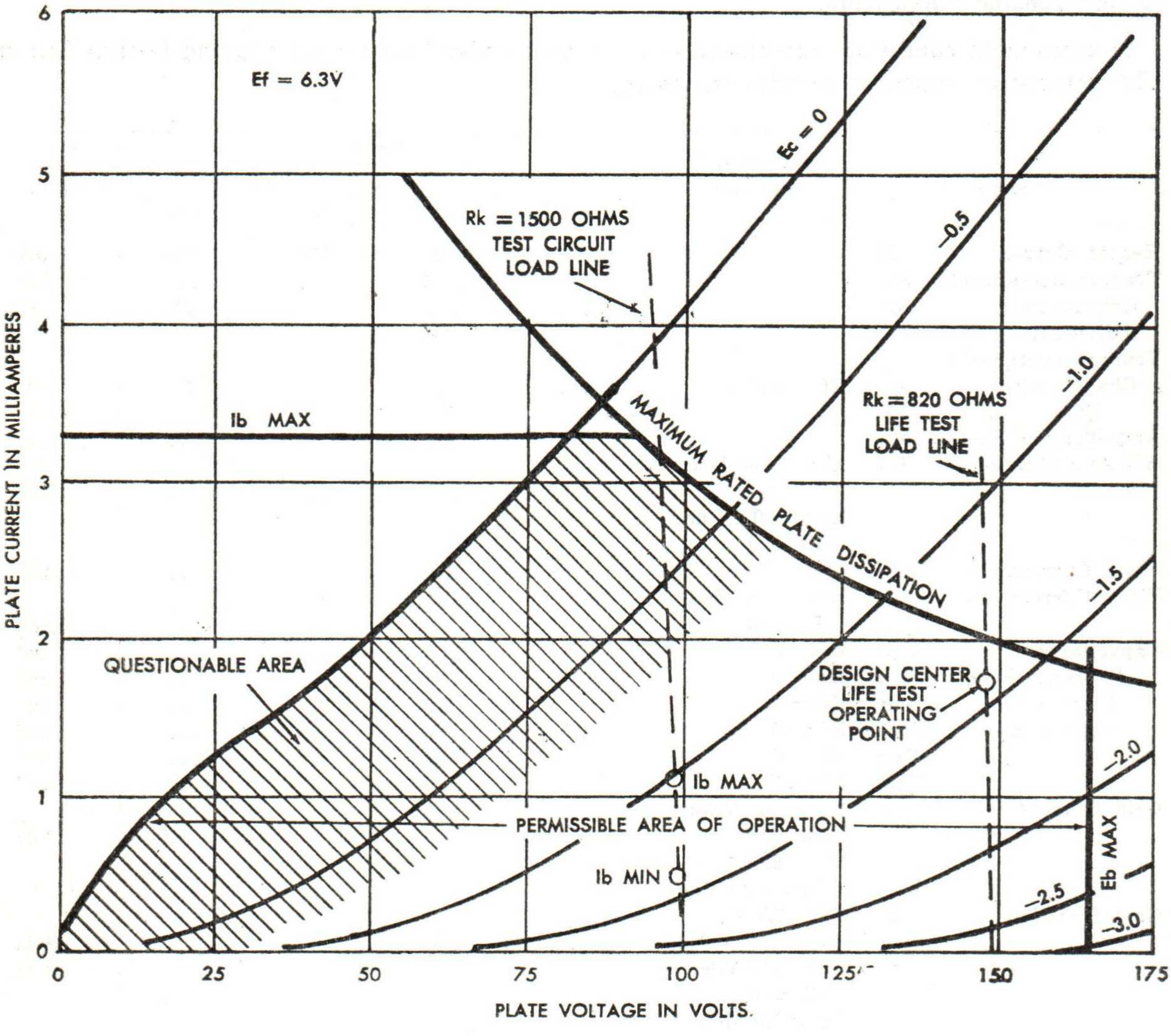


Figure 3-382. Average Static Plate Characteristics of JAN-6112; Permissible Area of Operation.

SPECIAL OPERATING CONDITIONS

In addition to the considerations noted above, JAN–6112 as reflected in Specification MIL–E–1/190C provides limited assurance of operation in the low plate-voltage, low plate-current region by an acceptance test for ac amplification using grid leak bias; 100 volt plate supply and 0.5 megohm plate load resistance. Any operation in this region other than that described above must be questioned, however, considering the variable effects that are manifested in the low-current and zero-bias regions.

VARIABILITY OF JAN–6112 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The chart below presents the limit behavior of static plate characteristics for JAN–6112 as defined by MIL–E–1/190C dated 14 May 1956.

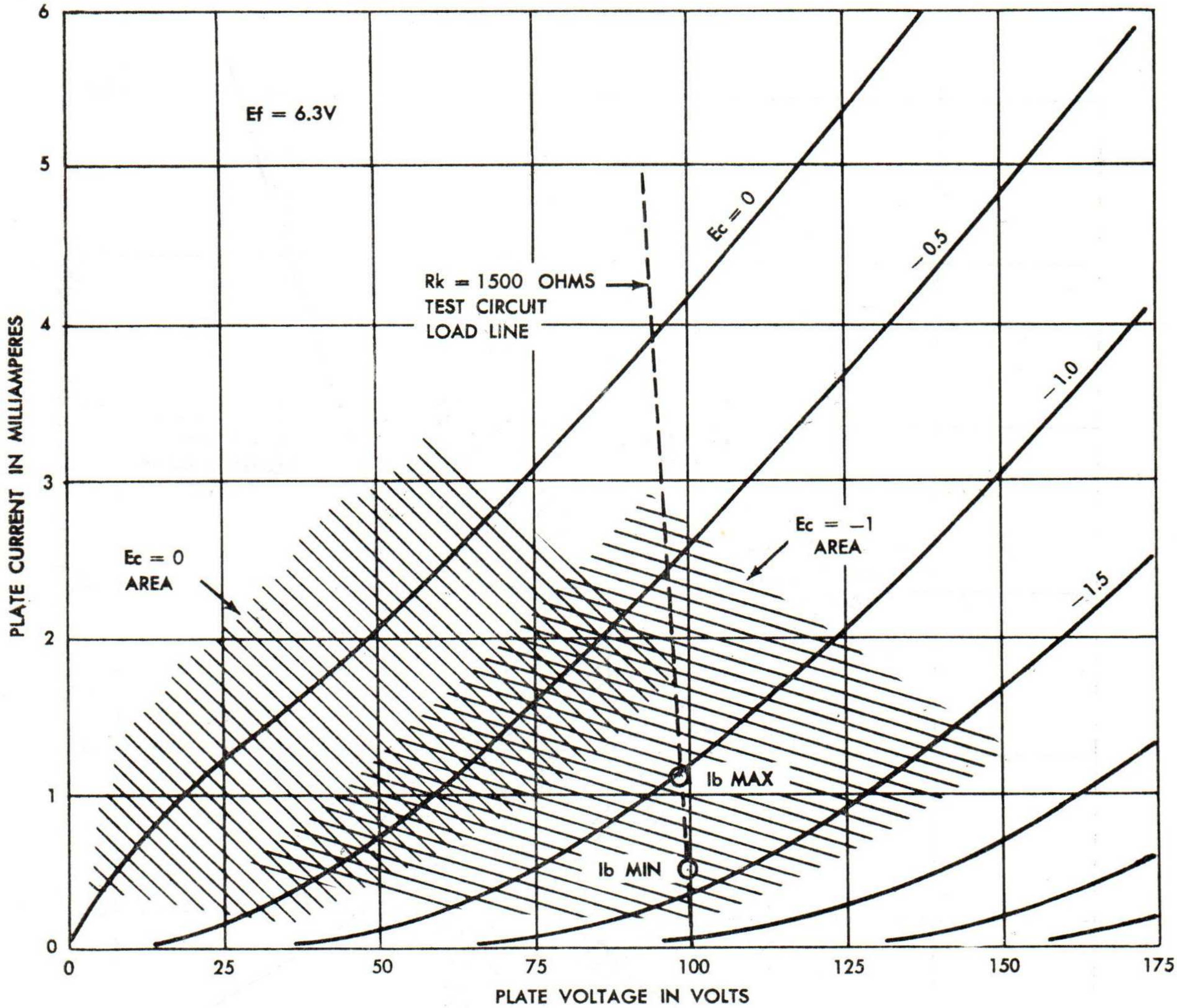


Figure 3-383. Limit Behavior of JAN-6112 Static Plate Data; Variability of Ib.

The chart below presents the limit behavior of transfer data for JAN–6112 as defined by MIL–E–1/190C dated 14 May 1956.

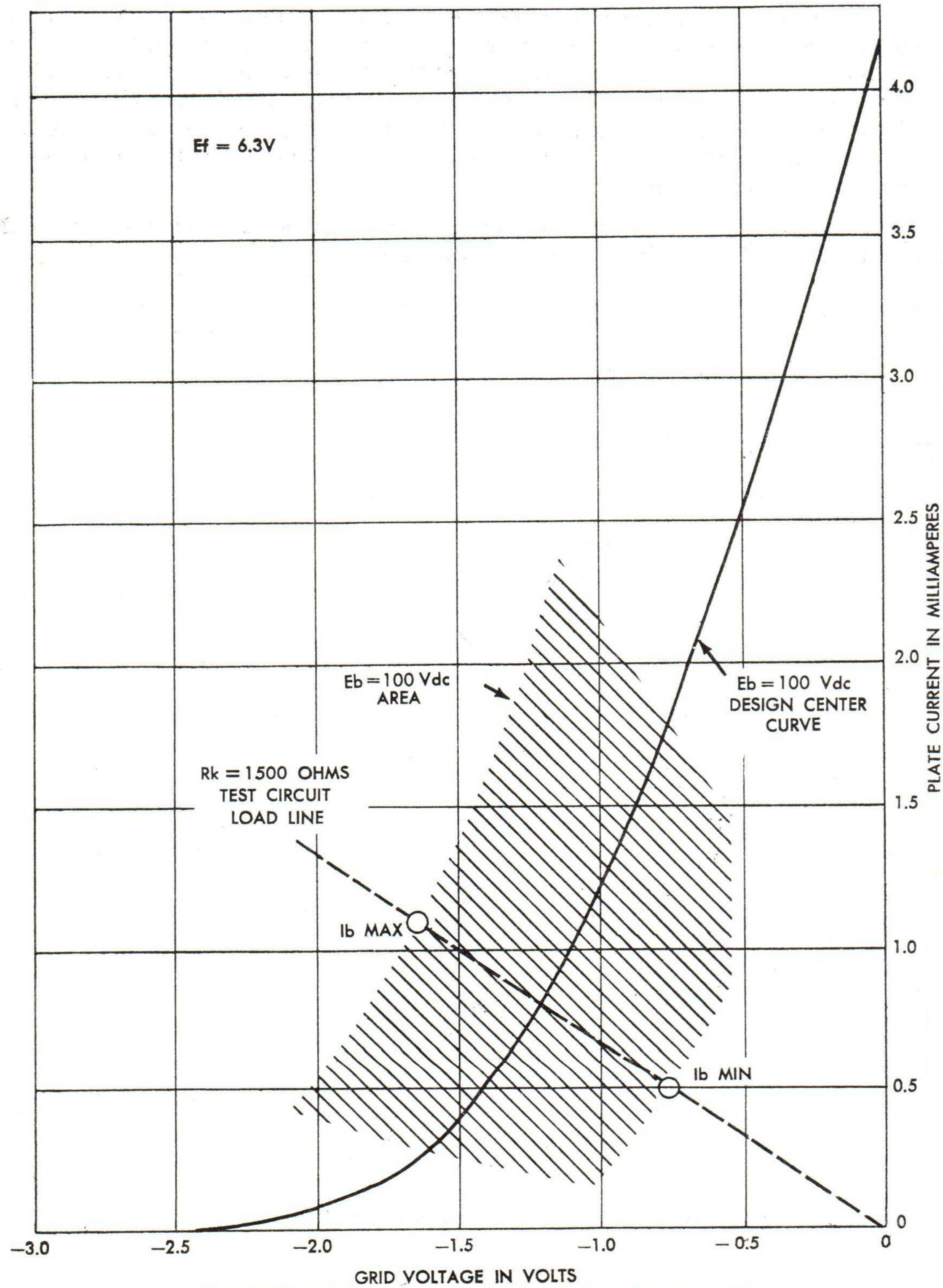


Figure 3-384. Limit Behavior of JAN-6112 Transfer Data; Variability of Ib.

DESIGN CENTER CHARACTERISTICS OF JAN–6112

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN–6112.

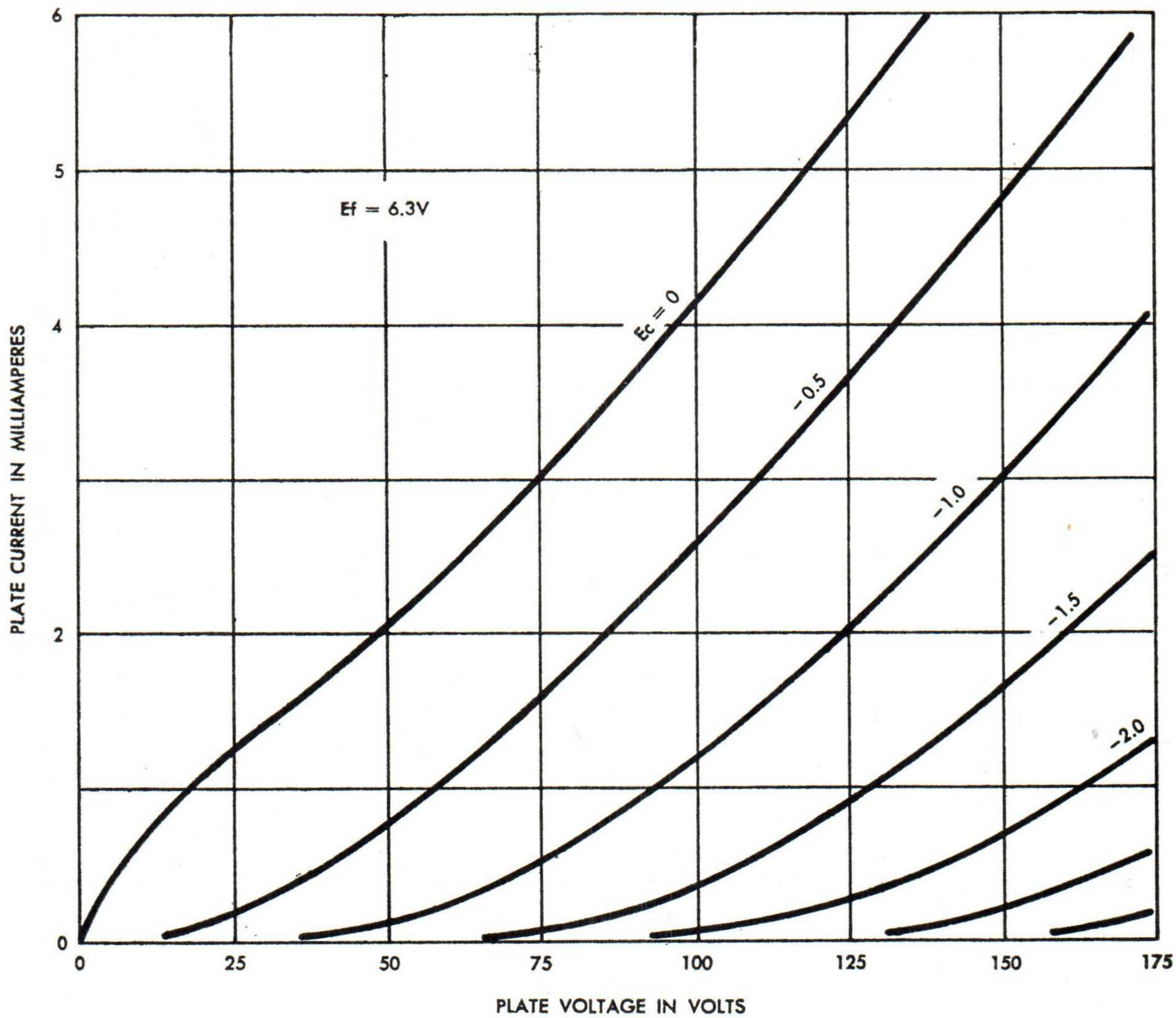


Figure 3-385. Average Static Plate Characteristics of JAN-6112.

The chart below presents the Average Plate Transfer Data for JAN-6112.

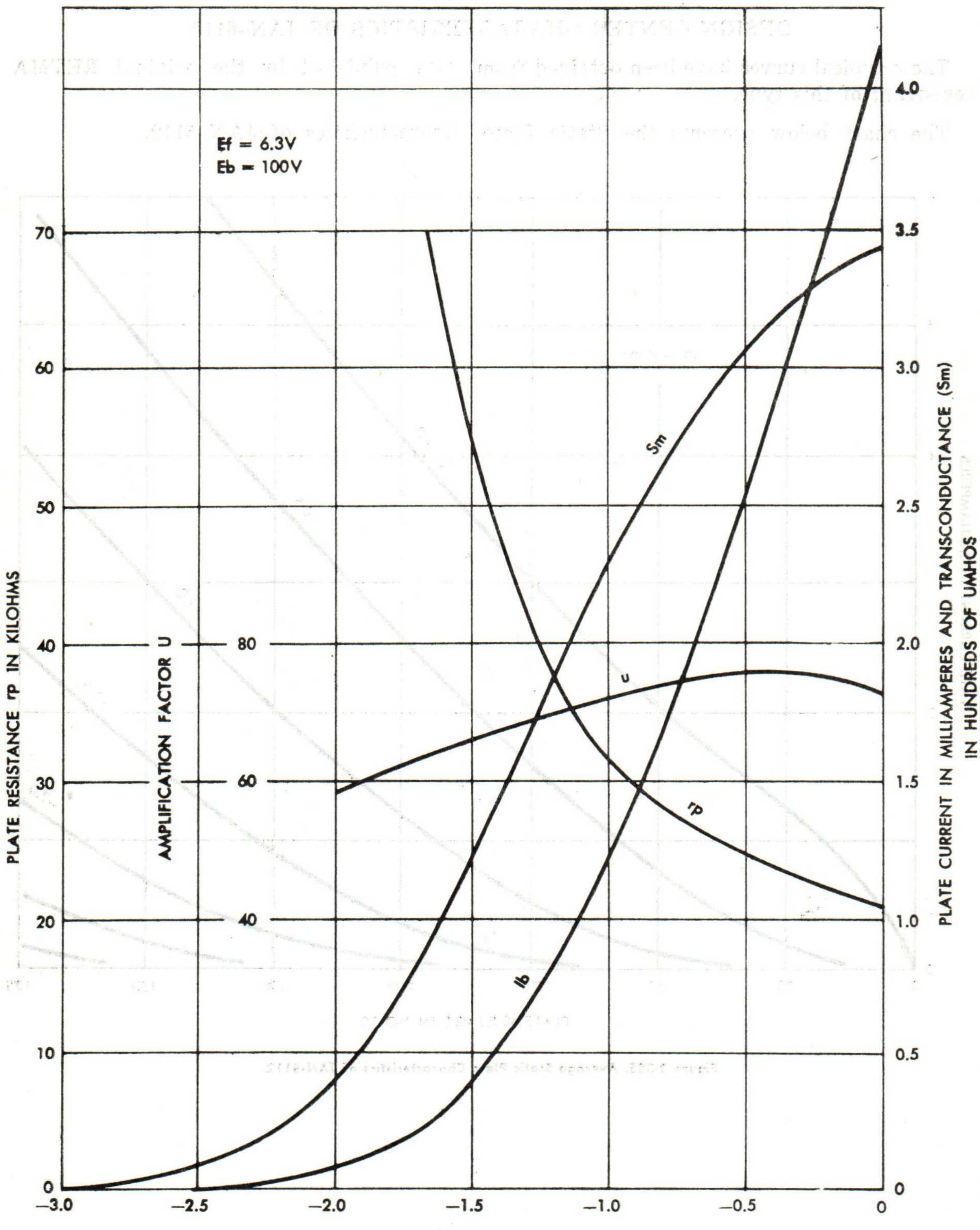


Figure 3-386. Average Transfer Characteristics of JAN-6112.

SECTION
TUBE TYPE JAN–6203

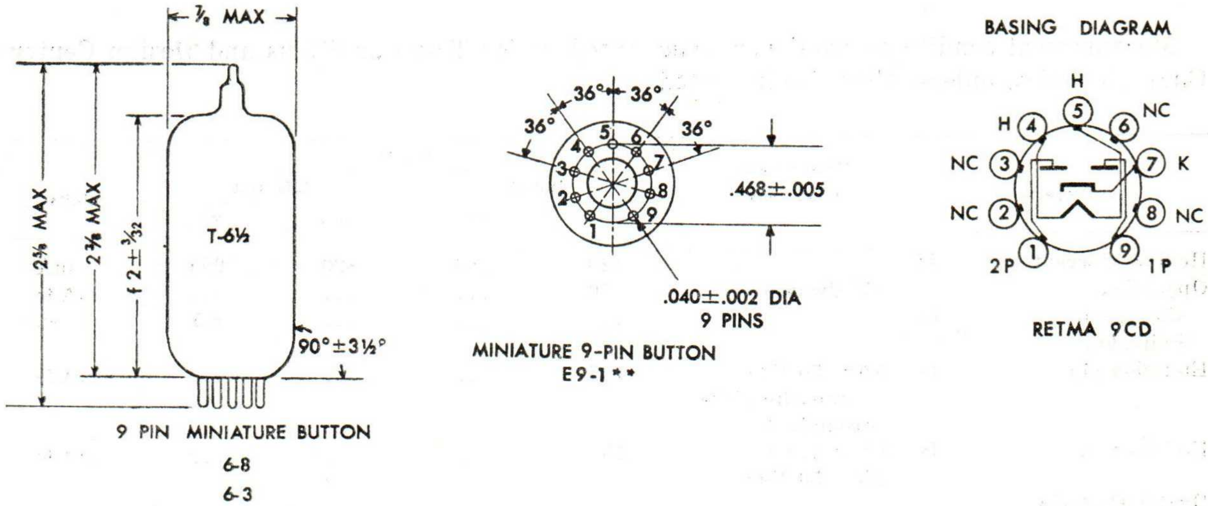
DESCRIPTION.

The JAN–6203 [1] is a 7 pin, miniature, full-wave, high-vacuum rectifier suitable for operation where the average dc output current does not exceed 70 milliamperes.

ELECTRICAL. The electrical characteristics are as follows:

Heater Voltage	6.3 V
Cathode	Coated Unipotential

MOUNTING. Any type of mounting is adequate.



ALL DIMENSIONS IN INCHES

* REFERS TO JETEC PUBLICATIONS J5-G2-1, NOVEMBER 1952
**REFERS TO JETEC PUBLICATION J0-G3-1, APRIL 1953

Figure 3-387. Outline Drawing and Base Diagram for JAN-6203.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage	6.3 V ± 0.6 V
Peak Inverse Plate Voltage	See Rating Chart I
Steady State Peak Plate Current (See Rating Chart II)	300 ma
*Transient Peak Plate Current (See Rating Chart III)	2.0 a
Bulb Temperature	180° C
Altitude Rating (See Altitude vs. Current and Voltage Charts)	60,000 ft

[1] The values and specification comments presented in this section are related to MIL-E-1/262A dated 23 June 1955.

* No measurement test at this rating exists in the specification.

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef .... 6.3 V
Plate Supply Voltage, Epp/p (unloaded) .... 400 Vac
Load Resistance (Unity Power Factor) .... 5800 ohms
Load Capacitance .... 8 uf

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properities for which measurement limits are provided. Specification MIL-E-1/262A dated 23 July 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits				Units
			Initial		Life test		
			Min	Max	Min	Max	
Heater Current	If		820	980	820	995	mA
Operation	Io	(Fullwave)	70	...	...	...	mAdc
Change in individual	Δ Io t		...	...	...	8.5	%
Emission (1)	Is	Eb = 50 Vdc (opposite plate grounded)	165	...	...	...	mAdc
Emission (2)	Is	Ef = 5.5 V Eb = 50 Vdc	150	...	...	...	mAdc
Heater-Cathode Leakage	Ihk	Ehk = —450 Vdc	...	75	...	75	uAdc
Insulation of Electrodes	R	Eb = —500 V	10	...	...	...	Meg

APPLICATION OF THE JAN-6203

Rating Chart, I, II, and III represent areas of permissible operation within which any application of the JAN-6203 must fall. Requirement of all charts must be satisfied simultaneously in capacitor-input filter applications.

RATING CHART I is based on absolute maximum rated conditions published in the specification. Point C corresponds to the simultaneous occurance of these two ratings, permissible only under choke-input filter conditions of rated dc output current into capacitor input filter. Area CDE is restricted to choke input service only.

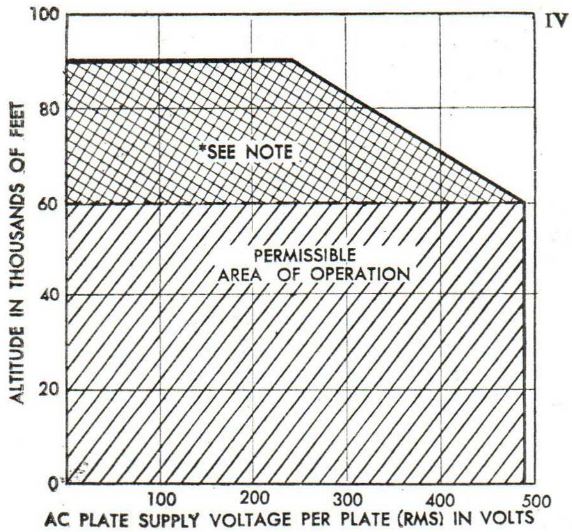


Figure 3-391. Rating Chart IV for JAN-6203.

Note: No specification assurance of life or behavior exists at pressures lower than 55 ± 5 mm of Hg (this pressure corresponds to an approximate altitude of 60,000 ft.)

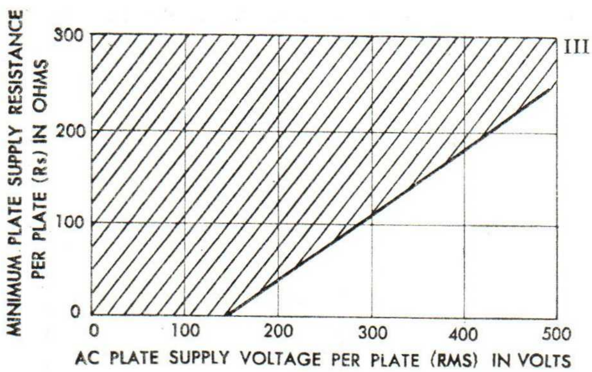


Figure 3-390. Rating Chart III for JAN-6203.

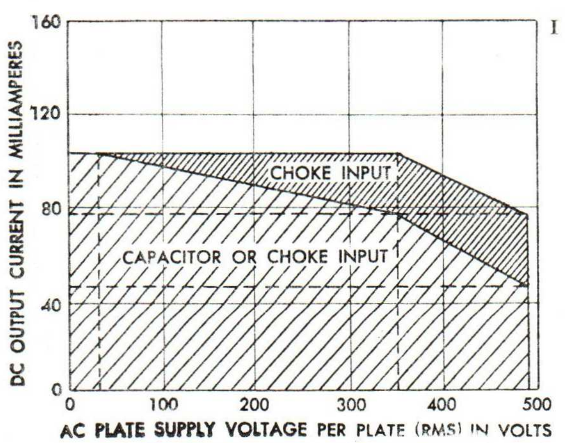


Figure 3-388. Rating Chart I for JAN-6203.

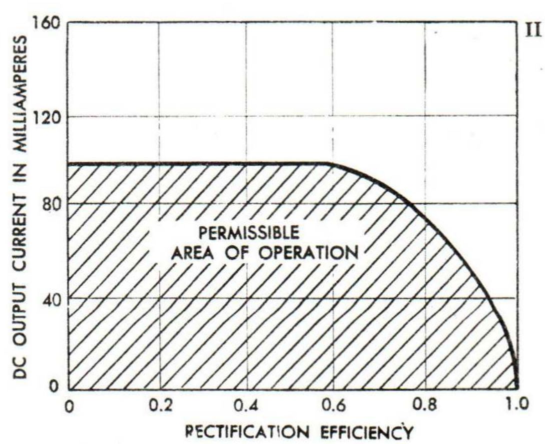


Figure 3-389. Rating Chart II for JAN-6203.

RATING CHART II for capacitor input filter applications, is based on maximum rated dc output current per plate (Io/p) and maximum rated steady state peak plate current of 300 milliamperes per plate. Rectification efficiency must not exceed 0.63 under conditions of maximum rated dc output current.

RATING CHART III for capacitor input filter is based on maximum rated surge current (i surge) of 2000 milliamperes per plate. Minimum permissible series resistance (Rs) is approximately 240 ohms per plate under conditions of maximum permissible supply voltage.

RATING CHART IV. ALTITUDE vs. VOLTAGE. This chart represents manufacturers rating information and is concerned with the plate supply voltage derating recommended at altitudes greater than 60,000 ft. It should be noted that no specification assurance of performance is afforded at altitudes greater than the MIL-E-1 absolute maximum.

TYPICAL CHARACTERISTICS OF JAN–6203

The chart below presents the Static Plate Characteristic of JAN–6203, reproduced from data published by the original RETMA registrant of the type. The extent of variation which may be exhibited among individual tubes cannot be completely derived from the specification which provides only limited information concerning emission.

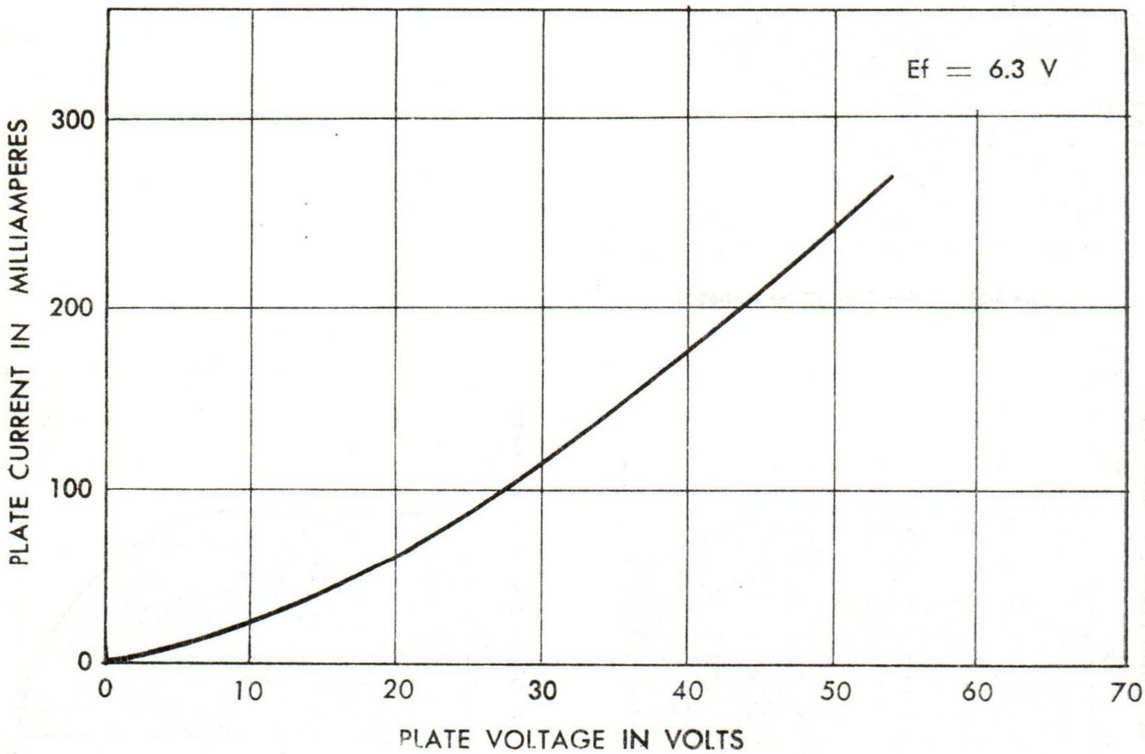


Figure 3-392. Typical Plate Characteristic of JAN-6203

SECTION
TUBE TYPE JAN-6533

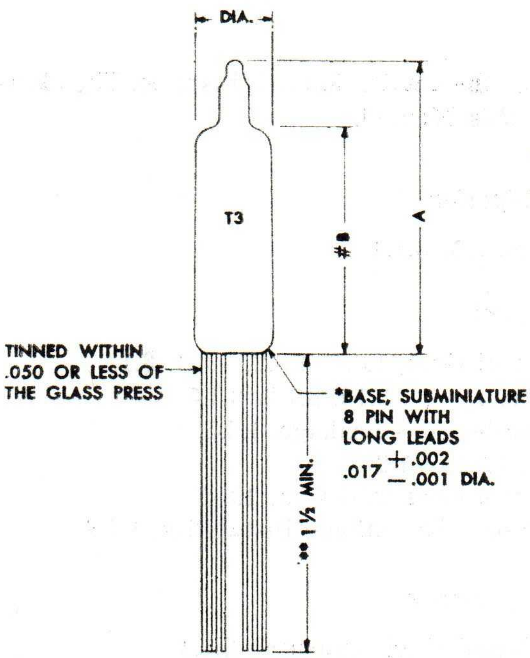
DESCRIPTION.

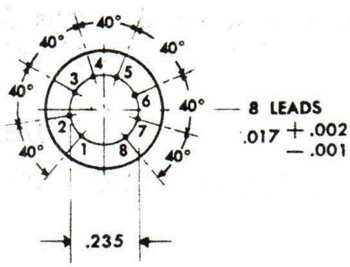
The JAN-6533 [1] is an 8 lead, button base, subminiature high Mu triode. It has a design center transconductance of 1750 micromhos. Specification tests provide assurance that microphonism of this type is approximately 20 db below other nearly equivalent types.

ELECTRICAL. The electrical characteristics are as follows:

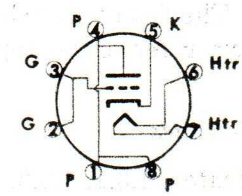
Heater Voltage .... 6.3 V
Heater Current, Design Center .... 200 mA
Cathode .... Coated Unipotential

MOUNTING. Any type of mounting is adequate.





LEAD CONNECTIONS



DIMENSIONS				
A MAX.	B		DIAMETER MAX	
	DIM	TOL. ±	C MAX	D MAX
1.500	1.300	.100	.385	.285

ALL DIMENSIONS IN INCHES

MEASURE FROM BASE SEAT TO BULB TOP-LINE AS DETERMINED BY RING GAGE OF .210 ± .001.

* LEAD DIAMETER TOLERANCE SHALL GOVERN BETWEEN .050 FROM THE GLASS TO .250 FROM THE GLASS.

** ALTERNATIVE LEAD LENGTH SHALL BE .200 ± .015 WHEN CUT LEADS ARE REQUIRED BY PROCUREMENT CONTRACT OR TSS. CUT LEADS SHALL BE ESSENTIALLY SQUARE CUT AND THE MAXIMUM BURR SHALL BE .003 INCREASE OVER THE ACTUAL LEAD DIAMETER.

Figure 3-393. Outline Drawing and Base Diagram of JAN-6533.

RATINGS, ABSOLUTE SYSTEM

The absolute system ratings are as follows:

Heater Voltage .... 6.3 ± 0.6 V
Plate Voltage .... 150 Vdc
Reference MIL-E-1C Section 6.5.1.1 *Plate Voltage*
Heater-Cathode Voltage .... 200 v

[1] The values and specification comments in this section are related to MIL-E-1/975 dated 5 December 1955.

RATINGS, ABSOLUTE SYSTEM (Continued)

Grid Series Resistance	1.2 Meg
Plate Current	2.5 mAdc
Plate Dissipation	0.5 W
Bulb Temperature	+220° C
Altitude Rating	60,000 ft

TEST CONDITIONS AND DESIGN CENTER CHARACTERISTICS

Test conditions and design center characteristics are as follows:

Heater Voltage, Ef	6.3 V
Plate Voltage, Eb	120 Vdc
Grid Voltage, Ec	0 Vdc
Heater-Cathode Voltage, Ehk	0 v
Cathode Resistance, Rk	1500 ohms
Heater Current, If	200 mA
Transconductance, Sm	1750 umhos

The following table lists general considerations for the applications of this type. The numbers refer to the applicable section or paragraph of this Manual.

Voltages

Heater, 1.3.1, 1.3.3, 1.3.4, 1.3.5, 1.3.8, 1.3.10, 3.1.5

Heater-Cathode, 1.3.7

Plate:
- High, 3.1.5
- Low, 3.1.5
- AC Operation, 1.3.3, 3.1.5
- 28 Volt, 3.1.5

Control Grid Bias:
- Low, 1.3.1, 1.3.2, 3.1.2
- Cathode, 2.1.1, 3.1.5
- Fixed, 1.3.1, 2.1.1, 3.1.3

Positive Grid Region, 3.1.5

Contact Potential, 1.3.1, 3.1.3, 3.1.5

Resistance

Control Grid Series, 1.3.2, 1.3.3, 1.3.4, 3.1.5

Cathode Interface, 1.3.10, 3.1.5

Cathode, 1.3.7, 2.1.1, 3.1.5

Dissipation

Plate, 2.1, 3.1.4

Current

Control Grid, 1.3.1, 1.3.2, 1.3.4, 3.1.2
Plate, Low, 1.3.10, 3.1.3, 3.1.5
Interelectrode Leakage, 1.3.5
Gas, 1.3.2, 3.1.2
Control Grid Emission, 1.3.3
Cathode, Thermionic Instability, 1.3.8

Temperature

Bulb and Environmental, 3.1.4

Miscellaneous

Pulse Operation, 3.1.5
Shielding, 3.1.4
Intermittent Operation, 3.1.5
Electron Coupling Effects, 1.3.9
Microphonics, 1.3.11, 3.1.5

SPECIAL CONSIDERATIONS

In addition to the general considerations referenced in the preceding table, the JAN-6533 as specified by MIL-E-1/975 has initial assurance of AC amplification and plate current cutoff as follows:

Plate Current Cut-Off is defined by two tests, one imposing a maximum Ib of 50 uAdc with -3.5 volt bias and a minimum Ib of 5 uAdc with -2.0 volt bias;

Vibration a test of microphonism under a 40 cps 15 G. Vibration environment reveals that acceptable tubes possess less than 85 microvolts (RMS) of noise—referenced to the grid by the test circuit.

ACCEPTANCE TEST LIMITS

The following table summarizes salient requirements set forth by the specification for which acceptance test limits exist. This table is in no wise intended to include all the properties for which measurement limits are provided. Specification MIL-E-1/975 dated 5 December 1955 should be referenced to determine further assurance of satisfactory operation in any specific application.

Measurement conditions are the same as stated under Test Conditions and Design Center Characteristics, unless otherwise indicated.

Property		Measurement Conditions	Limits: Initial Min	Initial Max	Life test Min	Life test Max	Units
Heater Current	If		187	213	185	215	mA
Transconductance (1)	Sm		1400	2100	...	...	umhos
Change in individual	Δ Sm t		...	...	...	20	%
Change in Average	Δ Sm t		...	...	...	15	%
Transconductance (2)	Δ Sm Ef		...	10	...	15	%
Amplification Factor	Mu		48	60	...	...	...
Plate Current (1)	Ib		.60	1.25	...	...	mAdc
Plate Current (2)	Ib	Ec = —3.5 Vdc; Rk = 0	...	50	...	...	uAdc
Plate Current (3)	Ib	Ec = —2.0 Vdc Rk = 0	5	...	...	...	uAdc
Vibration (2)	Ep	Rp = 10000; Ck = 1000 F = 40 CPS; G = 15	0	1.0	...	...	mVac
Capacitance	Cgp	Ef = 0	1.2	2.0	...	...	uuf
(Without shield)	Cin	Ef = 0	1.3	2.2	...	...	uuf
	Cout	Ef = 0	1.4	0.8	...	...	uuf
Grid Current	Ic		0	—0.1	0	—0.6	uAdc
Grid Emission	Ic	Ef = 7.5 V; Ec1 = —3.5 Vdc; Rg = 1.0 Meg	0	—0.3	...	...	uAdc
Heater-Cathode	Ihk	Ehk = +100 Vdc	...	5	...	10	uAdc
Leakage	Ihk	Ehk = —100 Vdc	...	—5	...	—10	uAdc
Insulation of	R(g-all)	Eg-all = —100 Vdc	...	...	50	...	Meg
Electrodes	R(p-all)	Ep-all = —300 Vdc	...	...	50	...	Meg

APPLICATION OF JAN-6533

The chart below shows the permissible operating area for JAN-6533 as defined by the rating in MIL-E-1/975 dated 5 December 1955. A discussion of the permissible operating area for triode tubes may be found in paragraph 3.1.2.

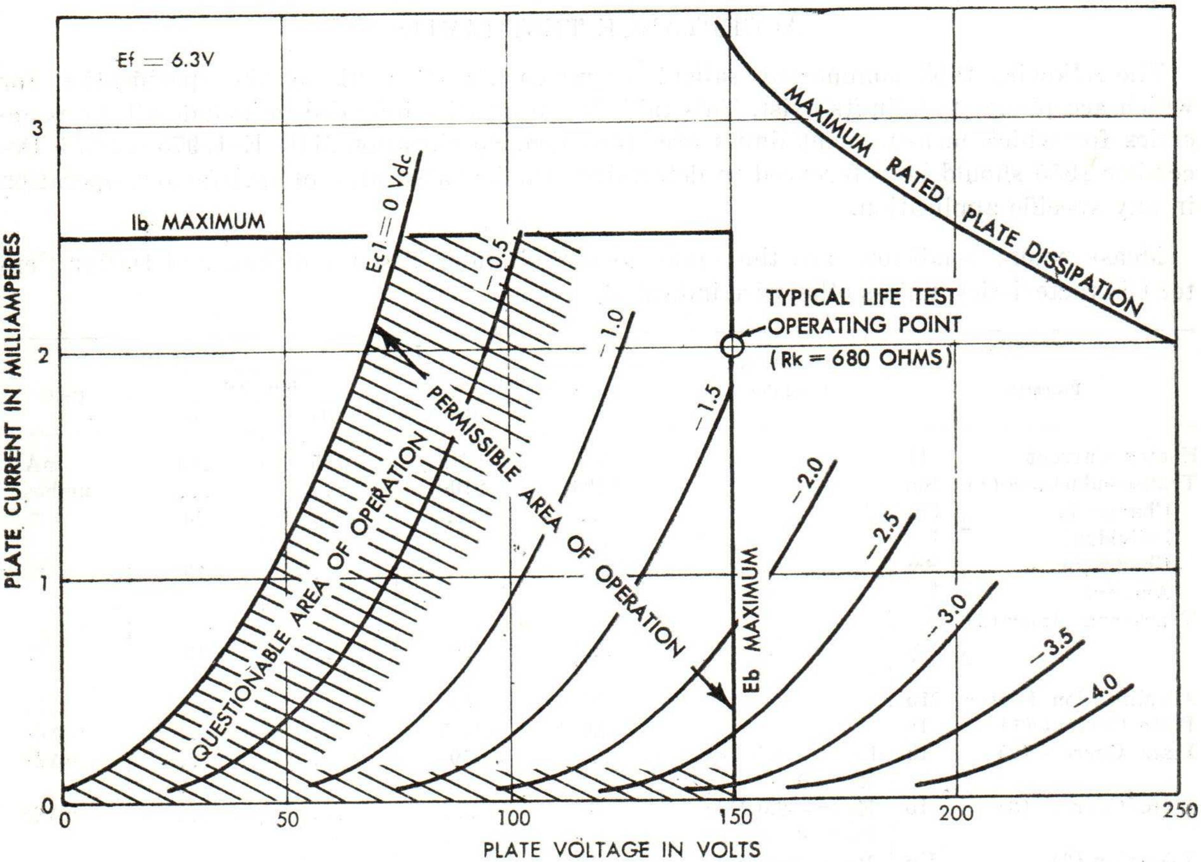


Figure 3-394. Typical Static Plate Characteristics of JAN-6533; Permissible Area of Operation.

VARIABILITY OF JAN-6533 CHARACTERISTICS

The published technical data which describe and define electron tubes, in general, present only average or center values. Consequently the variation inherent in a typical characteristic curve is frequently overlooked. The equipment designer has the responsibility for determining circuit design values compatible with the variation of tube characteristics. The following charts define the extent of variation which may be exhibited between individual tubes. The boundaries of this variability were determined from the acceptance limits given on the specification.

The charts below present the limit behavior of static plate and transfer characteristics for JAN-6533 as defined by MIL-E-1/975 dated 5 December 1955.

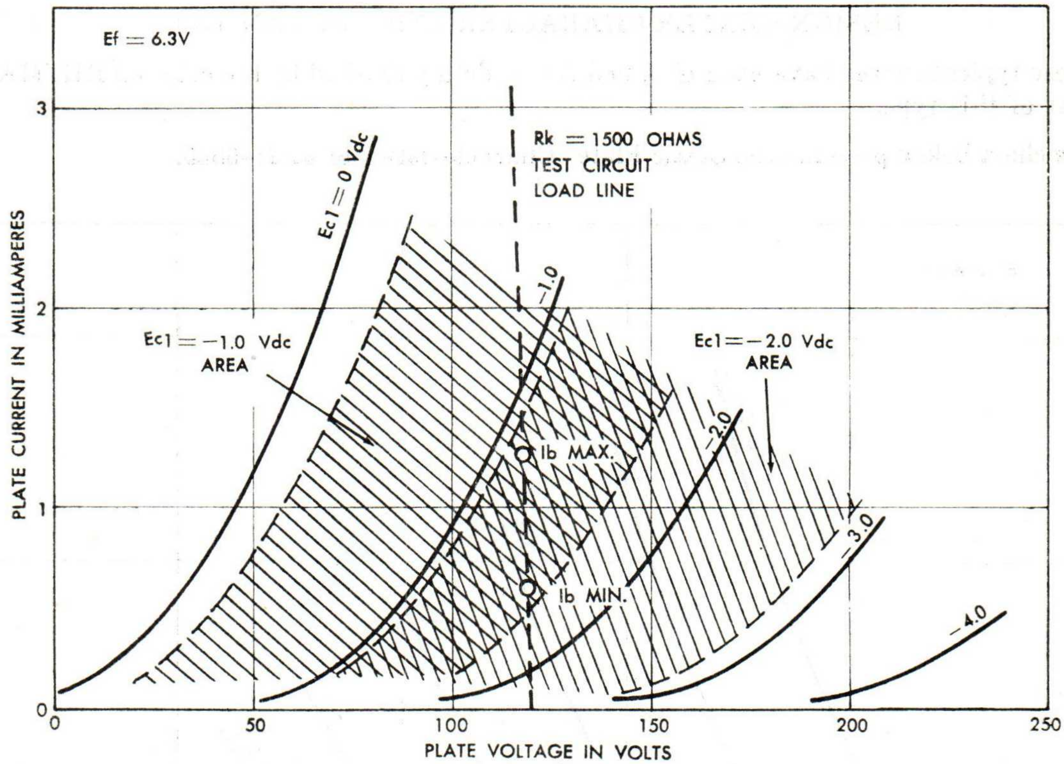


Figure 3-395. Limit Behavior of JAN-6533; Static Plate Data.

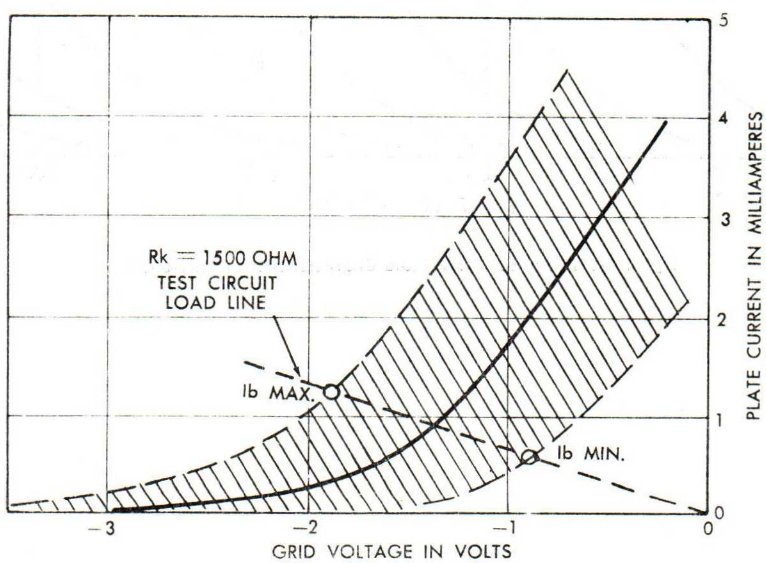


Figure 3-396. Limit Behavior of JAN-6533; Transfer Data.

DESIGN CENTER CHARACTERISTICS OF JAN-6533

These typical curves have been obtained from data published by the original RETMA registrant of this type.

The chart below presents the Static Plate Characteristics of JAN-6533.

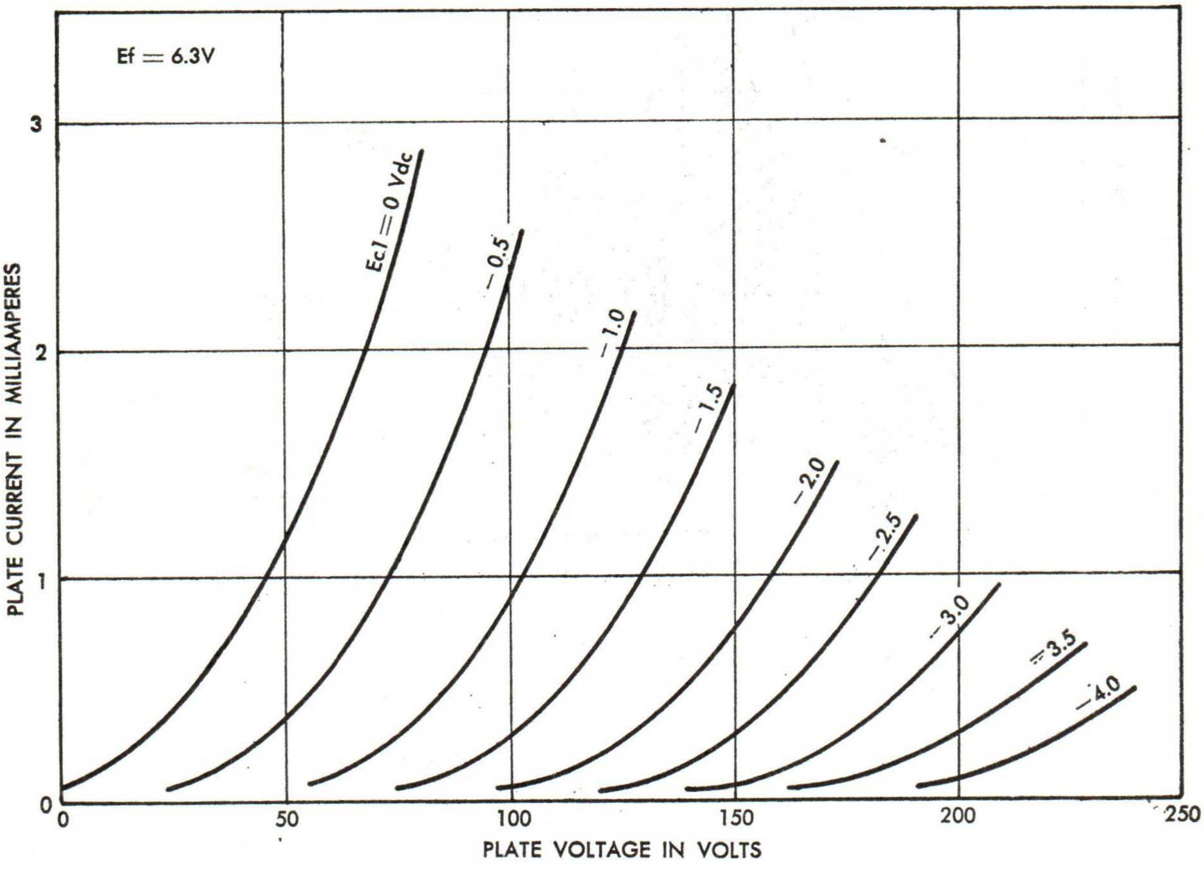


Figure 3-397. Typical Static Plate Characteristics of JAN-6533.

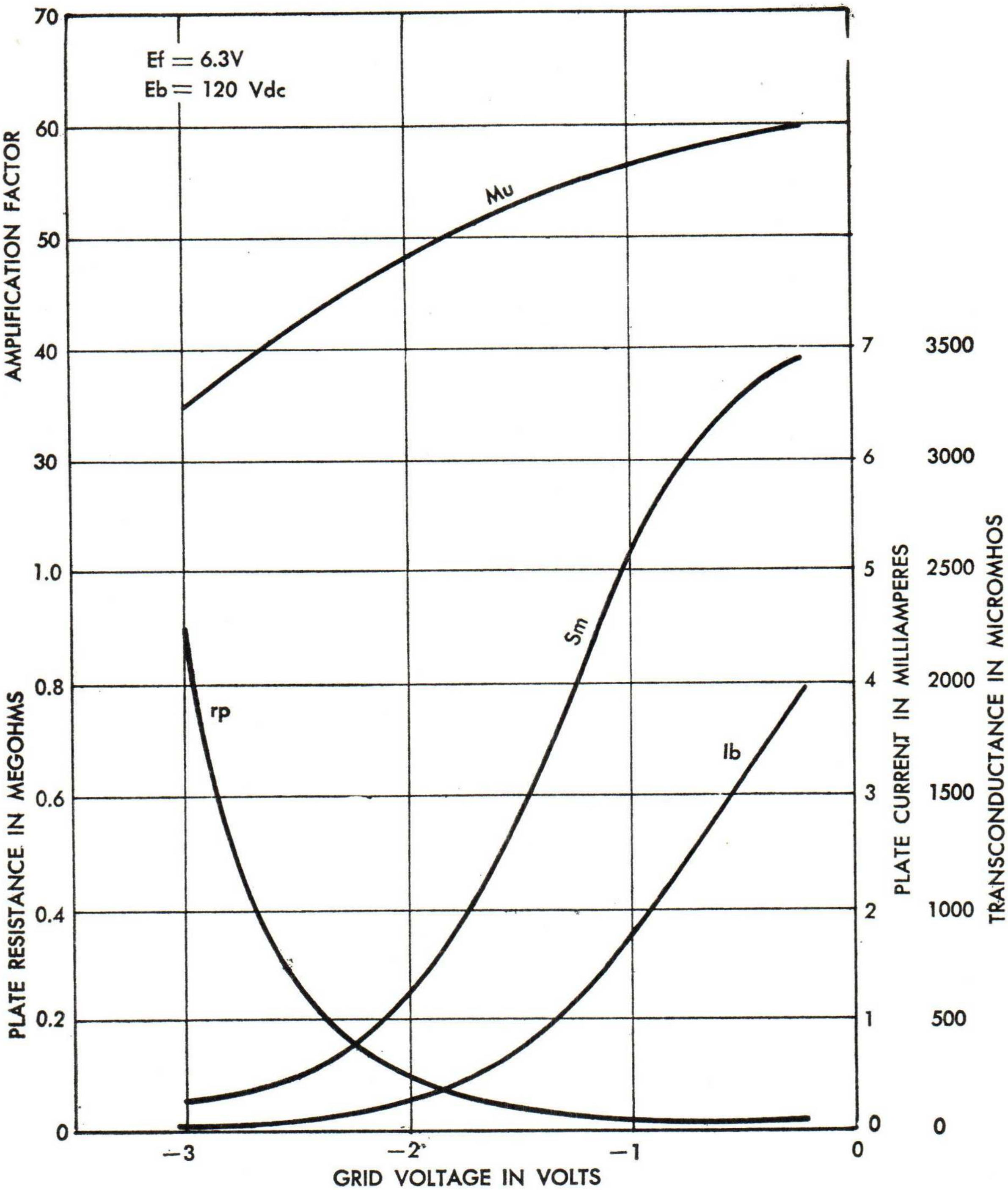


Figure 3-398. Typical Transfer Characteristics of JAN-6533.

PART IV
PROPERTY BEHAVIOR
OF THE RECEIVING TUBES
OF MIL-STD-200

PROPERTY BEHAVIOR OF THE RECEIVING TUBES OF MIL-STD-200

The histograms, charts, and tables in this part of the handbook were obtained from an analysis of data furnished by the qualified suppliers of each receiving tube type. The analysis is by no means complete and subsequent issues of this handbook will carry supplemental information.

In most cases the data was withdrawn from ten to twenty lots of the manufacturers' production, chosen randomly during the year 1956. In some instances, however, the data covers a larger span of time, or in the event of infrequent specification revision, may come from the previous year. The inoperatives data was developed from a summary furnished by several of the manufacturers of each type so treated. This summary was to extend backward in time, lot by lot, until either six failures had been obtained, the specification had been revised, or a severe processing change had been effected.

The analysis involved the handling of approximately 68,000 IBM cards. The tabled information presented on each histogram was computed by grouped data methods involving the cards. Information available for study on each histogram consists of the means and standard deviations of each hourly sumary, together with the $\pm$ 95% confidence limits on each. The moment ratios Beta 1 and Beta 2, as well as the sample size.

Study of part one and two of this handbook will aid in the interpretation of these parameters of the histograms.

The following data is arranged and paged in tube type order.

PROPERTY BEHAVIOR FOR JAN-1AD4

The histograms and data for Plate Current of JAN-1AD4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/20A dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

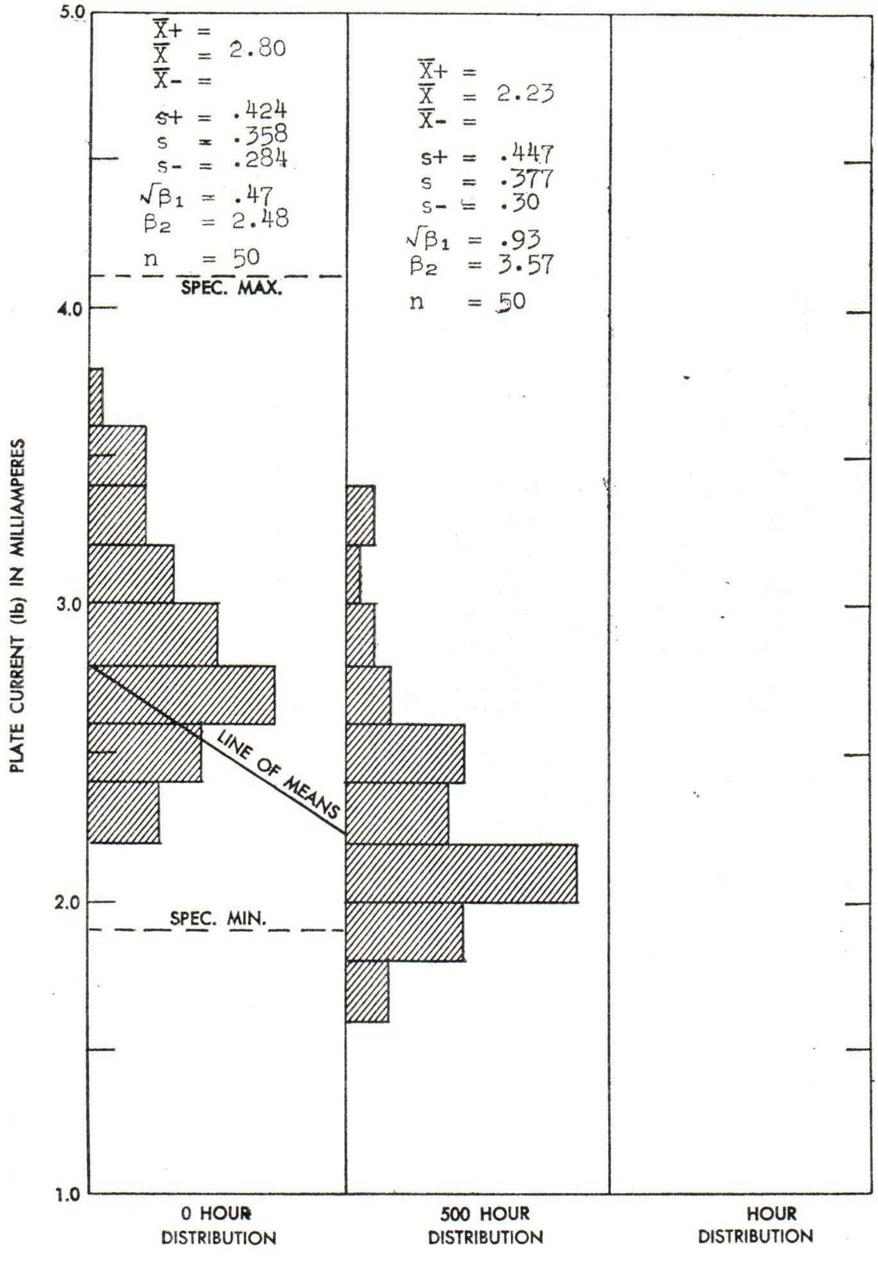


Figure 4-1. Distribution of Plate Current for JAN-1AD4.

PROPERTY BEHAVIOR FOR JAN–1AD4

The hisograms and data for Screen Current of JAN–1AD4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/20A dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

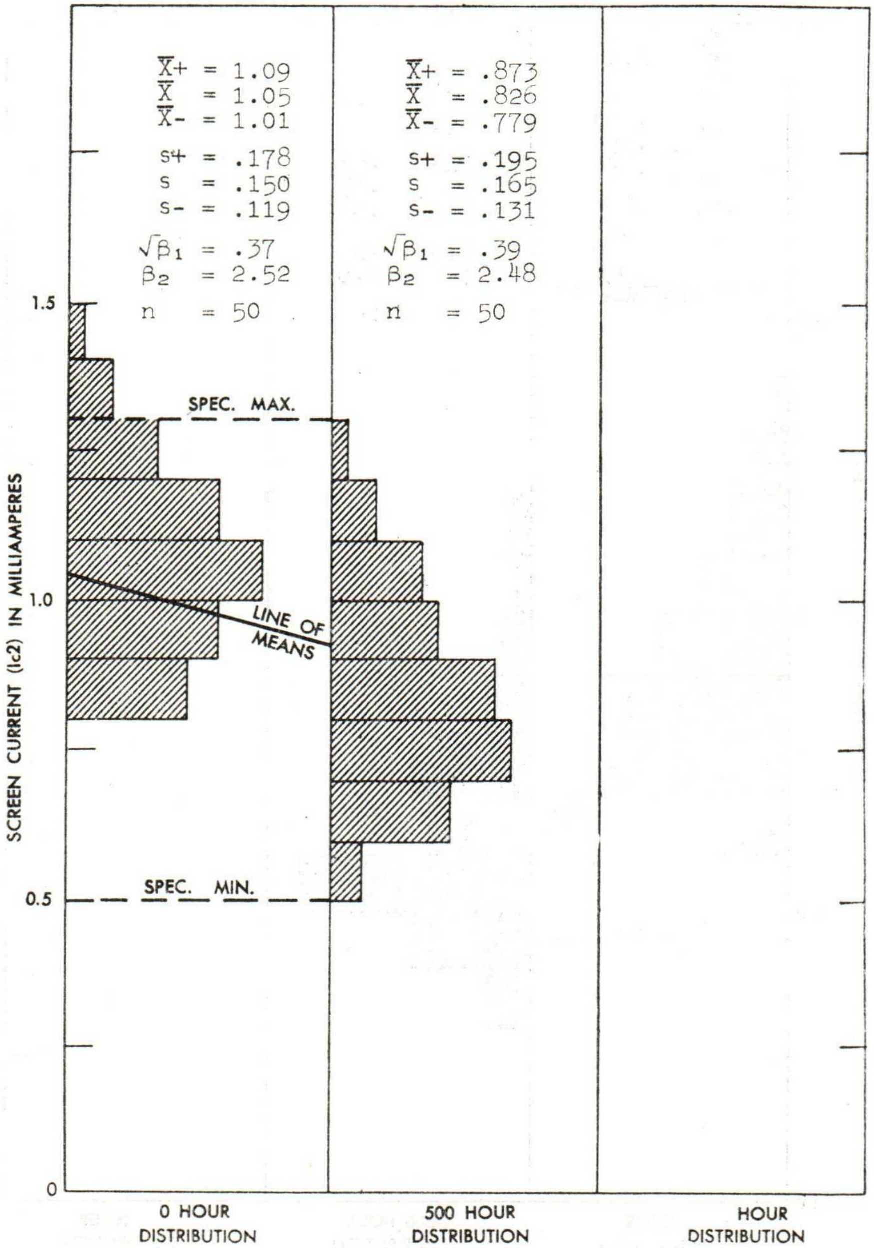


Figure 4-2. Distribution of Screen Grid Current for JAN-1AD4.

PROPERTY BEHAVIOR FOR JAN-1AD4

The histograms and data for Transconductance of JAN-1AD4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/20A dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

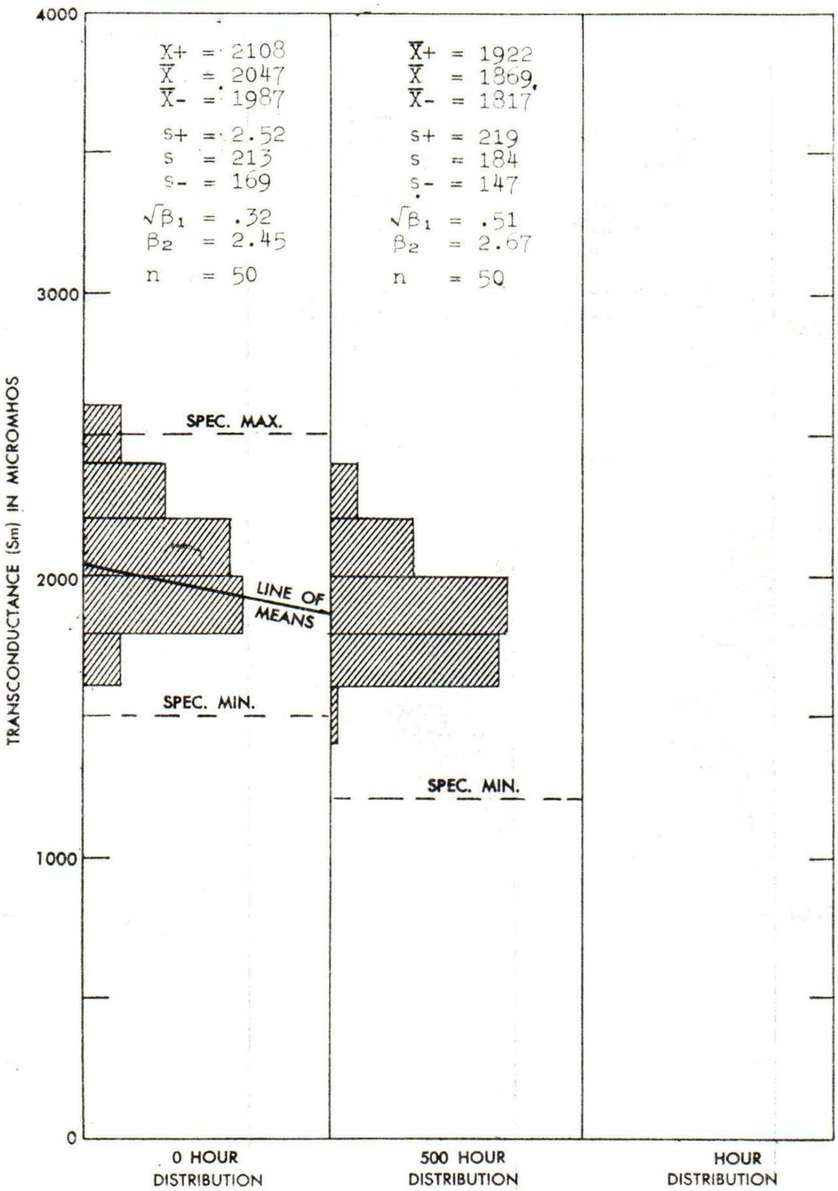


Figure 4-3. Distribution of Transconductance for JAN-1AD4.

PROPERTY BEHAVIOR FOR JAN-1AD4

The histograms and data for Reduced Ef Transconductance of JAN-1AD4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/20A dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

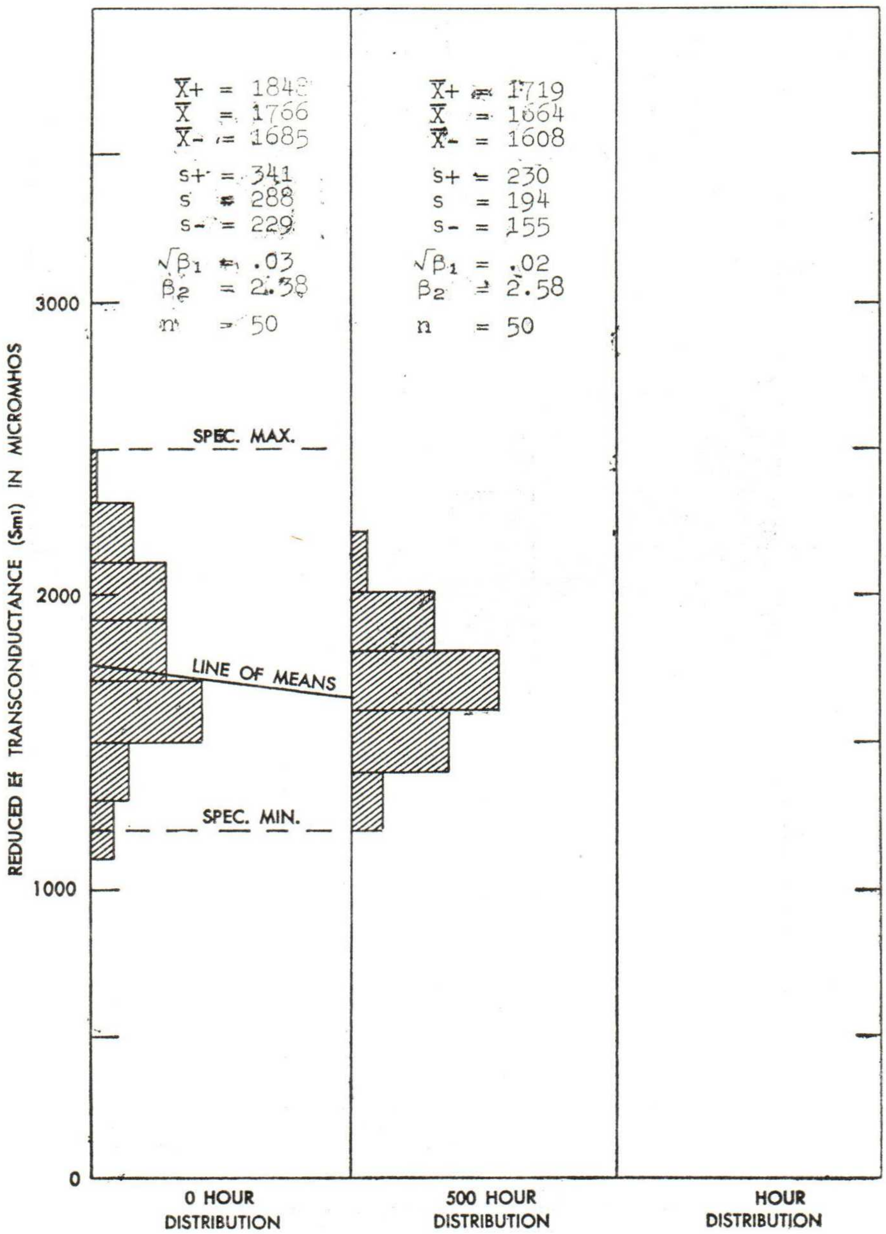


Figure 4-4. Distribution of Reduced Ef Transconductance for JAN-1AD4.

PROPERTY BEHAVIOR FOR JAN-1AH4

The histograms and data for Plate Current of JAN-1AH4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/316 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

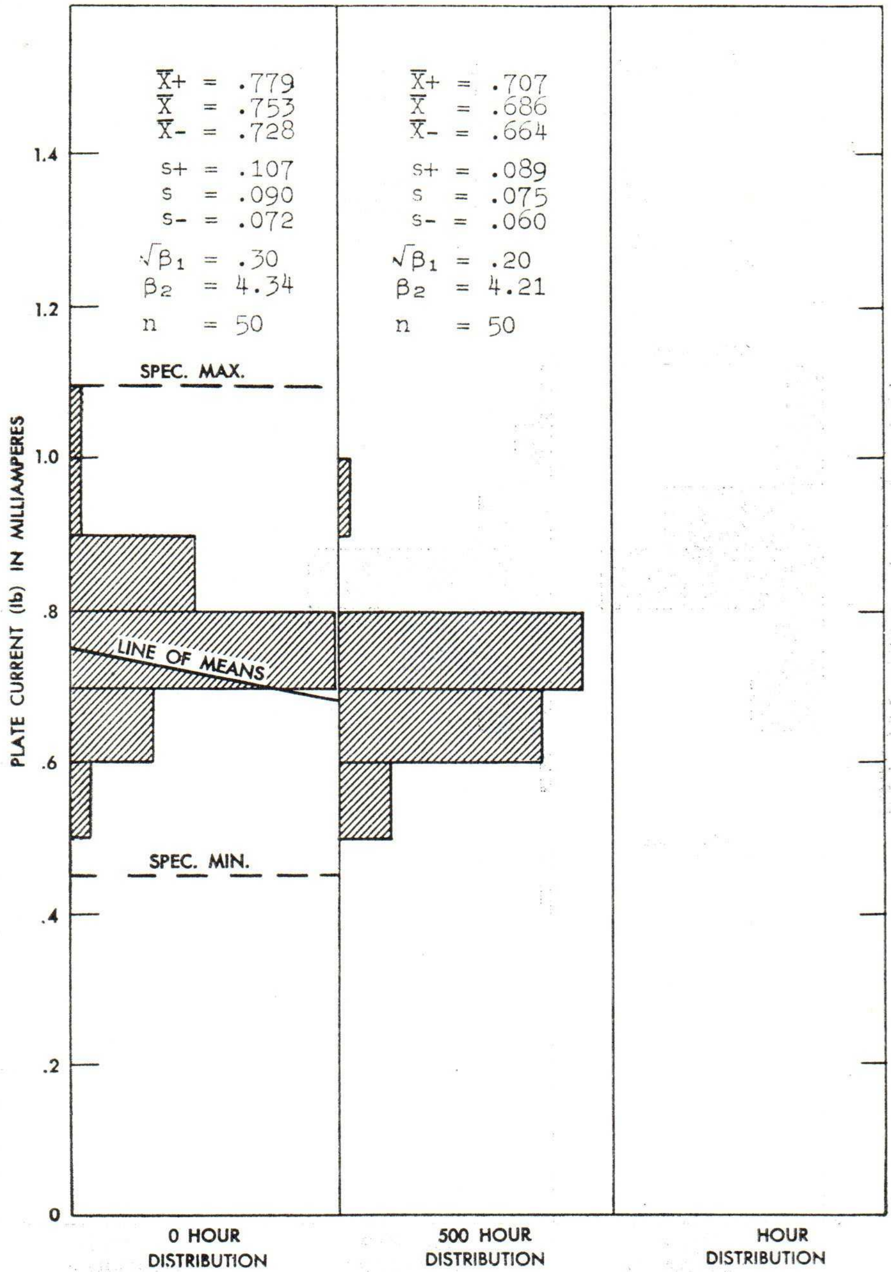


Figure 4-5. Distribution of Plate Current for JAN-1AH4.

PROPERTY BEHAVIOR FOR JAN-1AH4

The histograms and data for Screen Grid Current of JAN-1AH4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/316 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

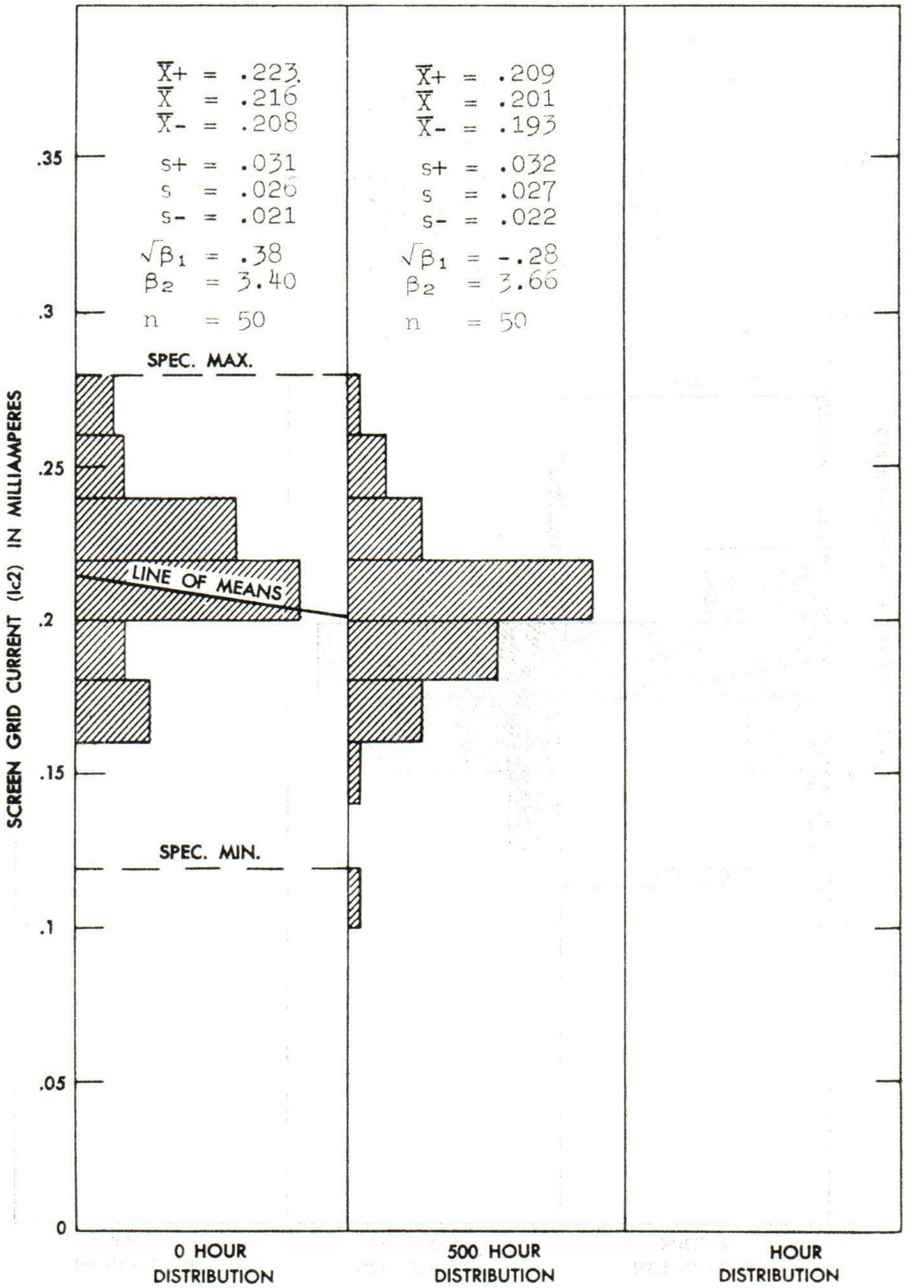


Figure 4-6. Distribution of Screen Grid Current for JAN-1AH4.

PROPERTY BEHAVIOR FOR JAN-1AH4

The histograms and data for Transconductance of JAN-1AH4 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/316 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

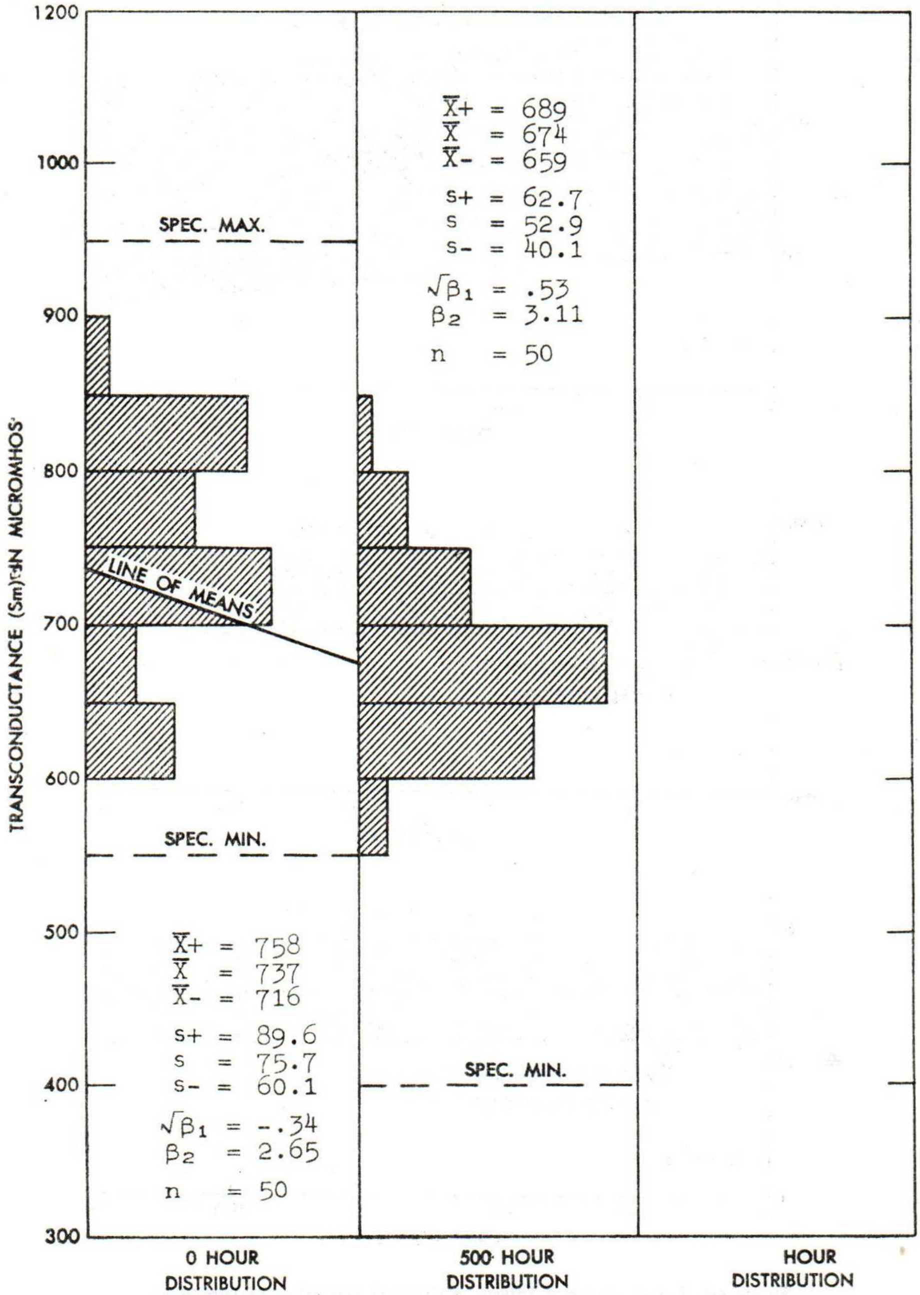


Figure 4-7. Distribution of Transconductance for JAN-1AH4.

REGRESSIONS AND TOLERANCE LIMITS OF PROPERTIES OF JAN-2C40

The regression lines and tolerance limits for the properties Po, Sm, and Ib for the tube type JAN-2C40 have been prepared from life tests of 1141 tubes manufactured and tested by the manufacturer of the type.

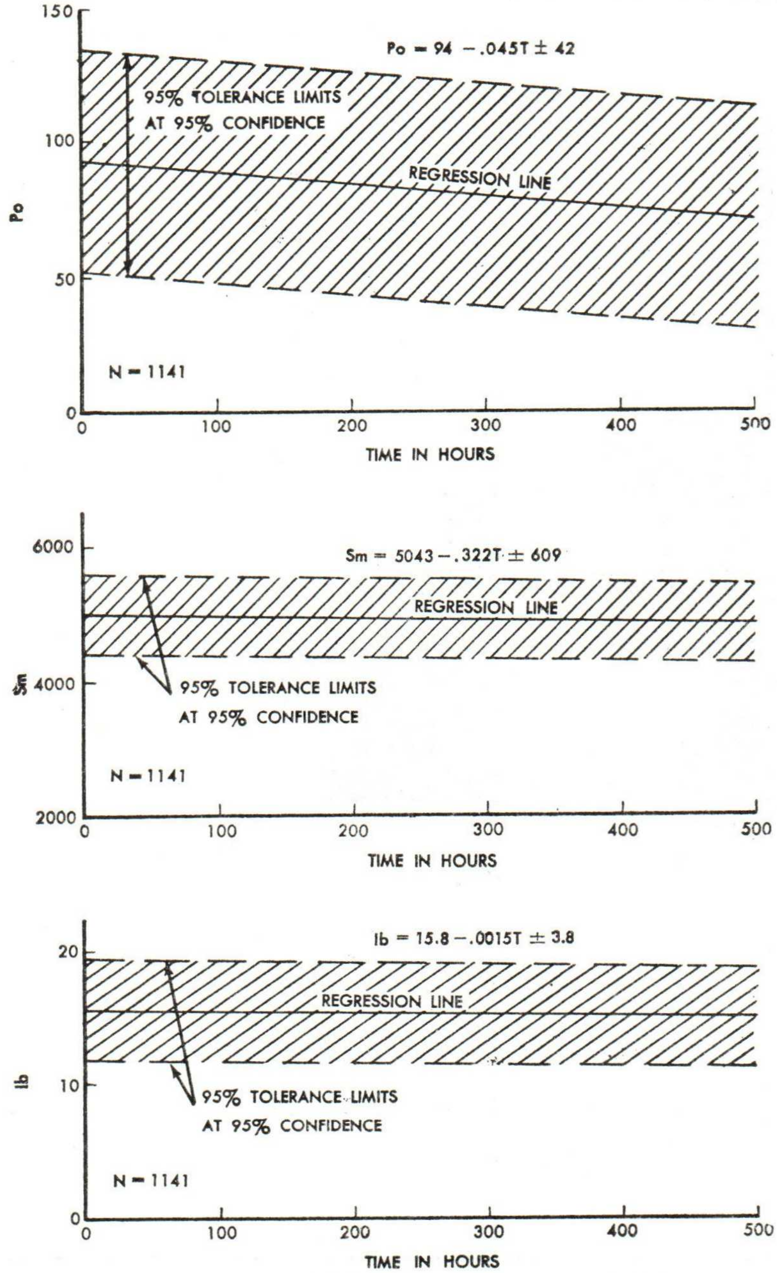


Figure 4-8. Regressions and Tolerance Limits of Properties of JAN-2C40.

PROPERTY BEHAVIOR FOR JAN-2E30

The histograms and data for Screen Grid Current of JAN-2E30 are based upon 100 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/32 dated 5 February 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

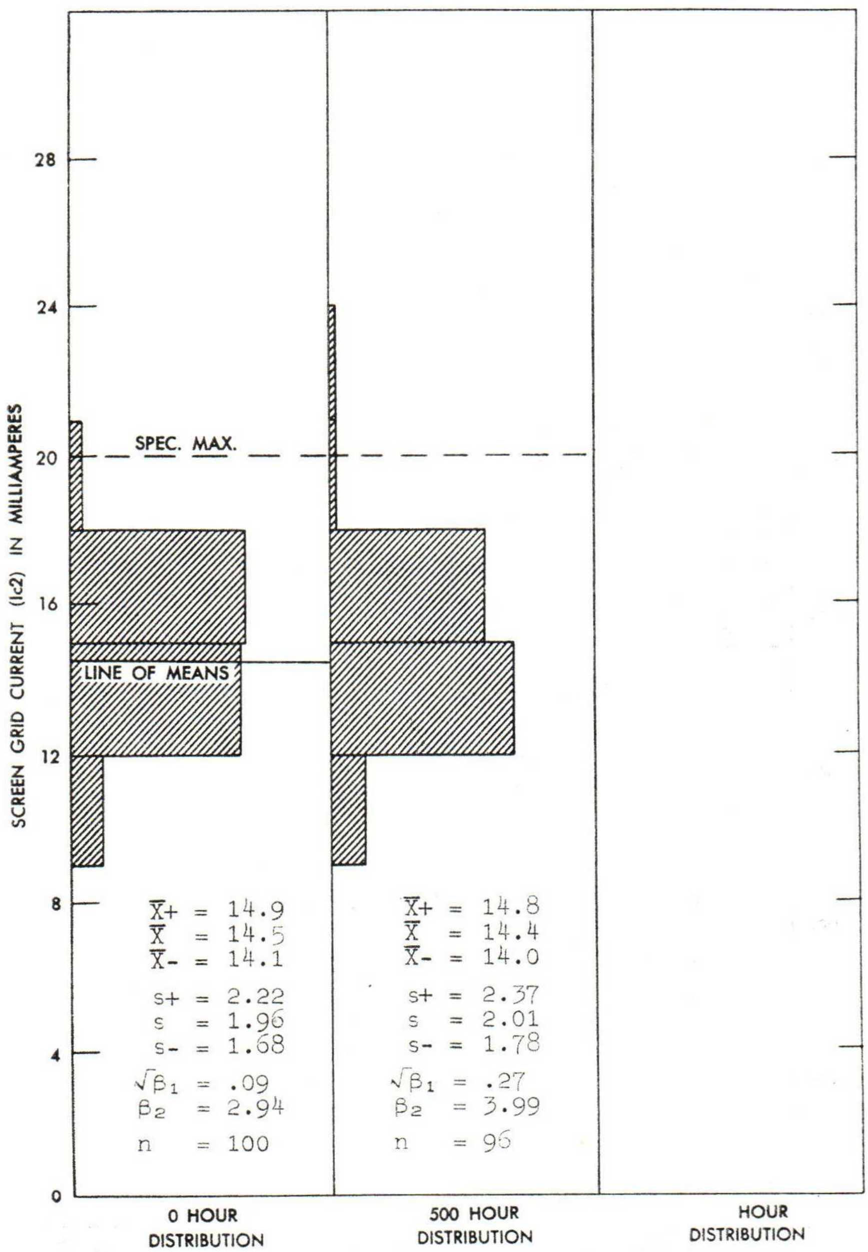


Figure 4-9. Distribution of Screen Grid Current for JAN-2E30.

PROPERTY BEHAVIOR FOR JAN-2E30

The histograms and data for Transconductance of JAN-2E30 are based upon 100 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/32 dated 5 February 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

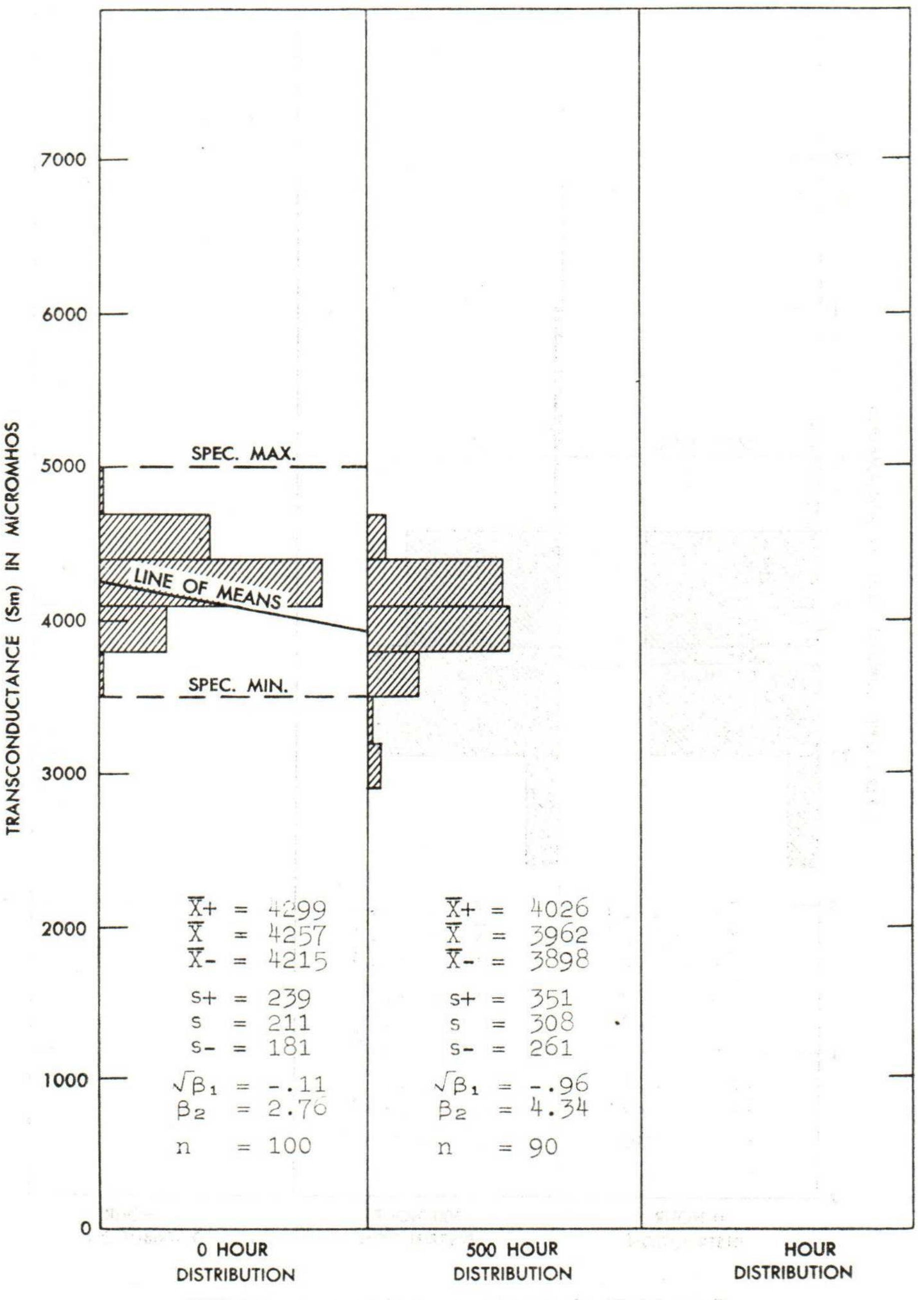


Figure 4-10. Distribution of Transconductance for JAN-2E30.

PROPERTY BEHAVIOR FOR JAN–3A5

The histograms and data for Plate Current of JAN–3A5 are based upon 220 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/33A dated 14 January 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

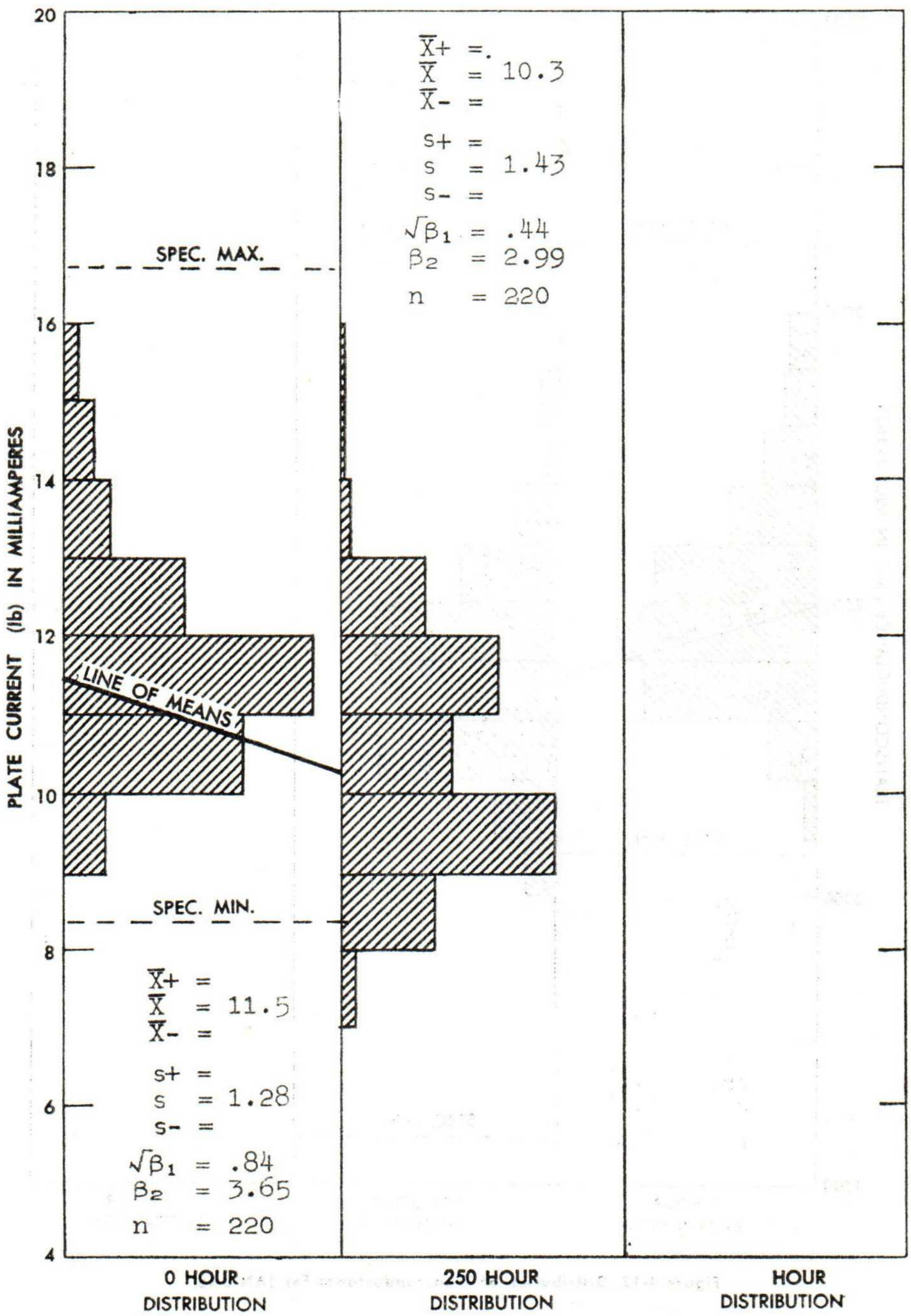


Figure 4-11. Distribution of Plate Current for JAN-3A5.

PROPERTY BEHAVIOR FOR JAN–3A5

The histograms and data for Transconductance of JAN–3A5 are based upon 220 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/33A dated 14 January 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

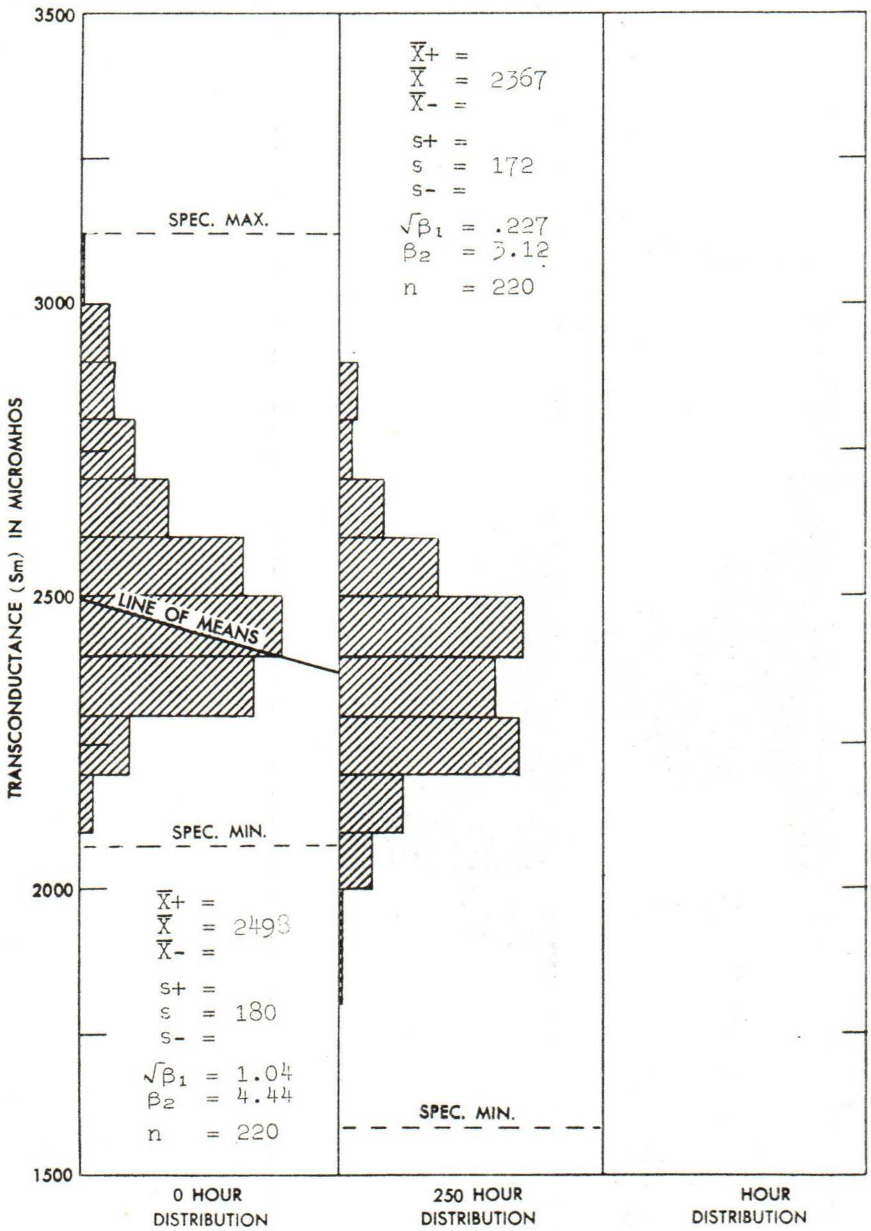


Figure 4-12. Distribution of Transconductance for JAN-3A5.

PROPERTY BEHAVIOR FOR JAN-3B4

The histograms and data for Plate Current of JAN-3B4 are based upon 60 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/34B dated 17 December 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

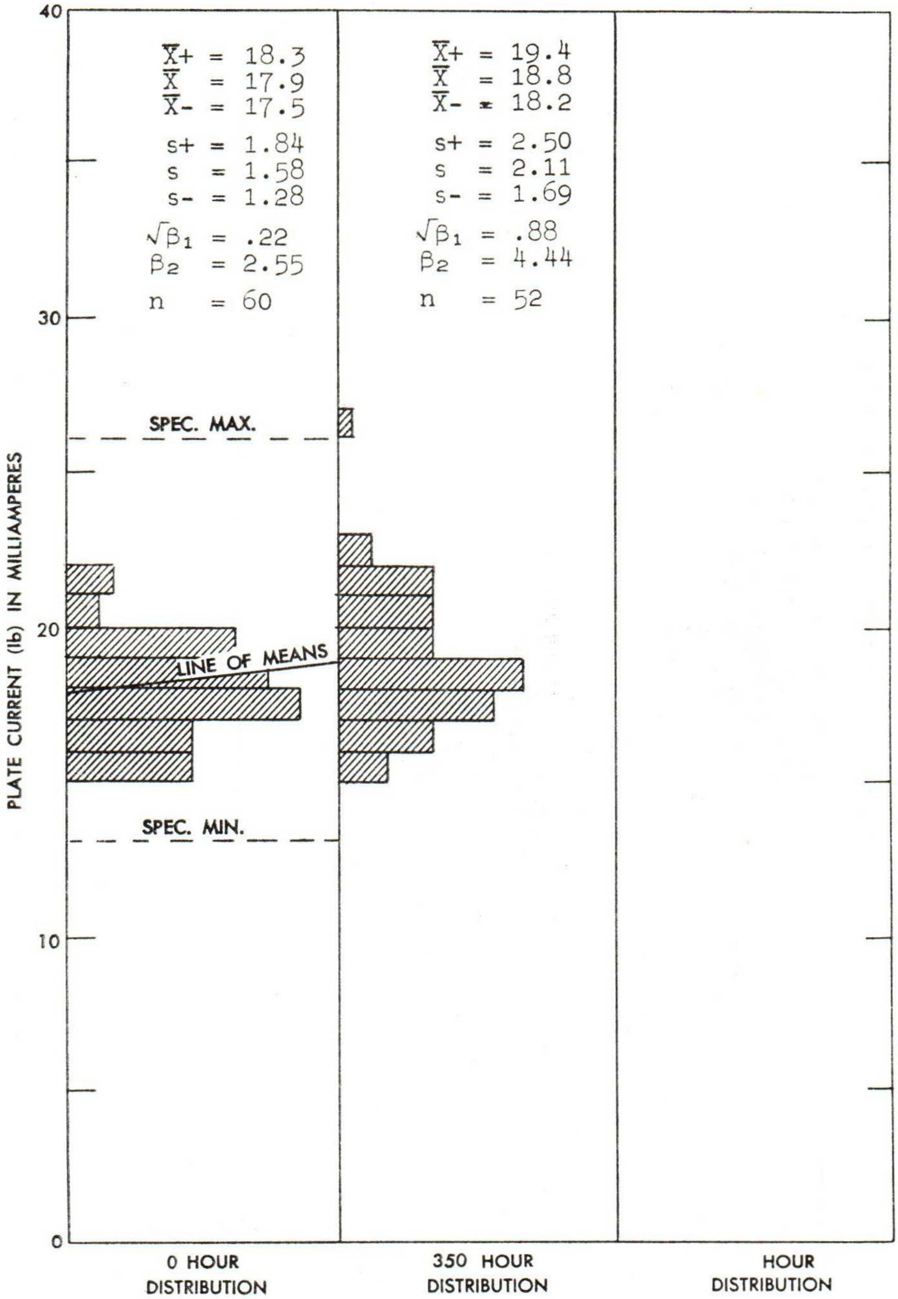


Figure 4-13. Distribution of Plate Current for JAN-3B4.

PROPERTY BEHAVIOR FOR JAN-3B4

The histograms and data for Operation Screen Grid Current of JAN-3B4 are based upon 100 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/34B dated 17 December 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

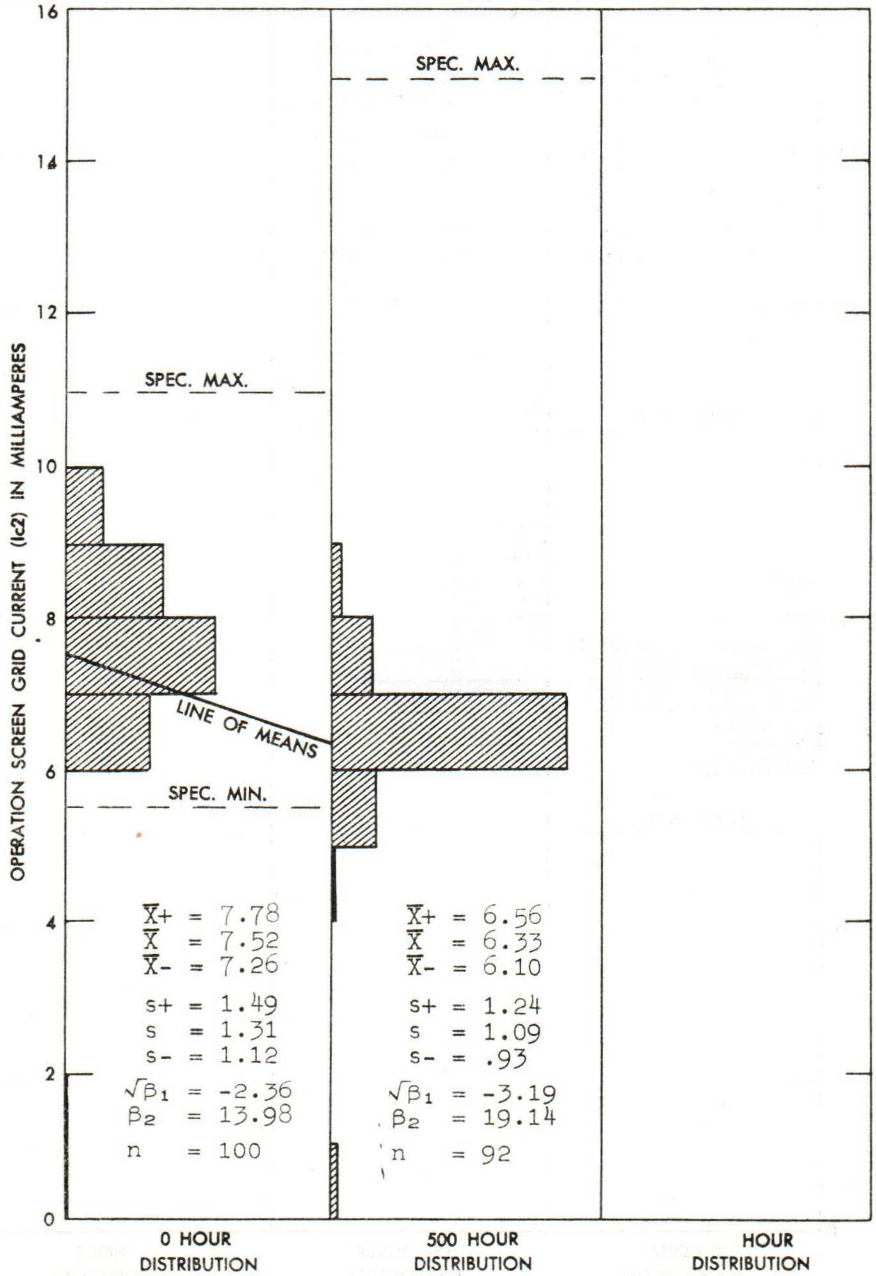


Figure 4-14 Distribution of Operation Screen Grid Current for JAN-3B4.

PROPERTY BEHAVIOR FOR JAN-3B4

The histograms and data for Transconductance of JAN-3B4 are based upon 38 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/34B dated 17 December 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

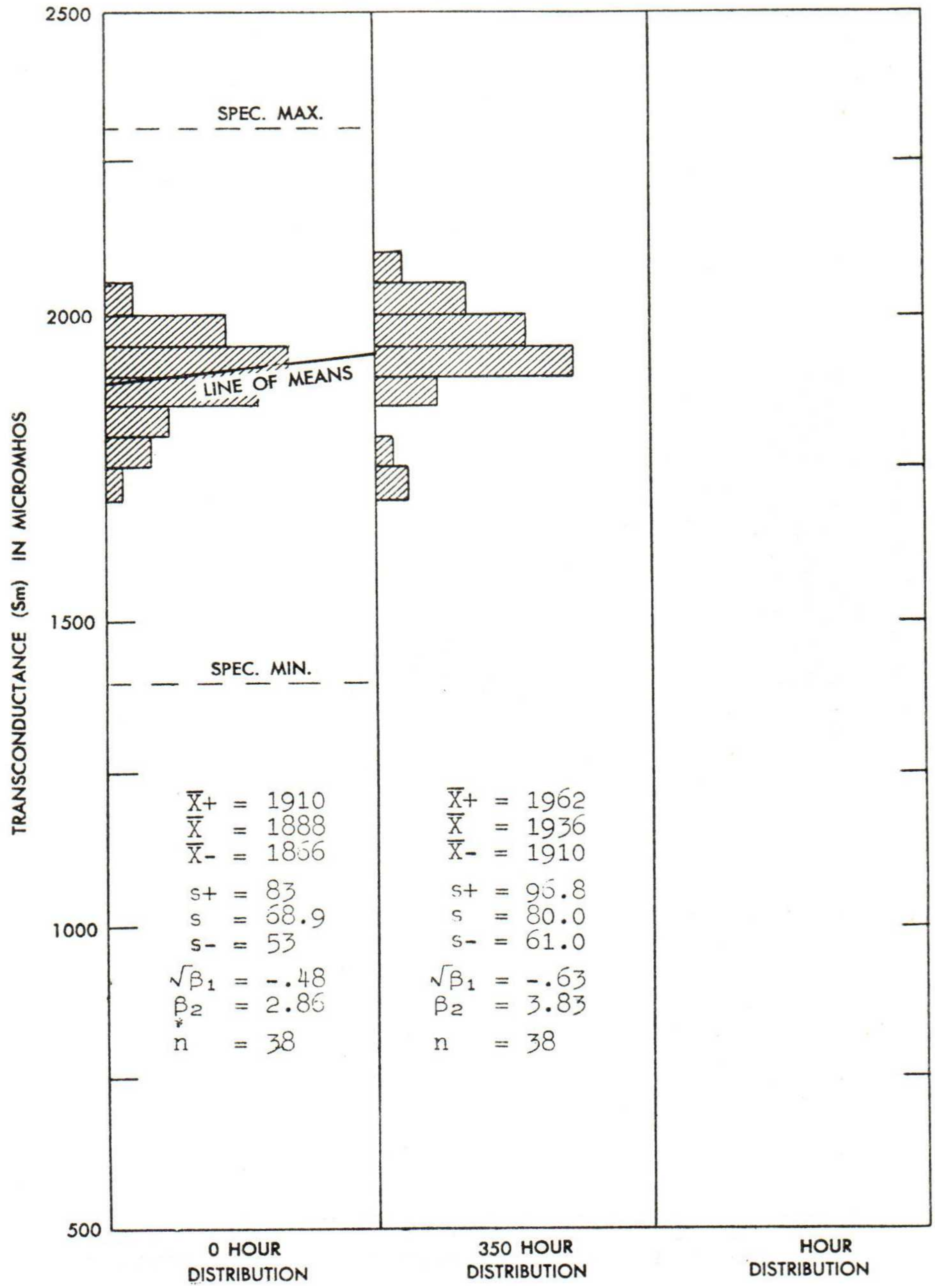


Figure 4-15. Distribution of Transconductance for JAN-3B4.

PROPERTY BEHAVIOR FOR JAN–3V4

The histograms and data for Plate Current of JAN–3V4 are based upon 354 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/343 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

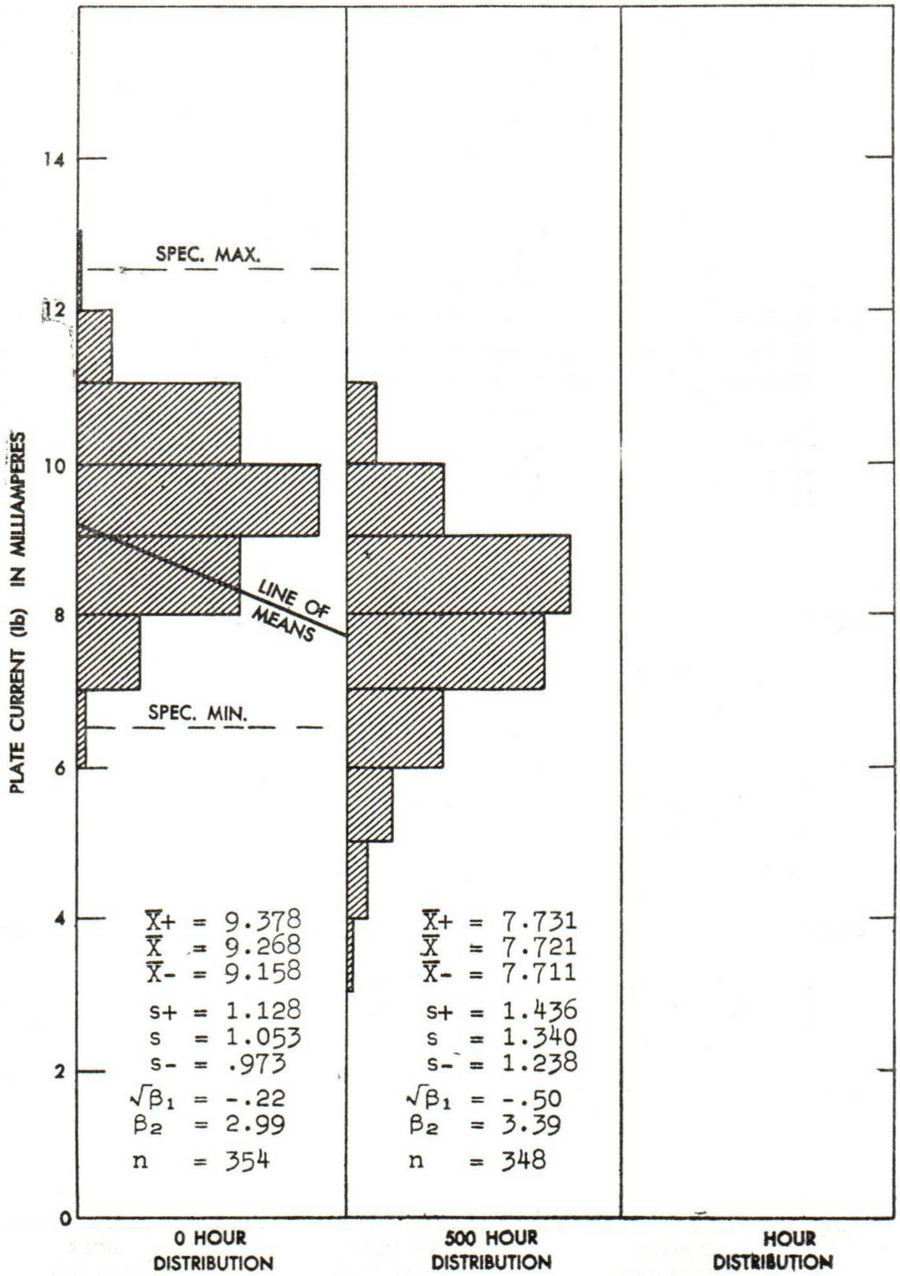


Figure 4-16. Distribution of Plate Current for JAN-3V4.

PROPERTY BEHAVIOR FOR JAN-3V4

The histograms and data for Power Output of JAN-3V4 are based upon 154 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/343 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

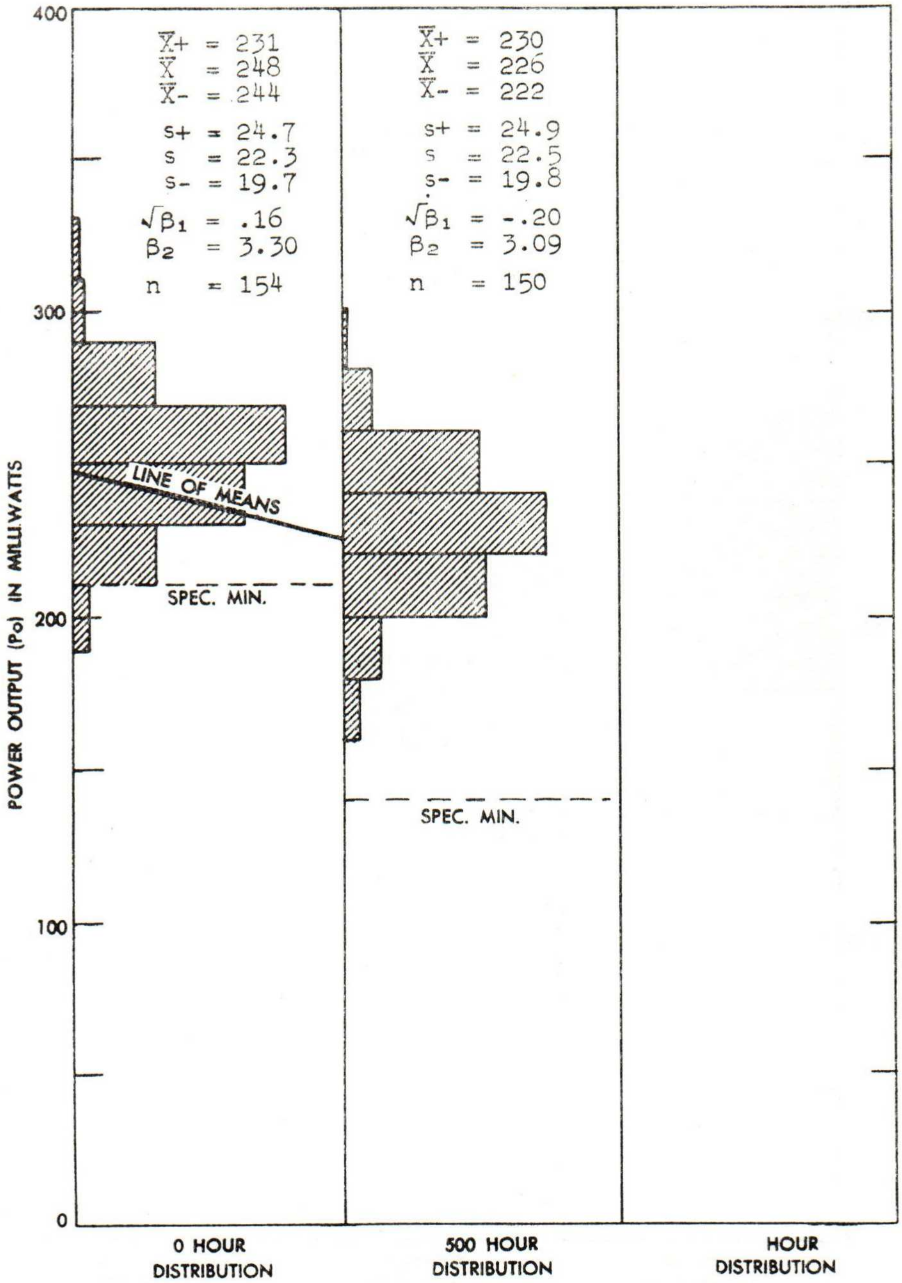


Figure 4-17. Distribution of Power Output for JAN-3V4.

PROPERTY BEHAVIOR FOR JAN-3V4

The histograms and data for Reduced Ef Power Output of JAN-3V4 are based upon 154 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/343 dated 14 August 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

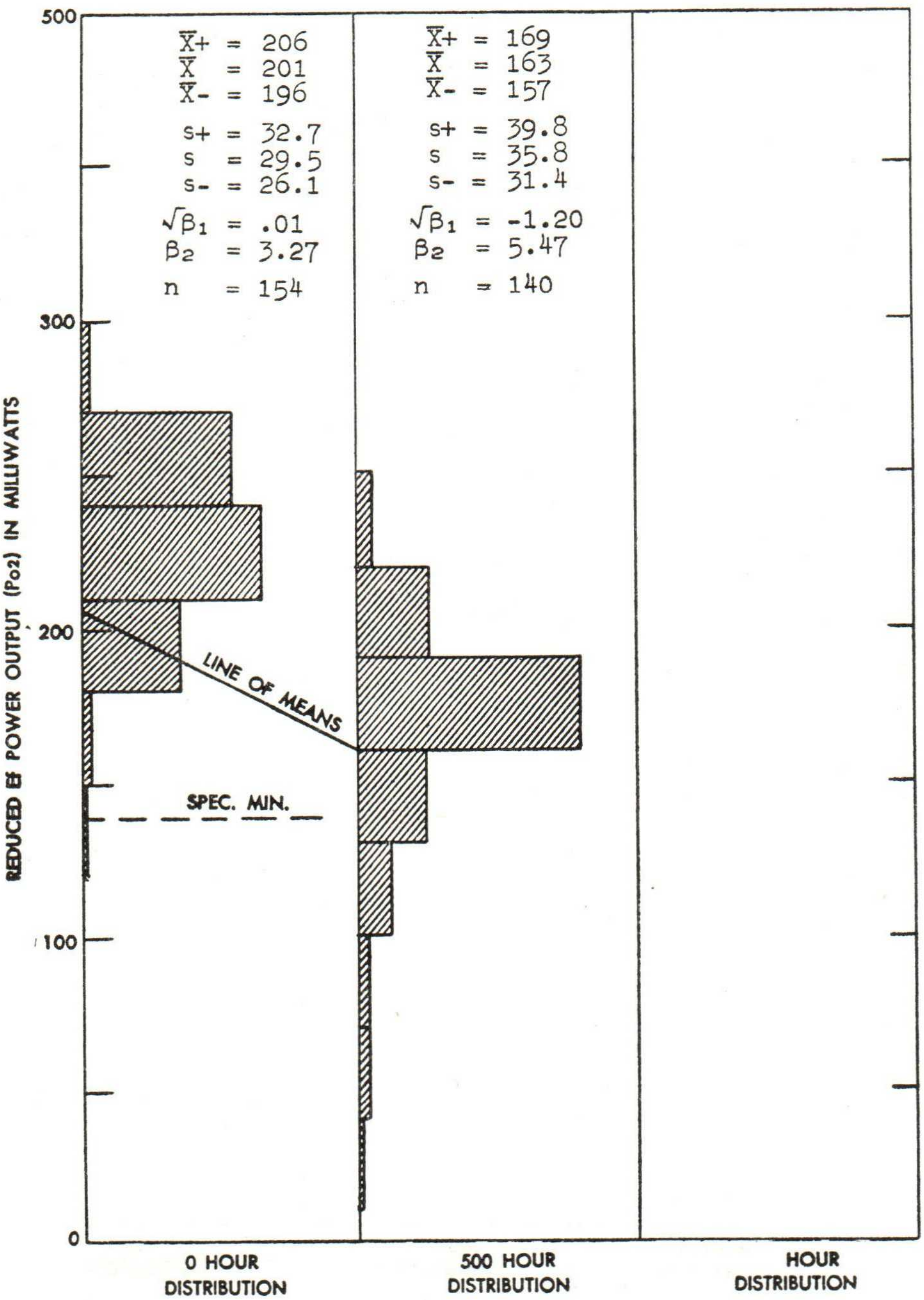


Figure 4-18. Distribution of Reduced Ef Power Output for JAN-3V4.

PROPERTY BEHAVIOR FOR JAN-5R4WGA

The histograms and data for Emission Current of JAN-5R4WGA are based upon 142 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/116A dated 4 March 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

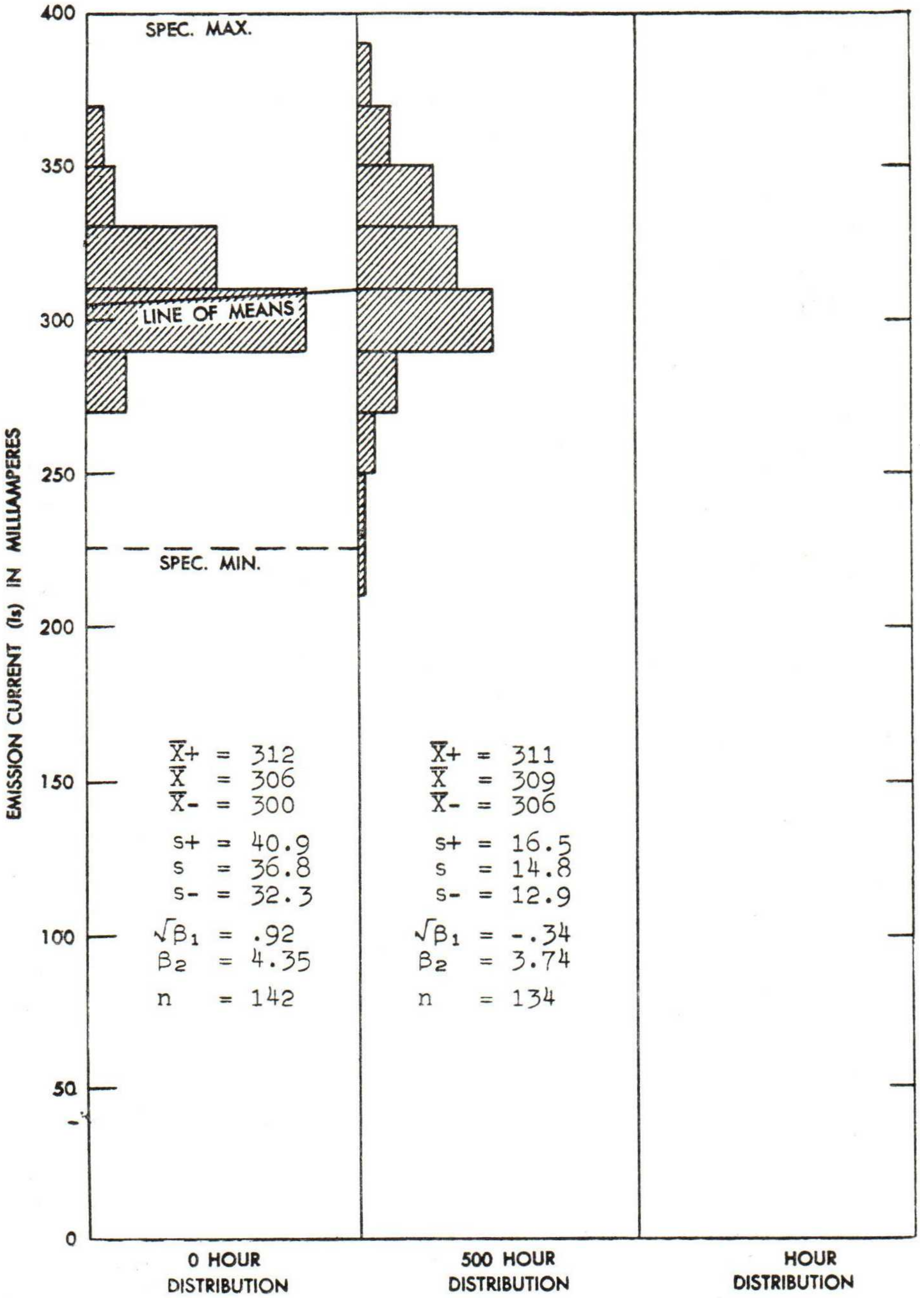


Figure 4-19. Distribution of Emission Current for JAN-5R4WGA.

PROPERTY BEHAVIOR FOR JAN-5R4WGA

The hisograms and data for Operation Current of JAN-5R4WGA are based upon 142 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/116A dated 4 March 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

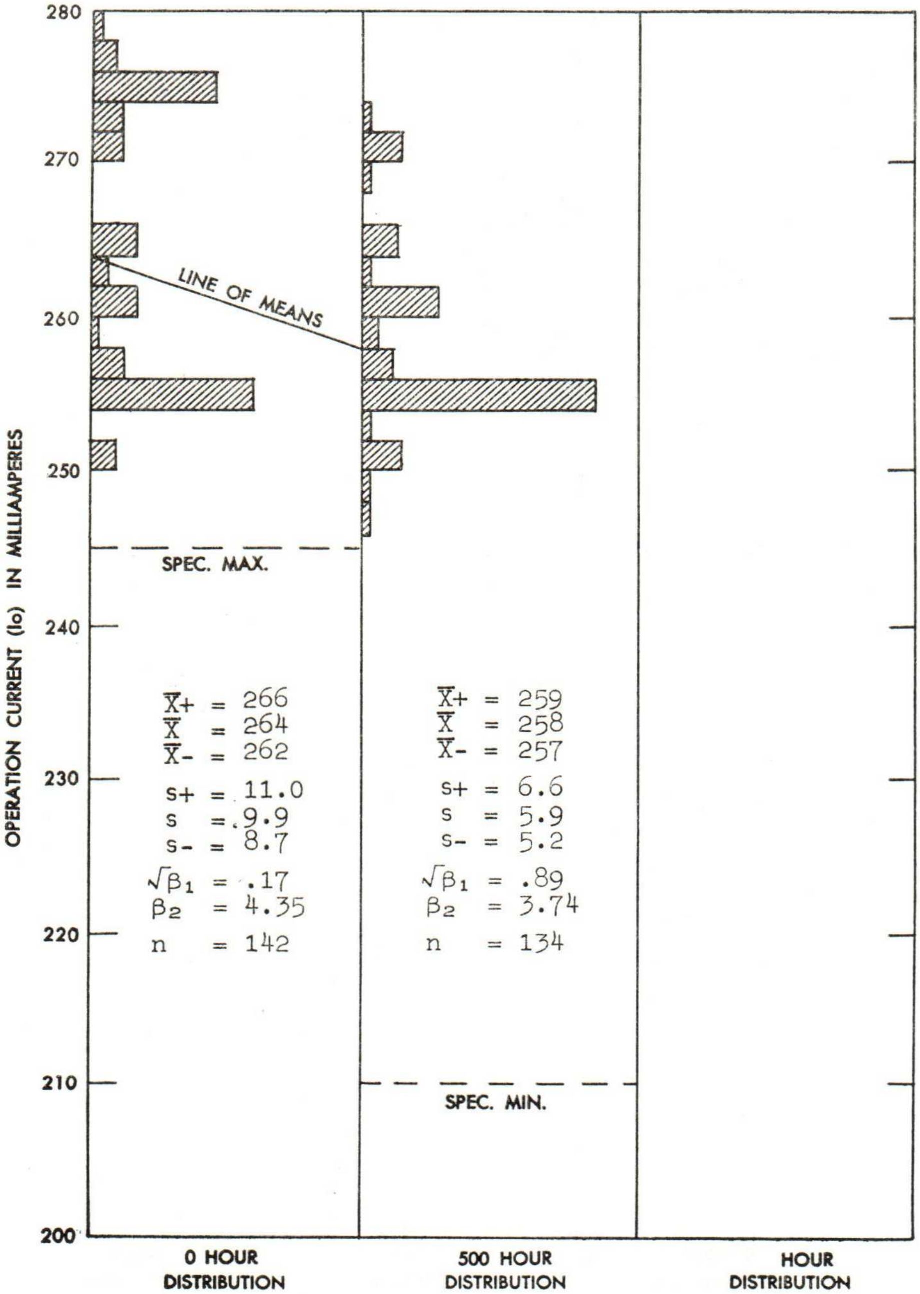


Figure 4-20. Distribution of Operation Current for JAN-5R4WGA.

PROPERTY BEHAVIOR FOR JAN-5Y3WGTA

The histograms and data for Emission of JAN-5Y3WGTA are based upon 100 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/1021 dated 28 June 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

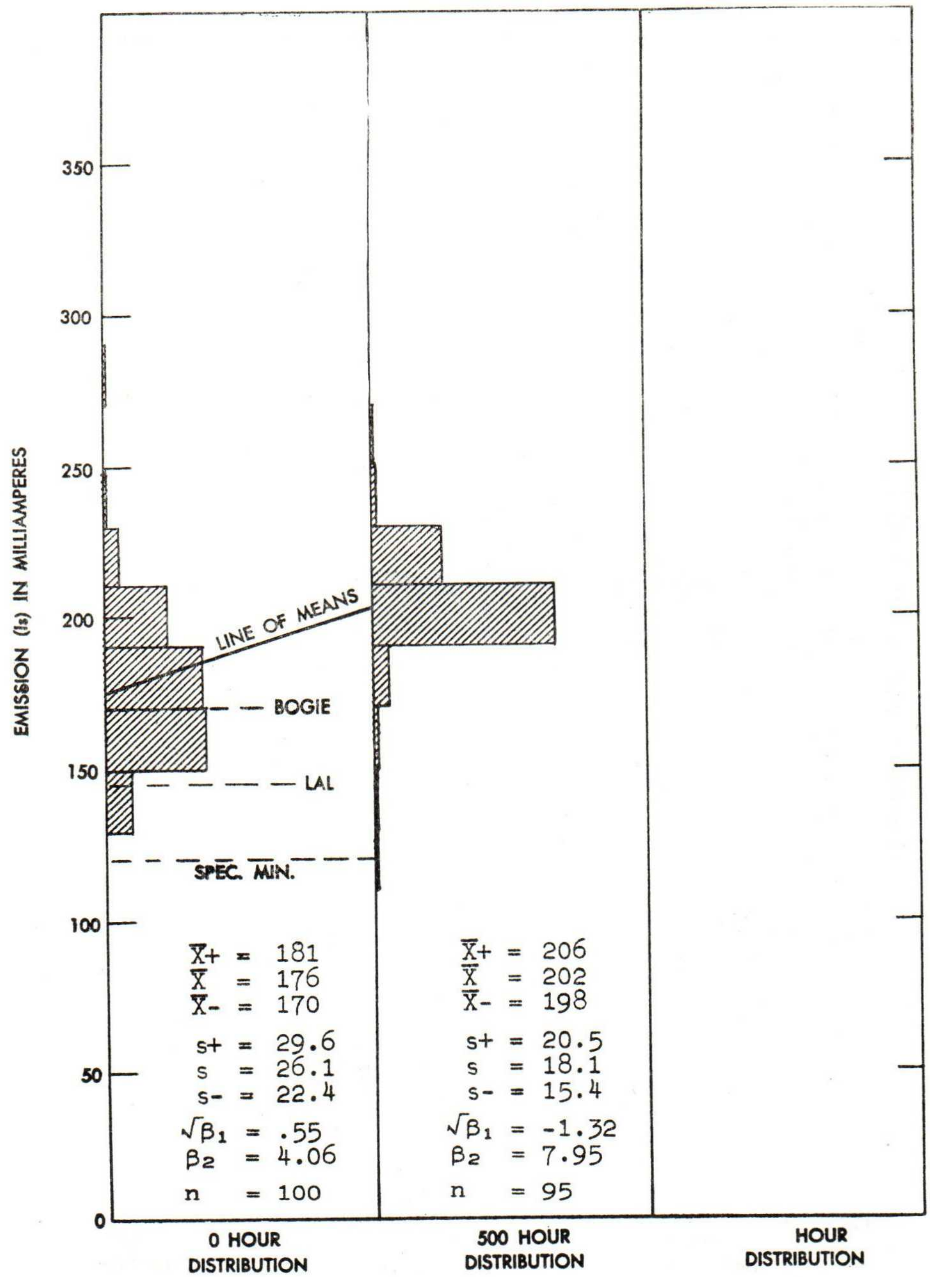


Figure 4-21. Distribution of Emission for JAN-5Y3WGTA.

PROPERTY BEHAVIOR FOR JAN-5Y3WGTA

The histograms and data for Operation Current of JAN-5Y3WGTA are based upon 100 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/1021 dated 28 June 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

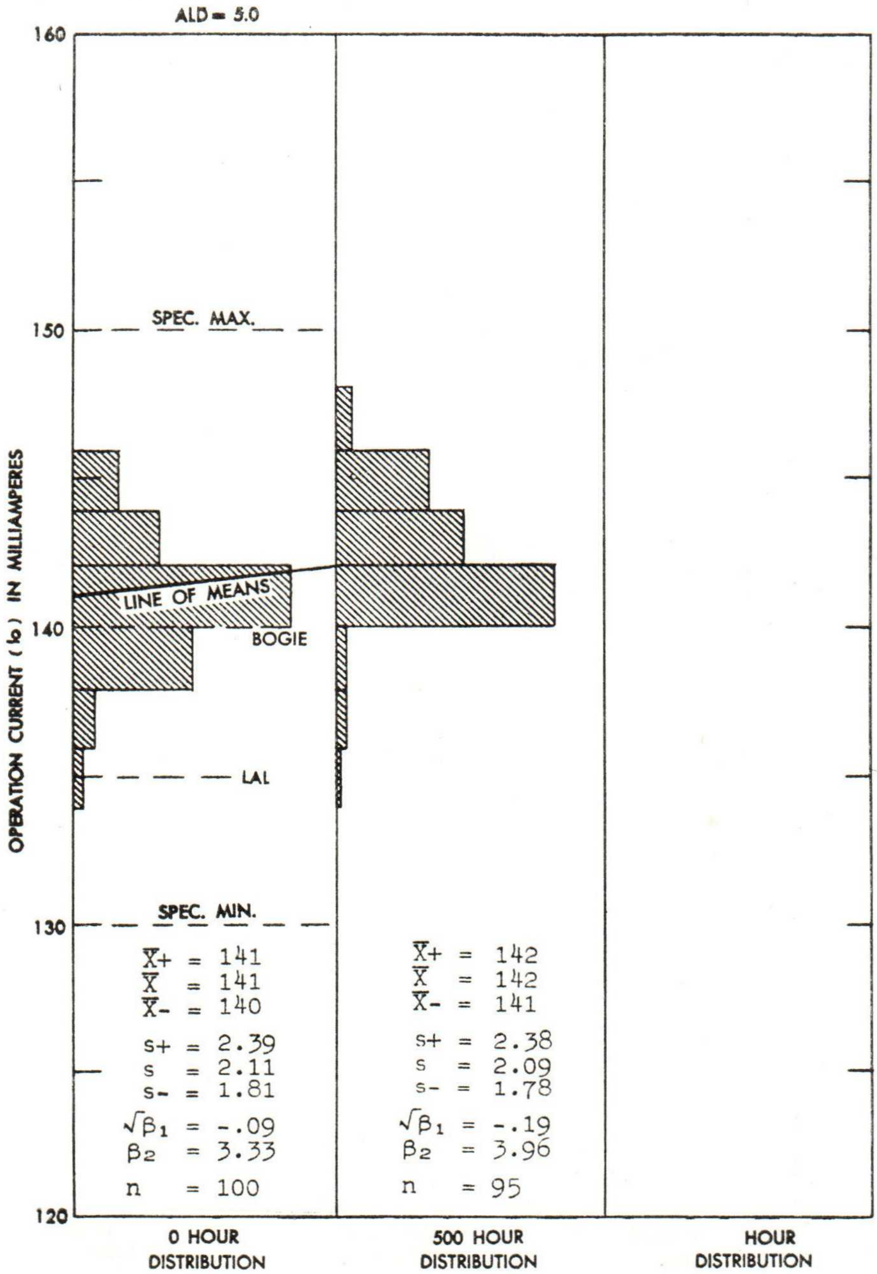


Figure 4-22. Distribution of Operation Current for JAN-5Y3WGTA.

PROPERTY BEHAVIOR FOR JAN-6AG7Y

The histograms and data for Plate Current of JAN-6AG7Y are based upon 210 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/45C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

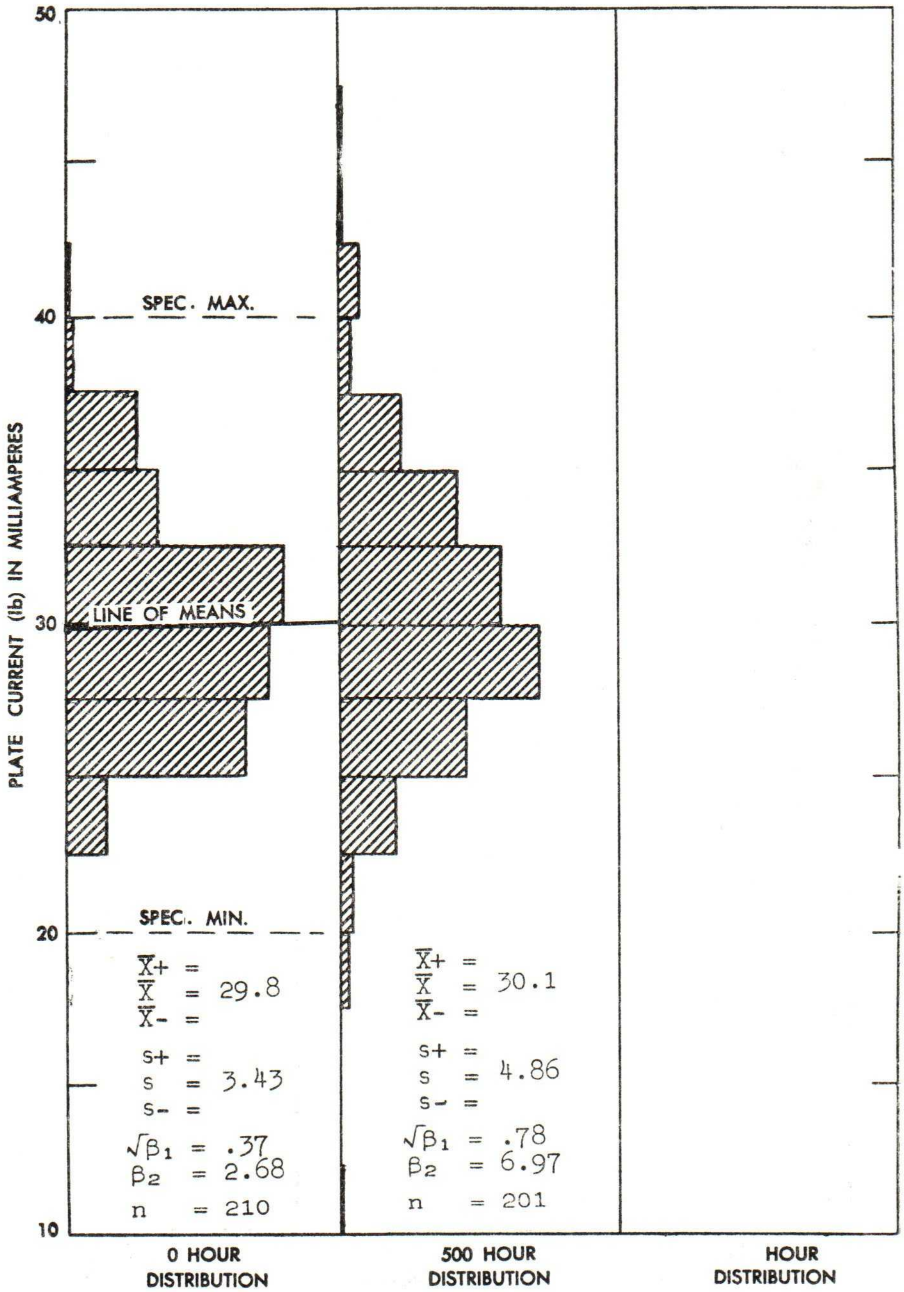


Figure 4-23. Distribution of Plate Current for JAN-6AG7Y.

PROPERTY BEHAVIOR FOR JAN-6AG7Y

The histograms and data for Power Output of JAN-6AG7Y are based upon 210 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/45C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

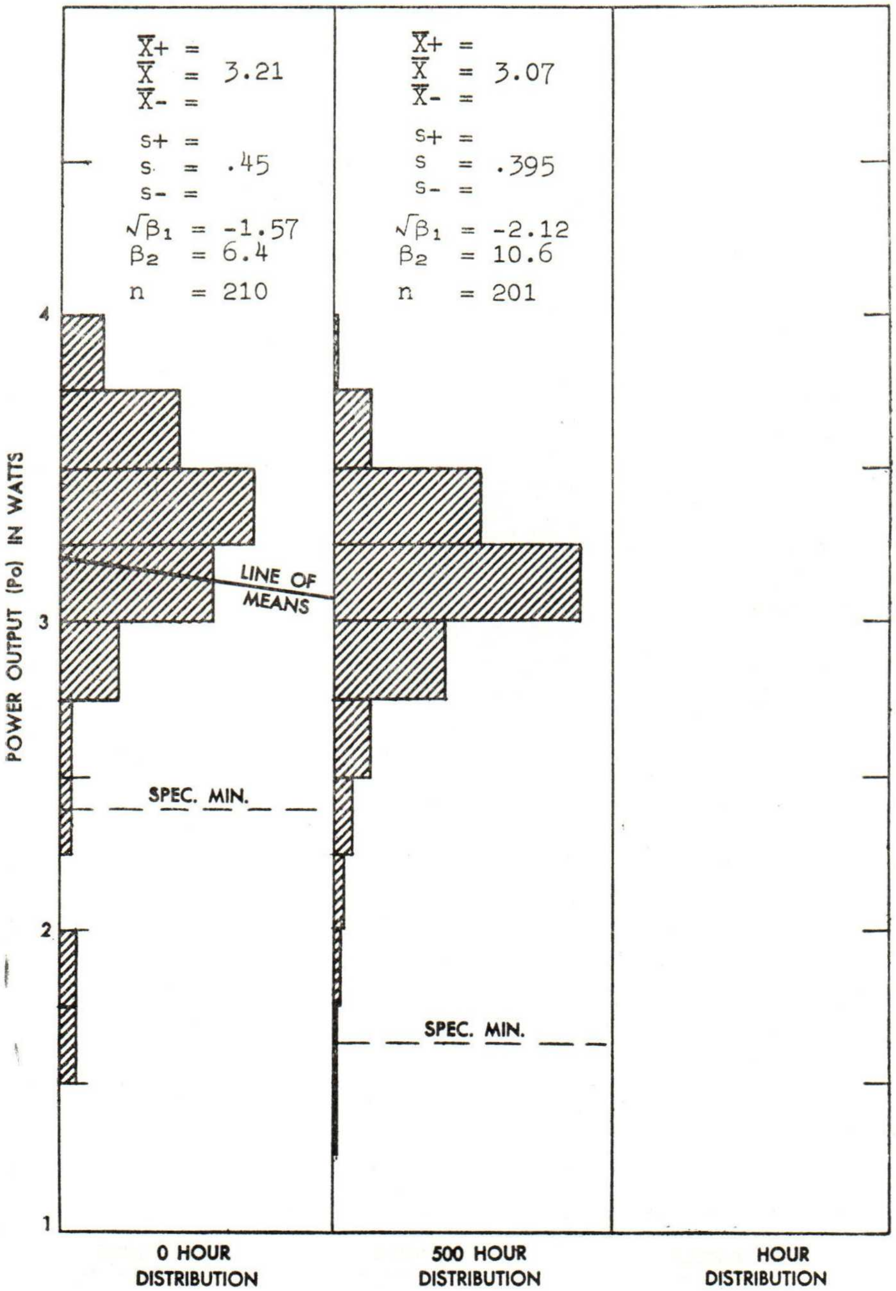


Figure 4-24. Distribution of Power Output for JAN-6AG7Y.

PROPERTY BEHAVIOR FOR JAN-6AH6

The histograms and data for Plate Current of JAN-6AH6 are based upon 55 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/46 dated 5 February 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

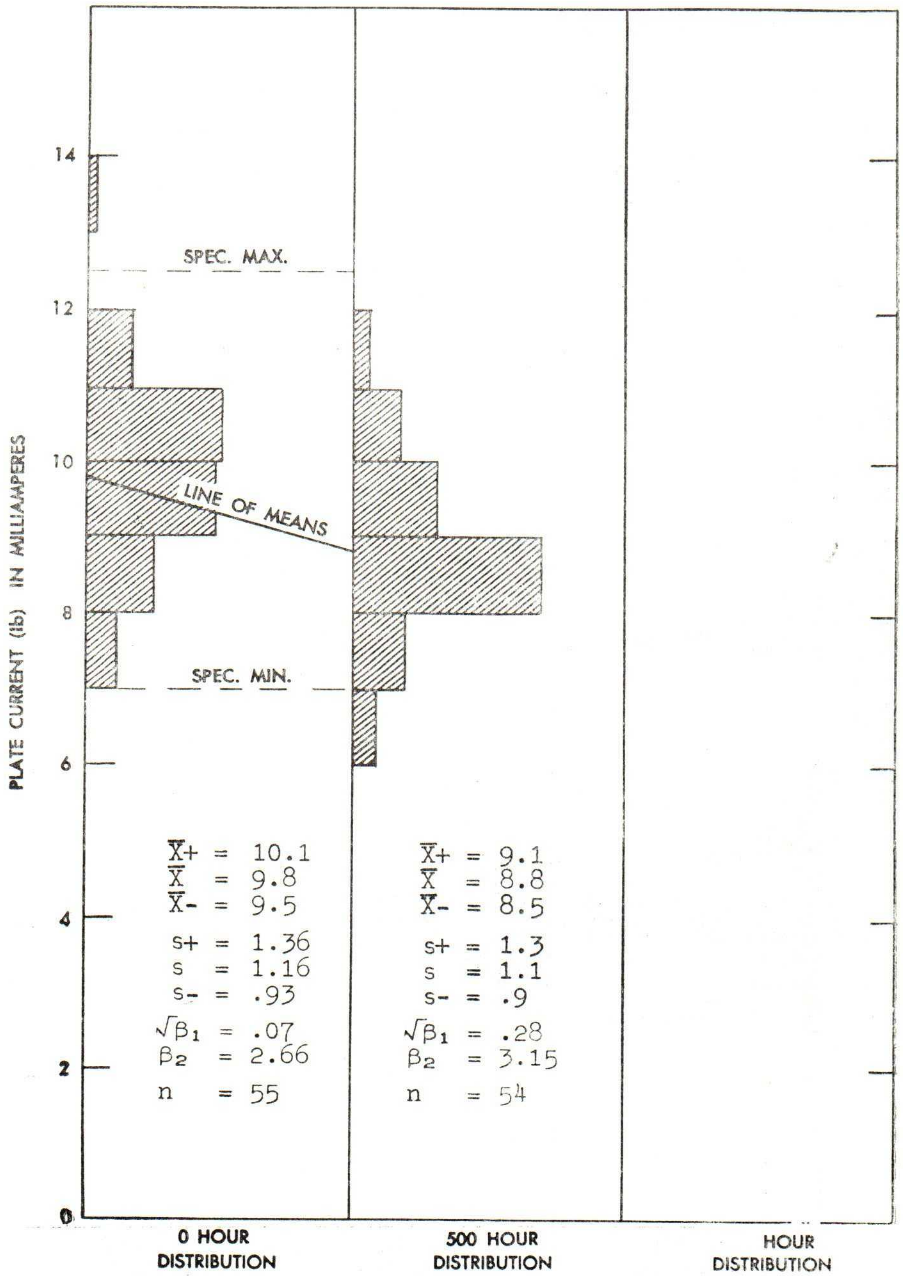


Figure 4-25. Distribution of Plate Current for JAN-6AH6.

PROPERTY BEHAVIOR FOR JAN-6AH6

The histograms and data for Screen Grid Current of JAN-6AH6 are based upon 54 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/46 dated 5 February 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

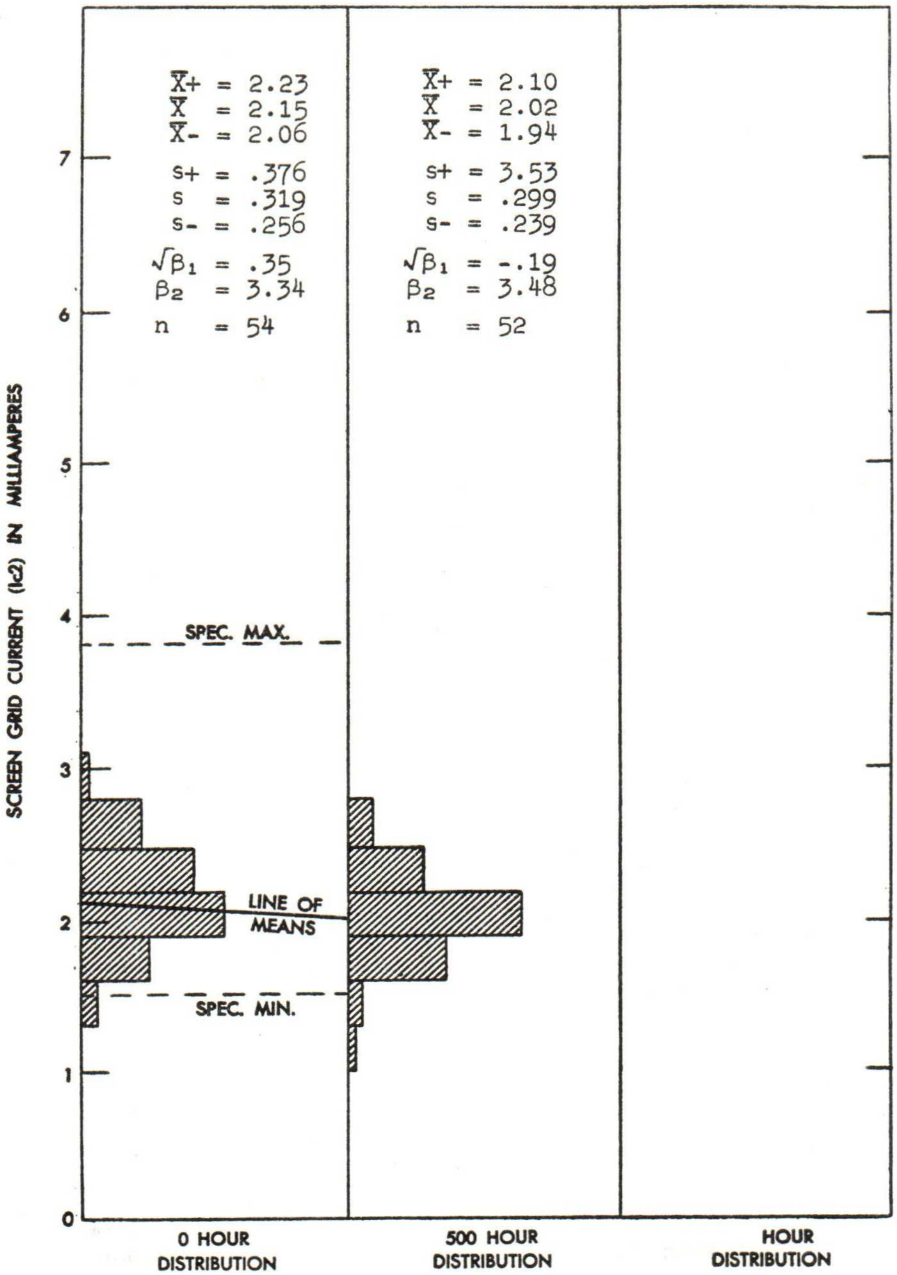


Figure 4-26. Distribution of Screen Grid Current for JAN-6AH6.

PROPERTY BEHAVIOR FOR JAN-6AH6

The histograms and data for Transconductance of JAN-6AH6 are based upon 55 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/46 dated 5 February 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

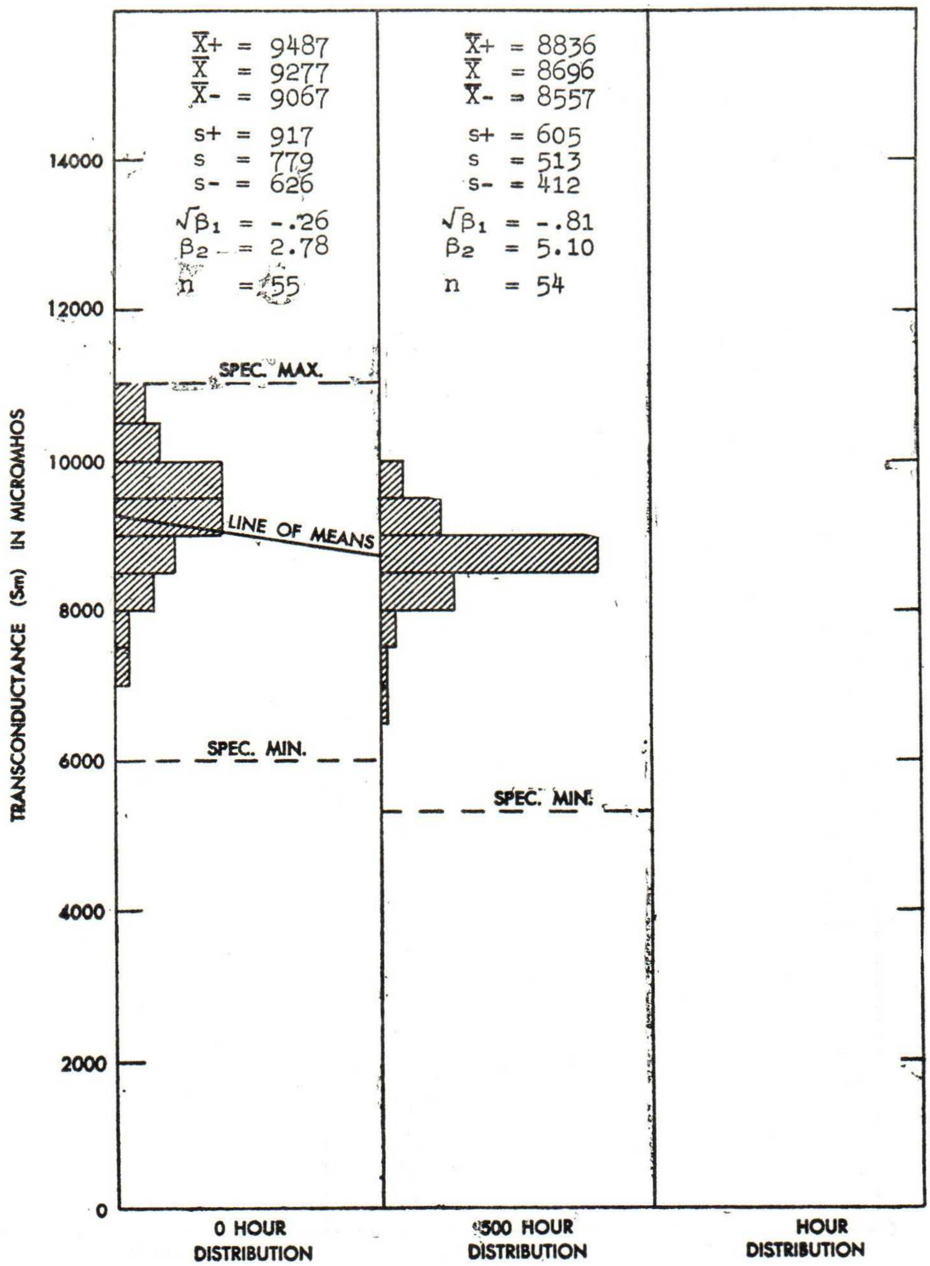


Figure 4-27. Distribution of Transconductance for JAN-6AH6.

PROPERTY BEHAVIOR FOR JAN-6AU6WA

The histograms and data for Plate Current of JAN-6AU6WA are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/1 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

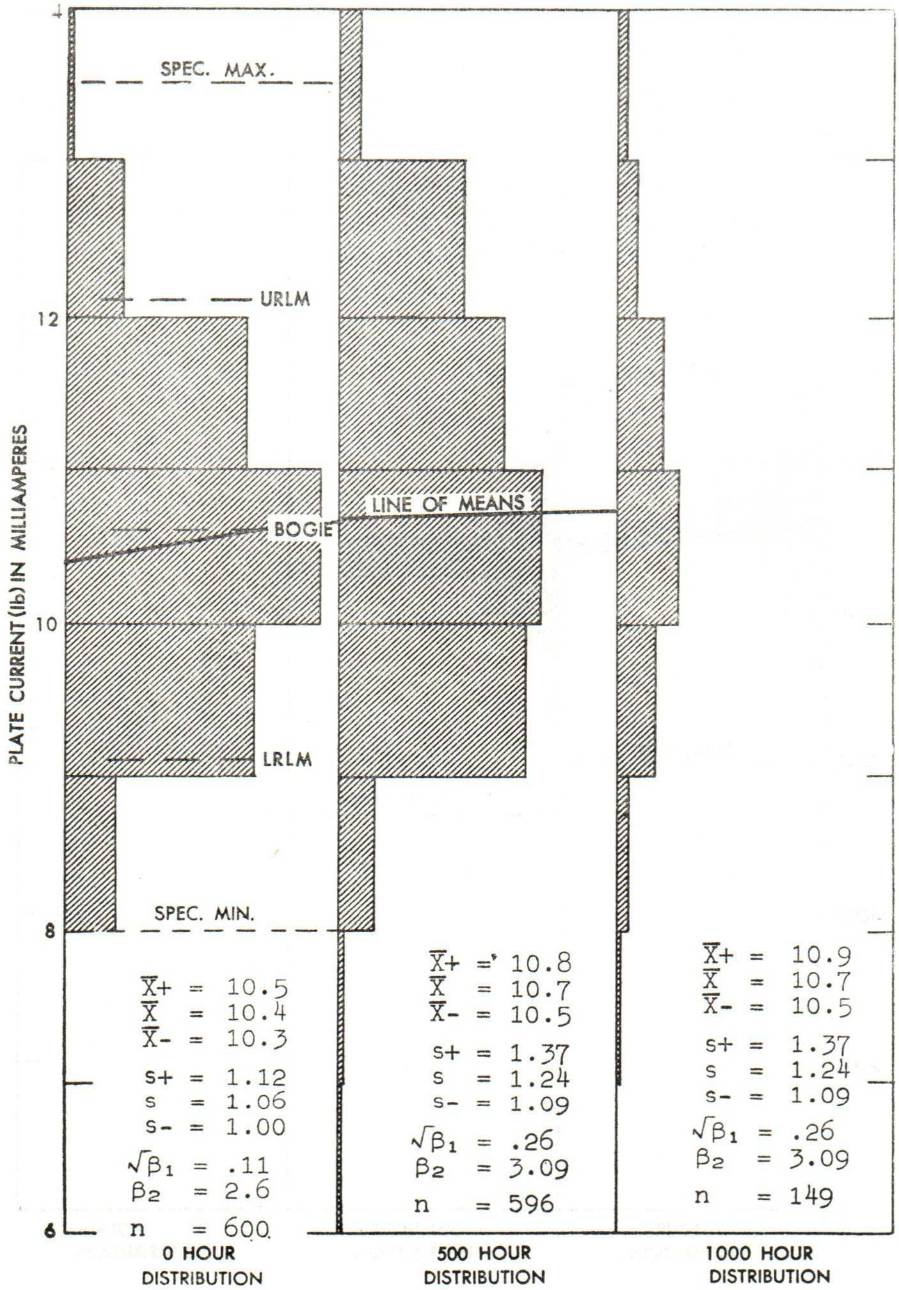


Figure 4-28. Distribution of Plate Current for JAN-6AU6WA.

PROPERTY BEHAVIOR FOR JAN-6AU6WA

The histograms and data for Screen Grid Current of JAN-6AU6WA are based upon 396 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/1 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

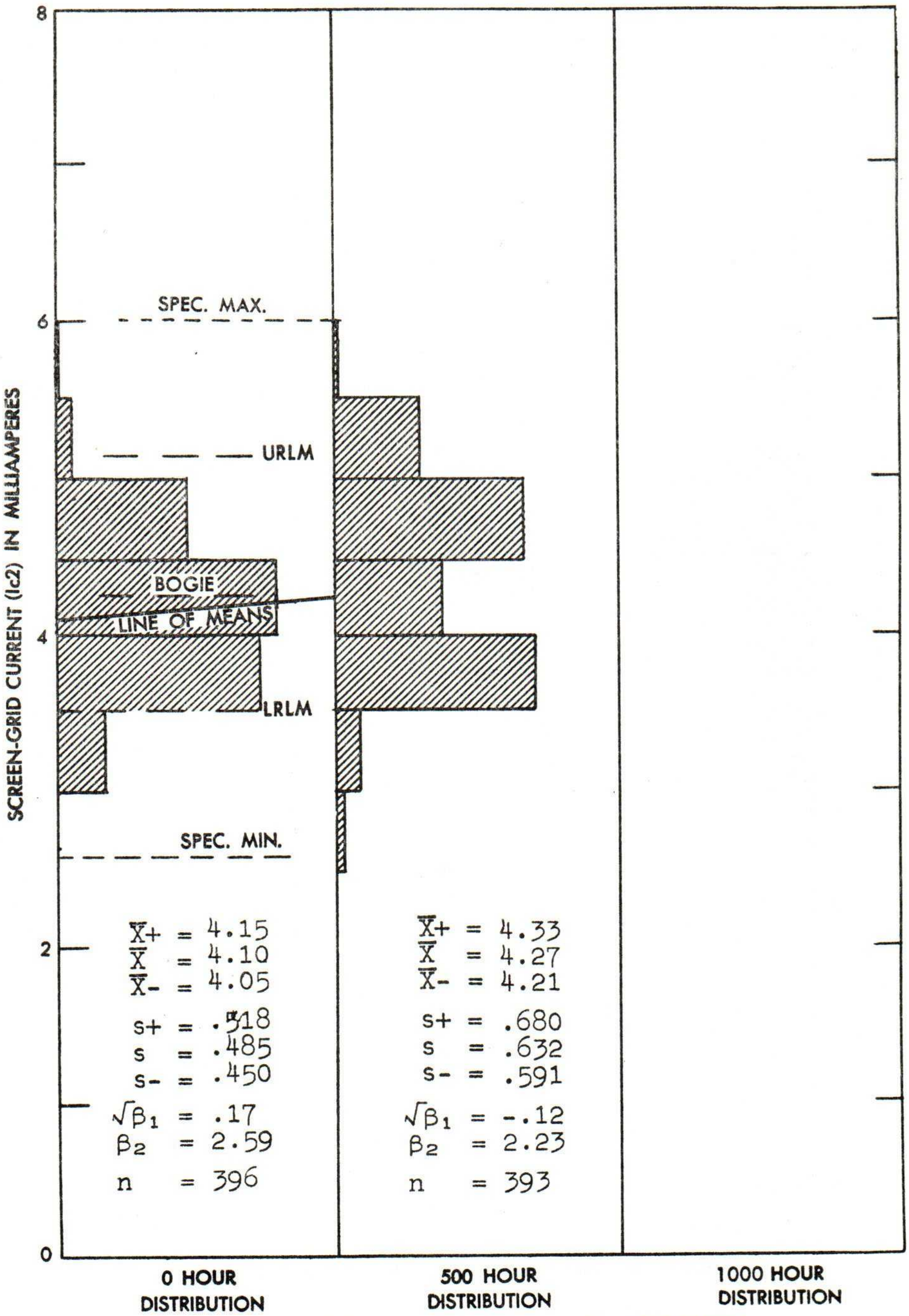


Figure 4-29. Distribution of Screen Grid Current for JAN-6AU6WA.

PROPERTY BEHAVIOR FOR JAN-6AU6WA

The histograms and data for Transconductance of JAN-6AU6WA are based upon 596 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/1 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

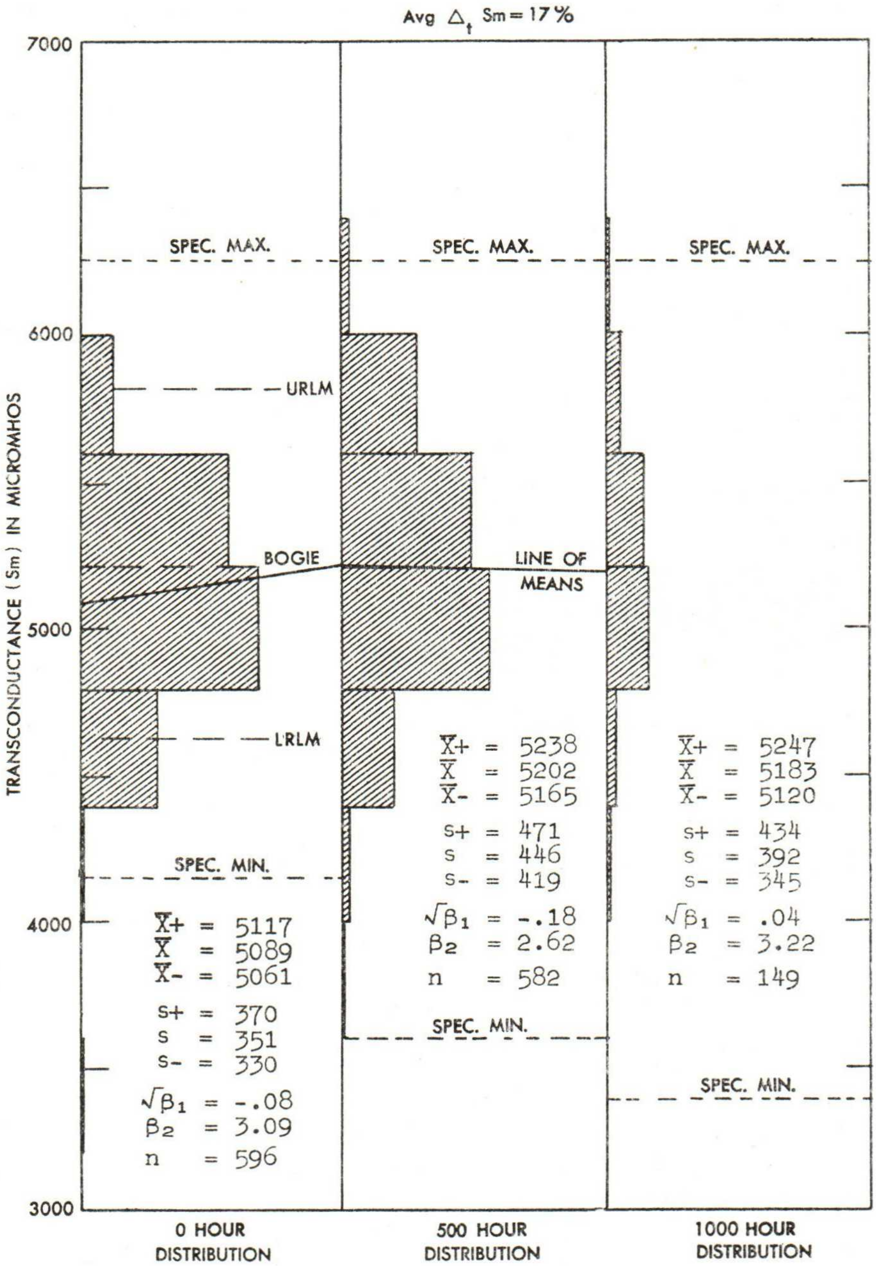


Figure 4-30. Distribution of Transconductance for JAN-6AU6WA.

PROPERTY BEHAVIOR FOR JAN-6C4W

The histograms and data for Plate Current of JAN-6C4W are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/55B dated 15 January 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

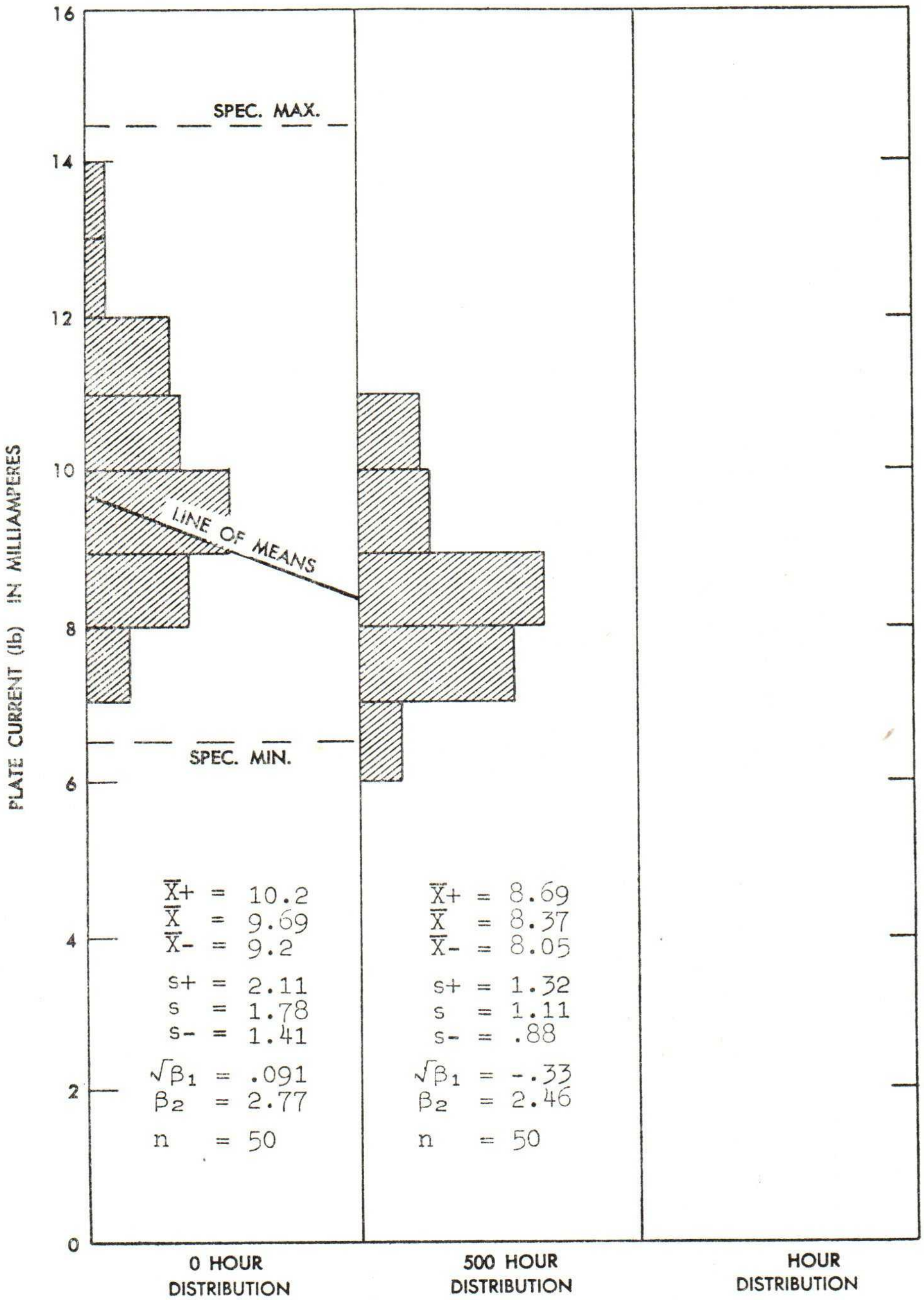


Figure 4-31. Distribution of Plate Current for JAN-6C4W.

PROPERTY BEHAVIOR FOR JAN-6C4W

The histograms and data for Transconductance of JAN-6C4W are based upon 50 tubes life-tested by one manufacturer of the twpe during the year 1956. The specification limits shown are taken from MIL-E-1/55B dated 15 January 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

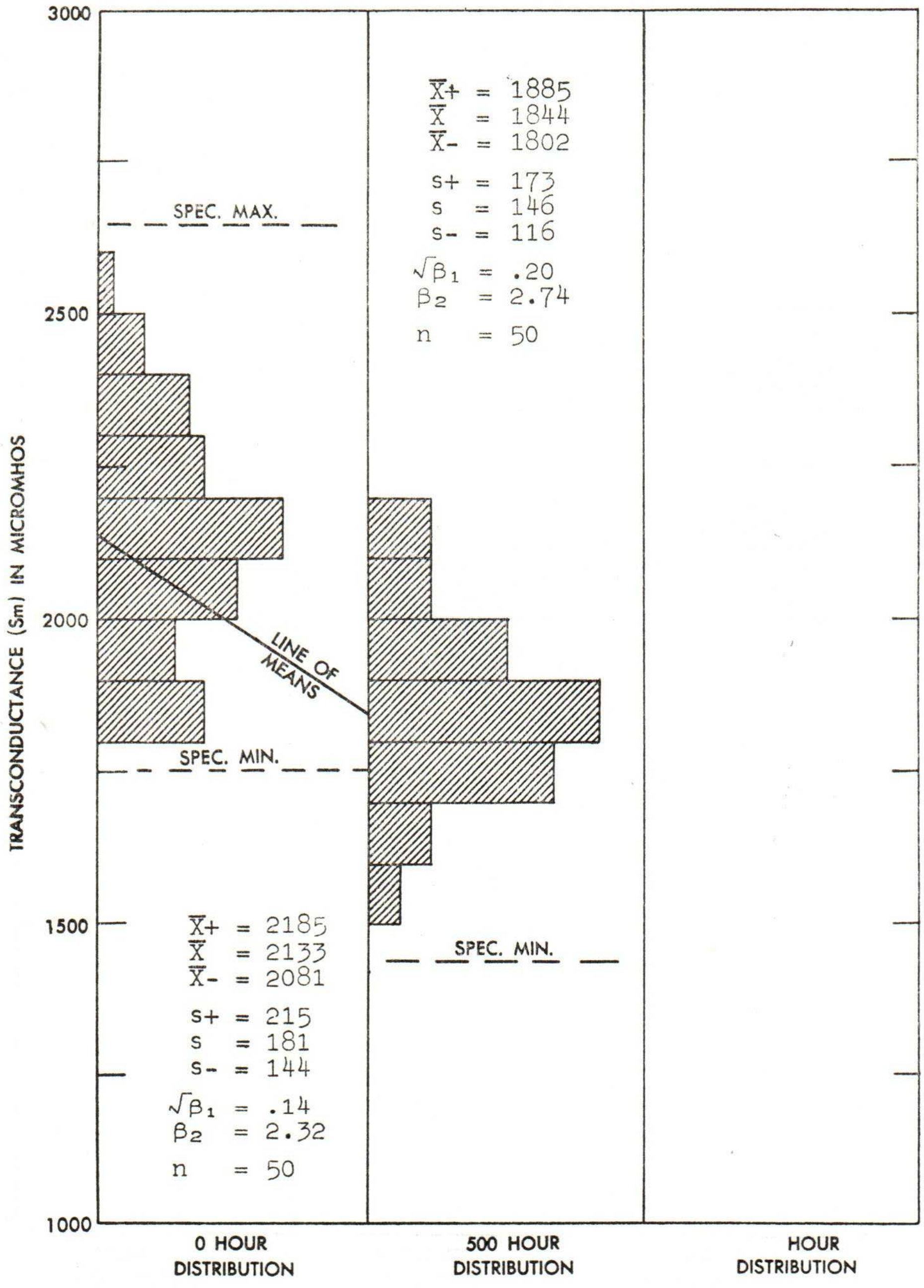


Figure 4-32. Distribution of Transconductance of JAN-6C4W.

TYPICAL THERMAL BEHAVIOR OF JAN-6C4W

These typical curves have been obtained by experimental procedures performed on a small sample of JAN-6C4W tubes. The specification ratings delineating a recommended or safe area of operation are shown. The effective environmental temperature was carefully determined for this particular experiment but there is considerable room for interpretation on an individual application basis.

Study of the chart should point out the fallacy of attempting operation beyond specification ratings by external reduction of the effective environmental temperature. This fallacy obtains because the plate temperature will most likely exceed the value which has been determined by the manufacturer as "safe" for this particular tube type.

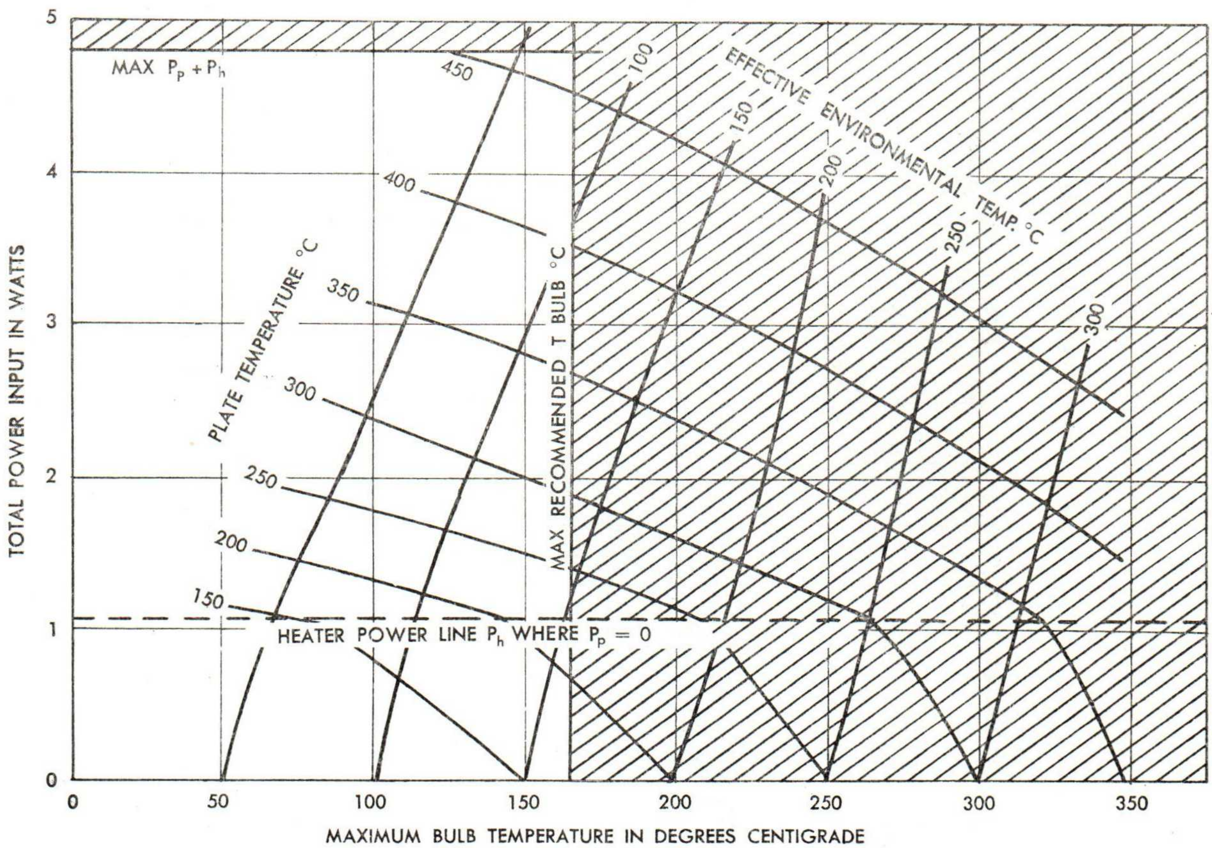


Figure 4-33. Typical Thermal Behavior for JAN-6C4W.

PROPERTY BEHAVIOR FOR JAN-6L6WGB

The histograms and data for Plate Current of JAN-6L6WGB are based upon 250 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/197 dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

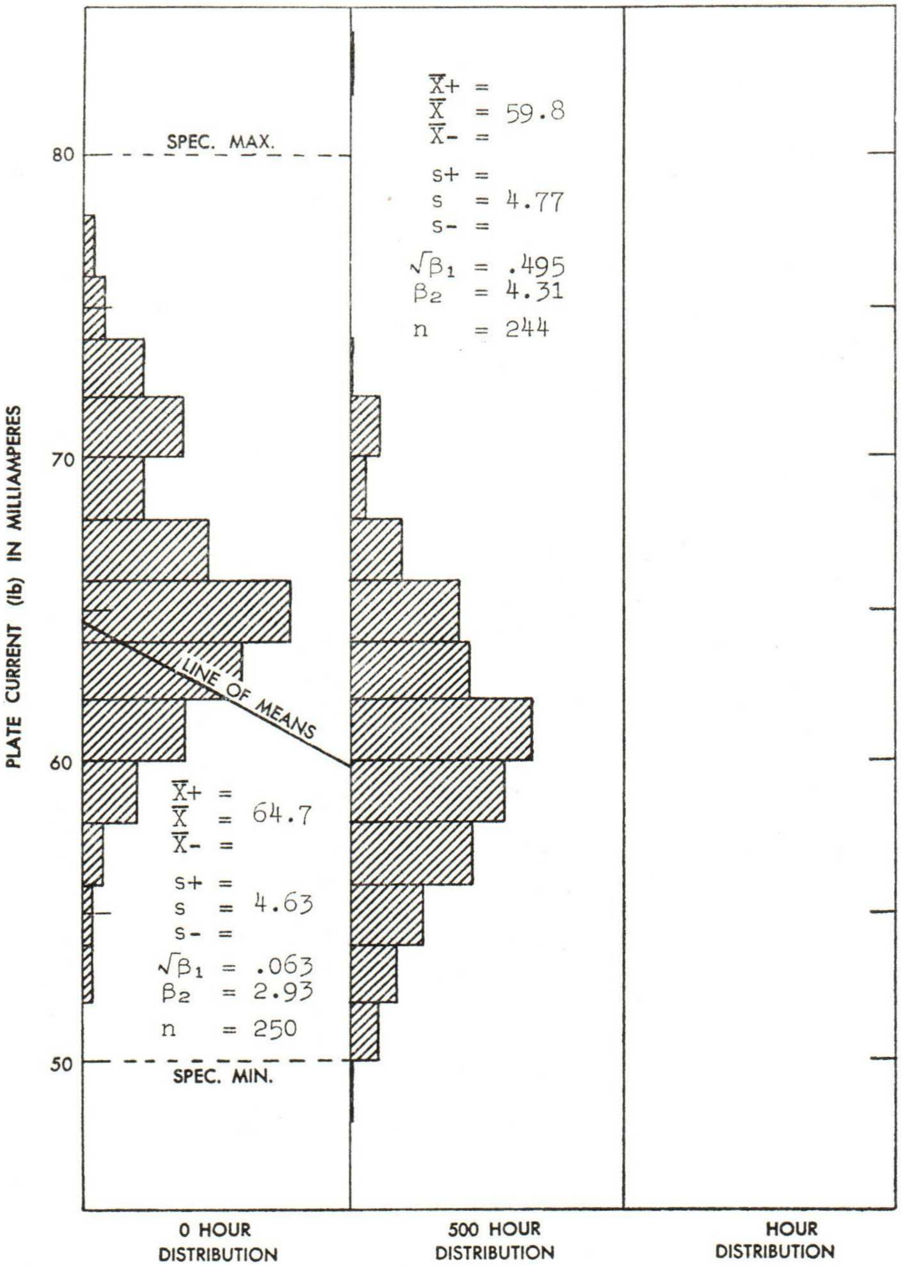


Figure 4-34. Distribution of Plate Current for JAN-6L6WGB.

PROPERTY BEHAVIOR FOR JAN-6L6WGB

The histograms and data for Power Output of JAN-6L6WGB are based upon 250 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/197 dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

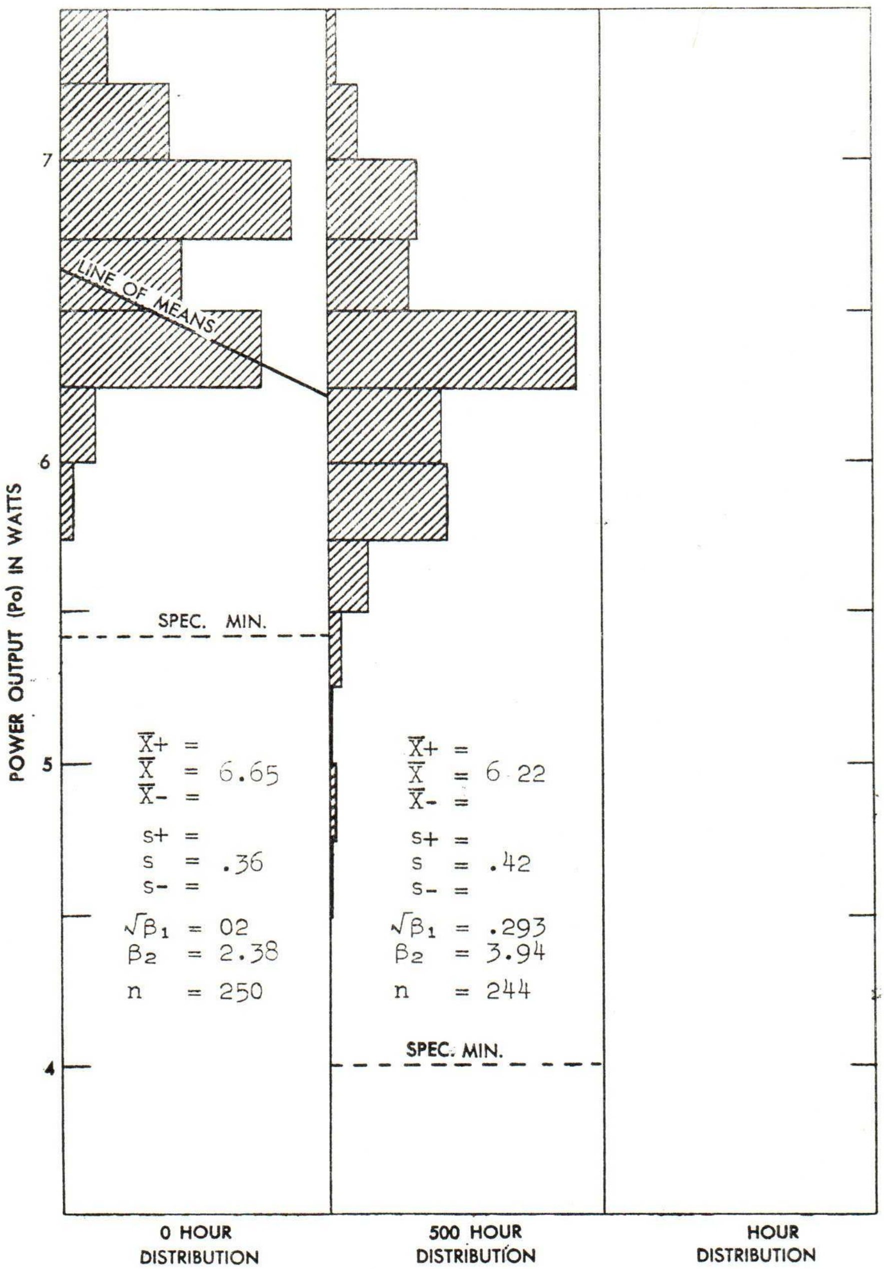


Figure 4-35. Distribution of Power Output for JAN-6L6WGB.

PROPERTY BEHAVIOR FOR JAN-6X4W

The histograms and data for Emission Current of JAN-6X4W are based upon 393 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/64A dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

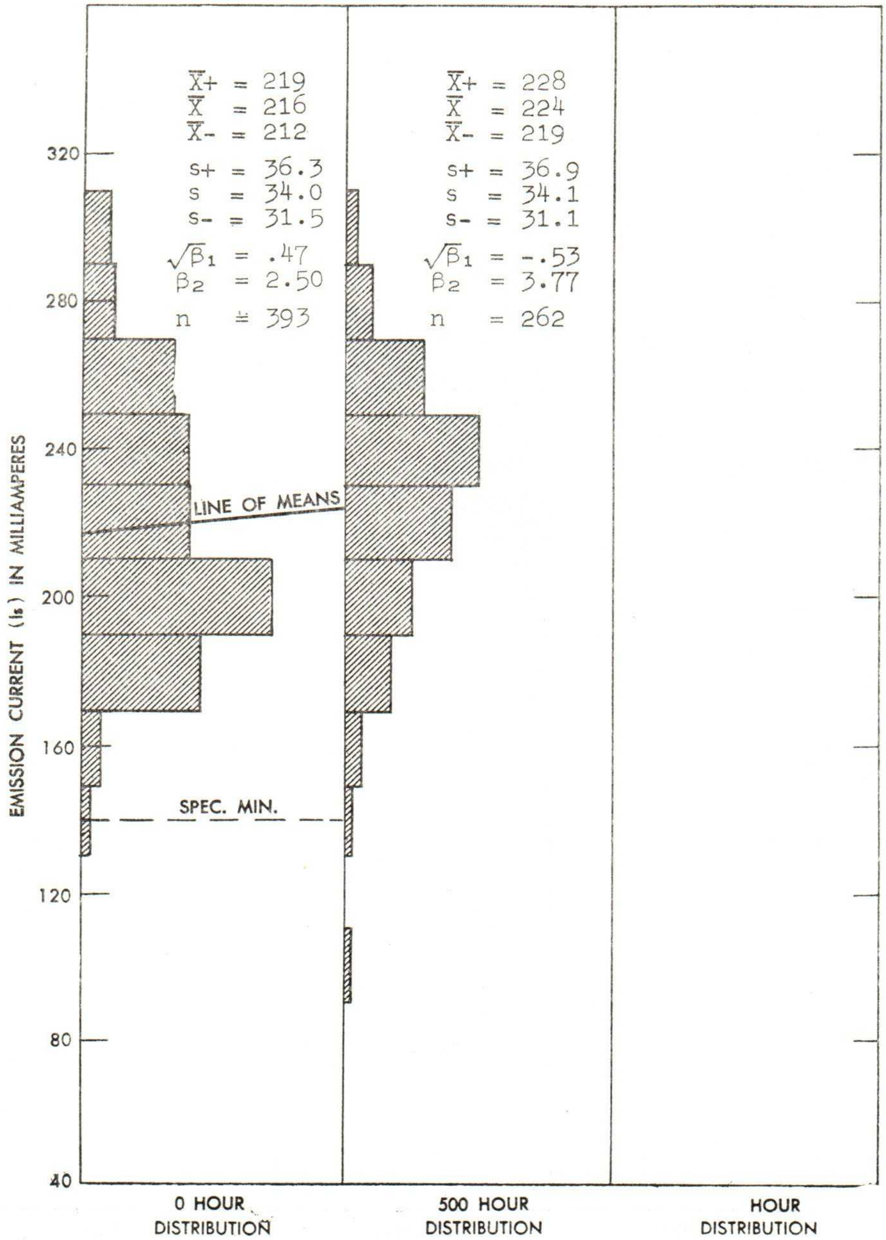


Figure 4-36. Distribution of Emission Current for JAN-6X4W.

PROPERTY BEHAVIOR FOR JAN-12AT7WA

The histograms and data for Transconductance of JAN-12AT7WA are based upon 795 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/3A dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

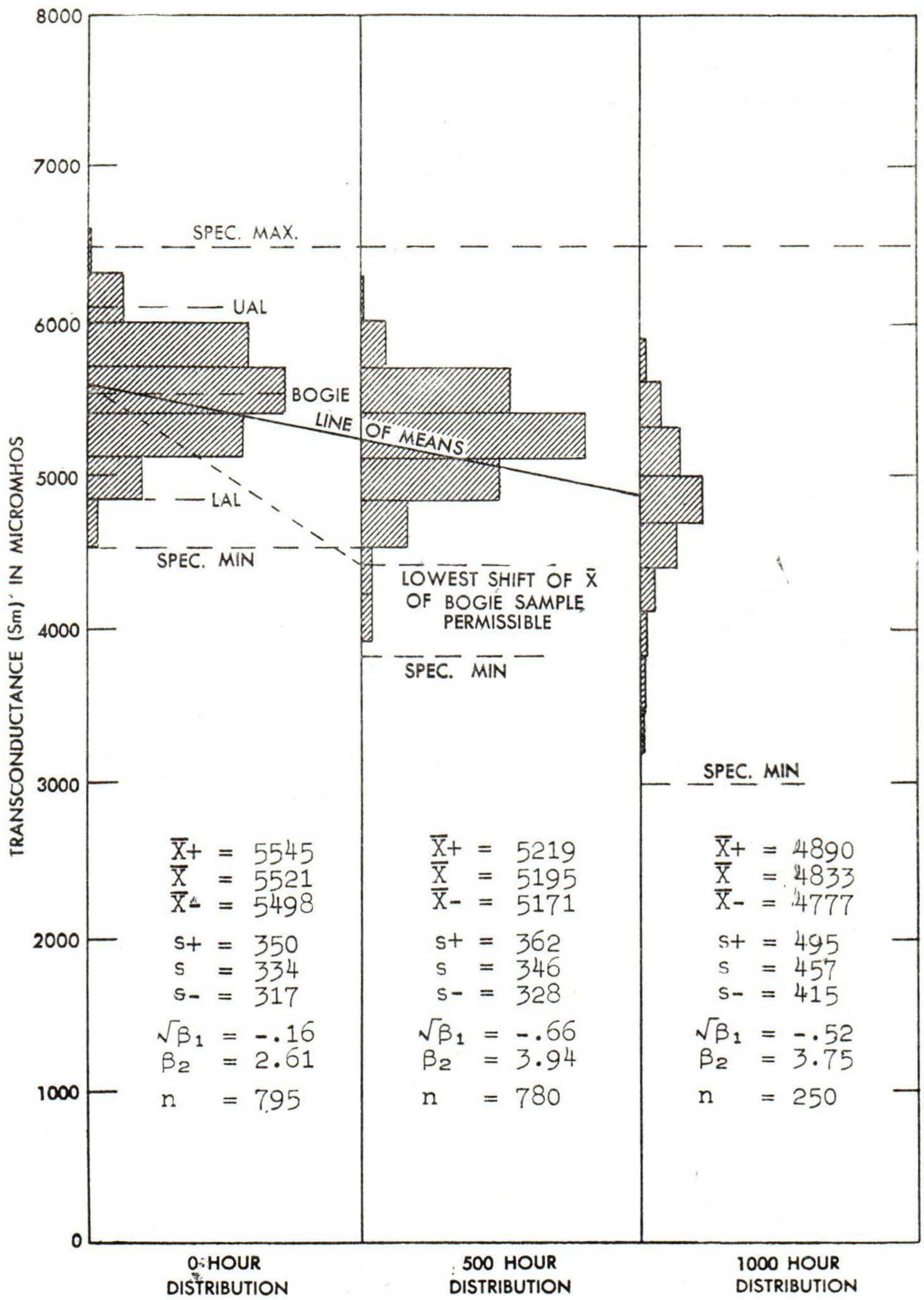


Figure 4-37. Distribution of Transconductance for JAN-12AT7WA.

DETERIORATION OF PERFORMANCE CHARACTERISTICS AND PROBABILITY OF SURVIVAL OF JAN-12AT7WA UNDER MIL-E-1 LIFE TEST

Study of this figure will reveal that in order to achieve, for example, a 90% assurance of survival to 400 hours, the circuit operating at MIL-E-1 test conditions must tolerate a low limit transconductance of 4200 micromhos.

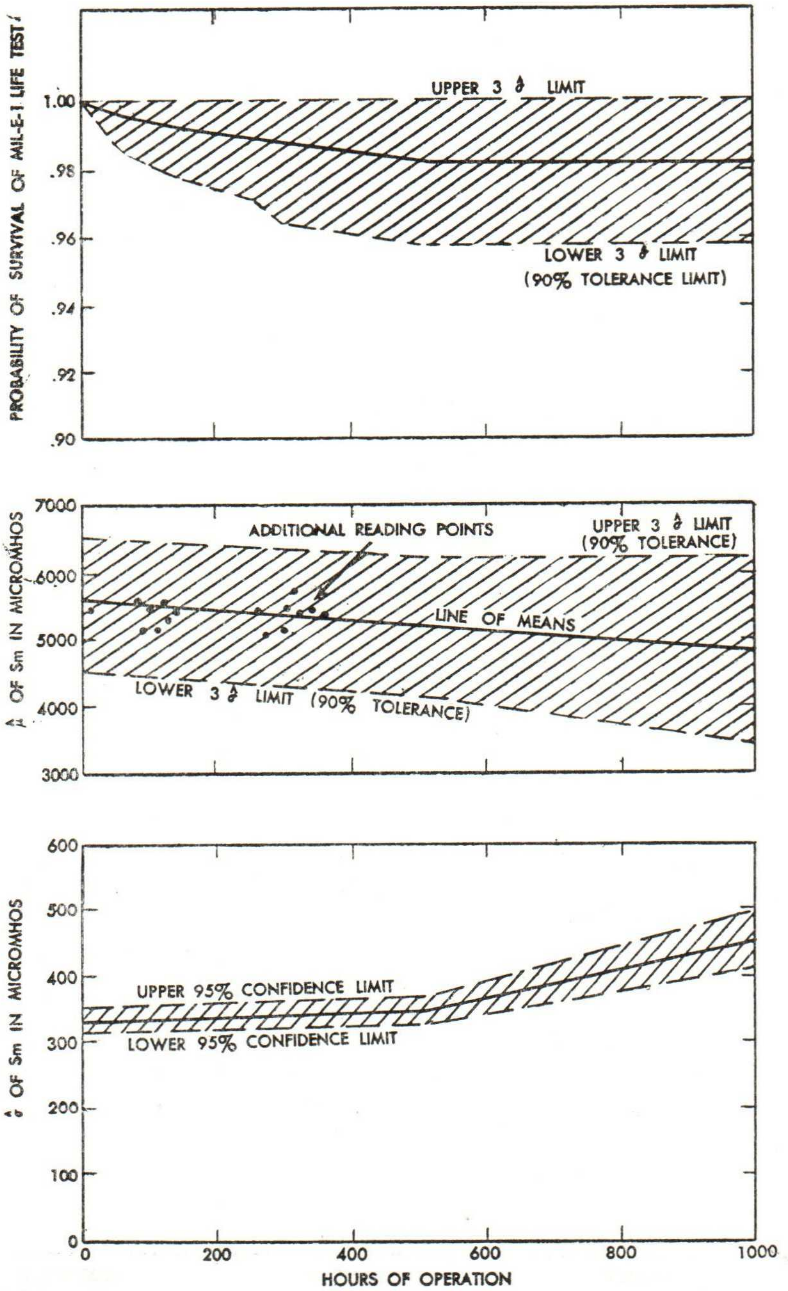


Figure 4-38. Deterioration of Performance Characteristics and Probability of Survival of JAN-12AT7WA Under MIL-E-1 Life Test.

PROPERTY BEHAVIOR FOR JAN-5636

The histograms and data for Transconductance of JAN-5636 are based upon 400 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/168C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

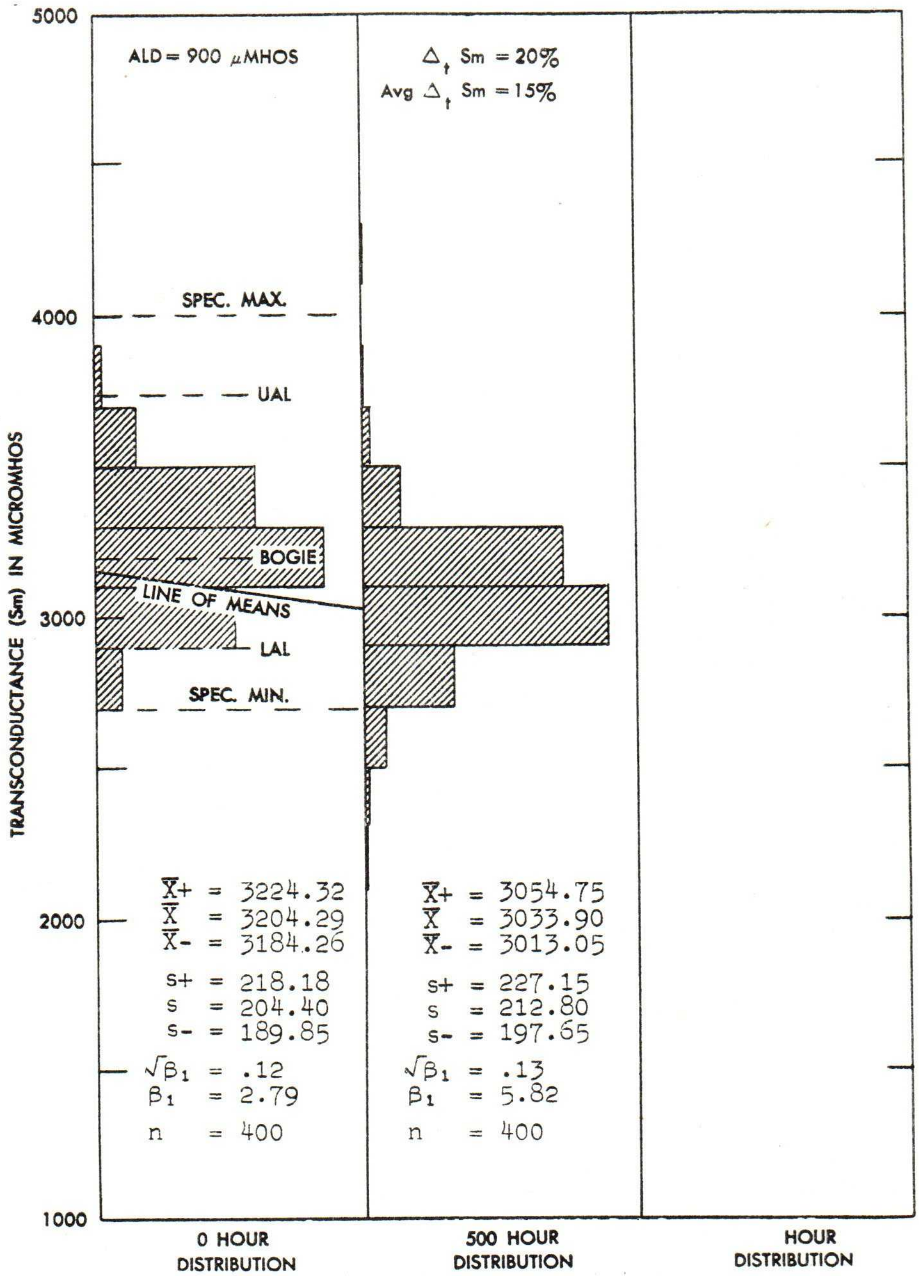


Figure 4-39. Distribution of Transconductance for JAN-5636.

PROPERTY BEHAVIOR FOR JAN-5636

The histograms and data for Reduced Ef Transconductance of JAN-5636 are based upon 400 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/168C dated 23 June 1955. Only data from lots accepted by the specification are used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

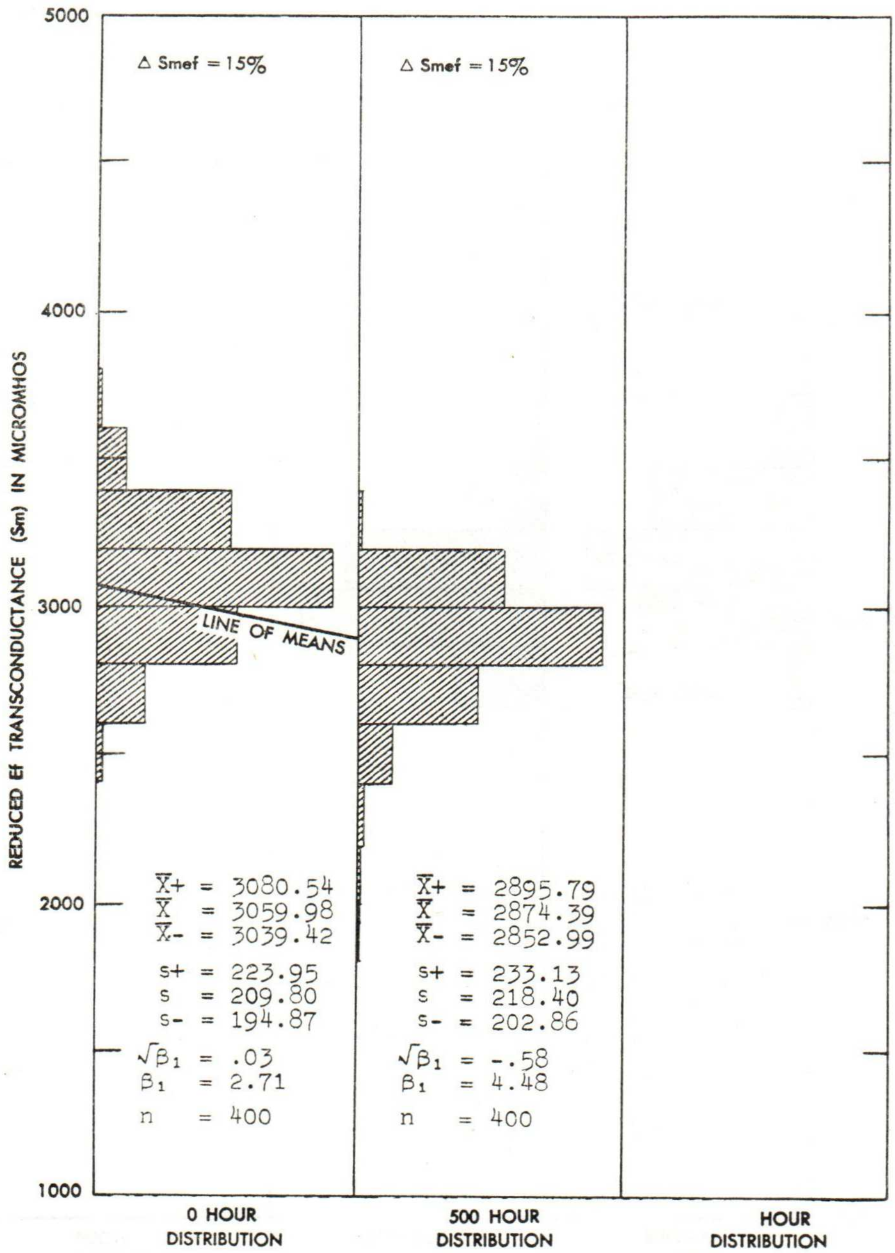


Figure 4-40. Distribution of Reduced Ef Transconductance for JAN-5636.

PROPERTY BEHAVIOR FOR JAN-5639

The histograms and data for Plate Current of JAN-5639 are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/169C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

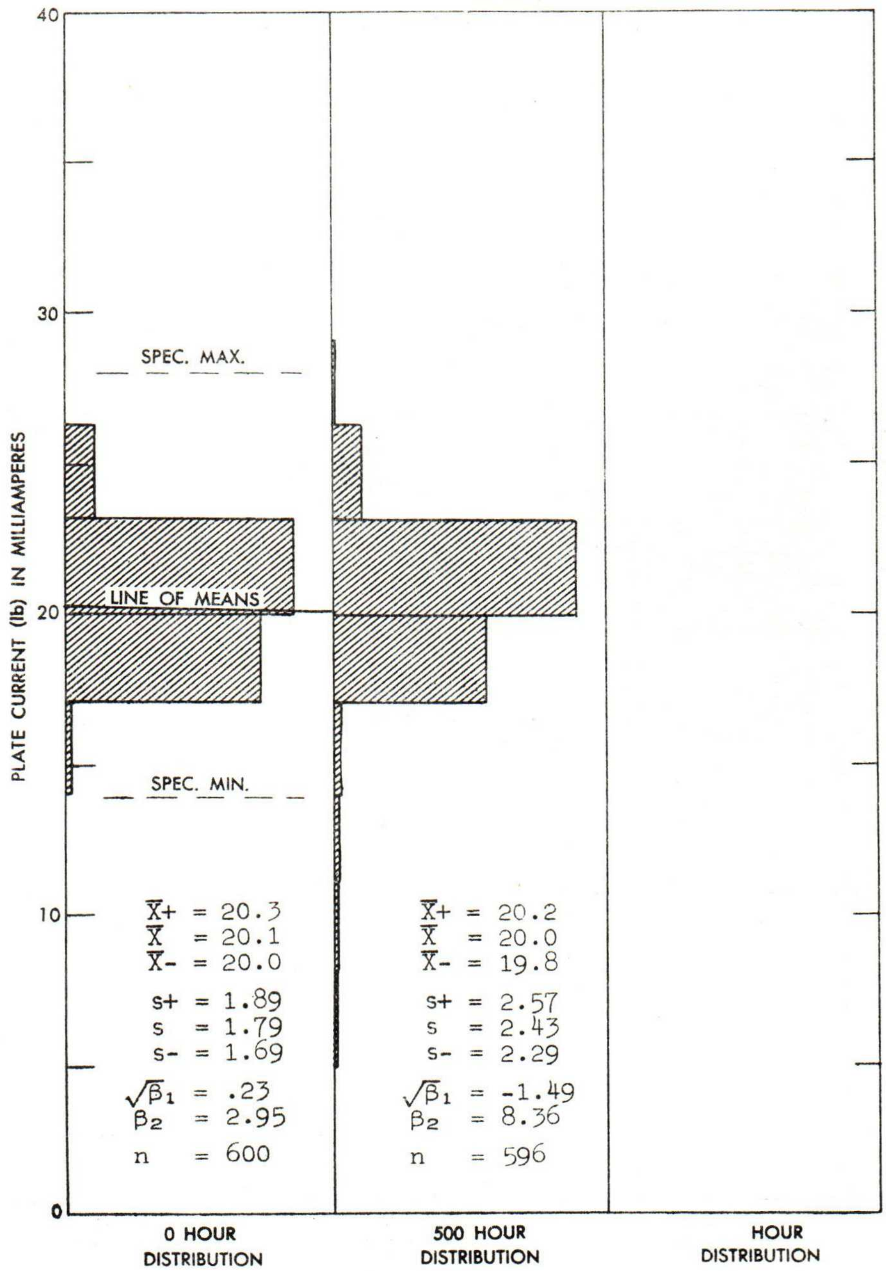


Figure 4-41. Distribution of Plate Current for JAN-5639.

PROPERTY BEHAVIOR FOR JAN-5639

The histograms and data for Screen Grid Current of JAN-5639 are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/169C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

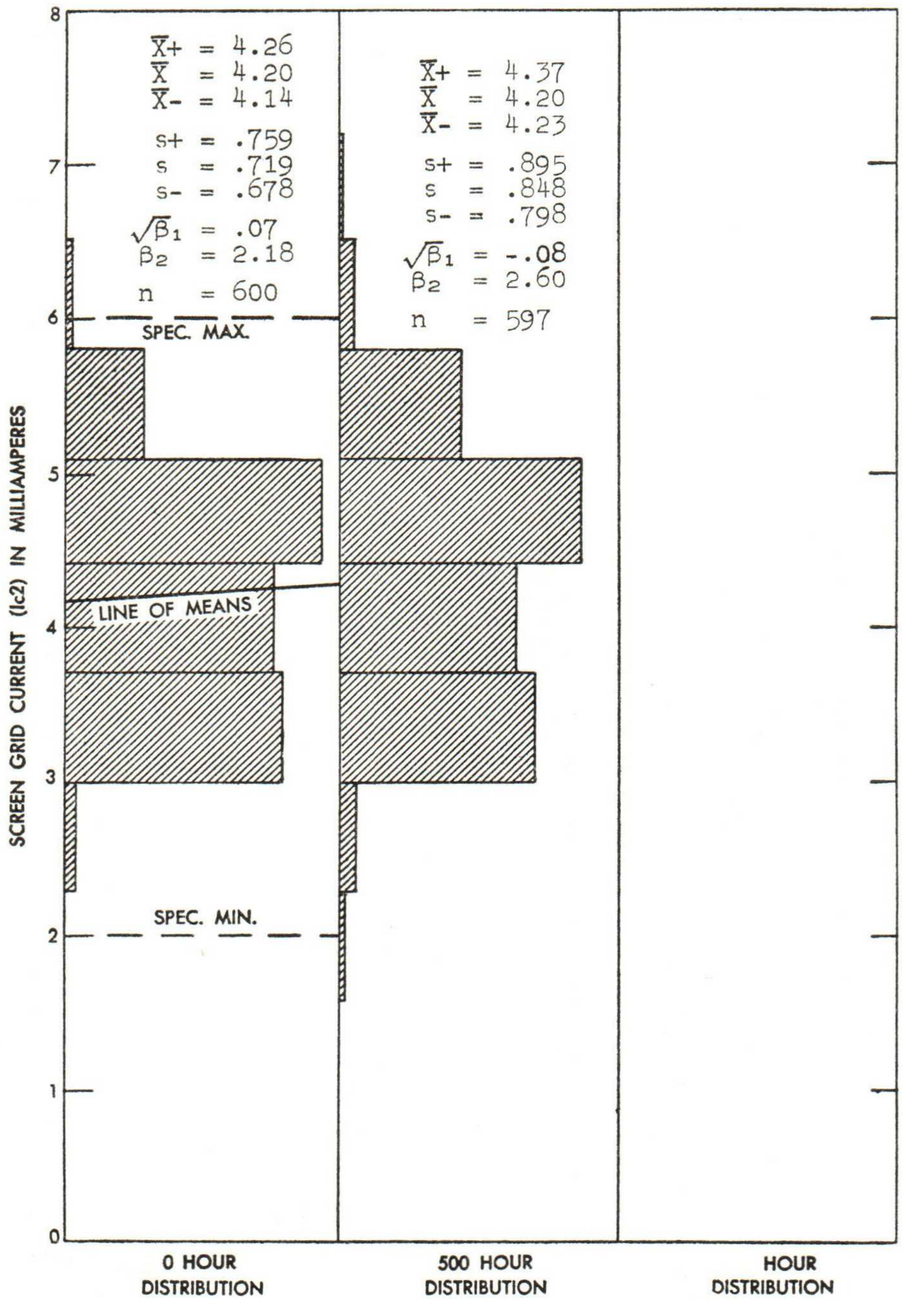


Figure 4-42. Distribution of Screen Grid Current for JAN-5639.

PROPERTY BEHAVIOR FOR JAN-5639

The histograms and data for Transconductance of JAN-5639 are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/169C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

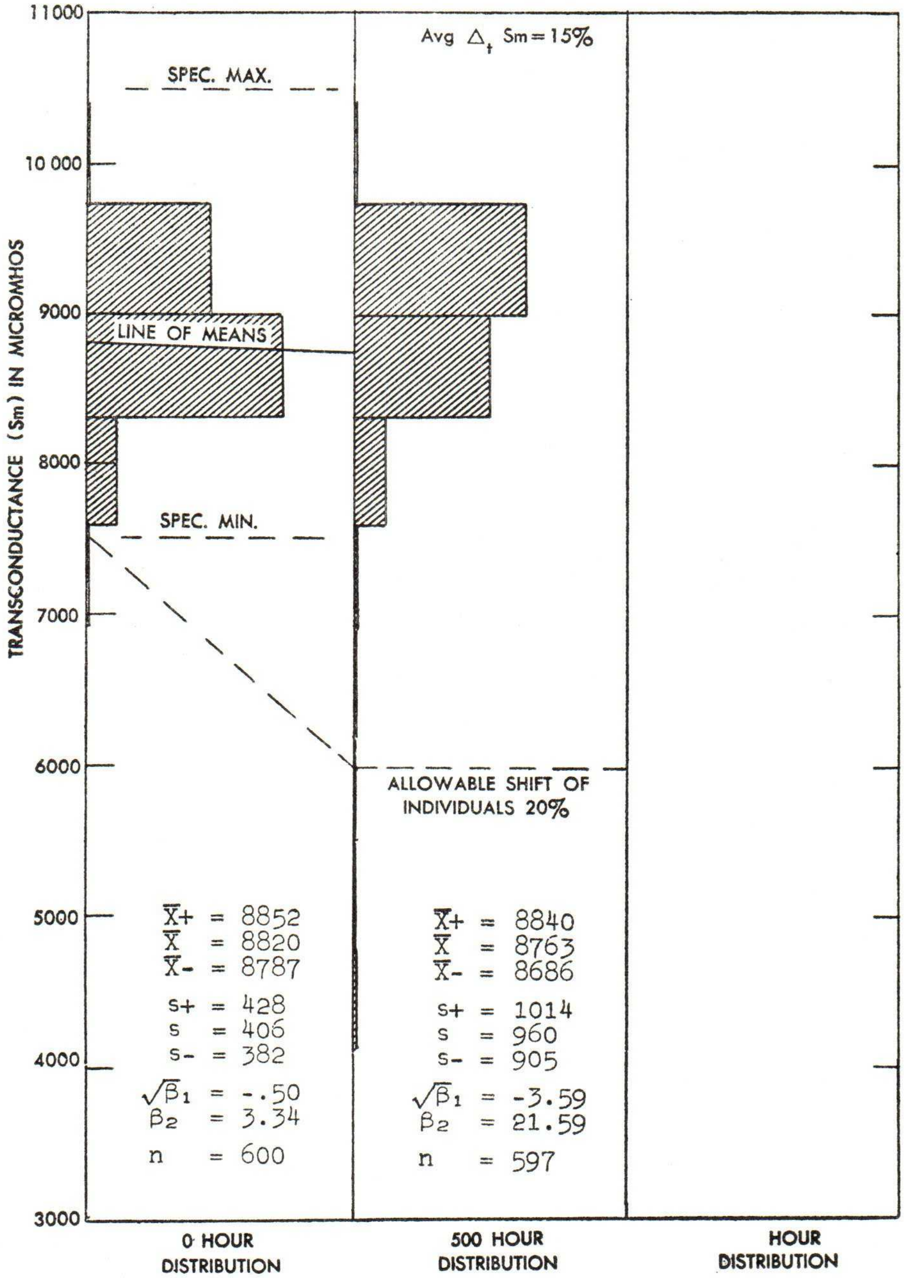


Figure 4-43. Distribution of Transconductance for JAN-5639.

PROPERTY BEHAVIOR FOR JAN-5639

The histograms and data for Reduced Ef Transconductance of JAN-5639 are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/169C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

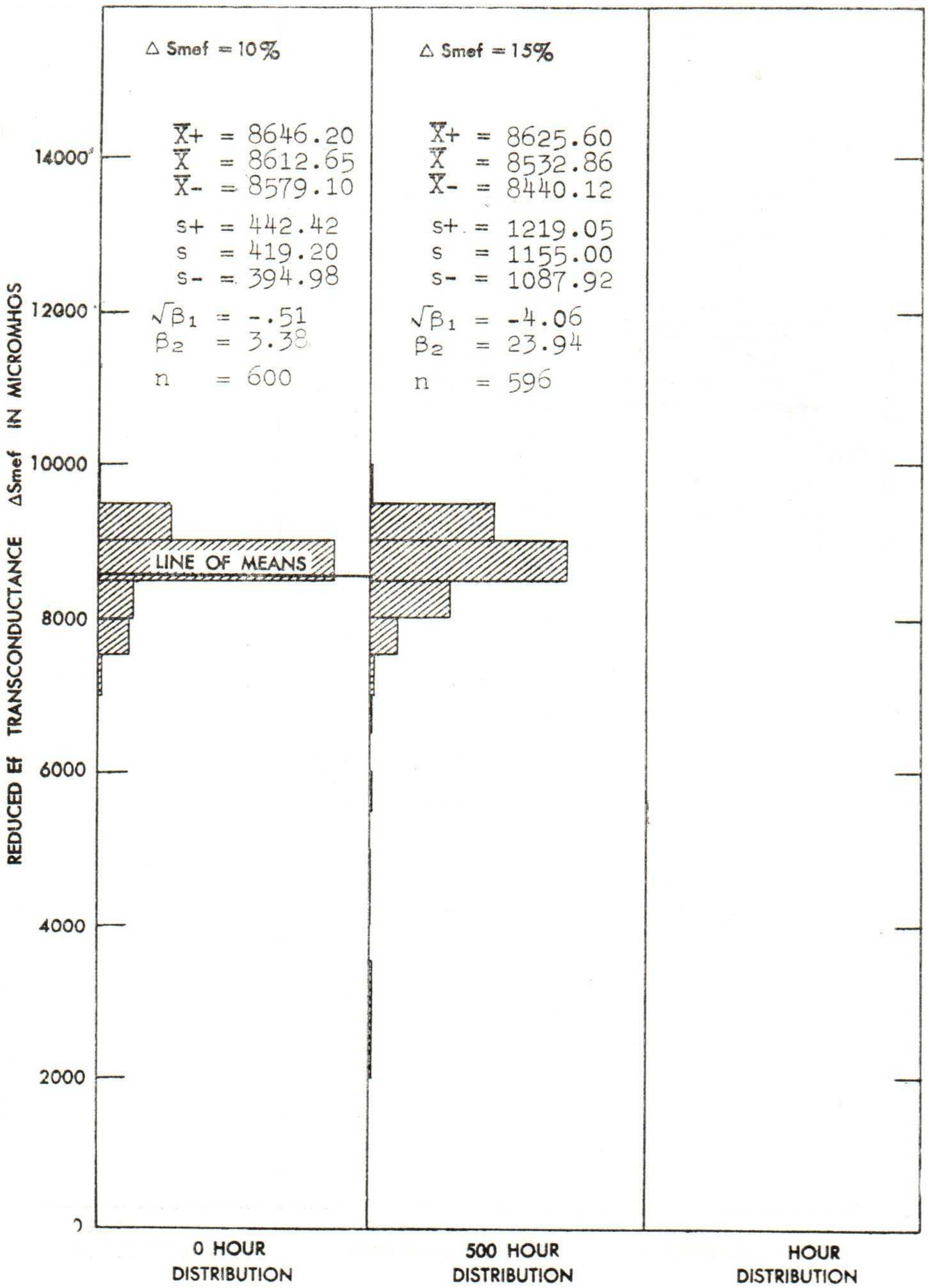


Figure 4-44. Distribution of Reduced Ef Transconductance for JAN-5639.

PROPERTY BEHAVIOR FOR JAN-5647

The histograms and data for Emission Current of JAN-5647 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/204C dated 18 June 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

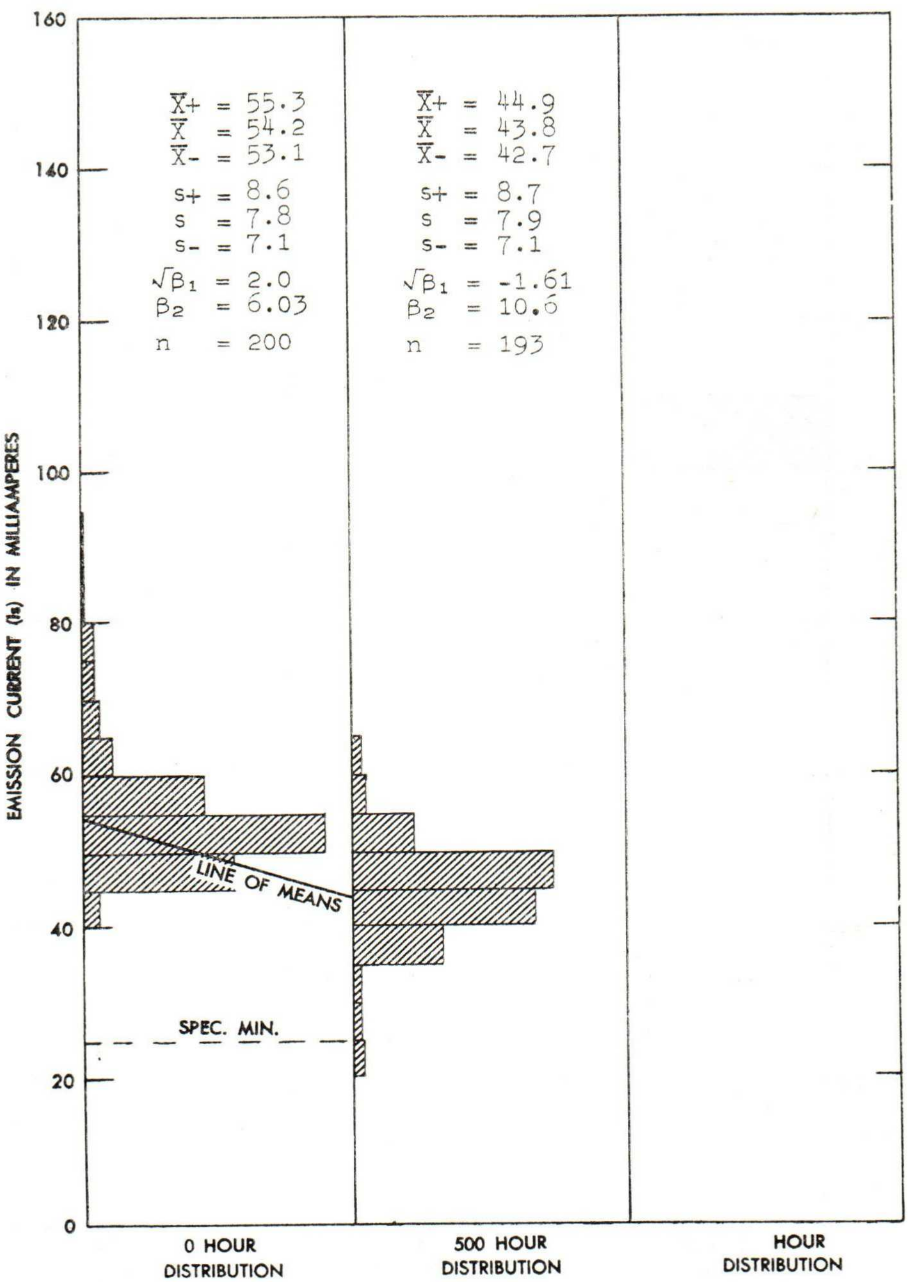


Figure 4-45. Distribution of Emission Current for JAN-5647.

PROPERTY BEHAVIOR FOR JAN-5647

The histograms and data for Operation Current of JAN-5647 are based upon 188 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/204C dated 18 June 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

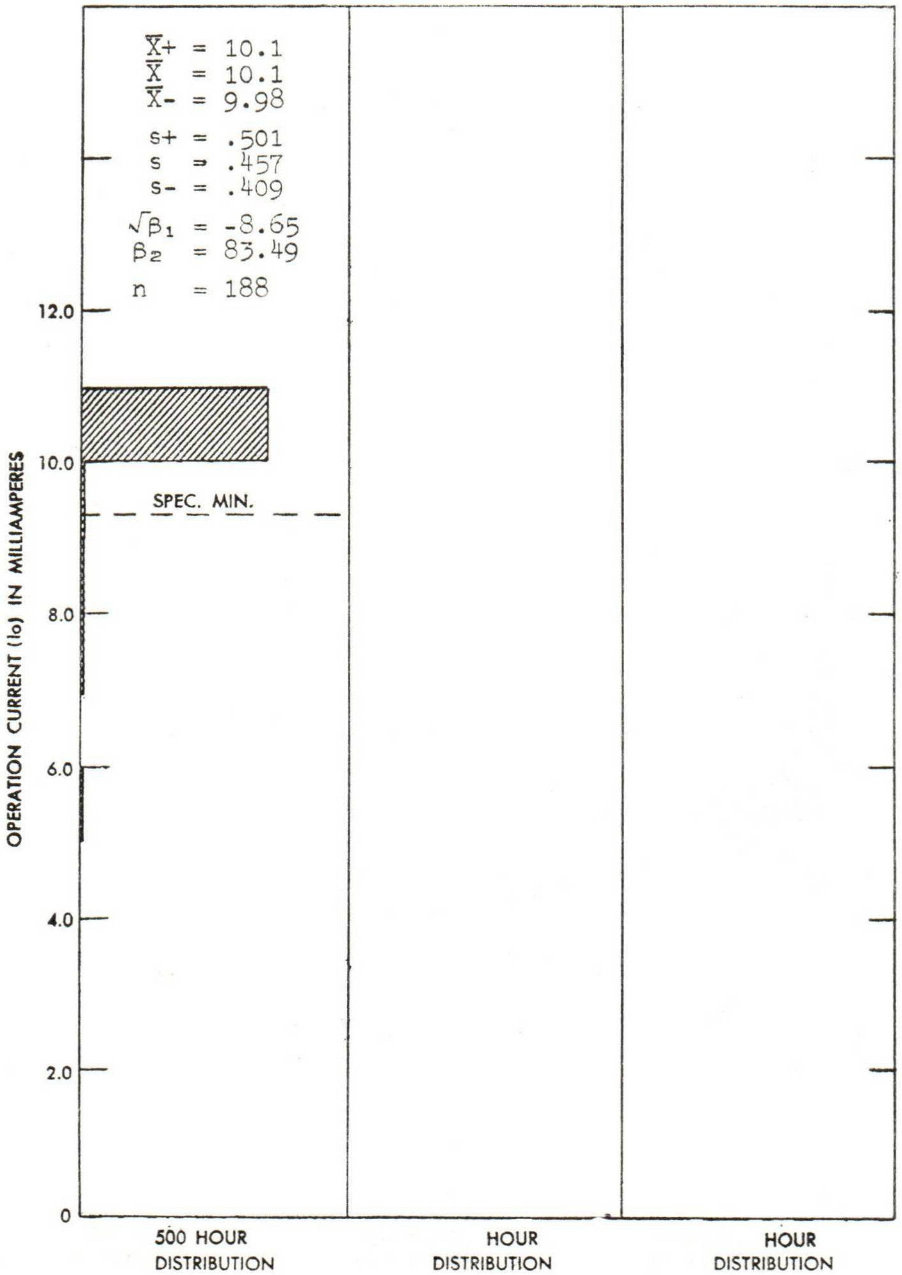


Figure 4-46. Distribution of Operation Current for JAN-5647.

PROPERTY BEHAVIOR FOR JAN-5654/6AK5W

The histograms and data for Plate Current of JAN-5654/6AK5W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/4A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

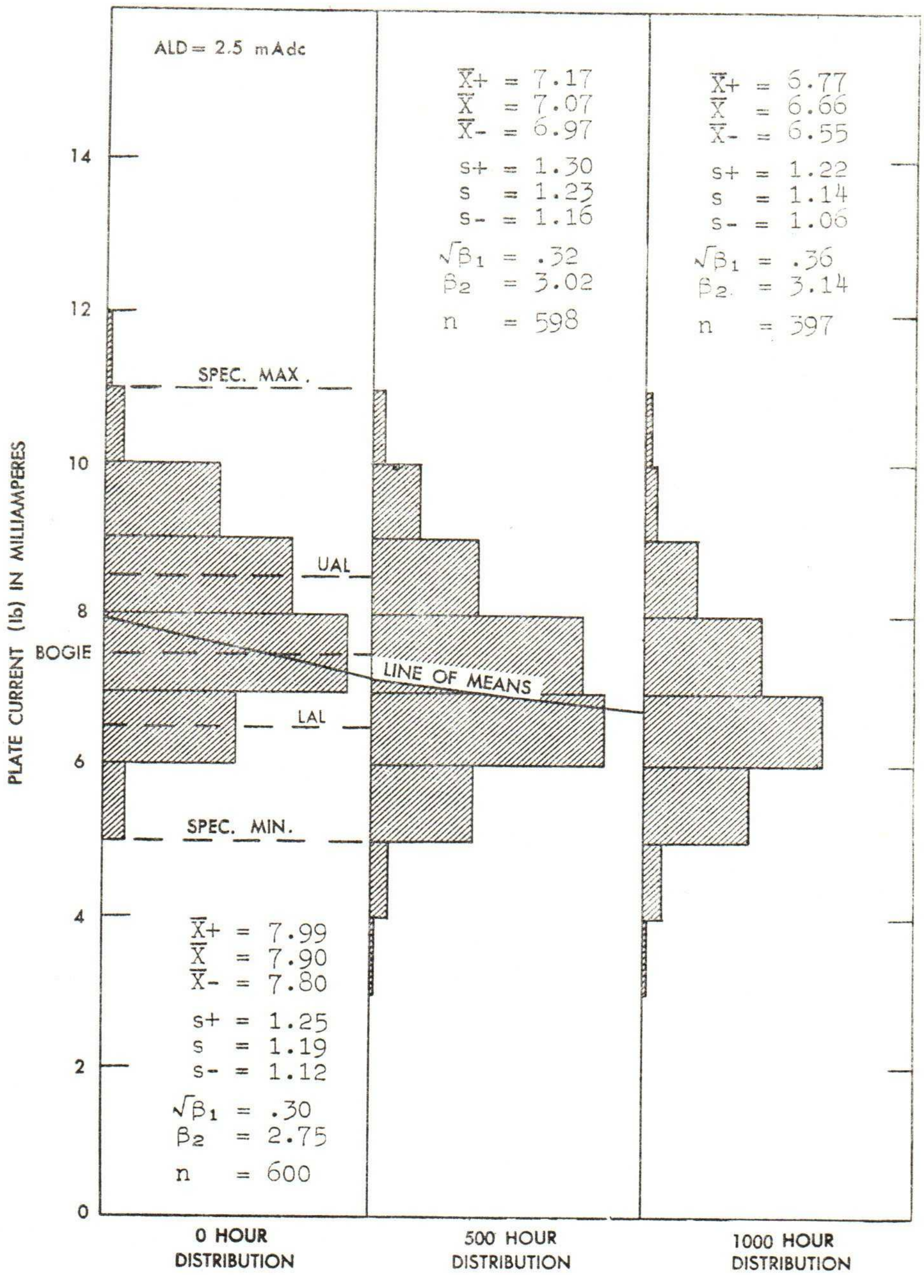


Figure 4-47. Distribution of Plate Current for JAN-5654/6AK5W.

PROPERTY BEHAVIOR FOR JAN-5654/6AK5W

The histograms and data for Screen Grid Current of JAN-5654/6AK5W are based upon 400 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/4A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

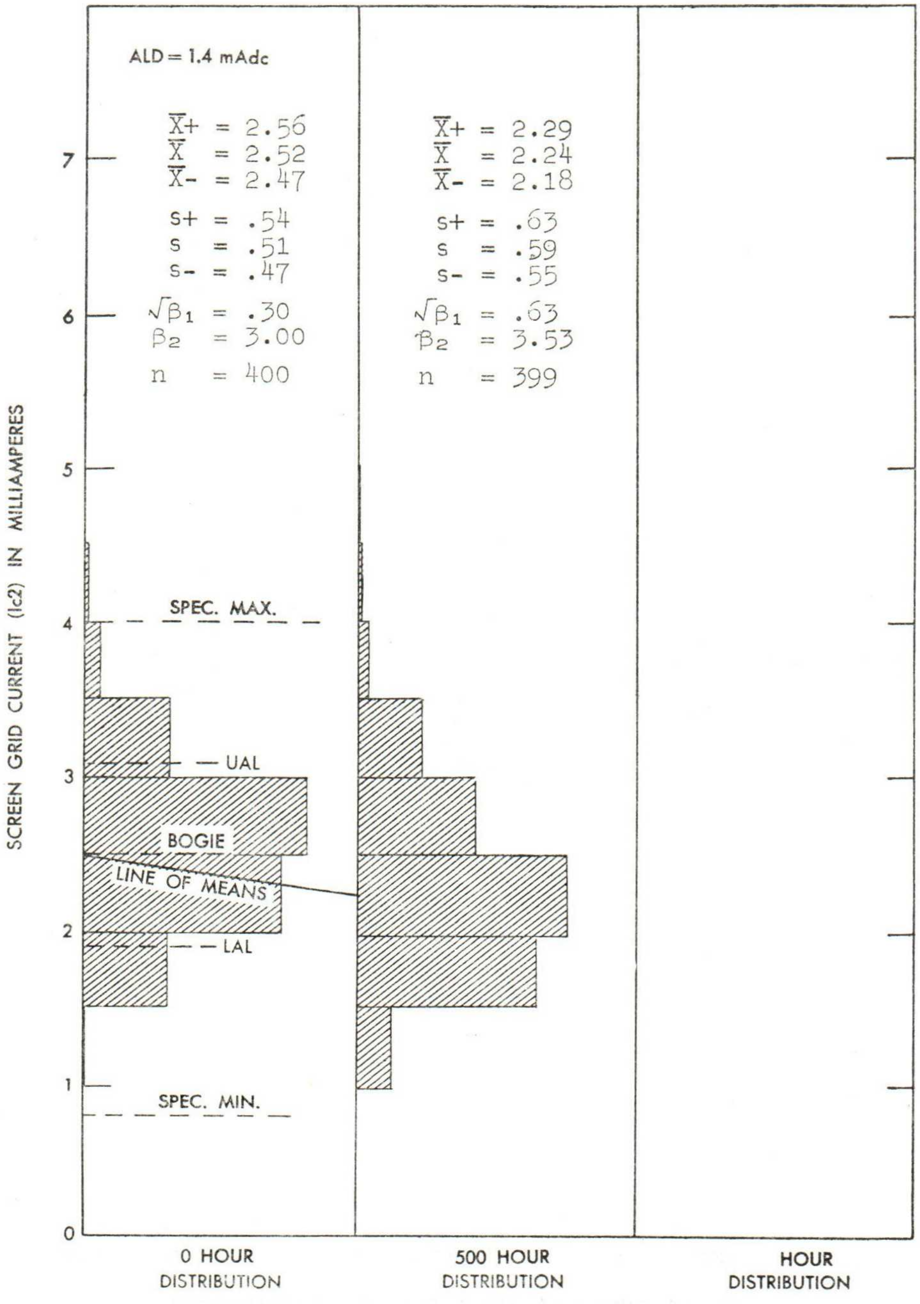


Figure 4-48. Distribution of Screen Grid Current for JAN-5654/6AK5W.

PROPERTY BEHAVIOR FOR JAN-5654/6AK5W

The histograms and data for Reduced Ef Transconductance of JAN-5654/6AK5W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/4A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

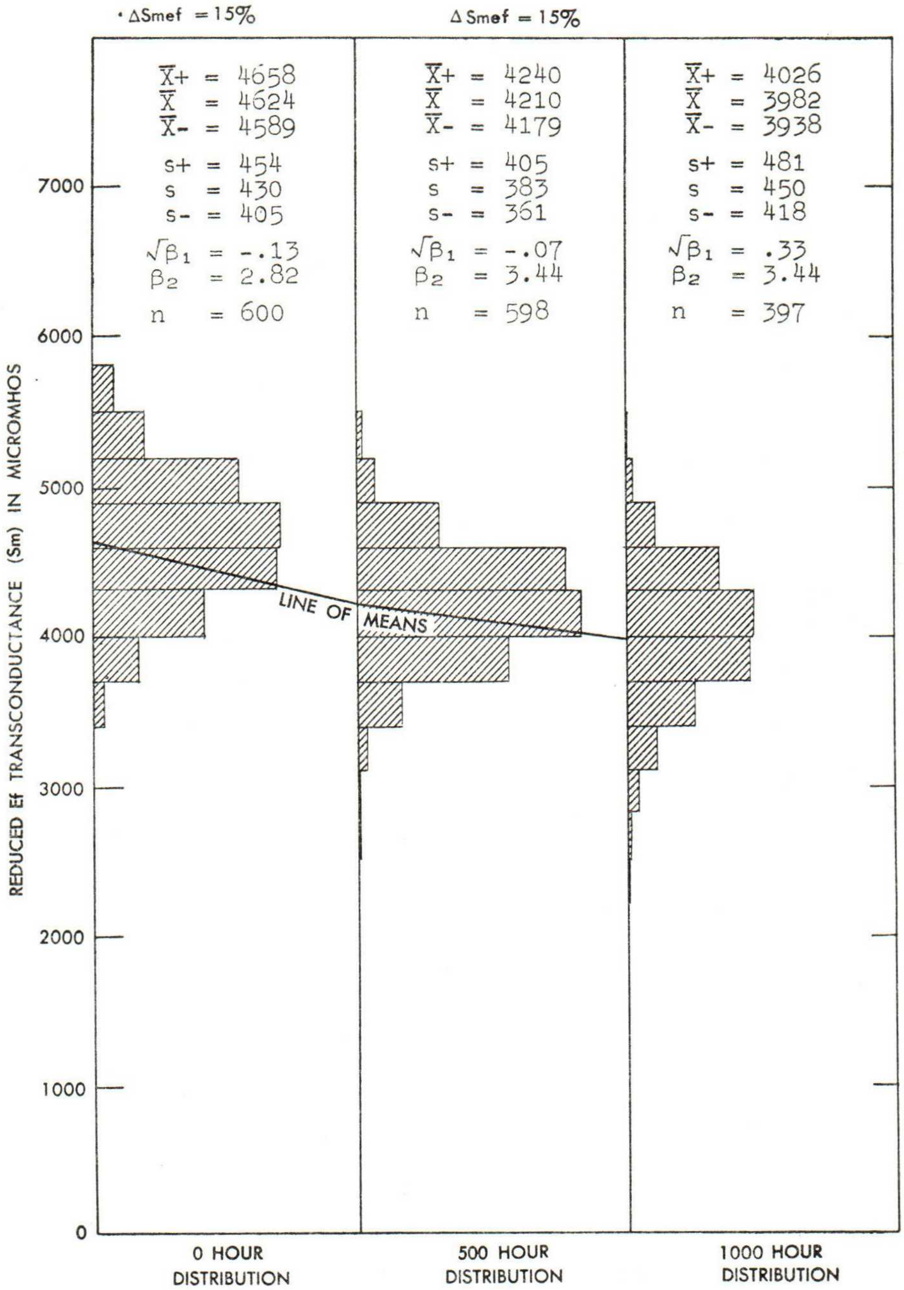


Figure 4-49. Distribution of Reduced Ef Transconductance for JAN-5654/6AK5W.

PROPERTY BEHAVIOR FOR JAN-5654/6AK5W

The histograms and data for Transconductance of JAN-5654/6AK5W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/4A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

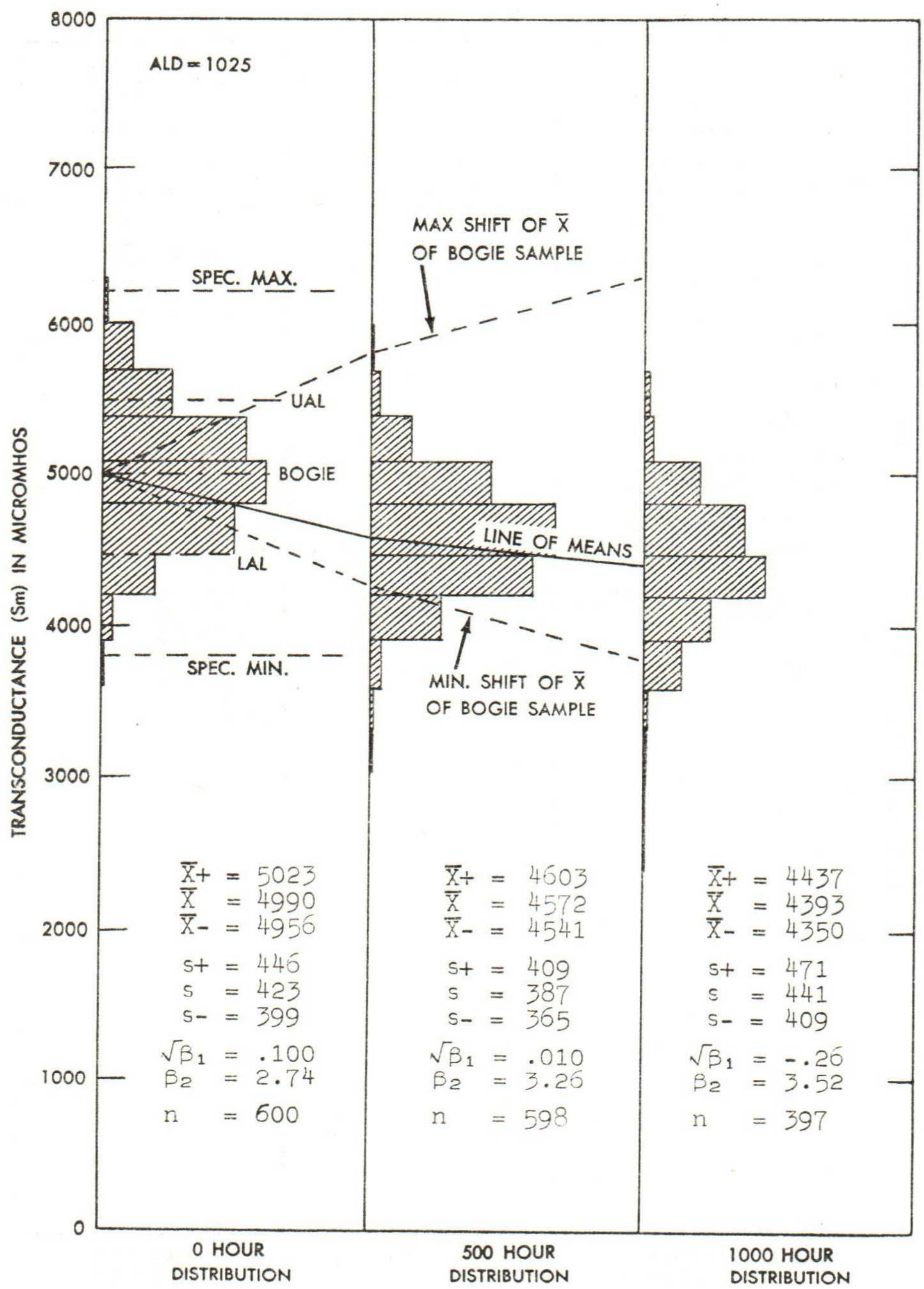


Figure 4-50. Distribution of Transconductance for JAN-5654/6AK5W.

TYPICAL THERMAL BEHAVIOR OF JAN-5654/6AK5W

This data was withdrawn from a sizeable sample of tubes operating under MIL-E-1 test conditions in the absence of any tube shield. It shows that at elevated environmental temperatures it is possible to exceed the maximum rated bulb temperature in every case. Attention of the designer is directed to the term effective environmental temperature. The effective environment seen by an electron tube is difficult to define, particularly with the presence or absence of ventilation, air circulation, liquid cooling, and shielding devices. It must be noted, however, that for a given total dissipation within the tube, the bulb temperature under bare bulb conditions will give a good indication of the effective environment.

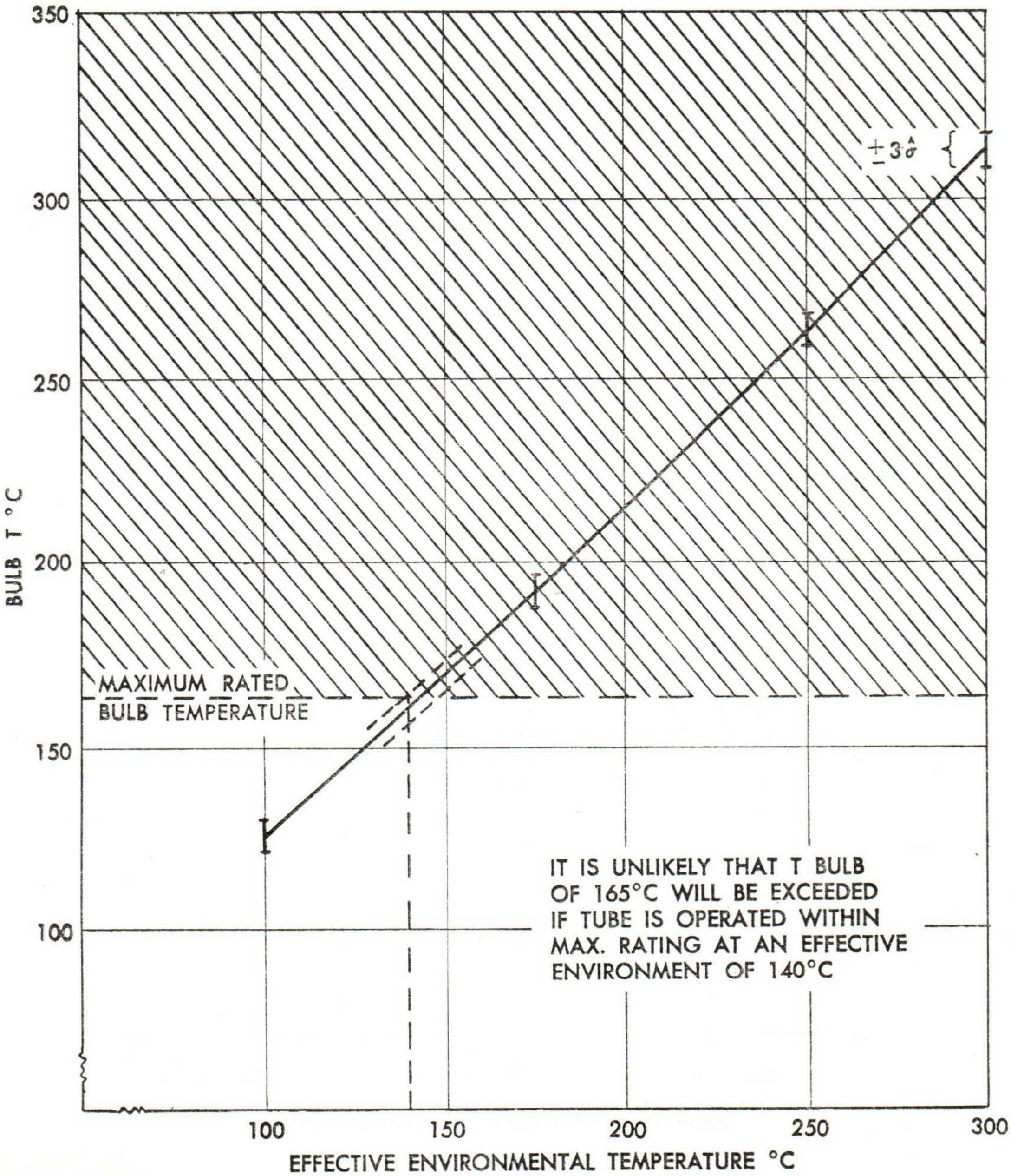


Figure 4-51. Typical Thermal Behavior for JAN-5654/6AK5W.

PROPERTY BEHAVIOR FOR JAN-5670

The histograms and data for Plate Current of JAN-5670 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/5A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

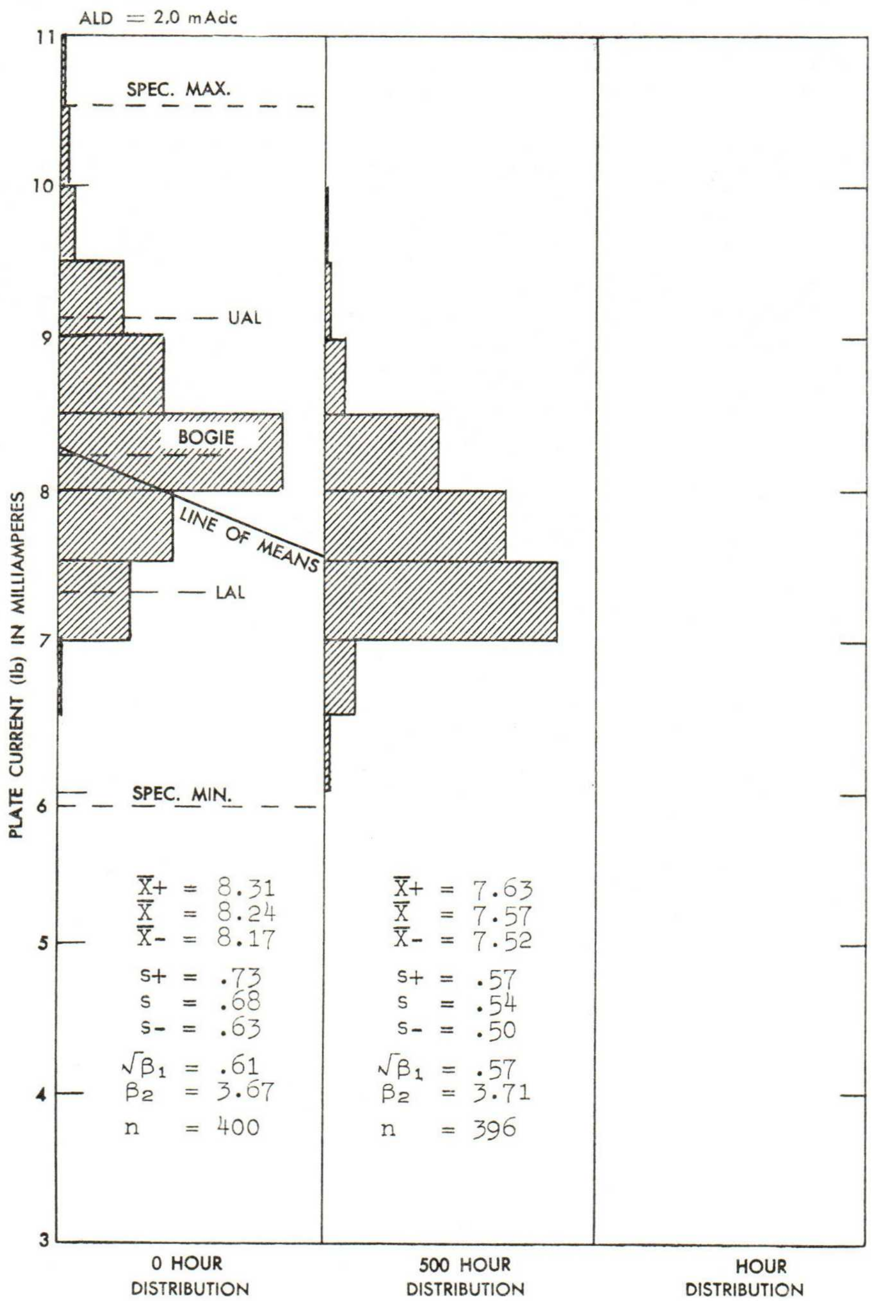


Figure 4-52. Distribution of Plate Current for JAN-5670.

PROPERTY BEHAVIOR FOR JAN-5670

The histograms and data for Transconductance of JAN-5670 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/5A dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

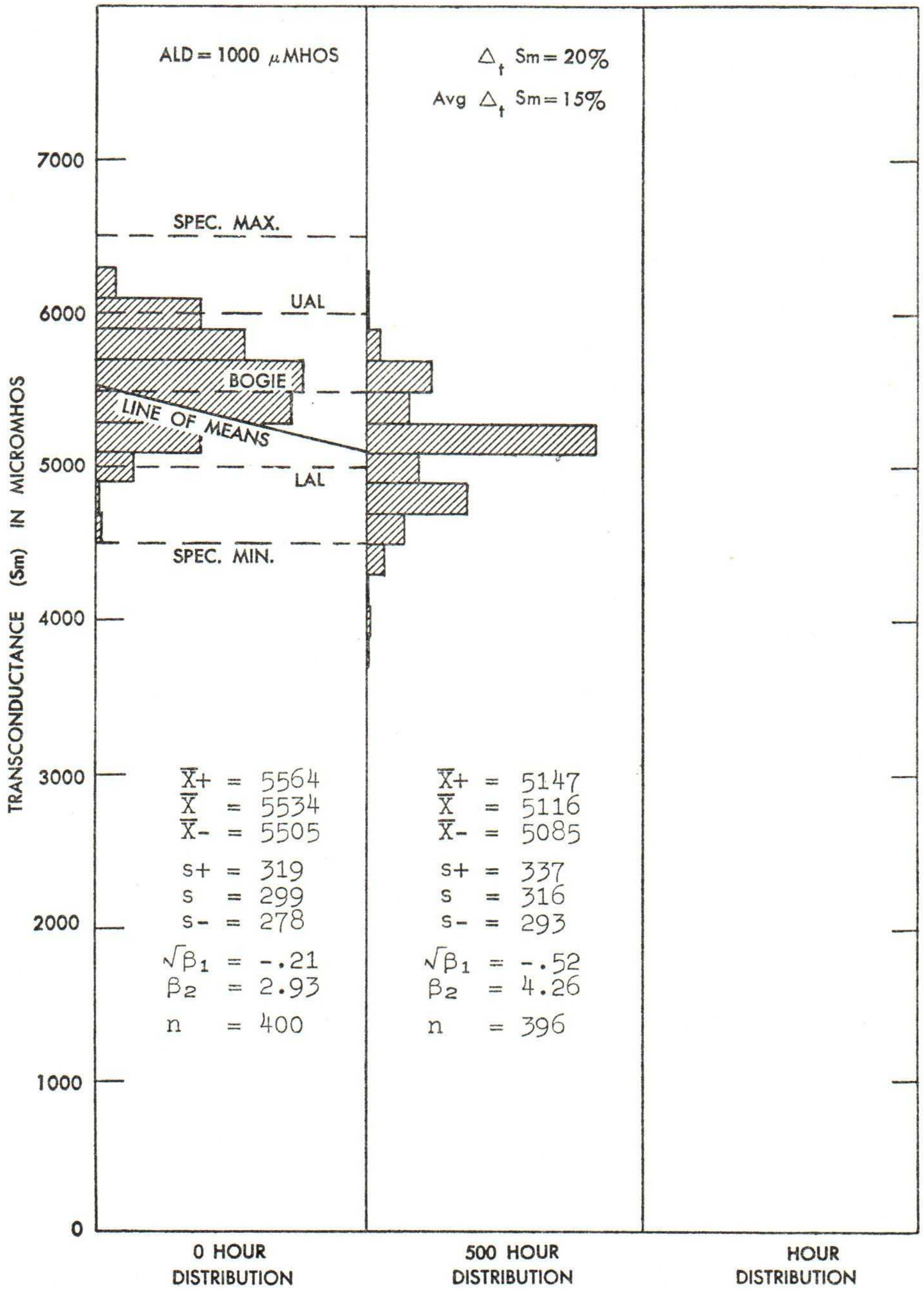


Figure 4-53. Distribution of Transconductance for JAN-5670.

TYPICAL THERMAL BEHAVIOR OF JAN–5670

This data was withdrawn from a sizeable sample of tubes operating under MIL–E–1 test conditions in the absence of any tube shield. It shows that at elevated environmental temperatures it is possible to exceed the maximum rated bulb temperature in every case. Attention of the designer is directed to the term effective environmental temperature. The effective environment seen by an electron tube is difficult to define, particularly with the presence or absence of ventilation, air circulation, liquid cooling, and shielding devices. It must be noted, however, that for a given total dissipation within the tube, the bulb temperaure under bare bulb conditions will give a good indication of ½ the effective environment.

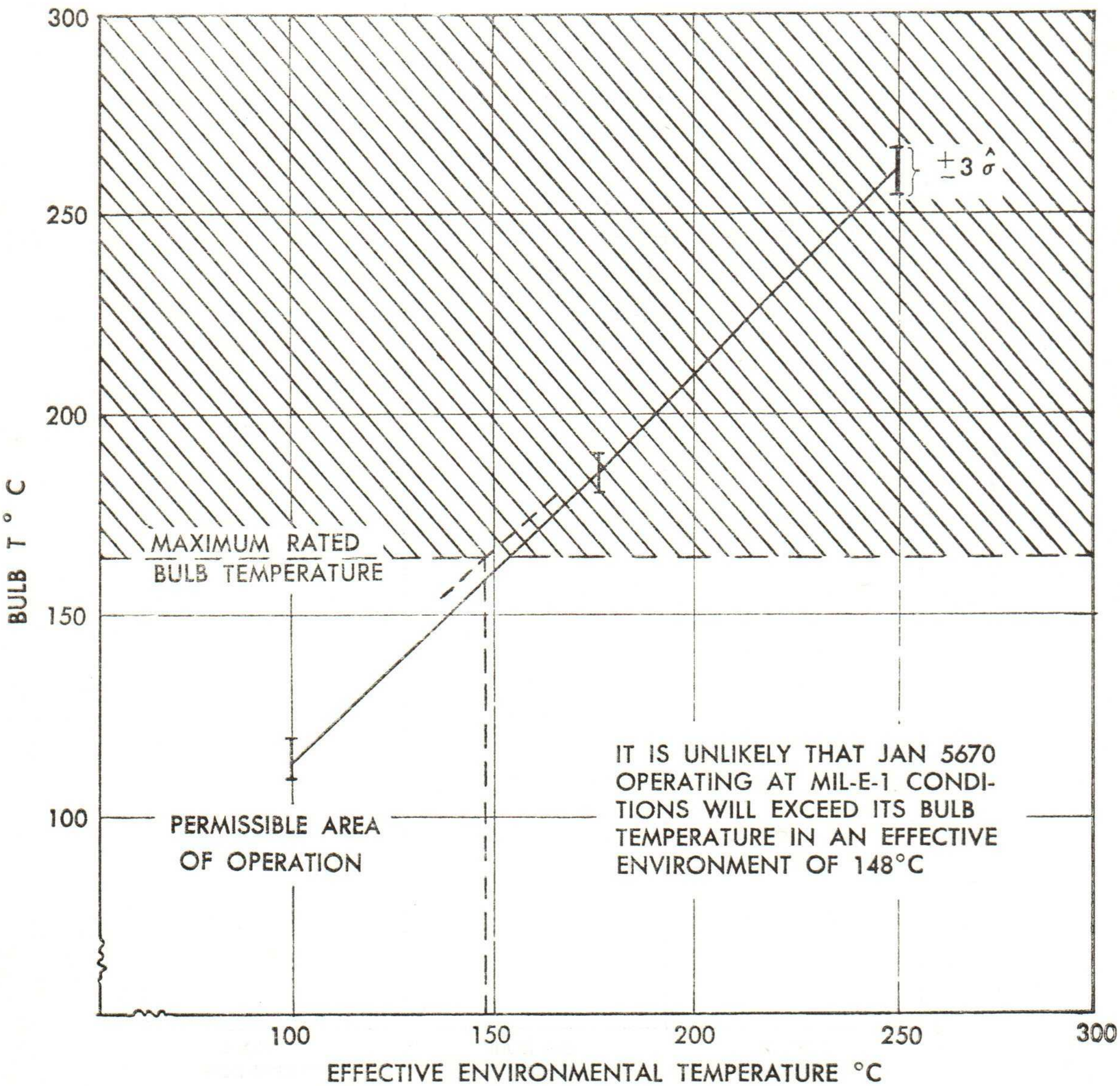


Figure 4-54. Typical Thermal Behavior of JAN-5670.

PROPERTY BEHAVIOR FOR JAN-5672

The histograms and data for Plate Current of JAN-5672 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/280 dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

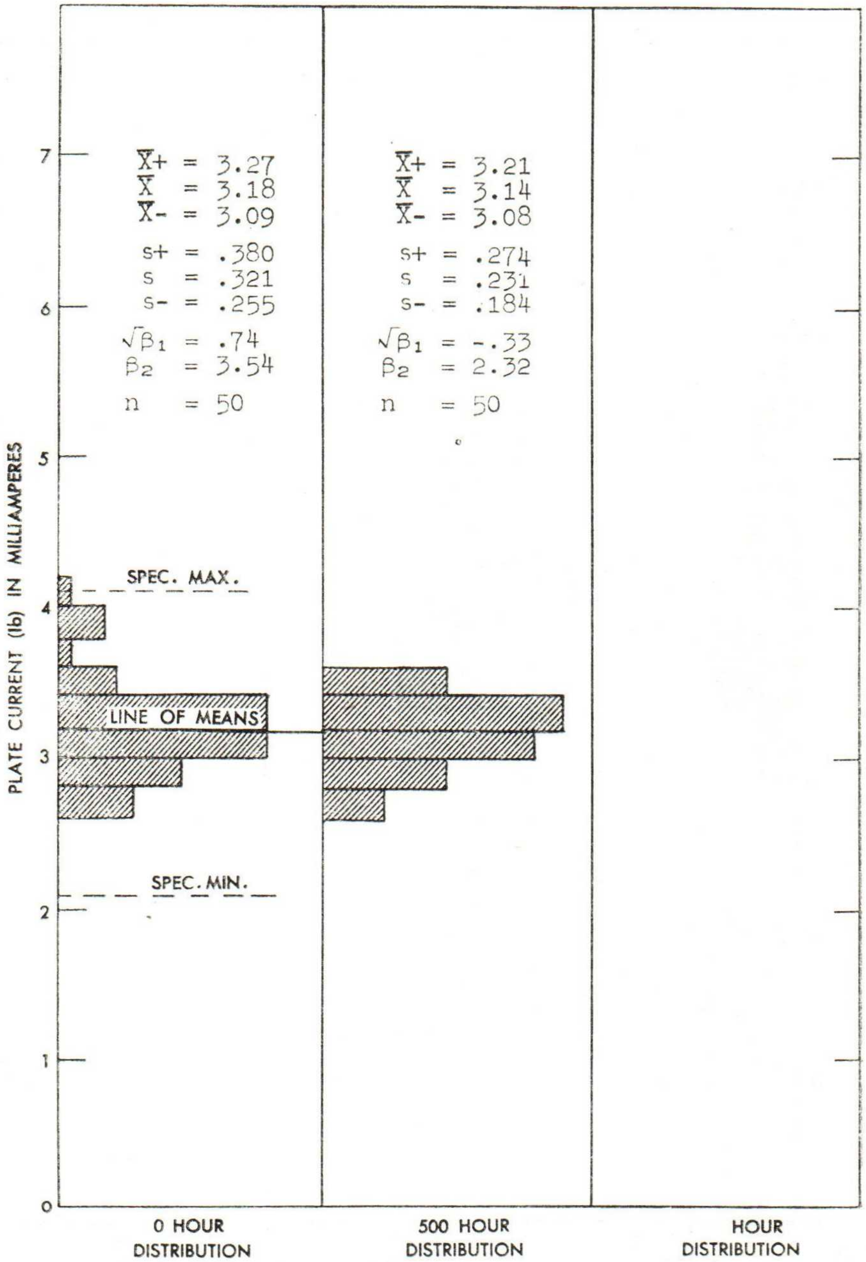


Figure 4-55. Distribution of Plate Current for JAN-5672.

PROPERTY BEHAVIOR FOR JAN-5672

The histograms and data for Screen Grid Current of JAN-5672 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/280 dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

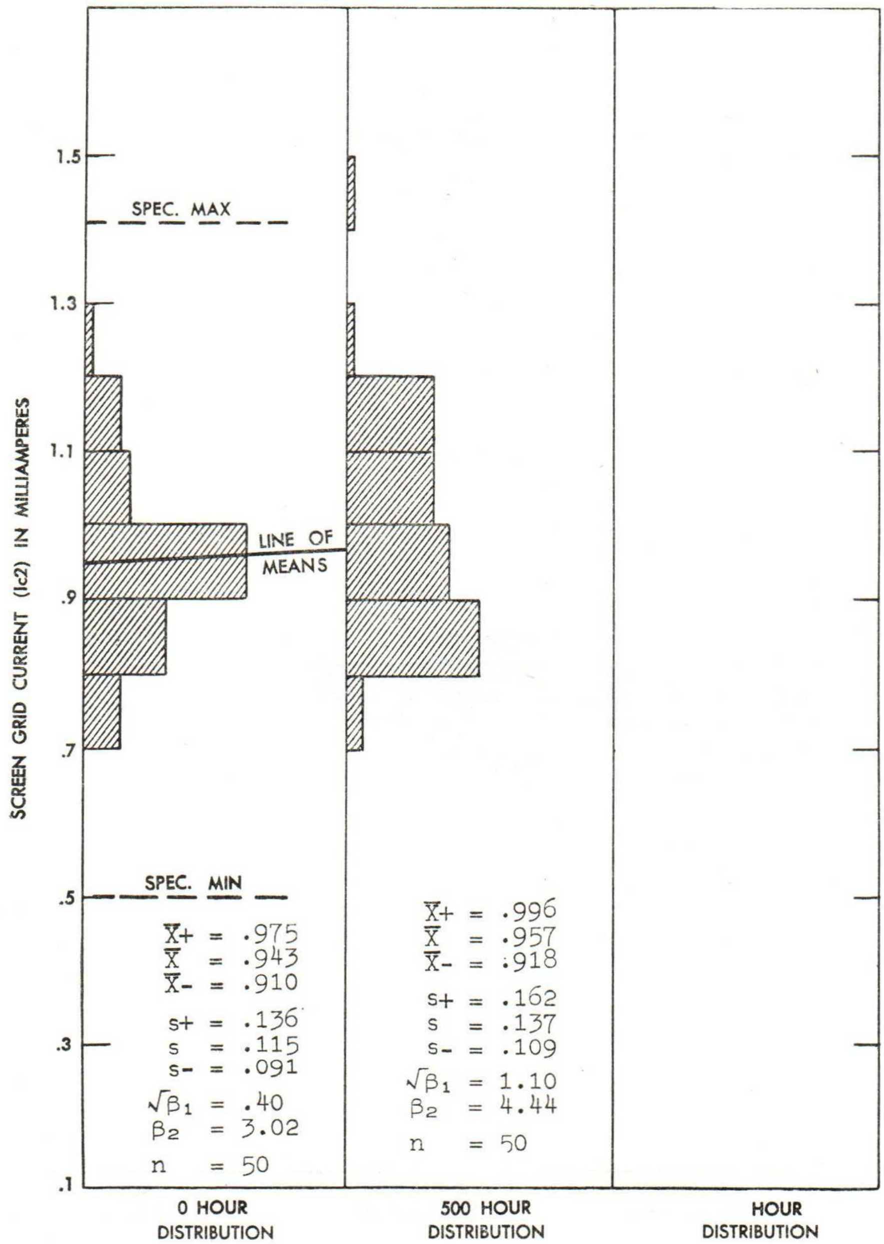


Figure 4-56. Distribution of Screen Grid Current for JAN-5672.

PROPERTY BEHAVIOR FOR JAN-5672

The histograms and data for Transconductance of JAN-5672 are based upon 50 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/280 dated 9 July 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

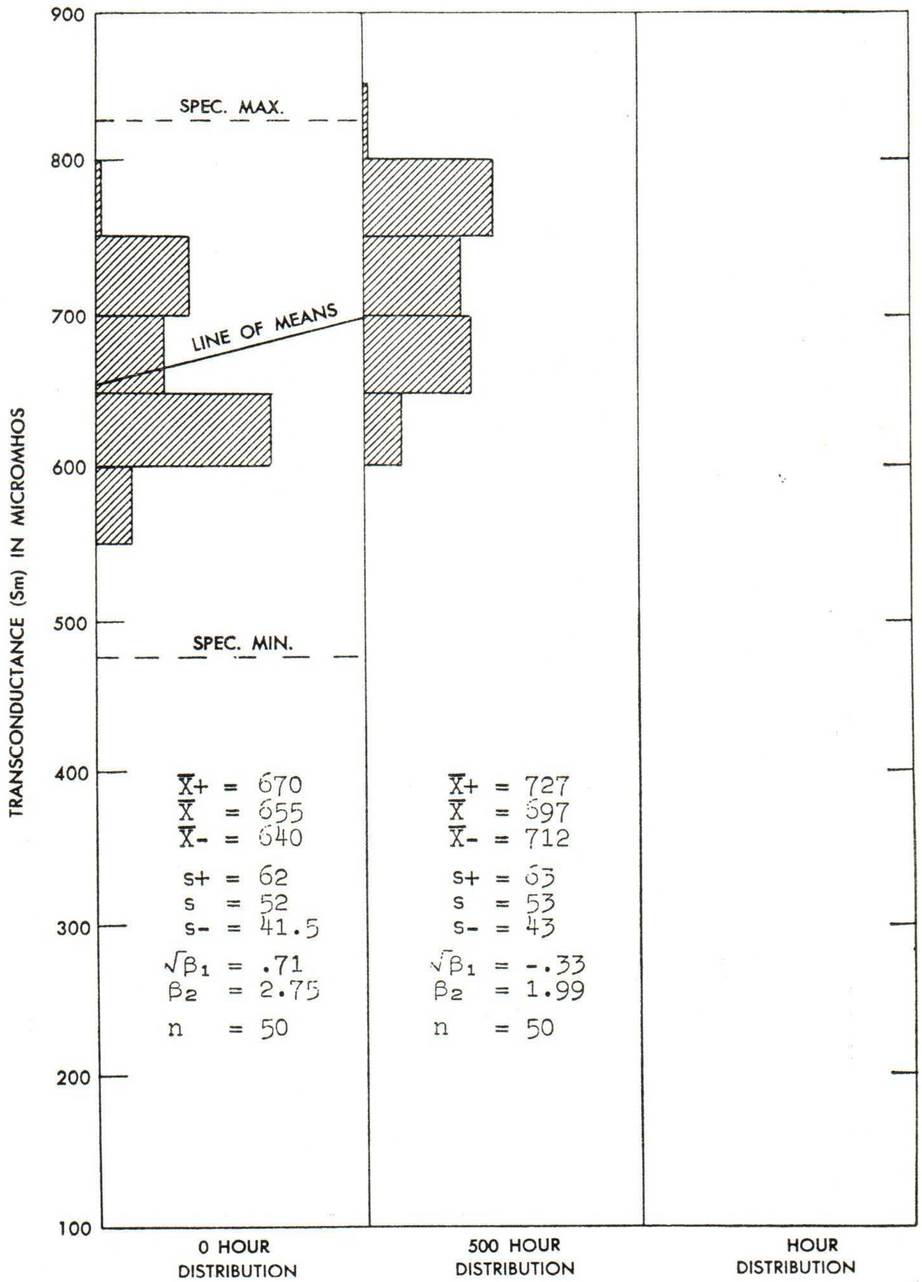


Figure 4-57. Distribution of Transconductance for JAN-5672.

PROPERTY BEHAVIOR FOR JAN–5686

The histograms and data for Plate Current of JAN–5686 are based upon 442 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/171 dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

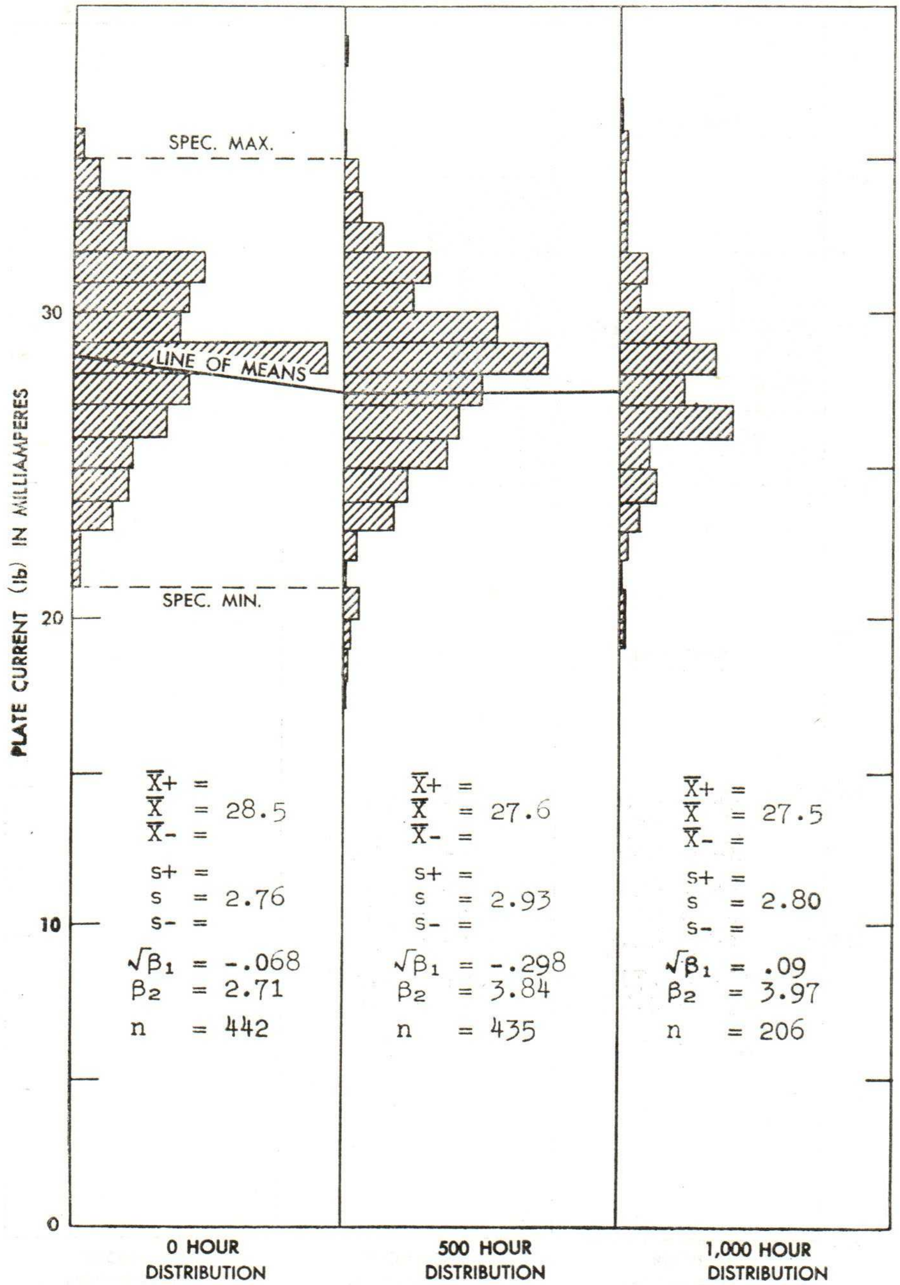


Figure 4-58. Distribution of Plate Current for JAN-5686.

PROPERTY BEHAVIOR FOR JAN-5686

The histograms and data for Screen Grid Current of JAN-5686 are based upon 442 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/171 dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

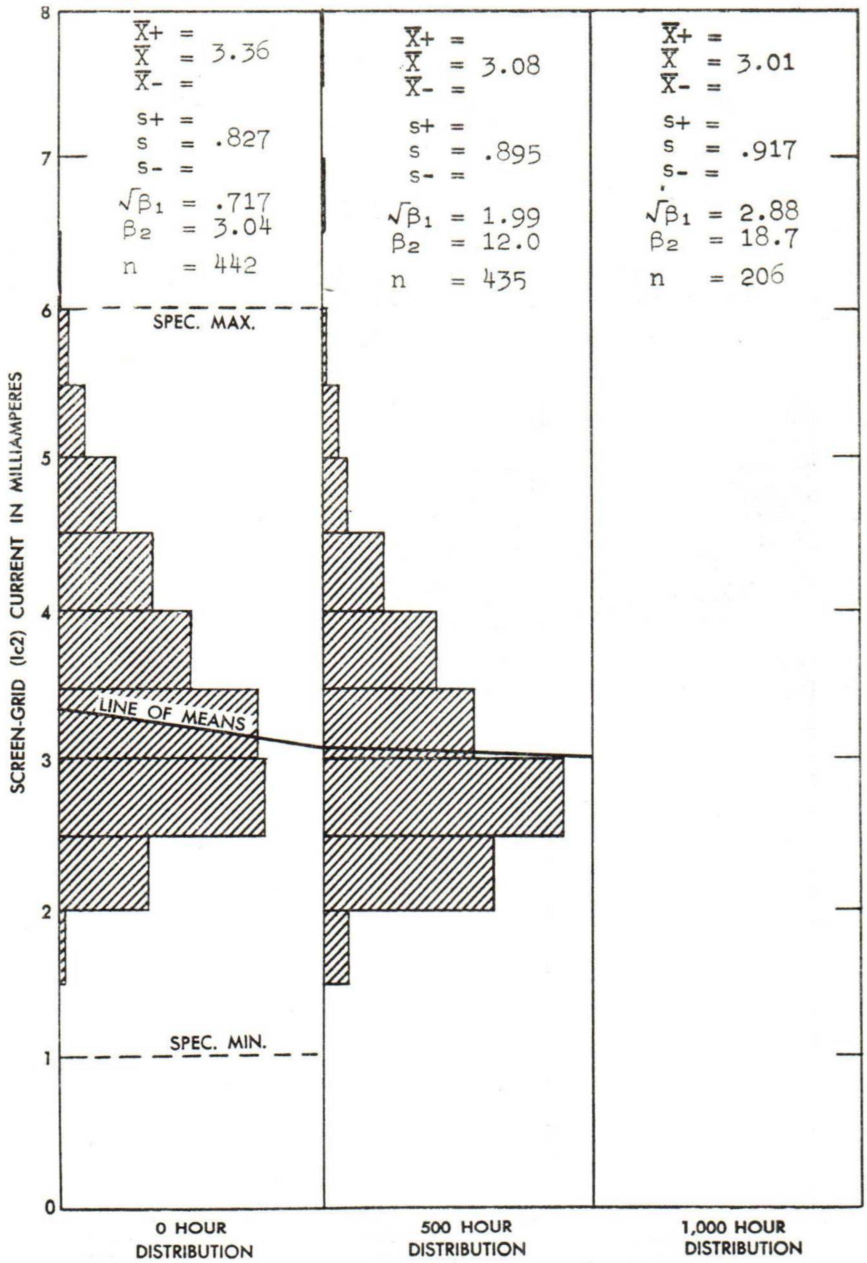


Figure 4-59. Distribution of Screen Grid Current for JAN-5686.

PROPERTY BEHAVIOR FOR JAN-5686

The histograms and data for Power Oscillation of JAN-5686 are based upon 442 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/171 dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

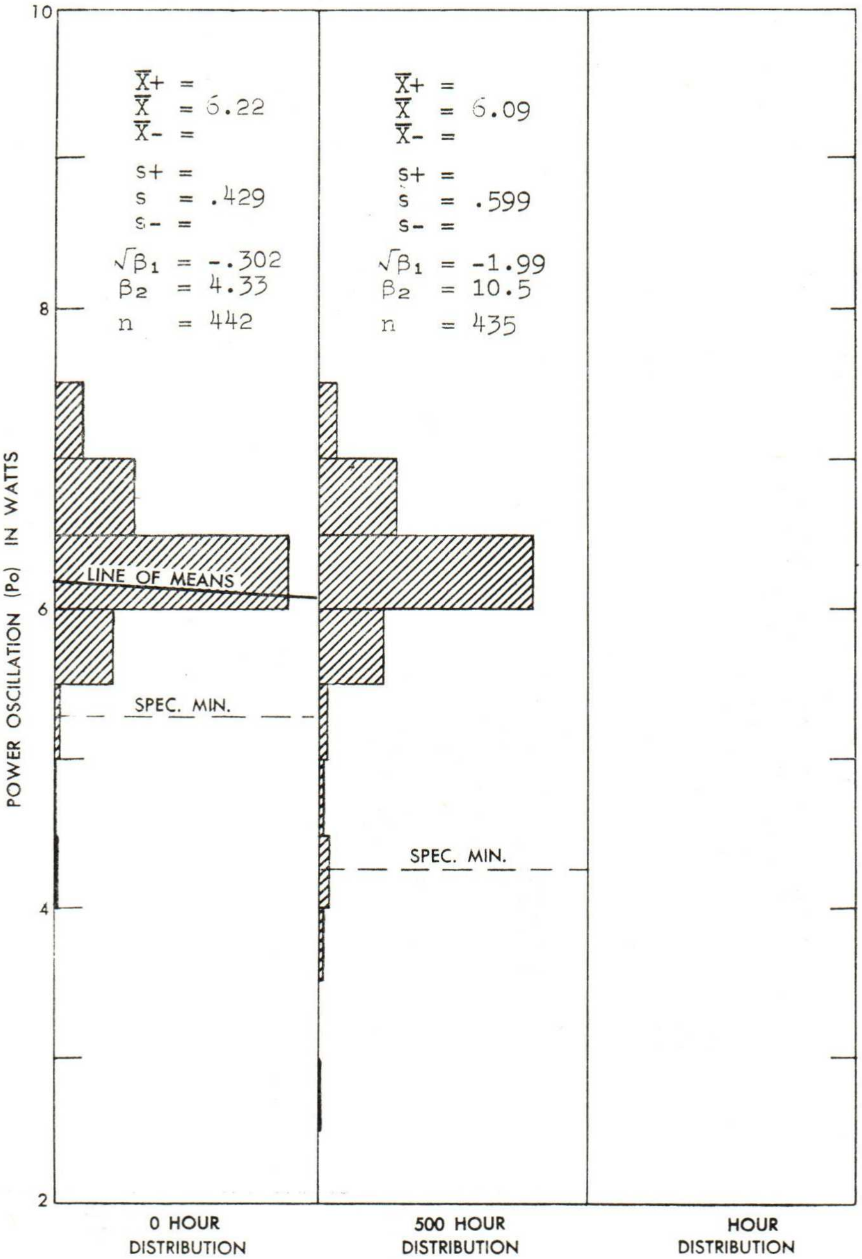


Figure 4-60. Distribution of Power Oscilation for JAN-5686.

PROPERTY BEHAVIOR FOR JAN-5687

The histograms and data for Plate Current of JAN-5687 are based upon 390 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/80C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

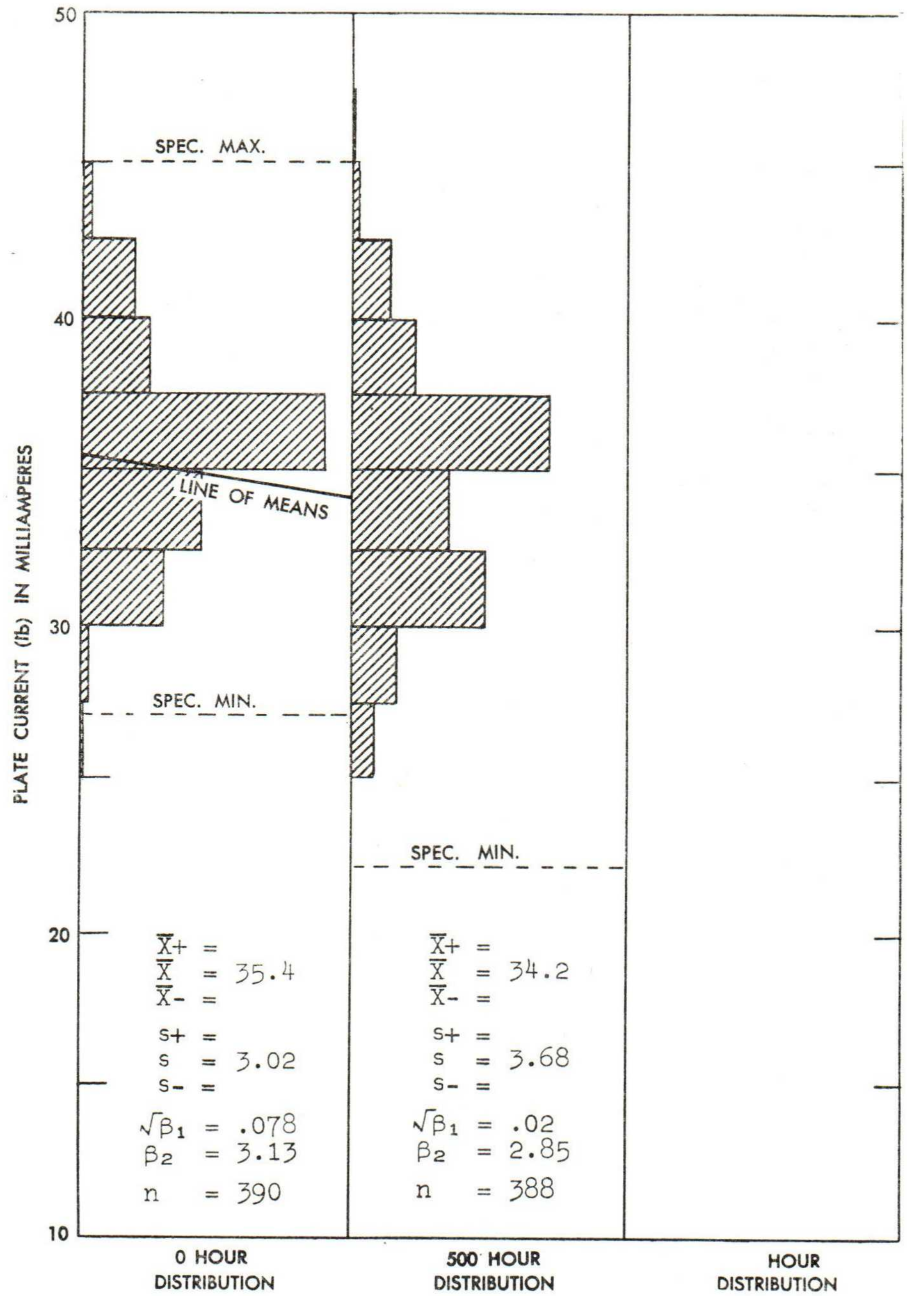


Figure 4-61. Distribution of Plate Current for JAN-5687.

PROPERTY BEHAVIOR FOR JAN-5687

The histograms and data for Transconductance of JAN-5687 are based upon 390 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/80C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

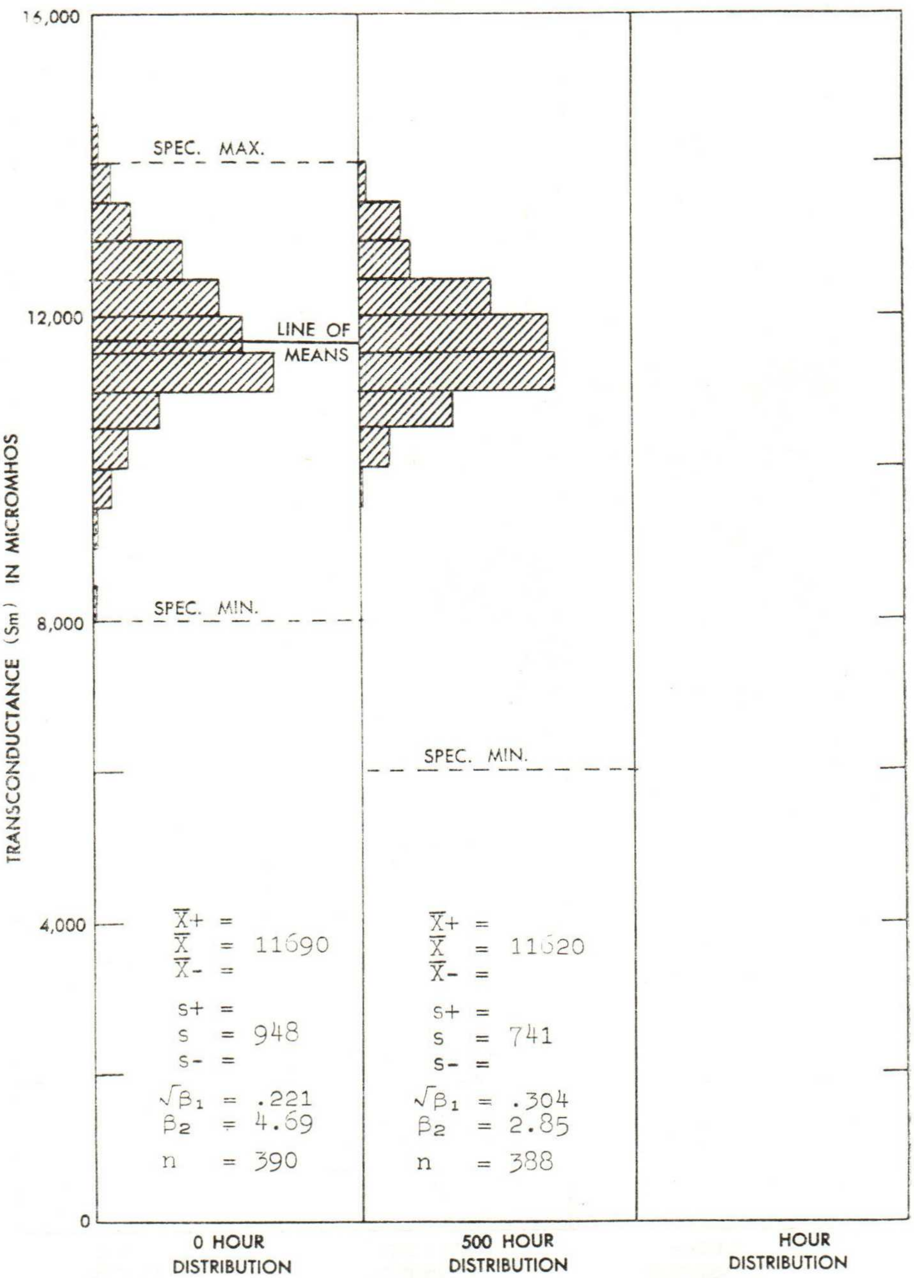


Figure 4-62. Distribution of Transconductance for JAN-5687.

PROPERTY BEHAVIOR FOR JAN-5702WA

The histograms and data for Plate Current of JAN-5702WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/82B dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

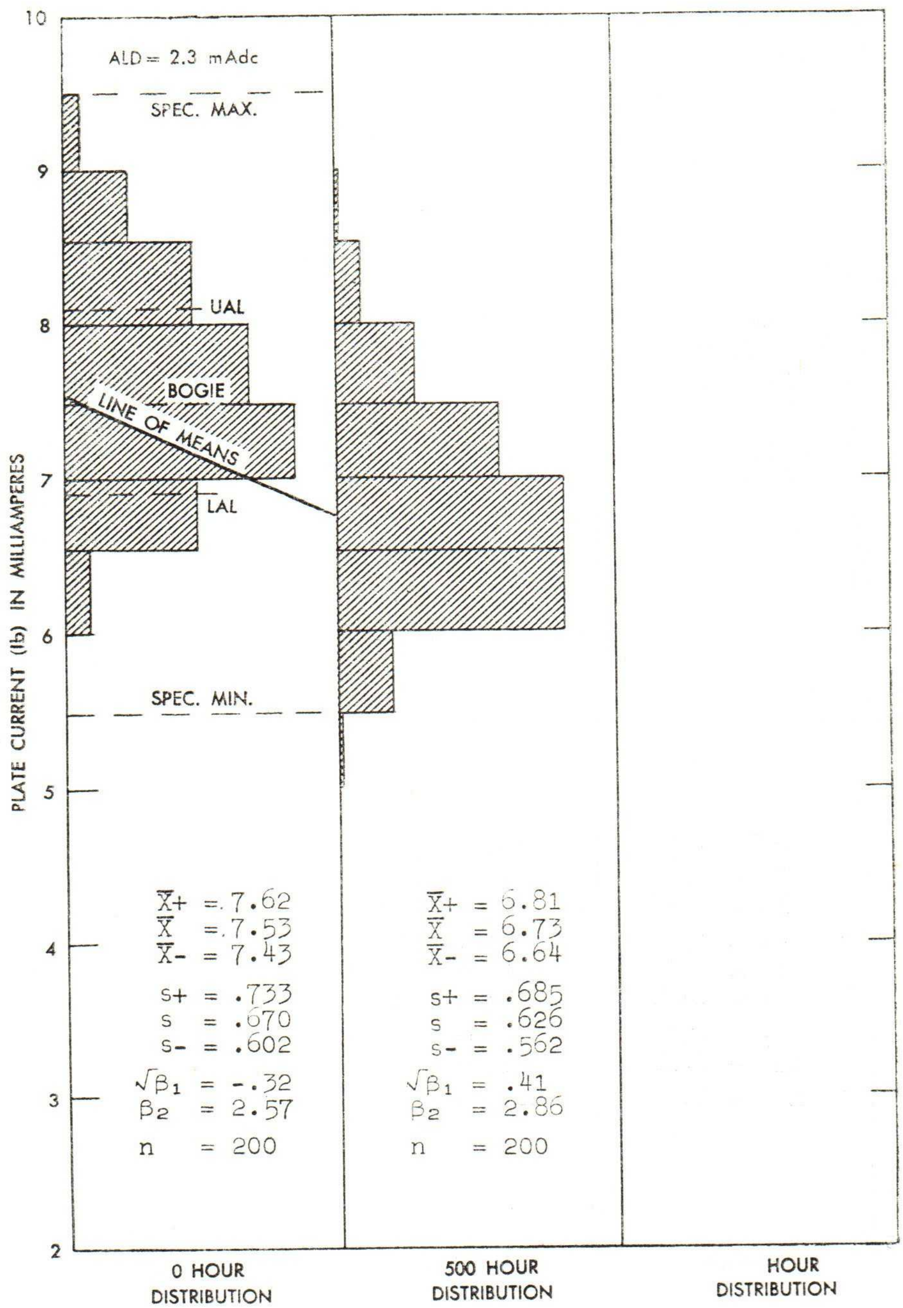


Figure 4-63. Distribution of Plate Current for JAN-5702WA.

PROPERTY BEHAVIOR FOR JAN-5702WA

The histograms and data for Screen Grid Current of JAN-5702WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/82B dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

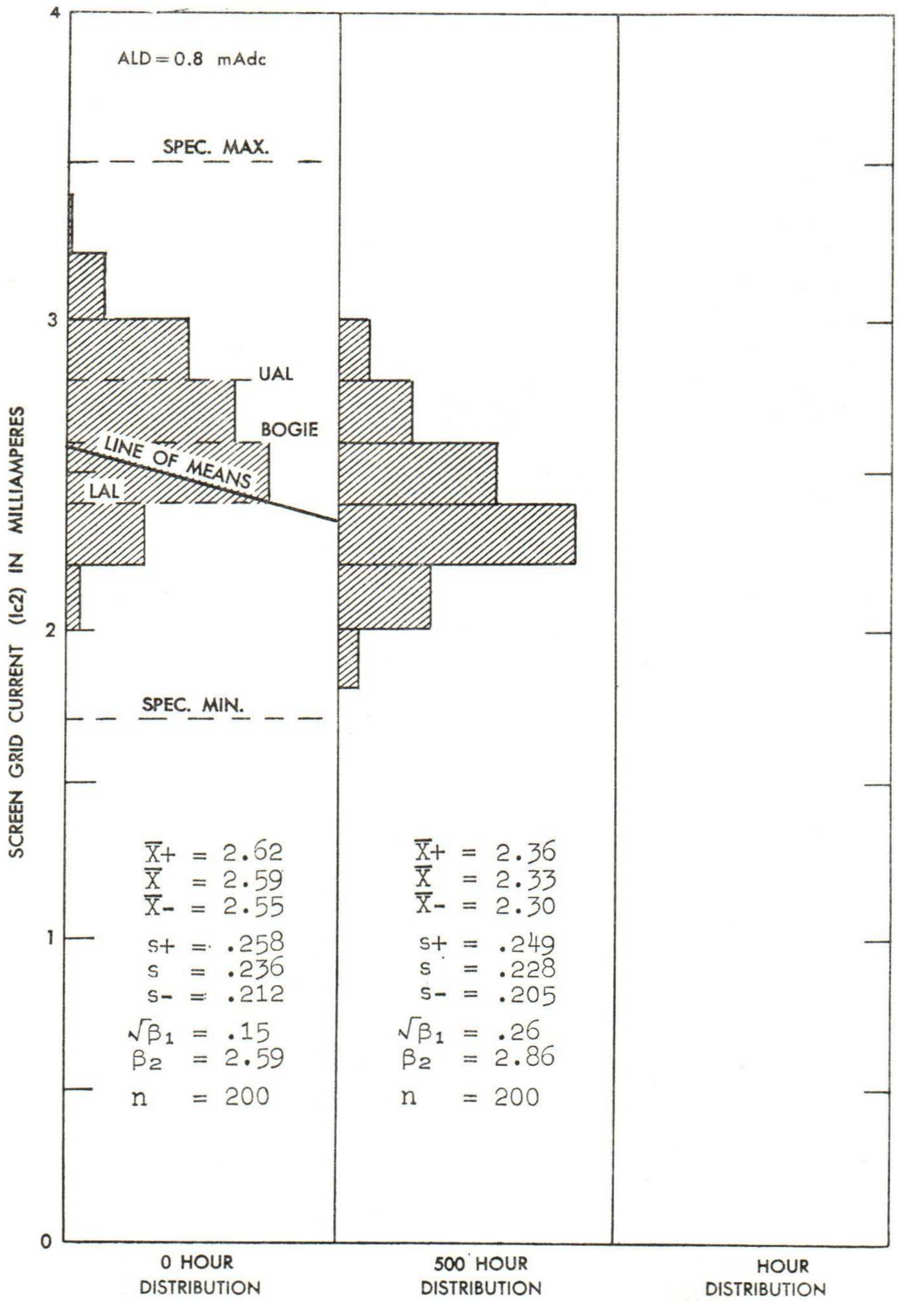


Figure 4-64. Distribution of Screen Grid Current for JAN-5702WA.

PROPERTY BEHAVIOR FOR JAN–5702WA

The histograms and data for Transconductance of JAN–5702WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/82B dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

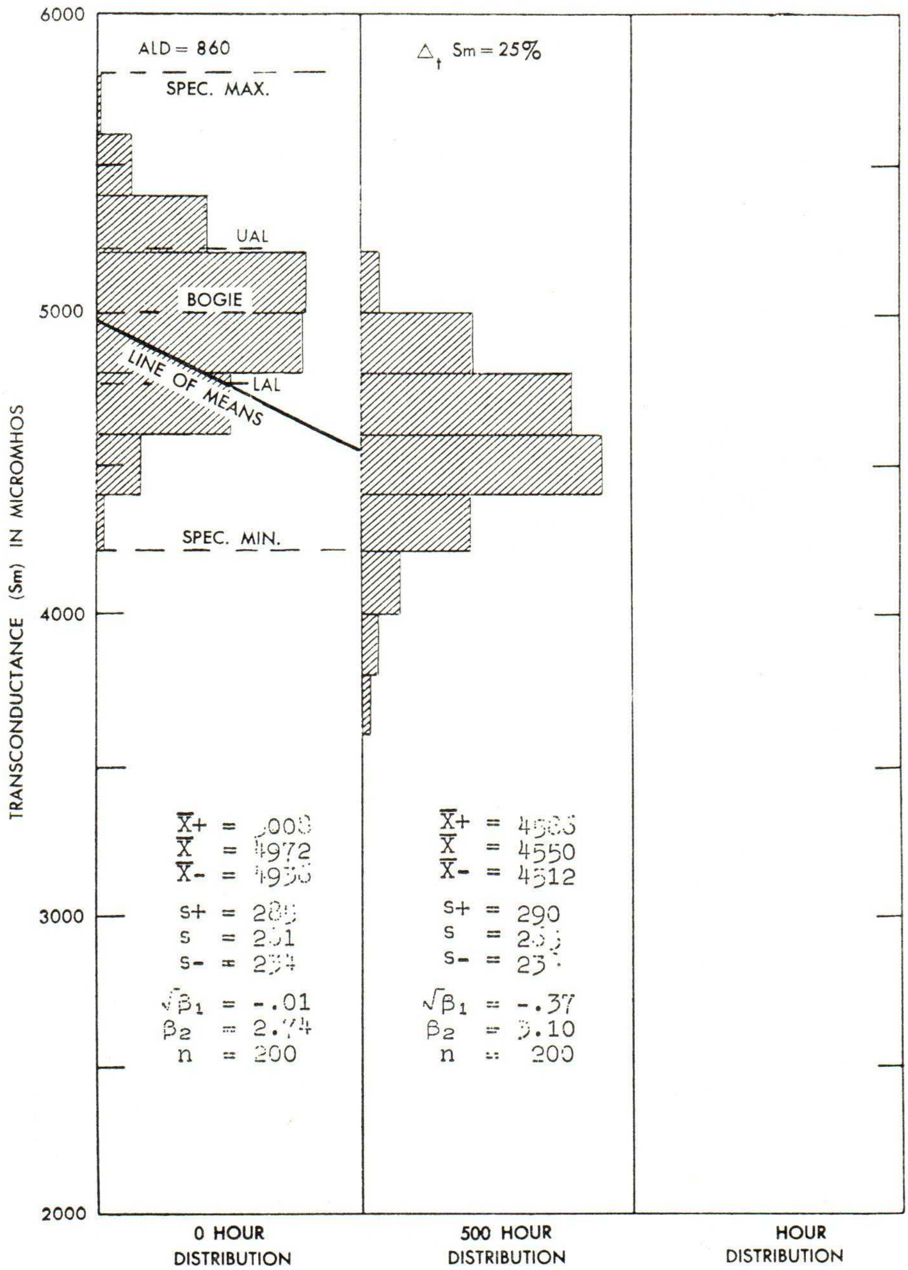


Figure 4-65. Distribution of Transconductance for JAN-5702WA.

PROPERTY BEHAVIOR FOR JAN-5702WA

The histograms and data for Reduced Ef Transconductance of JAN-5702WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/82B dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

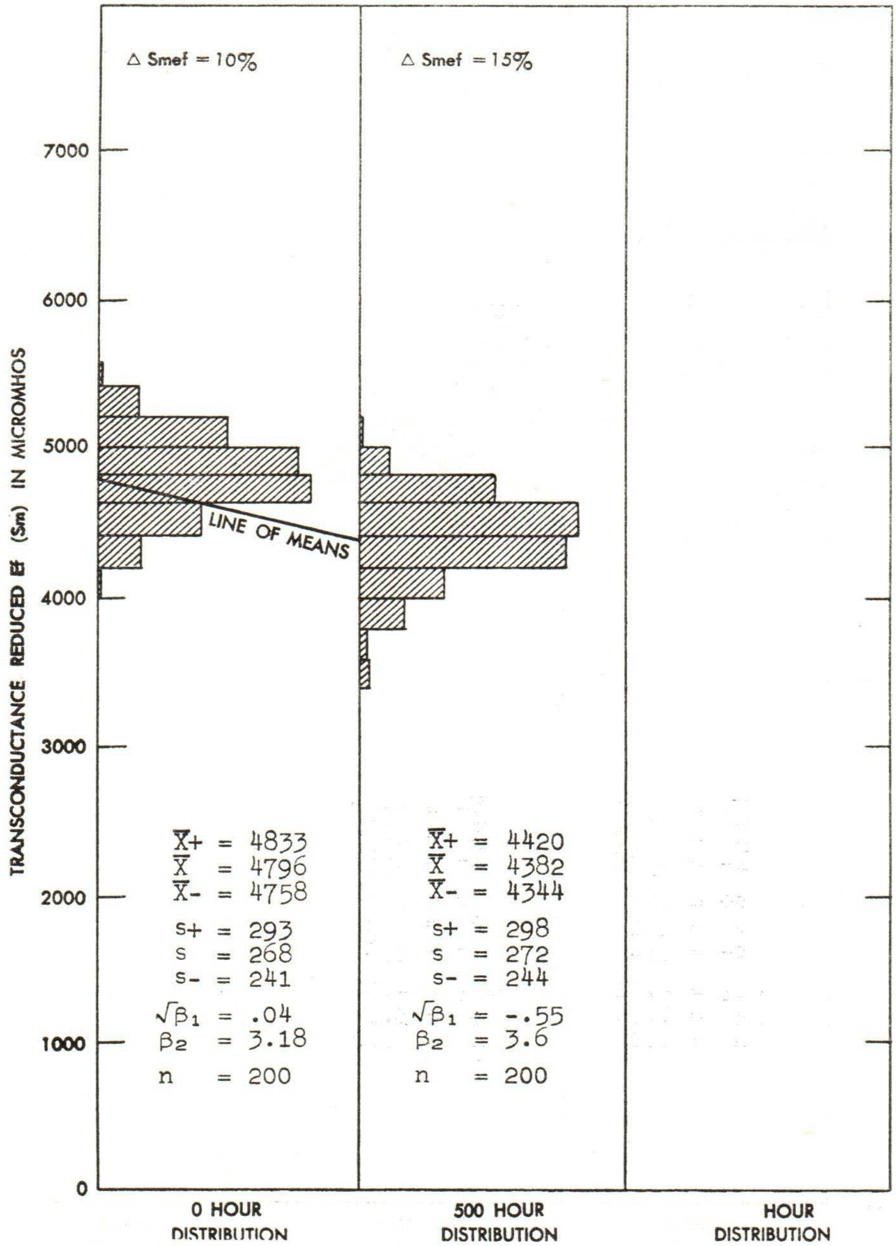


Figure 4-66. Distribution of Reduced Ef Transconductance for JAN-5702WA.

PROPERTY BEHAVIOR FOR JAN-5703WA

The histograms and date for Plate Current of JAN-5703WA are based upon 199 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/293C dated 17 September 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

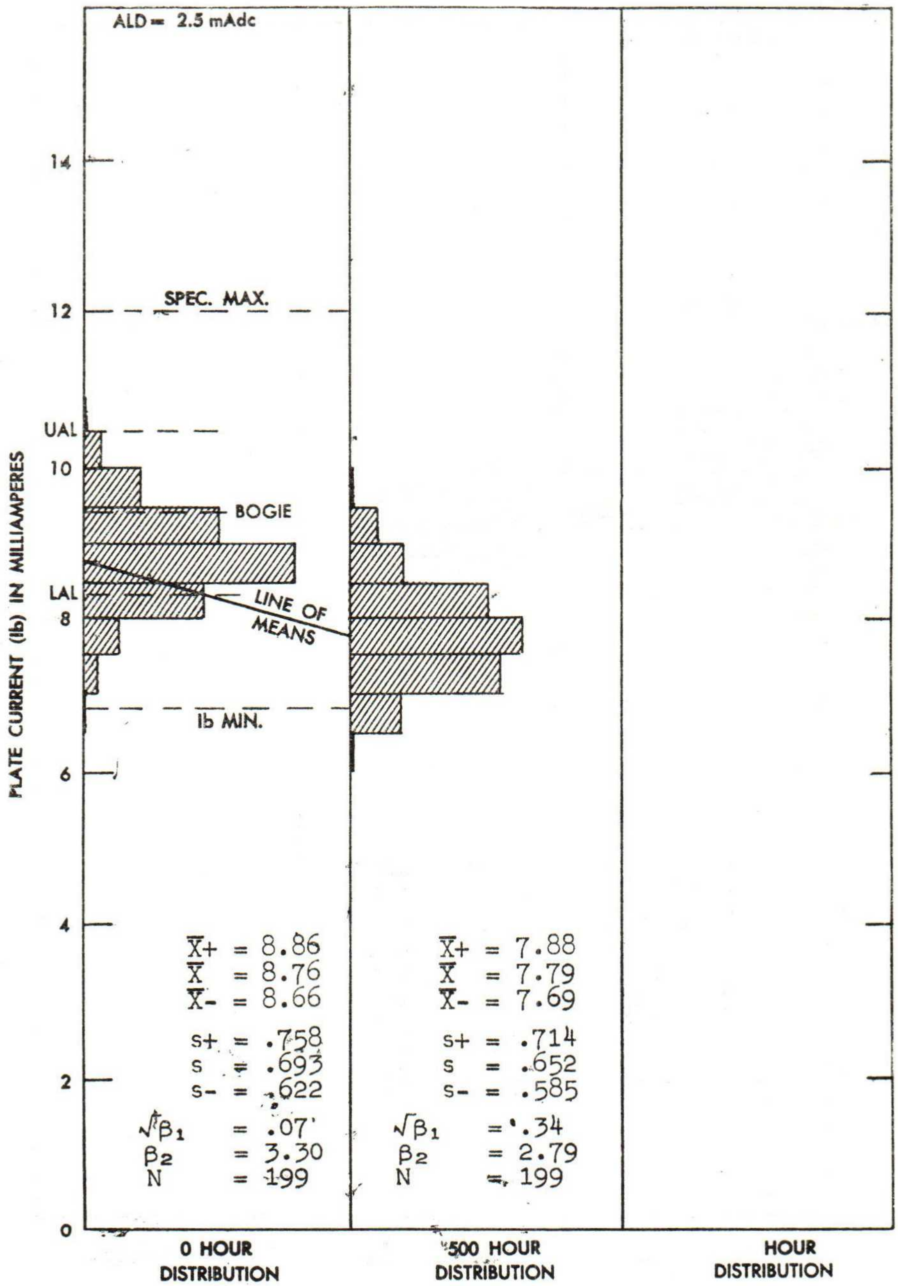


Figure 4-67. Distribution of Plate Current for JAN-5703WA.

PROPERTY BEHAVIOR FOR JAN-5703WA

The histograms and data for Transconductance of JAN-5703WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/293C dated 17 September 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

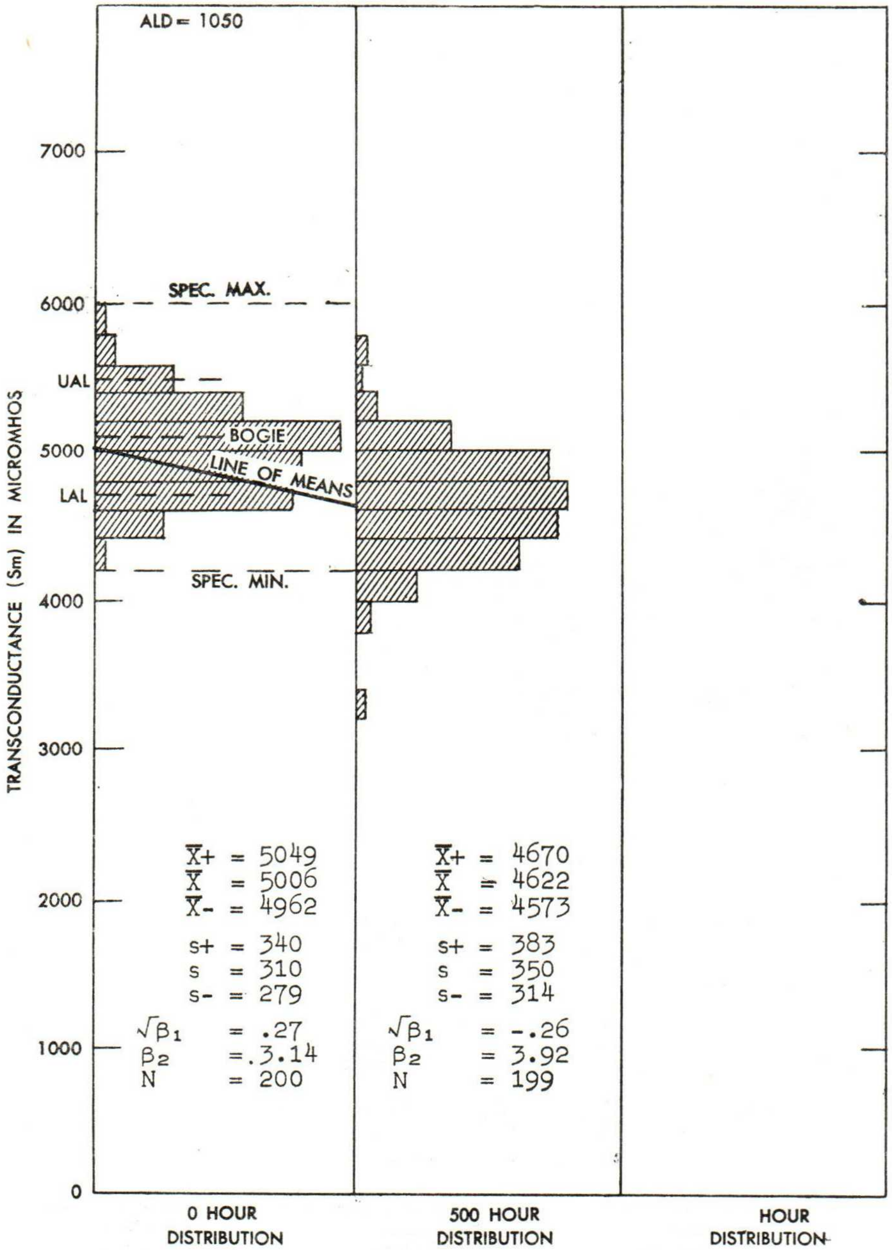


Figure 4-68. Distribution of Transconductance for JAN-5703WA.

PROPERTY BEHAVIOR FOR JAN-5703WA

The histograms and data for Reduced Ef Transconductance of JAN-5703WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/293C dated 17 September 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

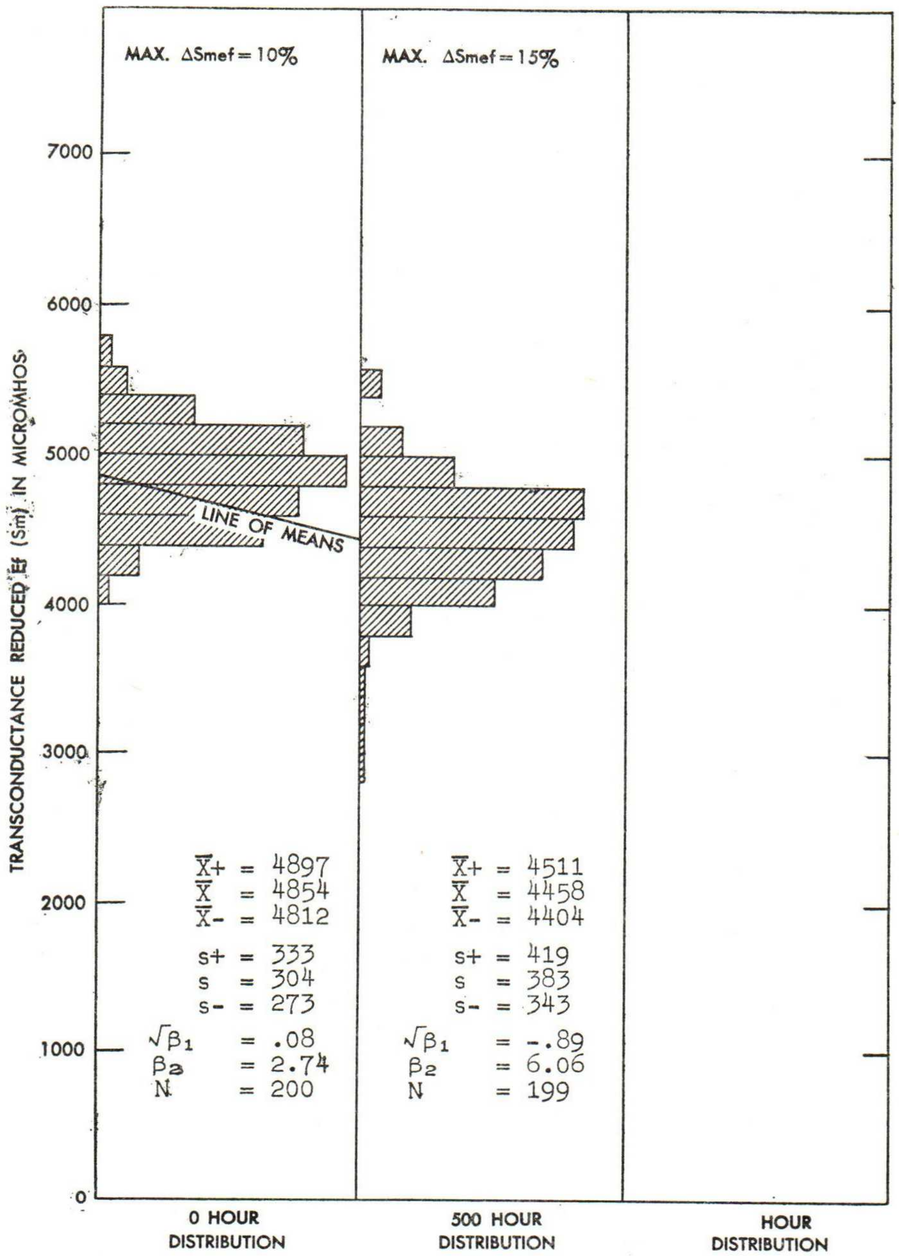


Figure 4-69. Distribution of Reduced Ef Transconductance for JAN-5703WA.

PROPERTY BEHAVIOR FOR JAN-5718

The histograms and data for Transconductance of JAN-5718 are based upon 944 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-172B dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

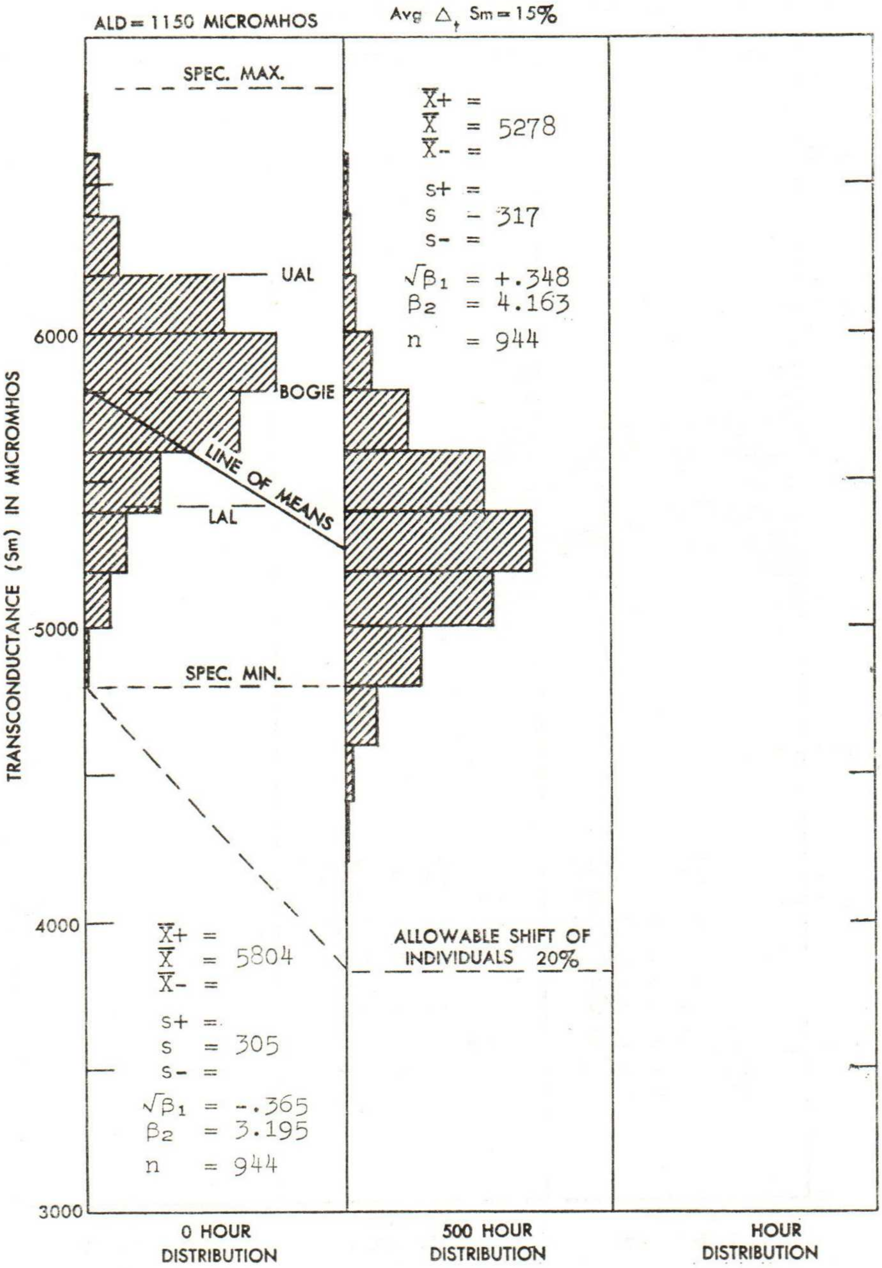


Figure 4-70. Distribution of Transconductance for JAN-5718.

PROPERTY BEHAVIOR FOR JAN-5718

These typical curves have been obtained by experimental procedures performed on a small sample of JAN-5718 tubes. The specification ratings delineating a recommended or safe area of operation are shown. The effective environmental temperature was carefully determined for this particular experiment but there is considerable room for interpretation on an individual application basis.

Study of the chart should point out the fallacy of attempting operation beyond specification ratings by external reduction of the effective environmental temperature. This fallacy obtains because the plate temperature will most likely exceed the value which has been determined by the manufacturer as "safe" for this particular tube type.

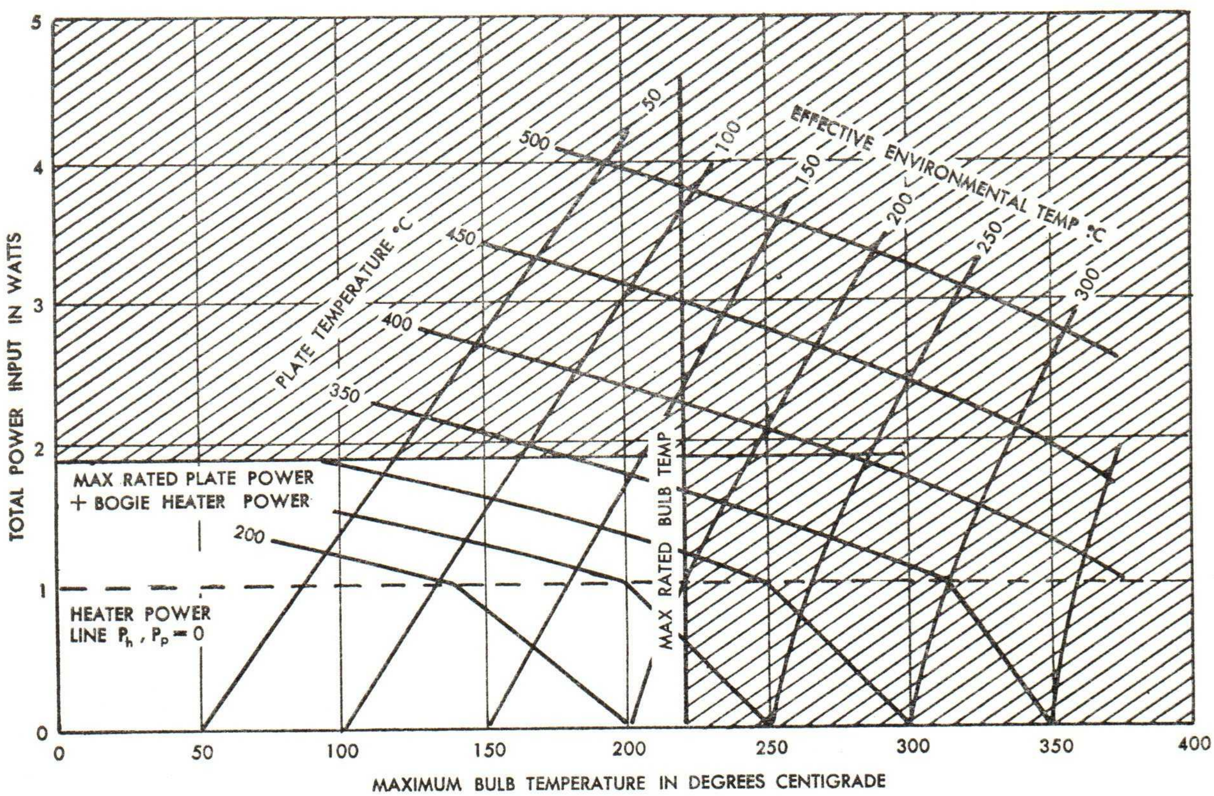


Figure 4-71. Typical Thermal Behavior for JAN-5718.

TYPICAL THERMAL BEHAVIOR OF JAN-5718

The histograms and data for Plate Current of JAN-5719 are based upon 298 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/173C dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

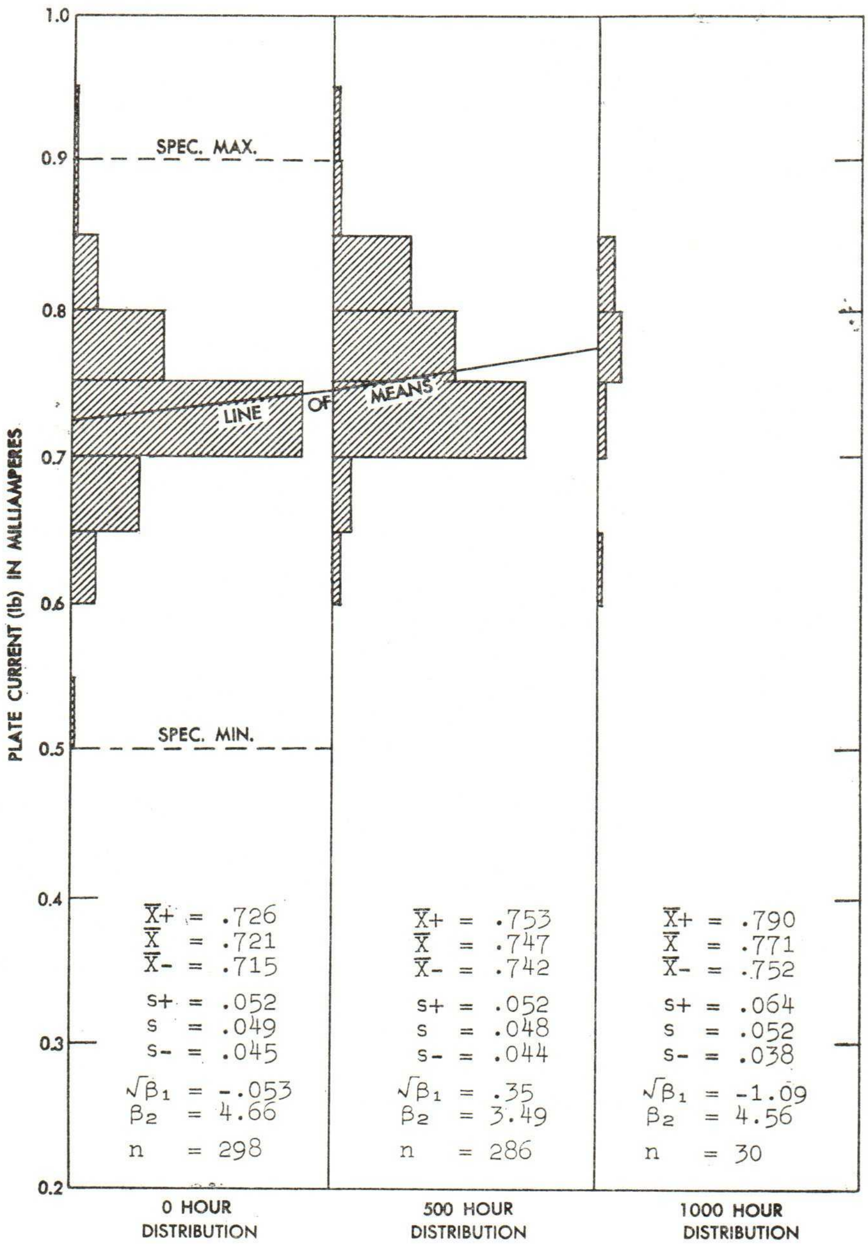


Figure 4-72. Distribution of Plate Current for JAN-5719.

PROPERTY BEHAVIOR FOR JAN-5719

The histograms and data for Transconductance of JAN-5719 are based upon 538 tubes life-tested by four manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/173C dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

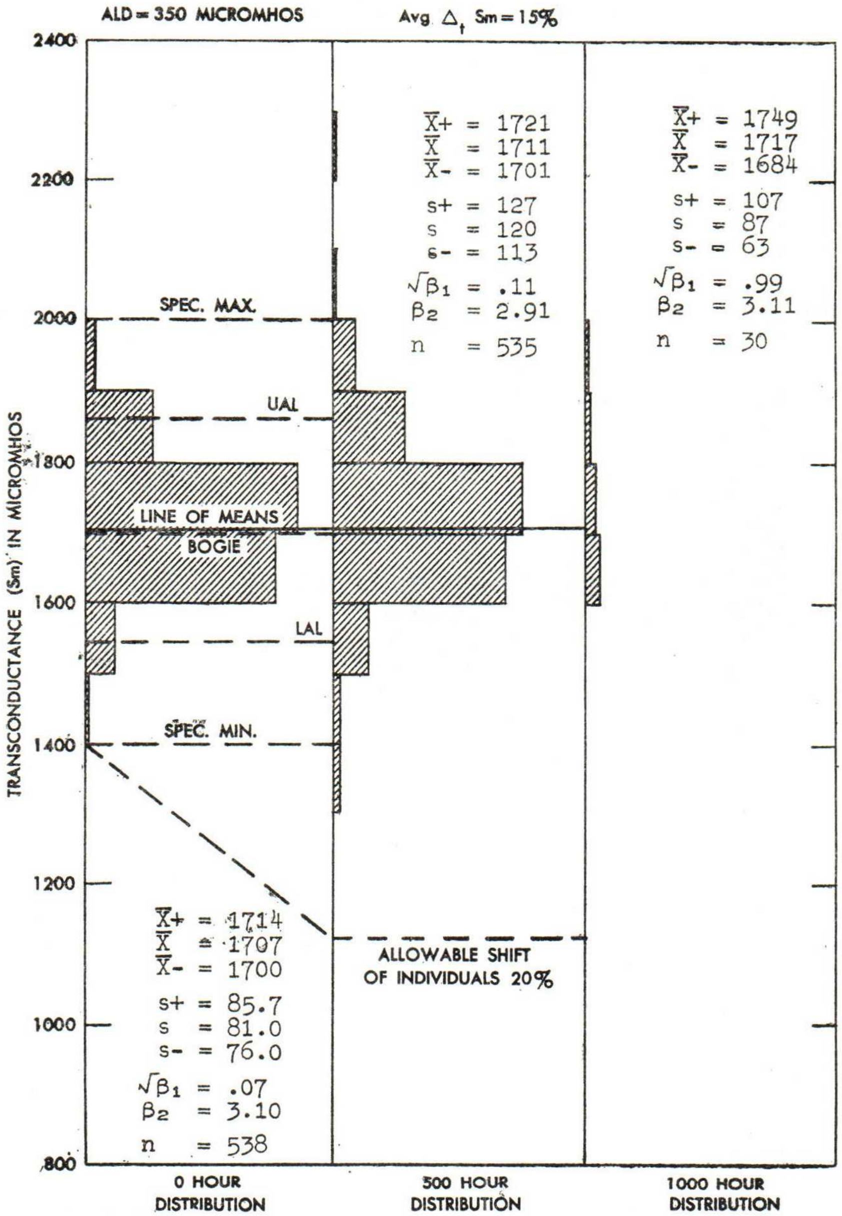


Figure 4-73. Distribution of Transconductance for JAN-5719.

PROPERTY BEHAVIOR FOR JAN-5719

The histograms and data for Reduced Ef Transconductance of JAN-5719 are based upon 535 tubes life-tested by four manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/173C dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

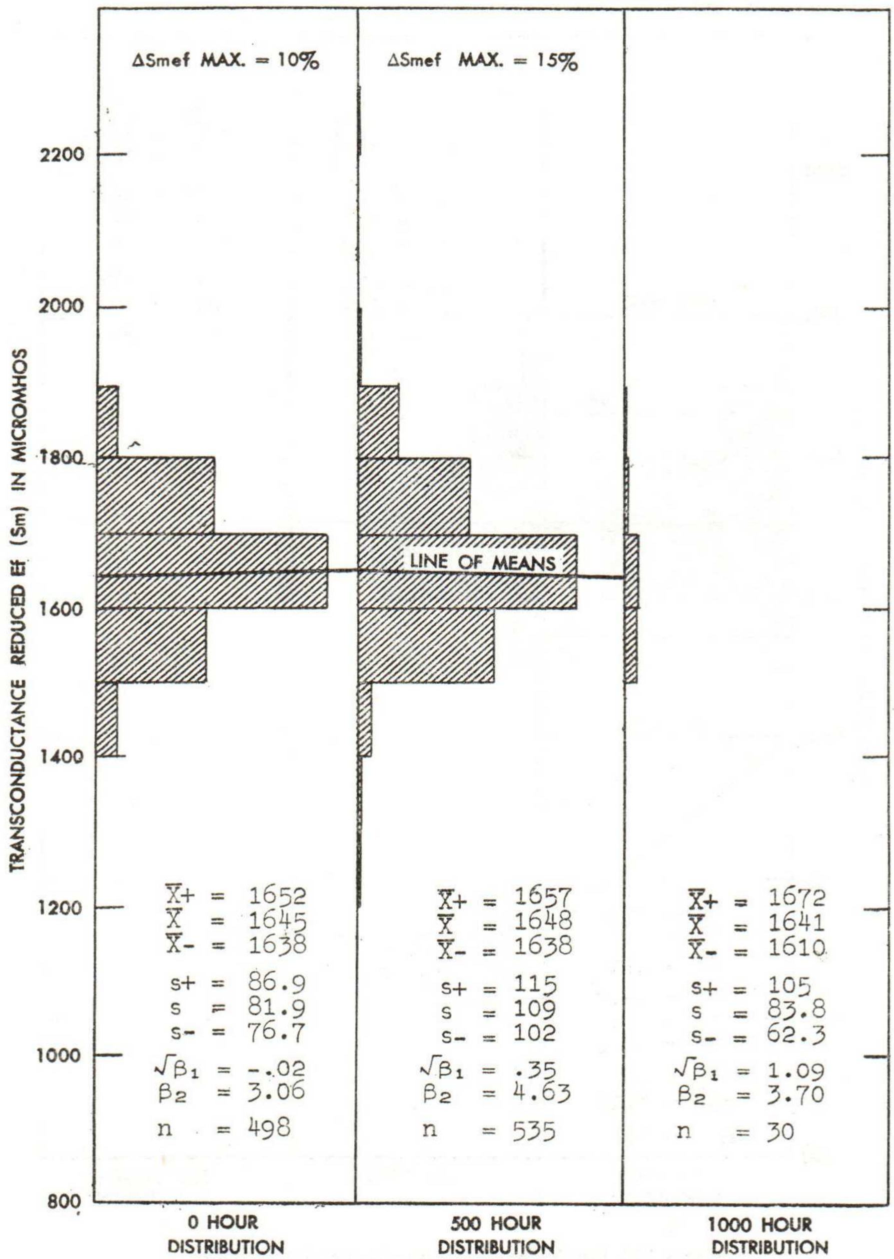


Figure 4-74. Distribution of Reduced Ef Transconductance for JAN-5719.

PROPERTY BEHAVIOR FOR JAN-5725/6AS6W

The histograms and data for Plate Current of JAN-5725/6AS6W are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/6C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

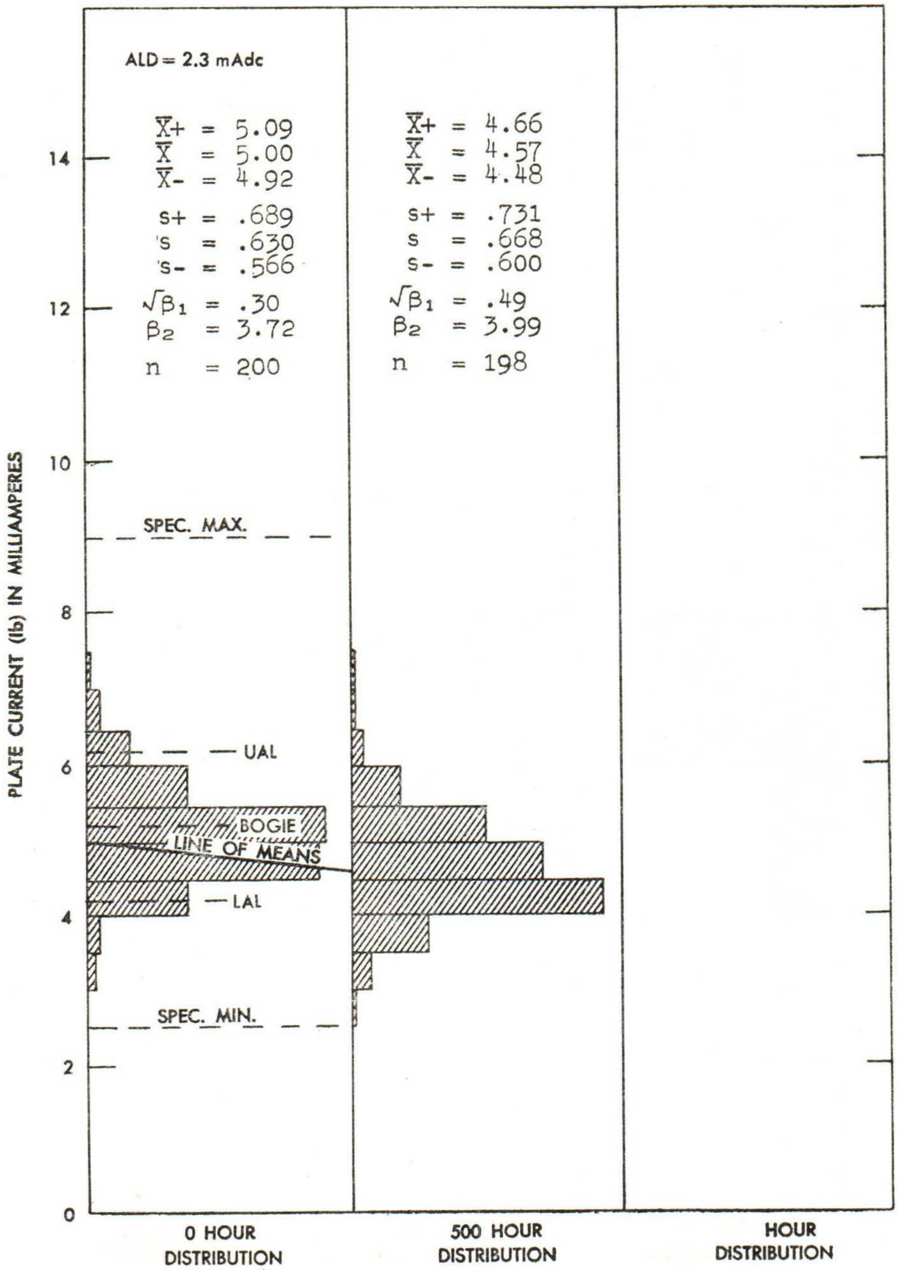


Figure 4-75. Distribution of Plate Current for JAN-5725/6AS6W.

PROPERTY BEHAVIOR FOR JAN-5725/6AS6W

The histograms and data for Screen Grid Current of JAN-5725/6AS6W are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/6C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

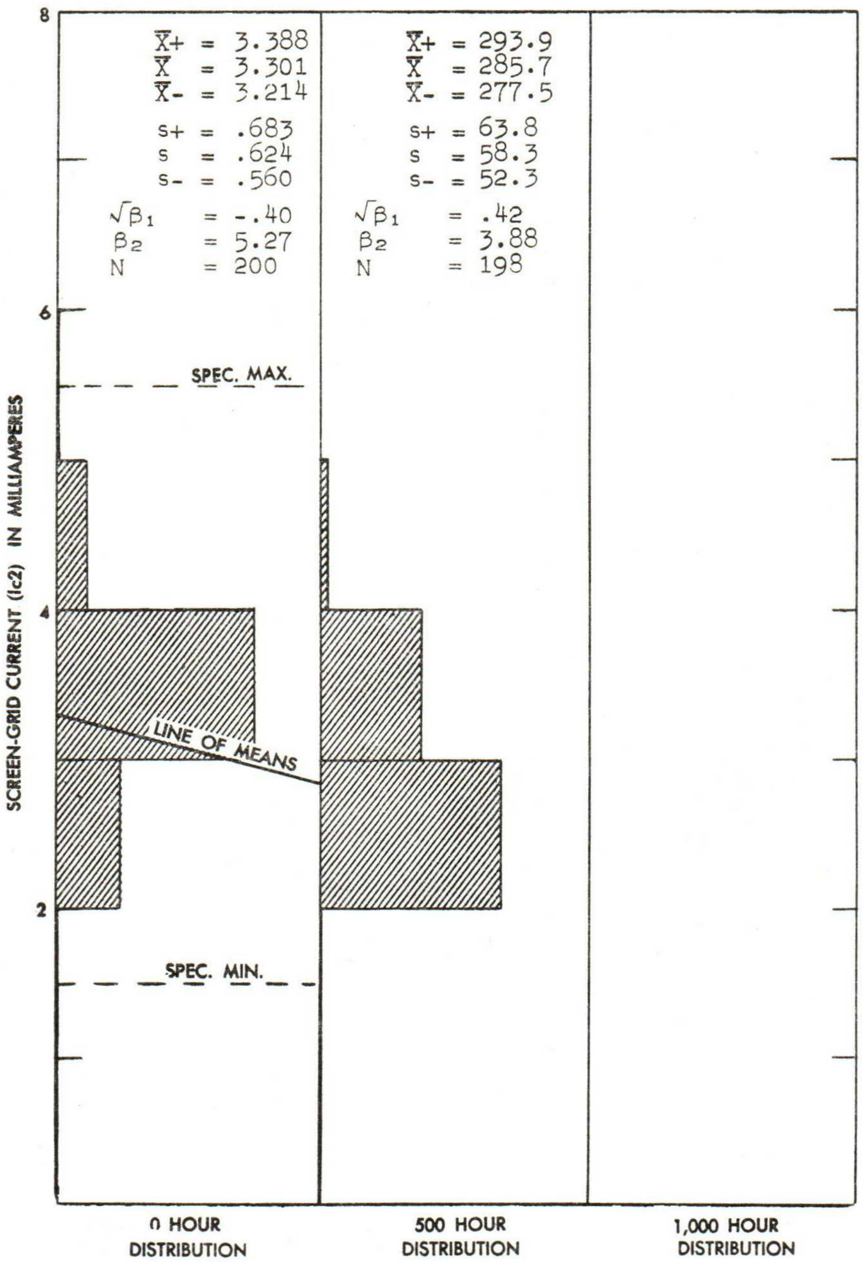


Figure 4-76. Distribution of Screen Grid Current for JAN-5725/6AS6W.

PROPERTY BEHAVIOR FOR JAN-5725/6AS6W

The histograms and data for Transconductance of JAN-5725/6AS6W are based upon 400 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/6C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

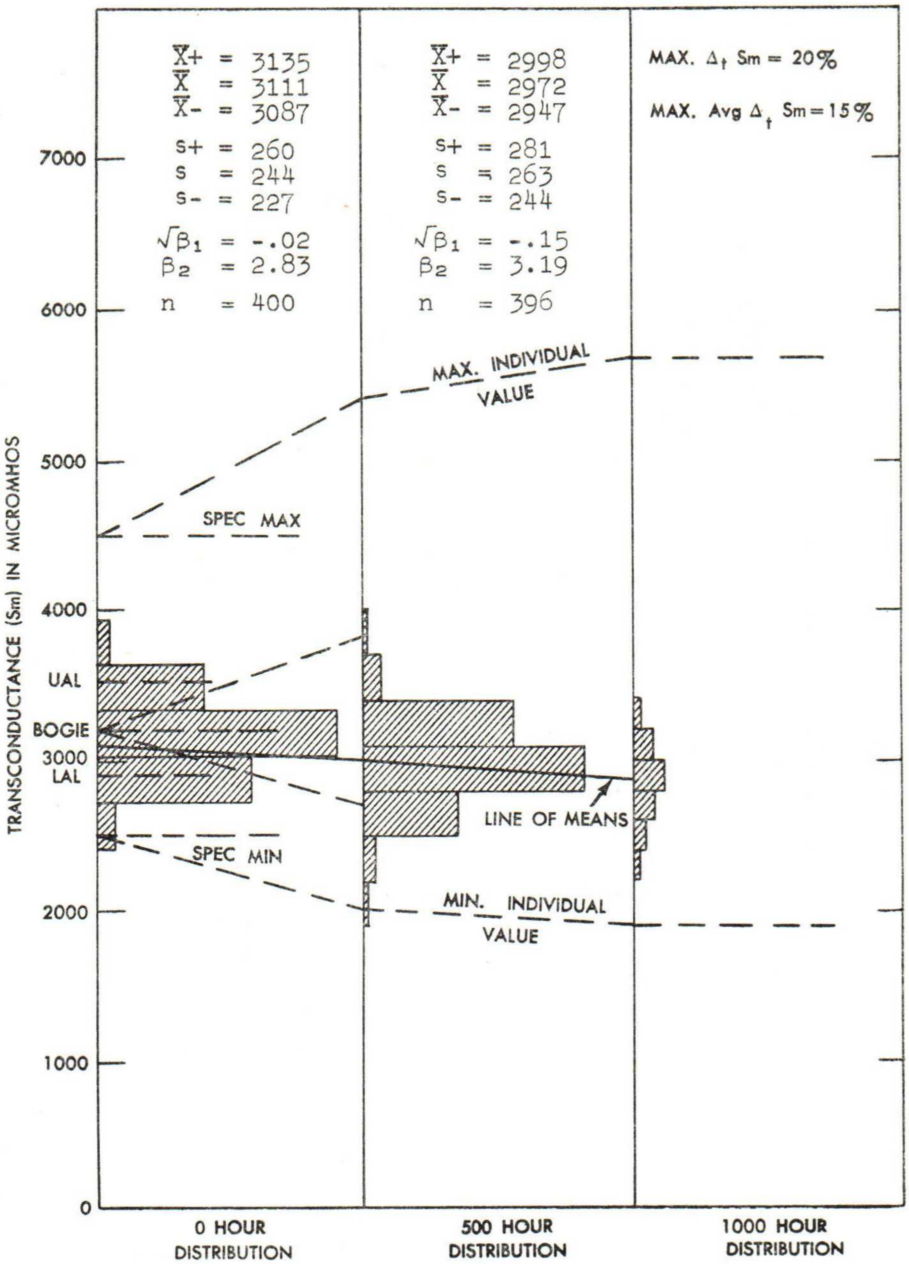


Figure 4-77. Distribution of Transconductance for JAN-5725/6AS6W.

PROPERTY BEHAVIOR FOR JAN-5725/6AS6W

The histograms and data for Reduced Ef Transconductance of JAN-5725/6AS6W are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/6C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

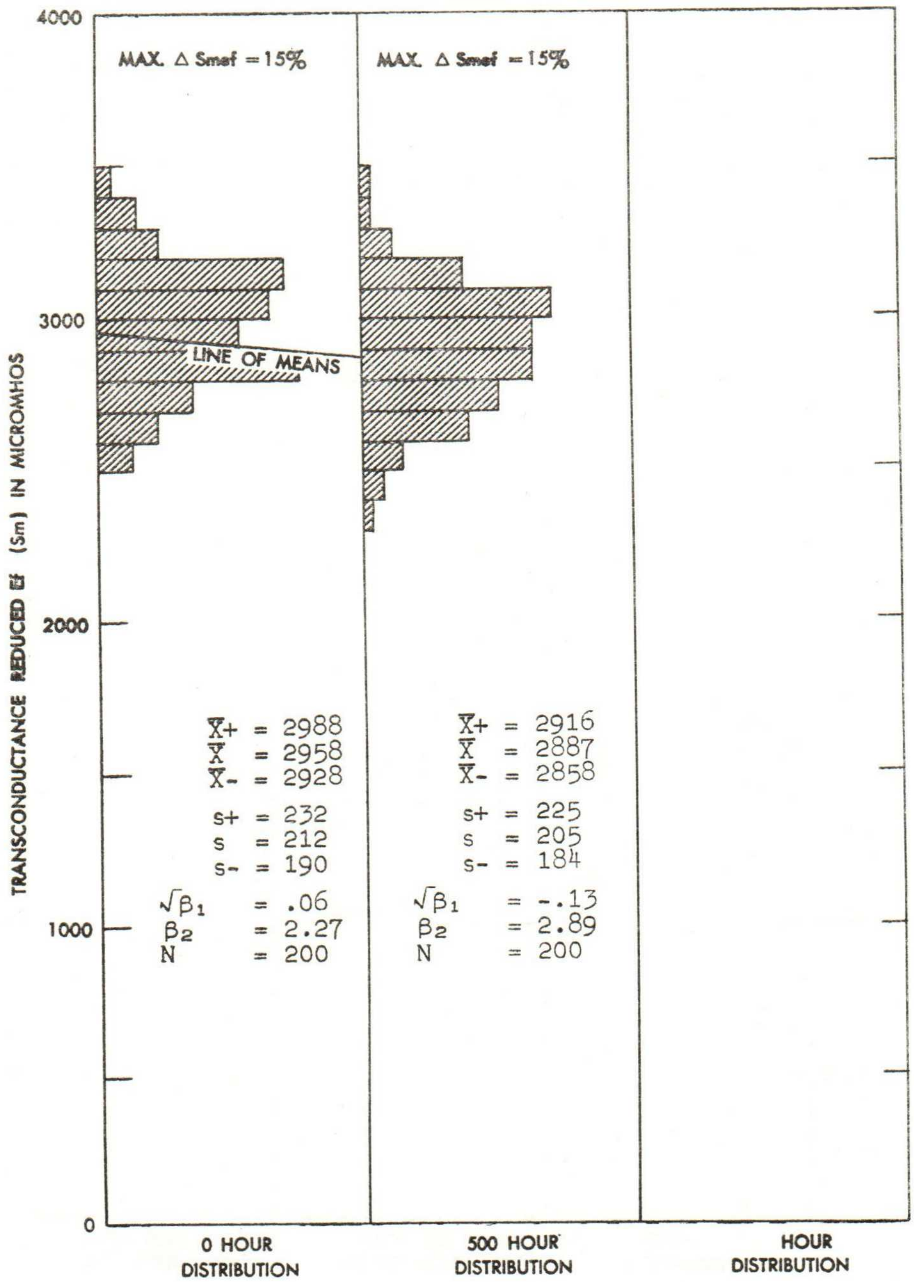


Figure. 4-78. Distribution of Reduced Ef Transconductance for JAN-5725/6AS6W.

PROPERTY BEHAVIOR FOR JAN-5726/6AL5W

The histograms and data for Plate Current of JAN-5726/6AL5W are based upon 398 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/7A dated 3 May 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

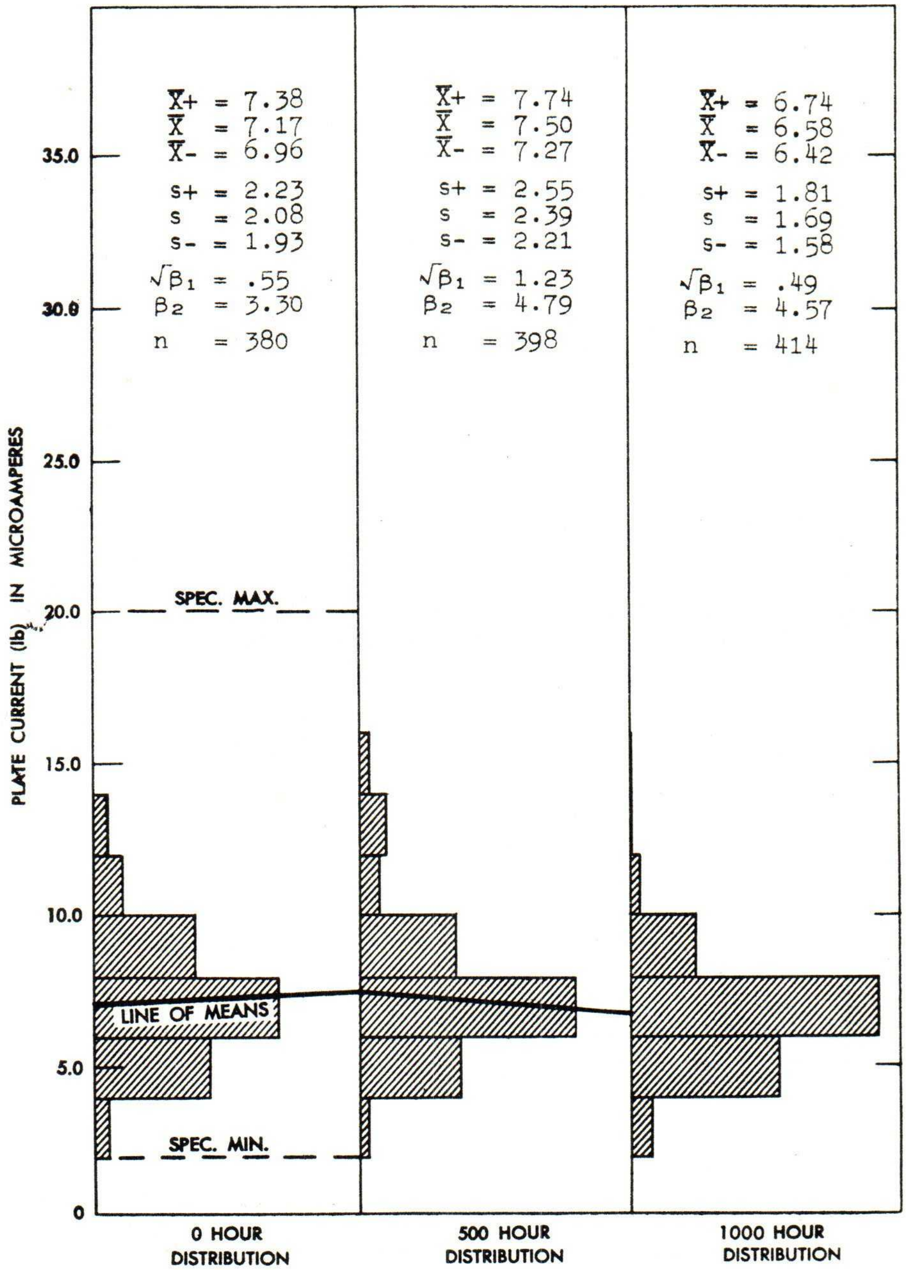


Figure 4-79. Distribution of Plate Current for JAN-5726/6AL5W.

PROPERTY BEHAVIOR FOR JAN-5726/6AL5W

The histograms and data for Emission of JAN-5726/6AL5W are based upon 398 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/7A dated 3 May 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

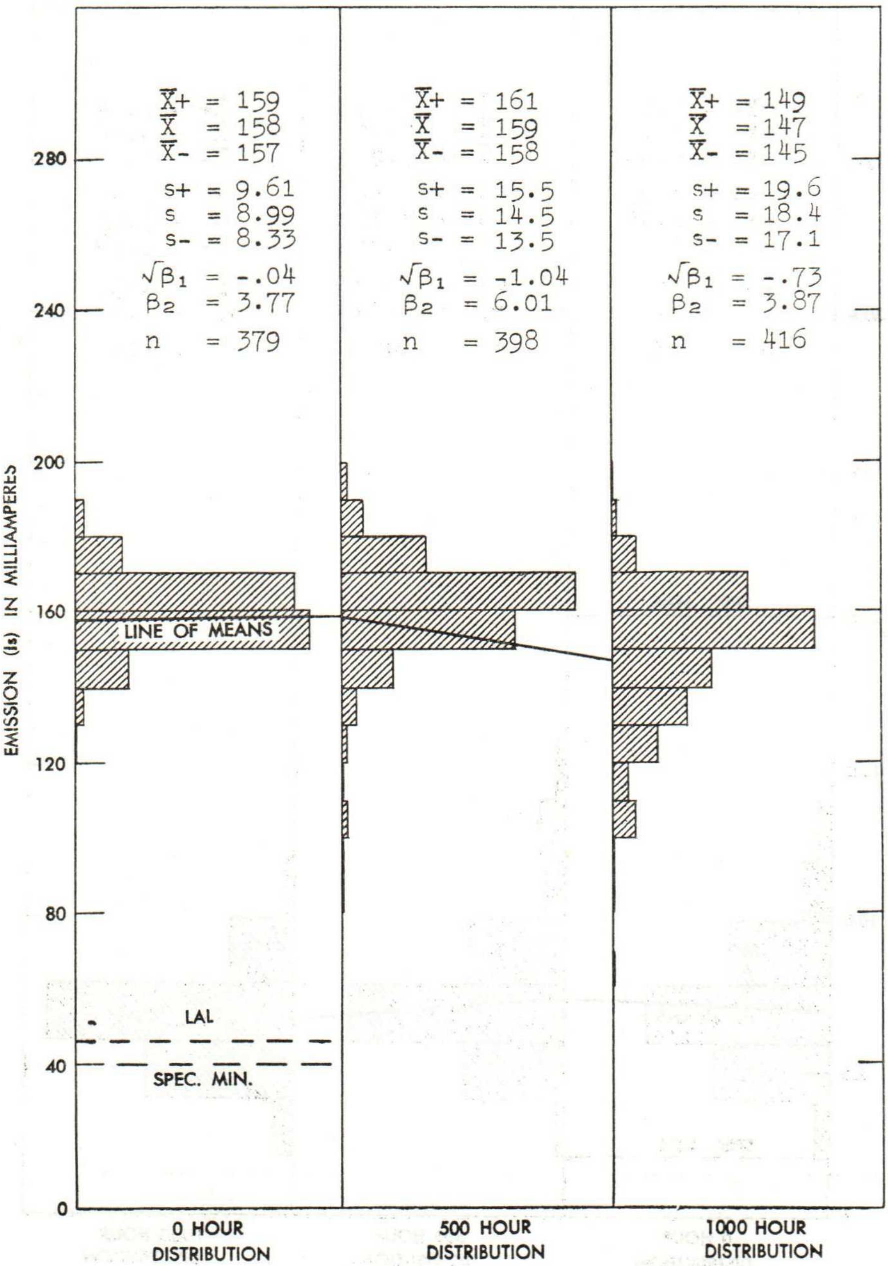


Figure 4-80. Distribution of Emission for JAN-5726/6AL5W.

PROPERTY BEHAVIOR FOR JAN-5744WA

The histograms and data for Plate Current of JAN-5744WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/84C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

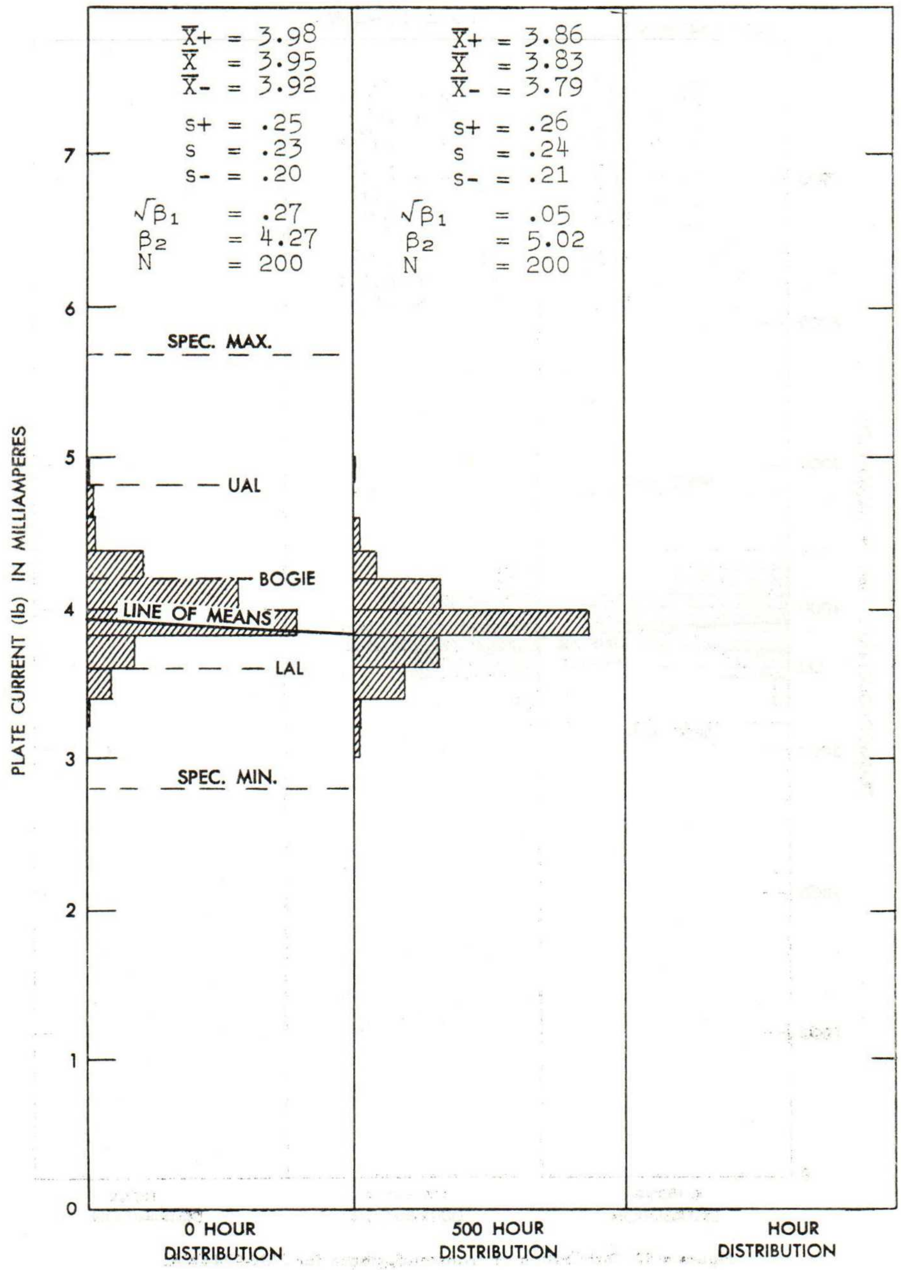


Figure 4-81. Distribution of Plate Current for JAN-5744WA.

PROPERTY BEHAVIOR FOR JAN–5744WA

The histograms and data for Transconductance of JAN–5744WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/84C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

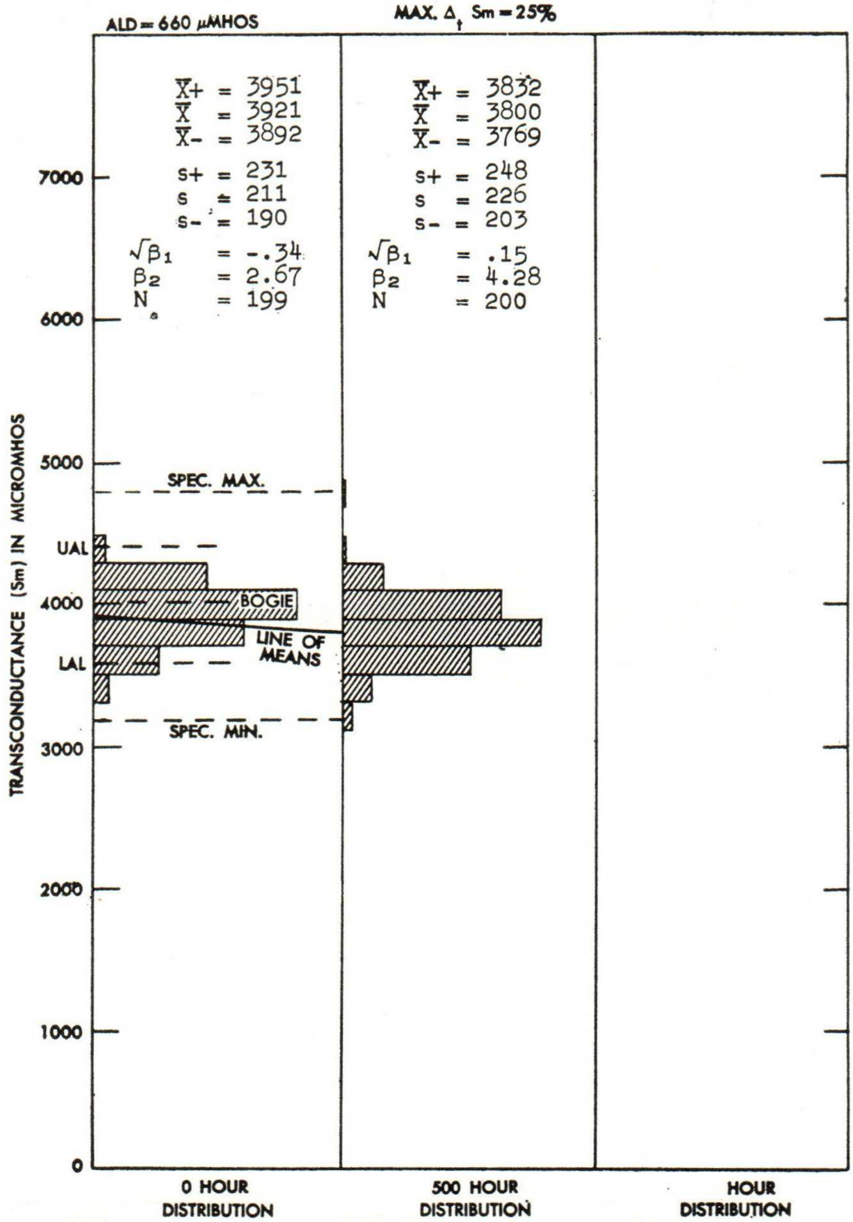


Figure 4-82. Distribution of Transconductance for JAN-5744WA.

PROPERTY BEHAVIOR FOR JAN-5744WA

The histograms and data for Reduced Ef Transconductance of JAN-5744WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/84C date 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

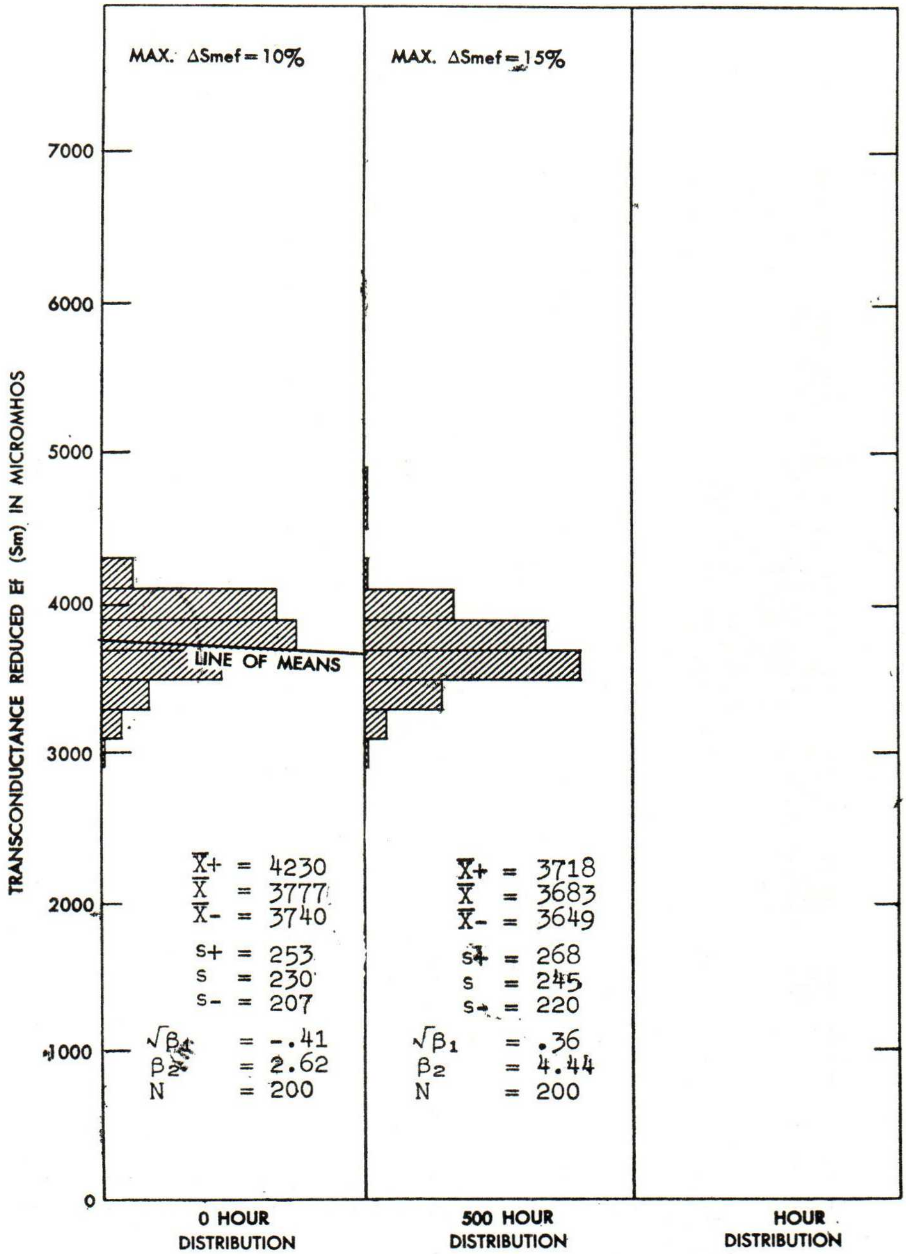


Figure 4-83. Distribution of Reduced Ef Transconductance for JAN-5744WA.

PROPERTY BEHAVIOR FOR JAN–5749/6BA6W

The histograms and data for Plate Current of JAN–5749/6BA6W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL–E–1/8 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

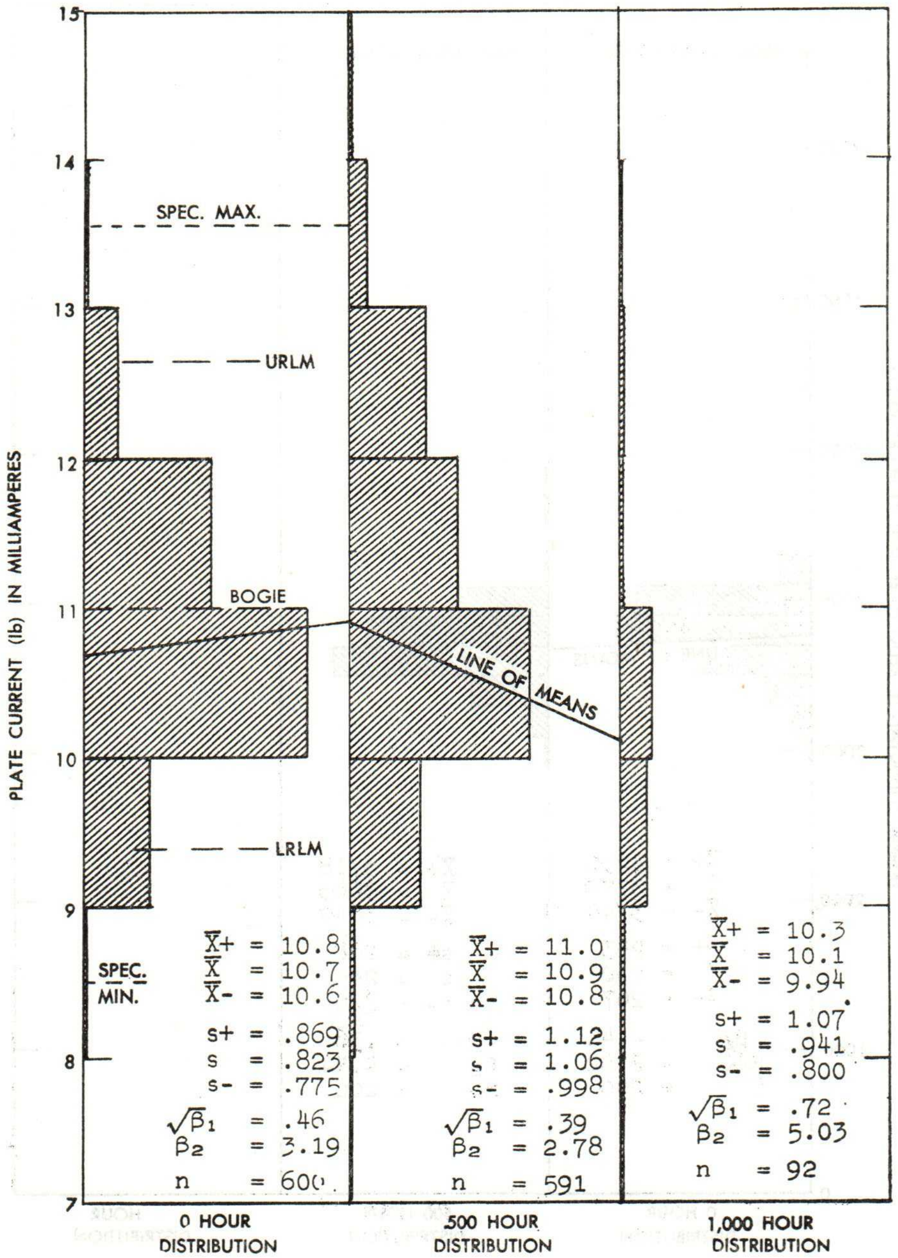


Figure 4-84. Distribution of Plate Current for JAN-5749/6BA6W.

PROPERTY BEHAVIOR FOR JAN-5749/6BA6W

The histograms and data for Screen Grid Current of JAN-5749/6BA6W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/8 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

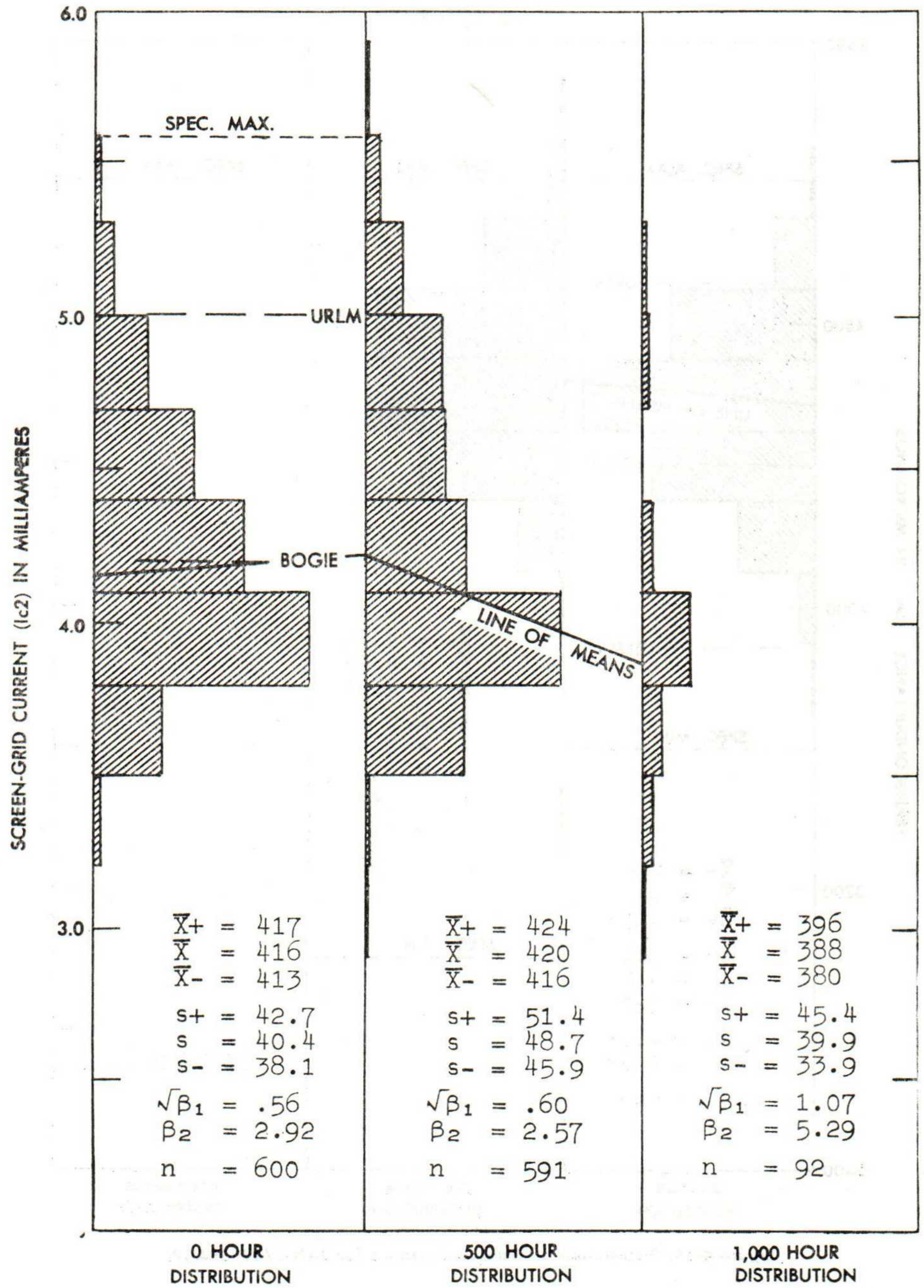


Figure 4-85. Distribution of Screen Grid Current for JAN-5749/6BA6W.

PROPERTY BEHAVIOR FOR JAN-5749/6BA6W

The histograms and data for Transconductance of JAN-5749/6BA6W are based upon 600 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/8 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

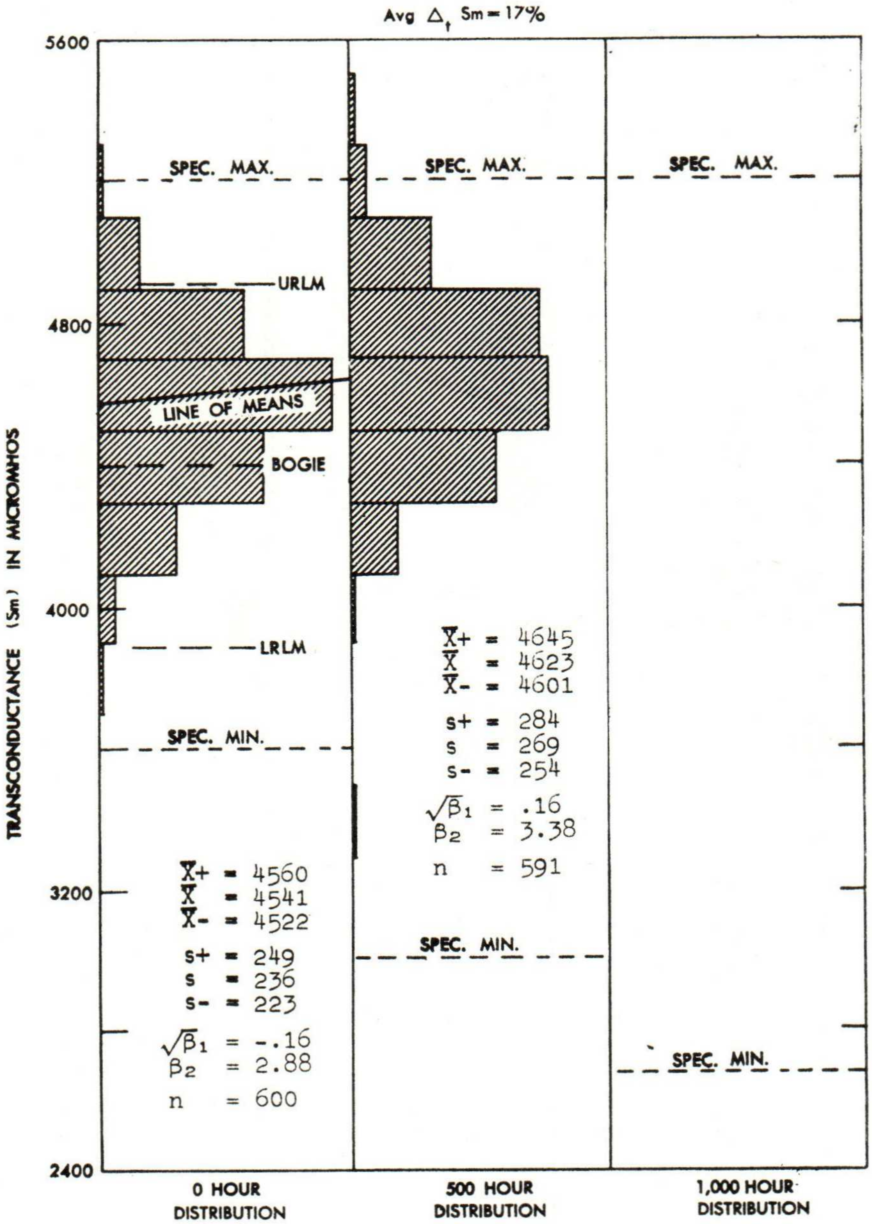


Figure 4-86. Distribution of Transconductance for JAN-5749/6BA6W.

PROPERTY BEHAVIOR FOR JAN-5749/6BA6W

This figure presents the inoperative probability of survival under MIL-E-1 specification life test conditions for tube type JAN-5749/6BA6W during the production year 1956. This figure is derived from data supplied by two manufacturers, 1140 tubes with 12 failures occurring prior to 1000 hour test point.

The definition of "Inoperatives" coincides with that found in the appropriate paragraphs of MIL-E-1.

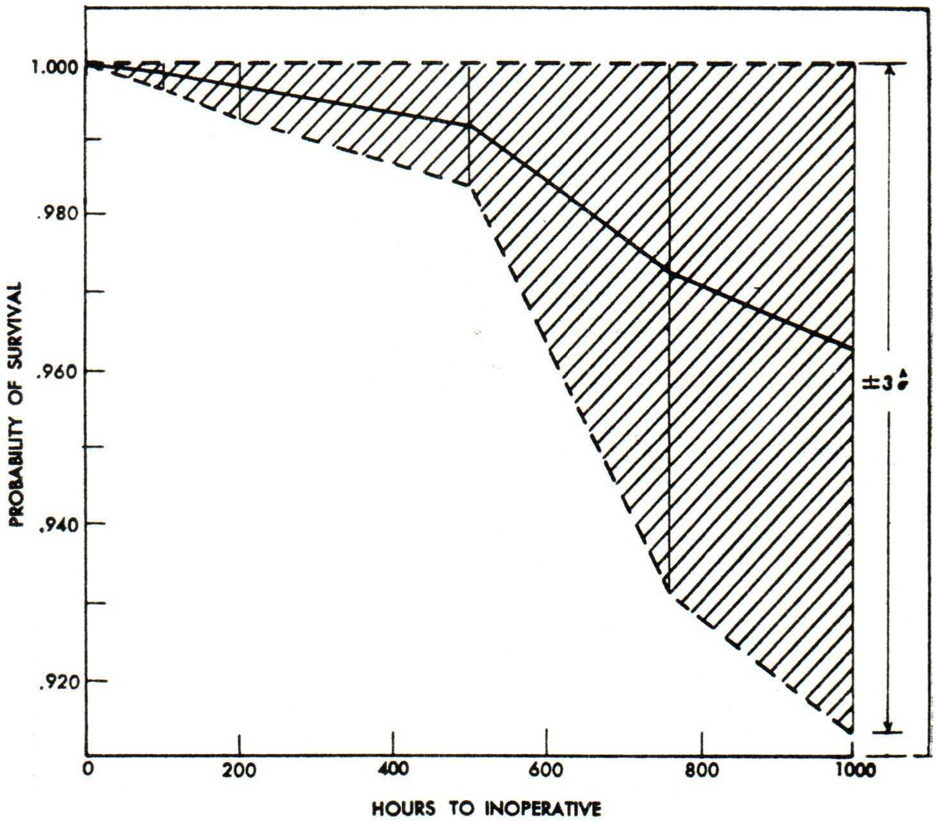


Figure 4-87. Probability of Survival for JAN-5749/6BA6W Under MIL-E-1 Conditions.

PROPERTY BEHAVIOR FOR JAN-5750/6BE6W

The histograms and data for Cathode Current of JAN-5750/6BE6W are based upon 422 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/9 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

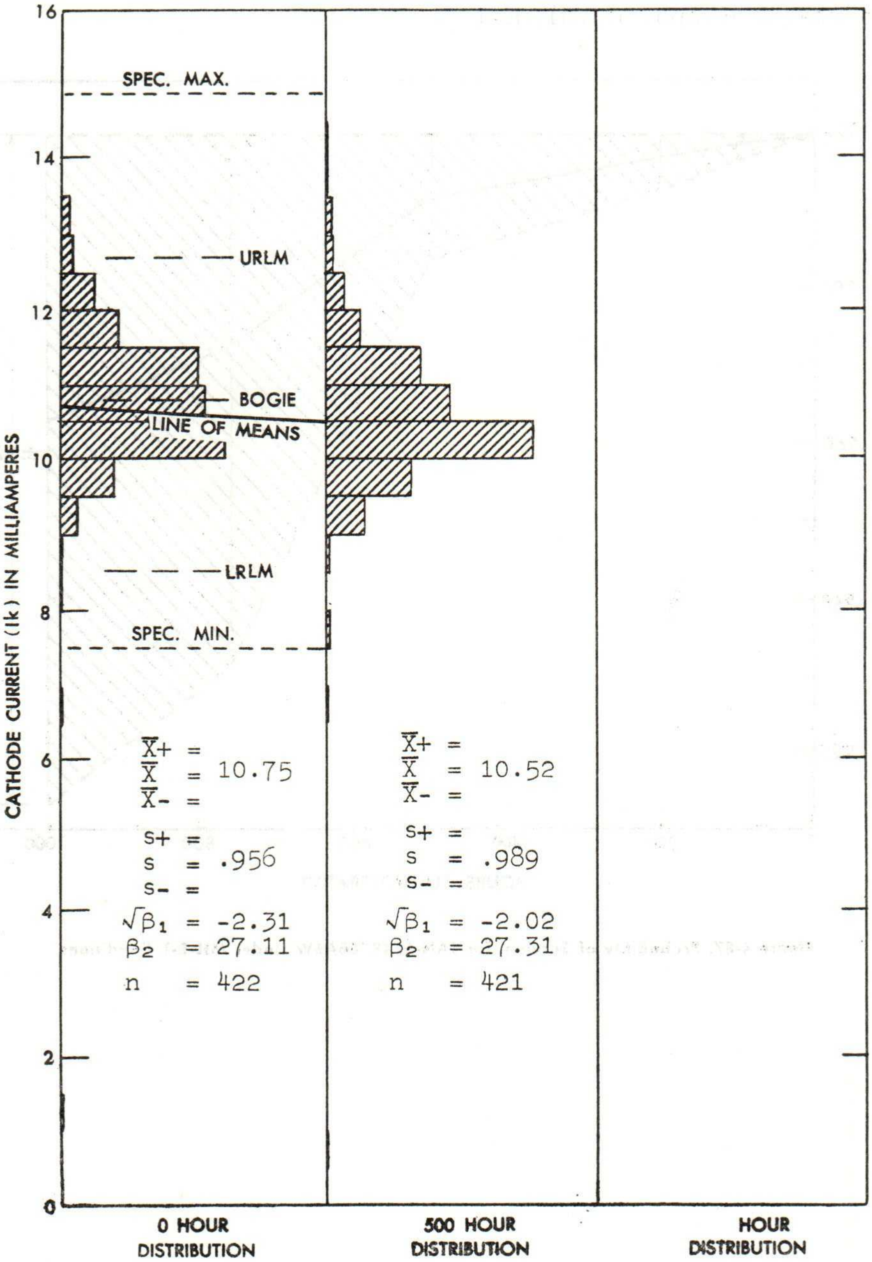


Figure 4-88. Distribution of Cathode Current for JAN-5750/6BE6W.

PROPERTY BEHAVIOR FOR JAN-5750/6BE6W

The histograms and data for Conversion Transconductance of JAN-5750/6BE6W are based upon 422 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/9 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

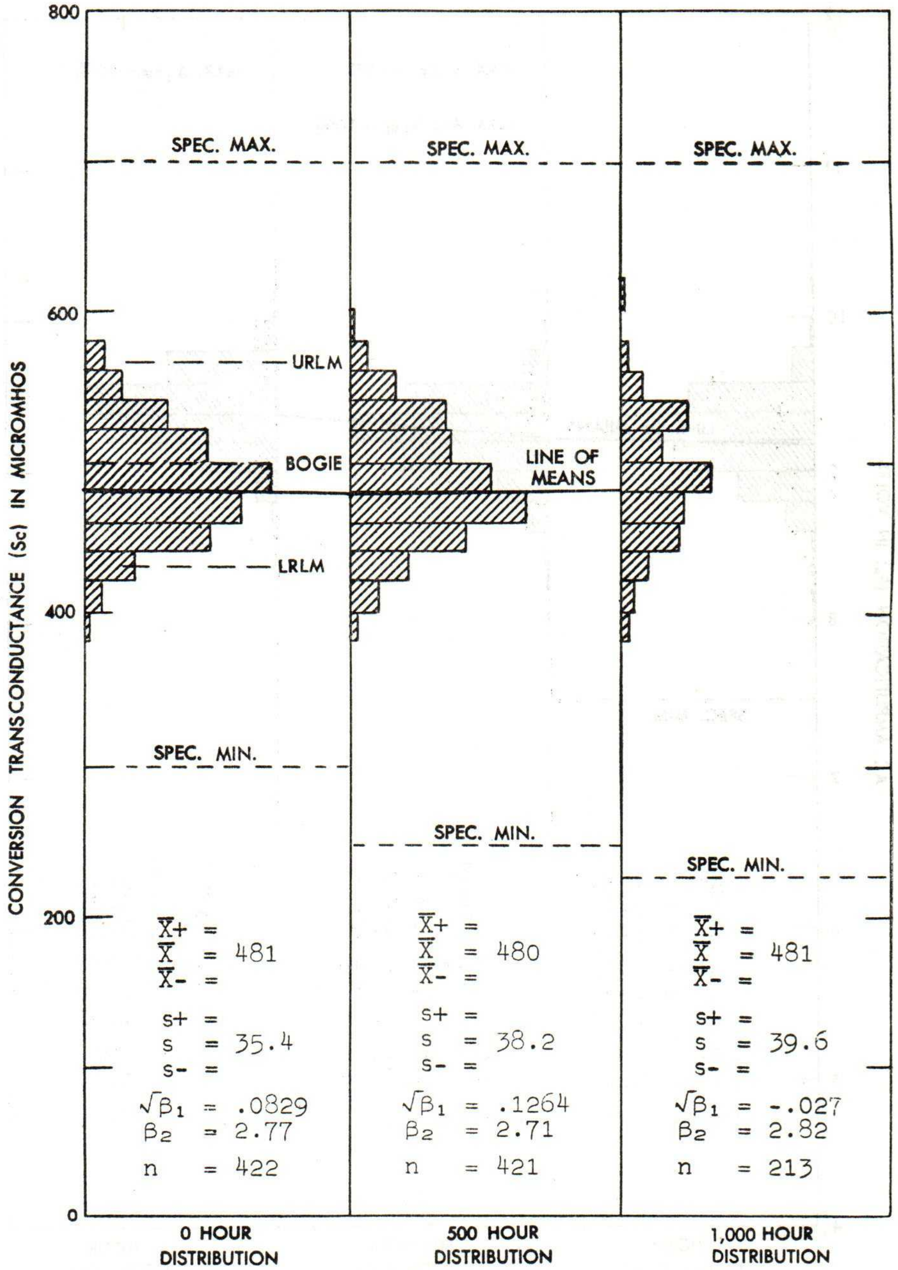


Figure 4-89. Distribution of Conversion Transconductance for JAN-5750/6BE6W.

PROPERTY BEHAVIOR FOR JAN-5751

The histograms and data for AC Amplification of JAN 5751 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/10 dated 13 January 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

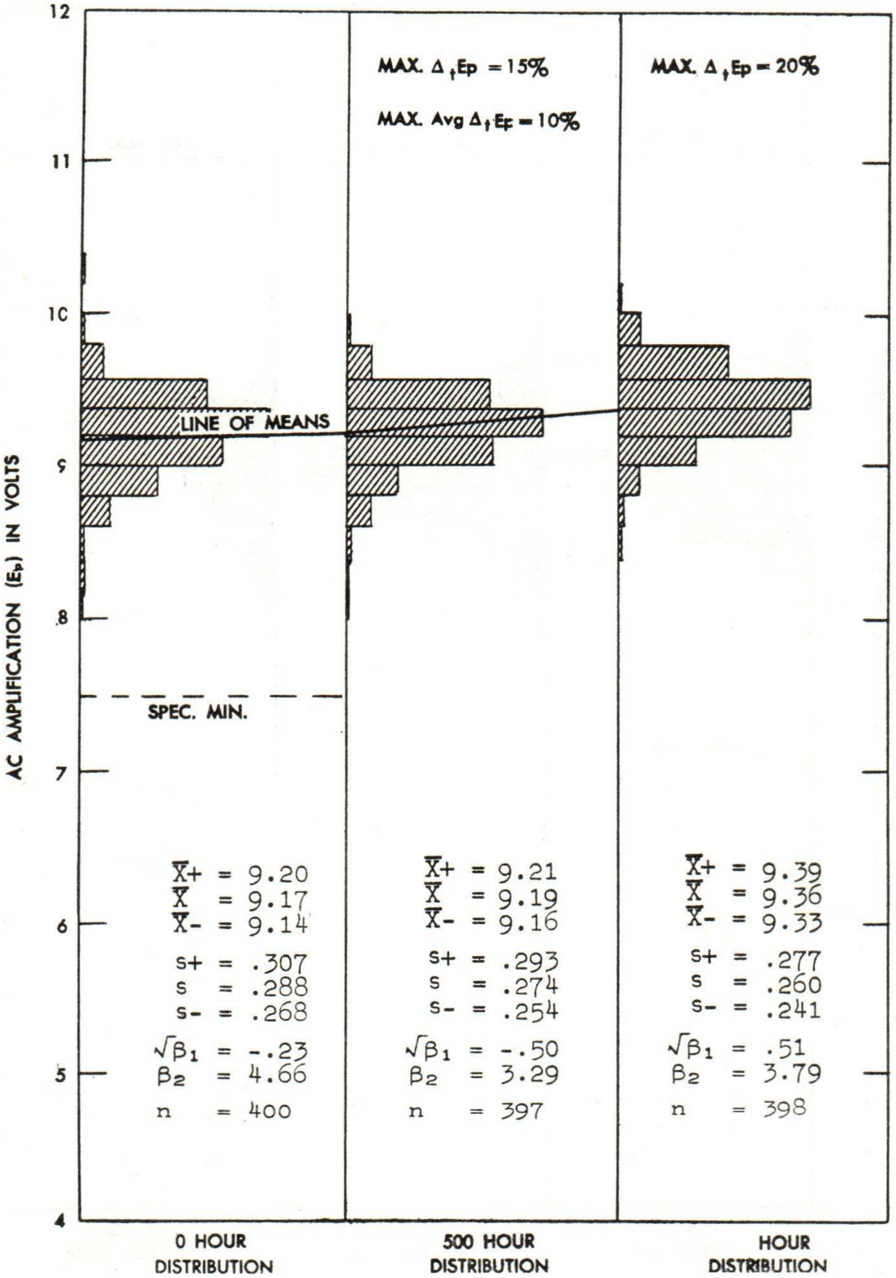


Figure 4-90. Distribution of AC Amplification for JAN-5751.

PROPERTY BEHAVIOR FOR JAN-5784WA

The histograms and data for Plate Current of JAN-5784WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/88C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still at the time associated with that curve.

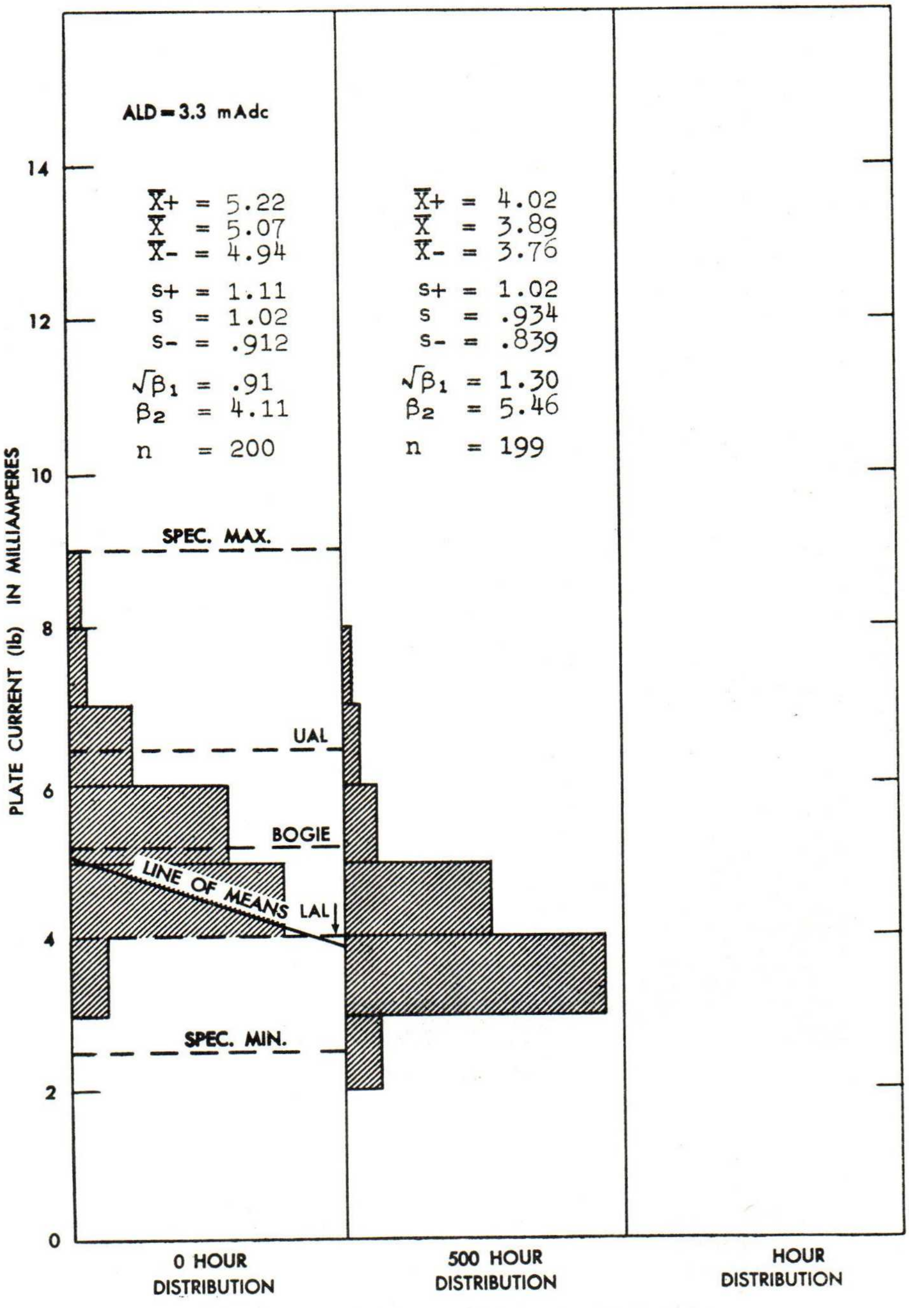


Figure 4-91. Distribution of Plate Current for JAN-5784WA.

PROPERTY BEHAVIOR FOR JAN-5784WA

The histograms and data for Screen Grid Current of JAN-5784WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/88C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

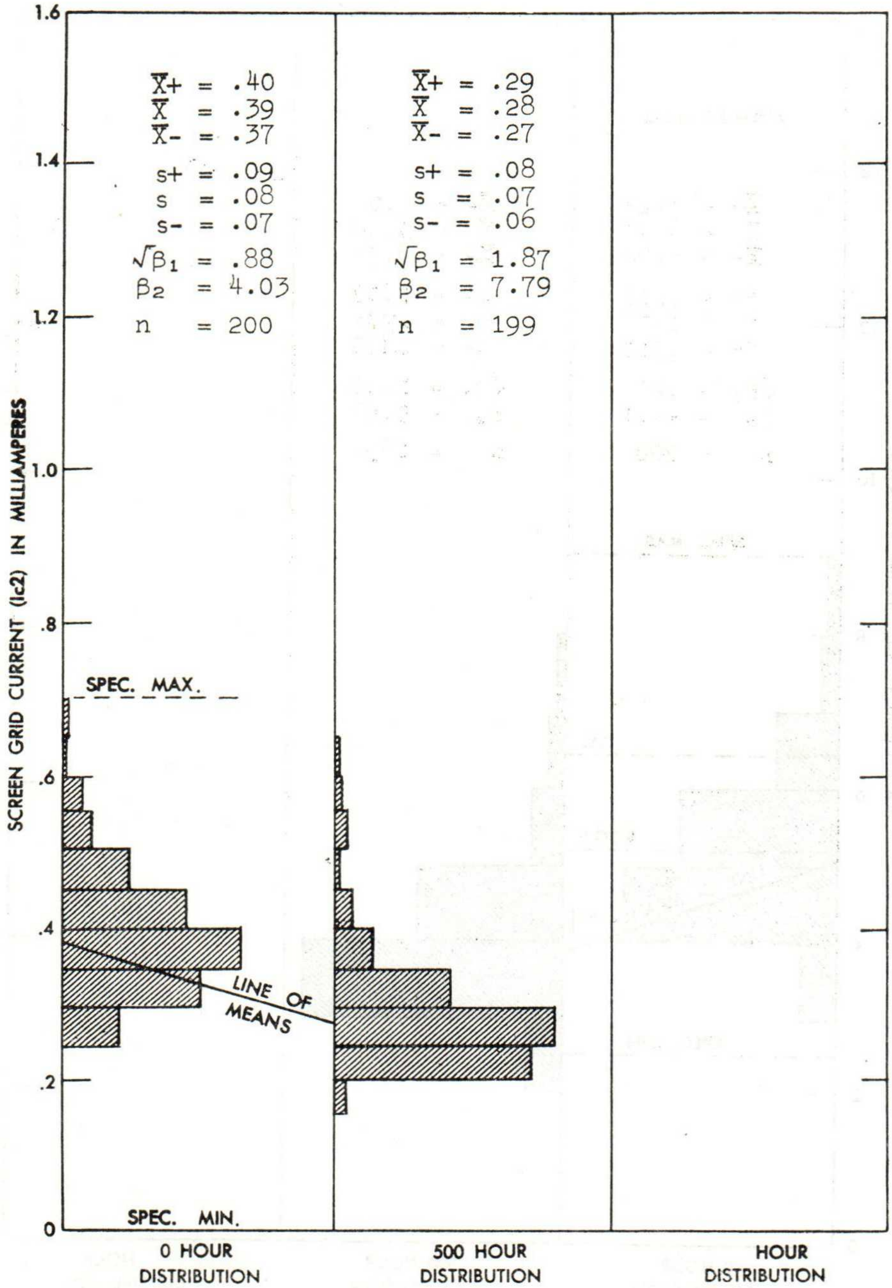


Figure 4-92. Distribution of Screen Grid Current for JAN-5784WA.

PROPERTY BEHAVIOR FOR JAN-5784WA

The histograms and data for Transconductance of JAN-5784WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/88C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

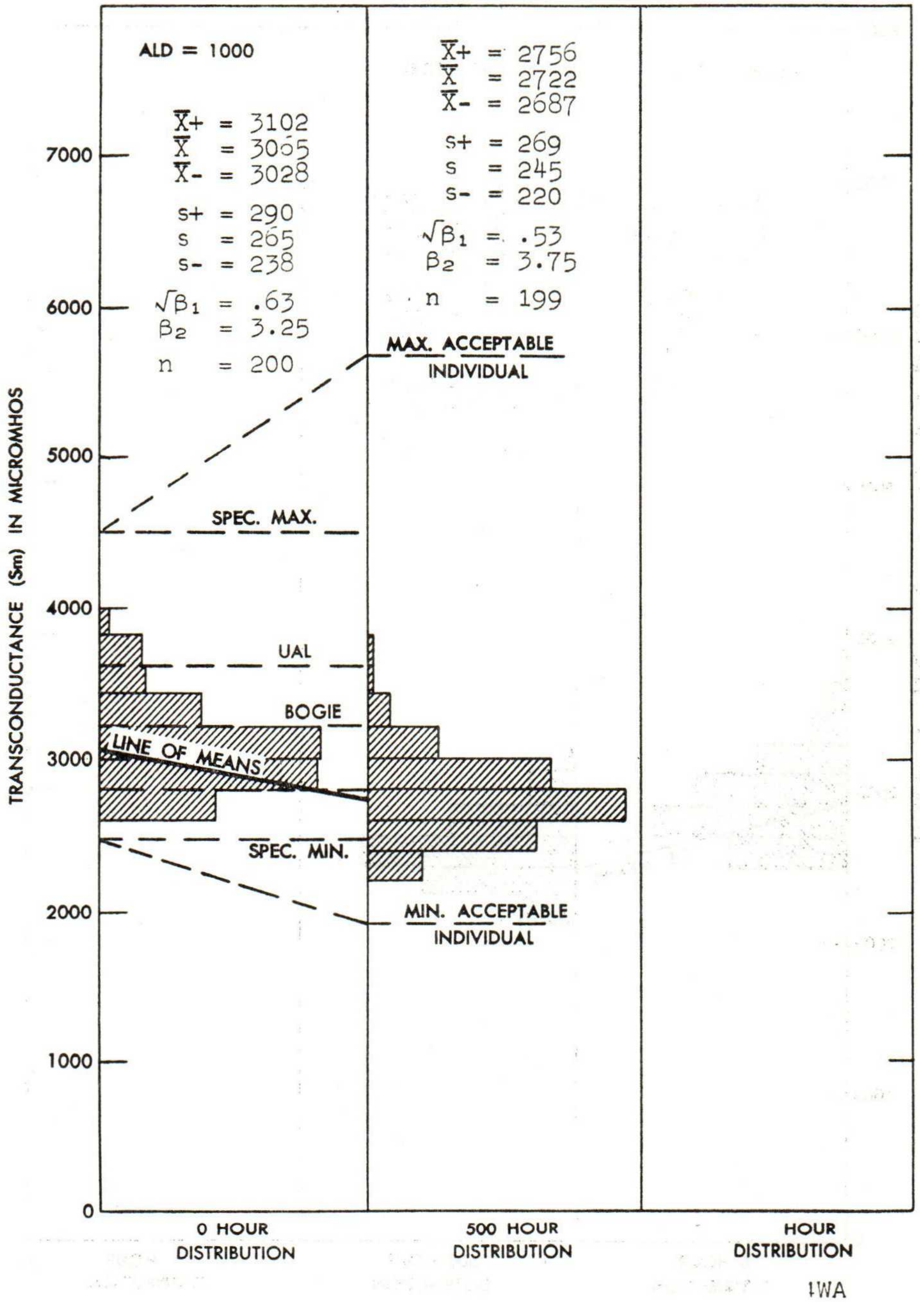


Figure 4-93. Distribution of Transconductance for JAN-5784 WA.

PROPERTY BEHAVIOR FOR JAN-5784WA

The histograms and data for Reduced Ef Transconductance of JAN-5784WA are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/88C dated 25 July 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

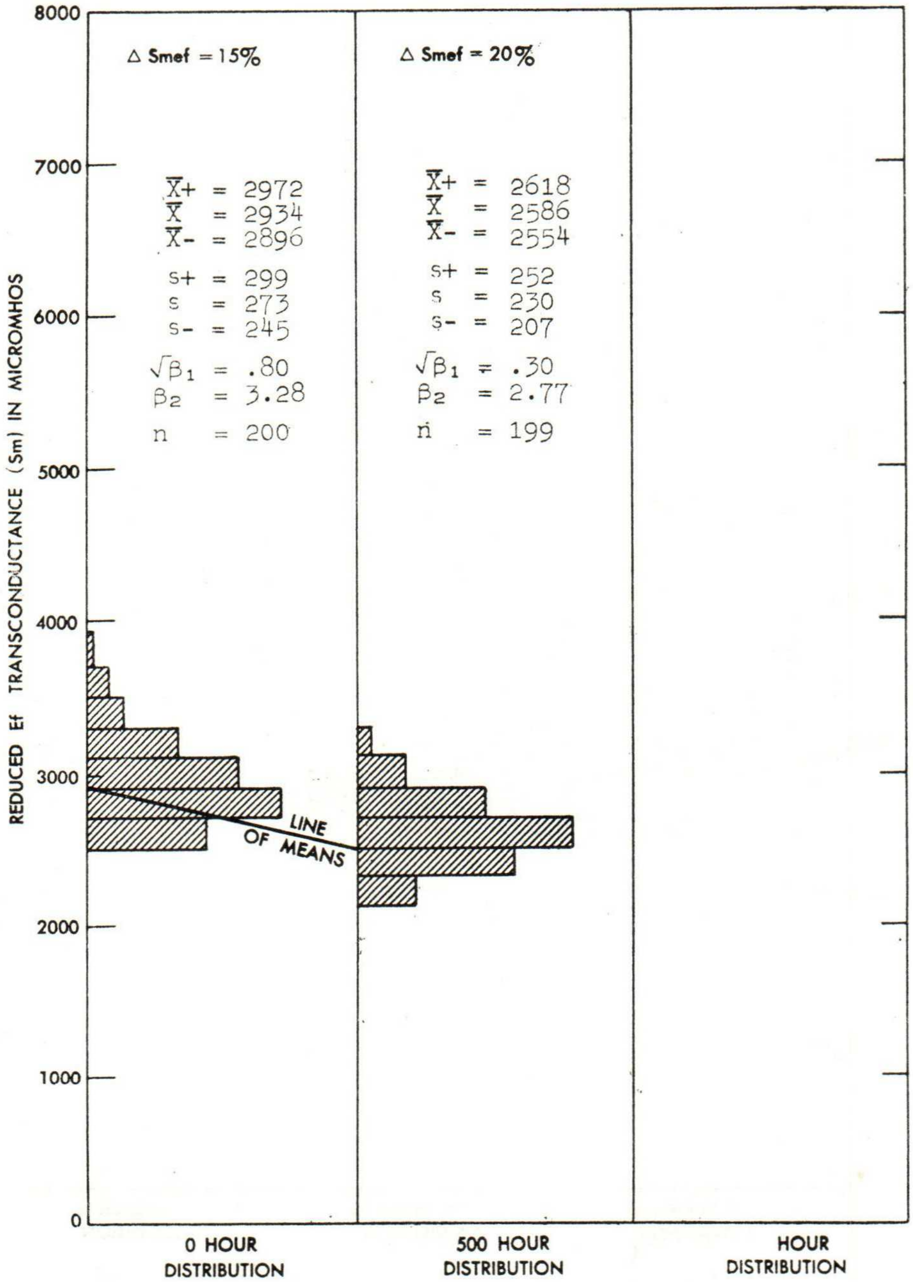


Figure 4-94. Distribution of Reduced Ef Transconductance for JAN-5784WA.

PROPERTY BEHAVIOR FOR JAN-5814A

The histograms and data for Transconductance of JAN-5814A are based upon 800 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/12A dated 23 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

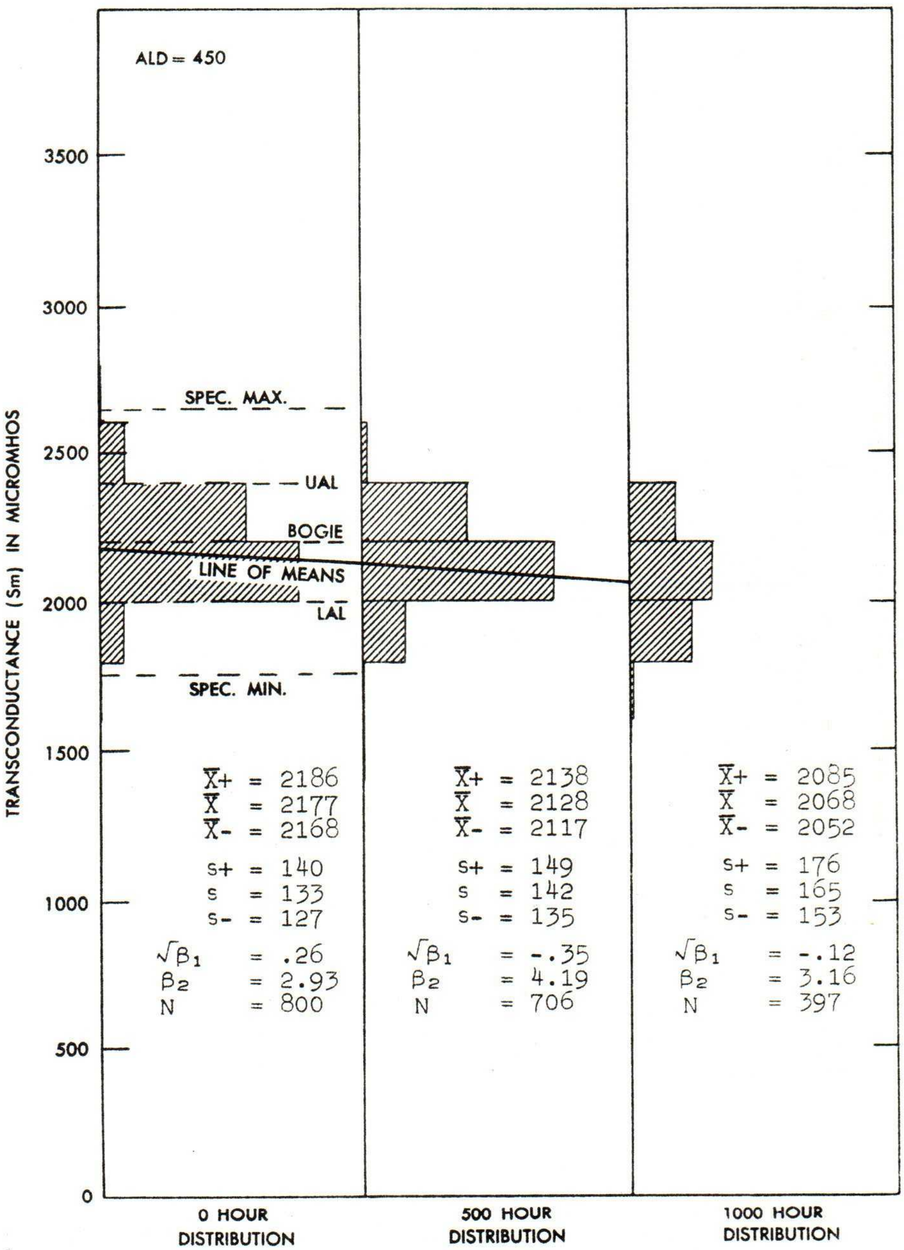


Figure 4-95. Distribution of Transconductance for JAN-5814A.

PROPERTY BEHAVIOR FOR JAN-5814A

The histograms and data for Reduced Ef Transconductance of JAN-5814A are based upon 800 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/12A dated 23 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

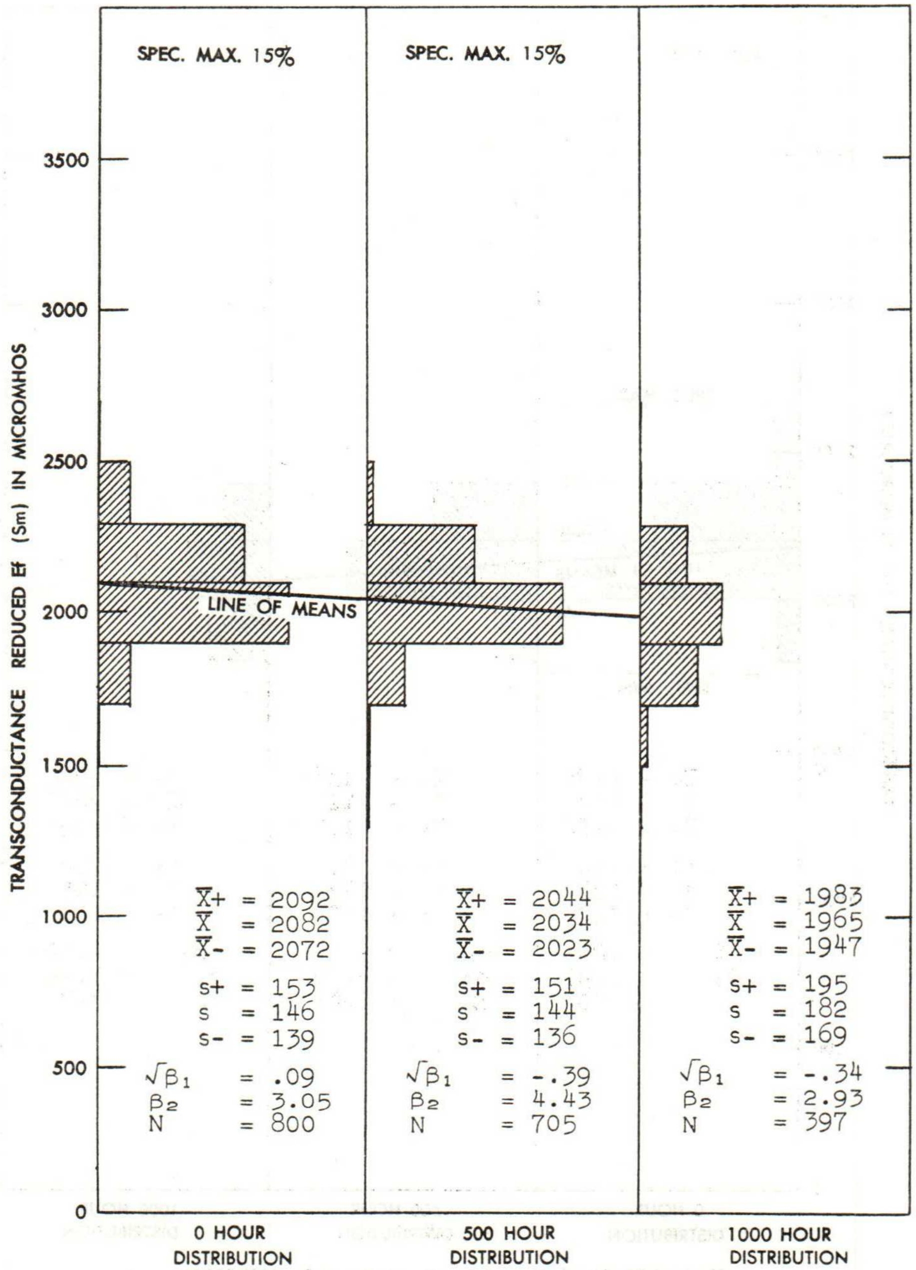


Figure 4-96. Distribution of Reduced Ef Transconductance for JAN-5814A.

PROPERTY BEHAVIOR FOR JAN-5840

The histograms and data for Transconductance of JAN-5840 are based upon 299 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/140B dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

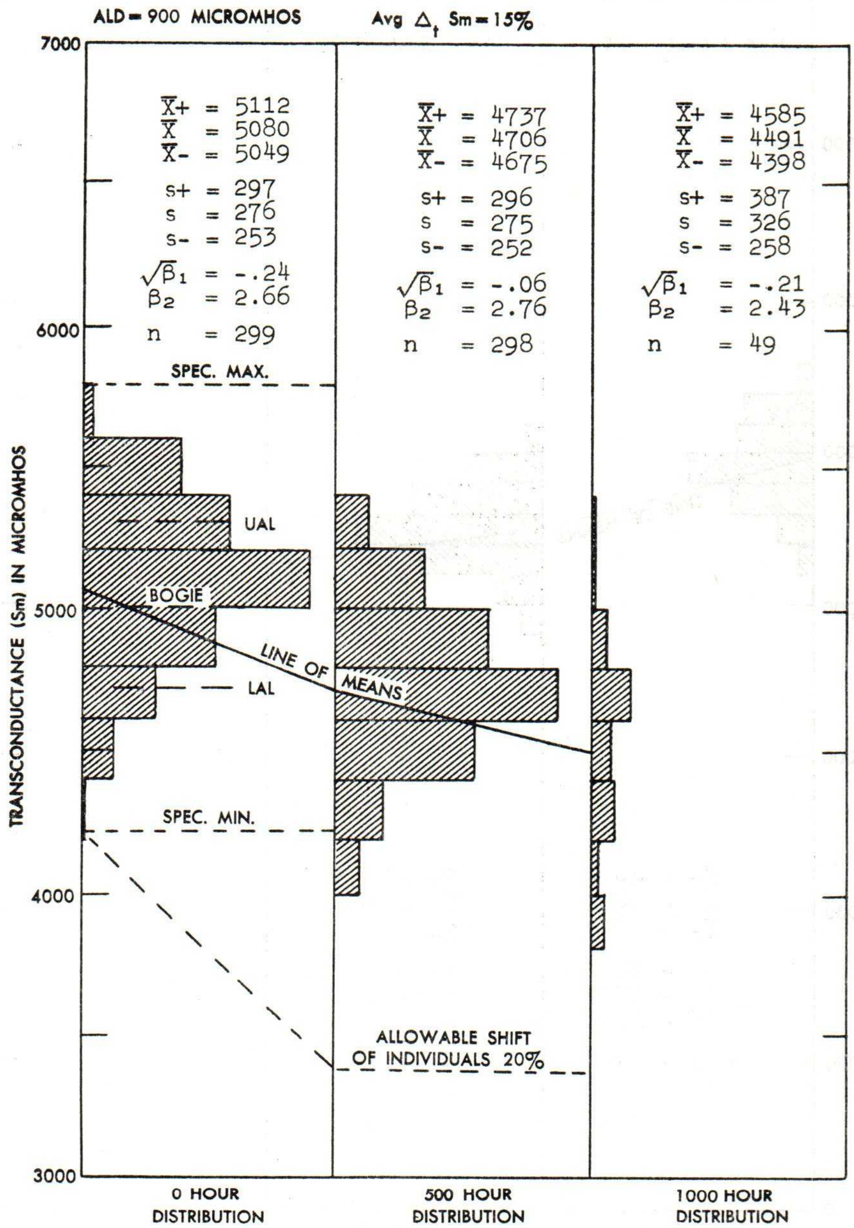


Figure 4-97. Distribution of Transconductance for JAN-5840.

PROPERTY BEHAVIOR FOR JAN-5840

The histograms and data for Reduced Ef Transconductance of JAN-5840 are based upon 298 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/140B dated 5 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

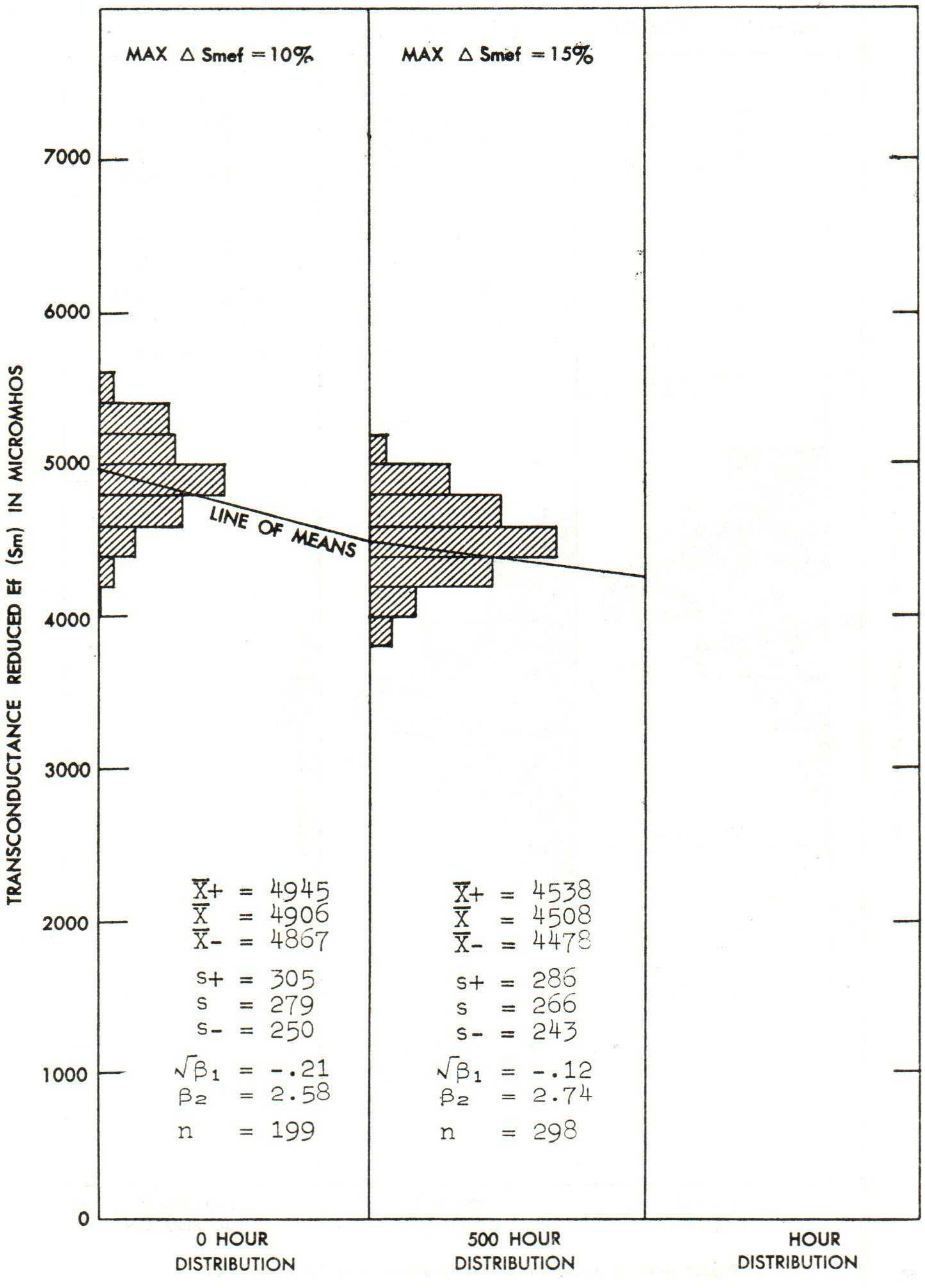


Figure 4-98. Distribution of Reduced Ef Transconductance for JAN-5840.

PROPERTY BEHAVIOR FOR JAN-5896

The histograms and data for Plate Current of JAN-5896 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/174C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes operative at the time associated with that curve.

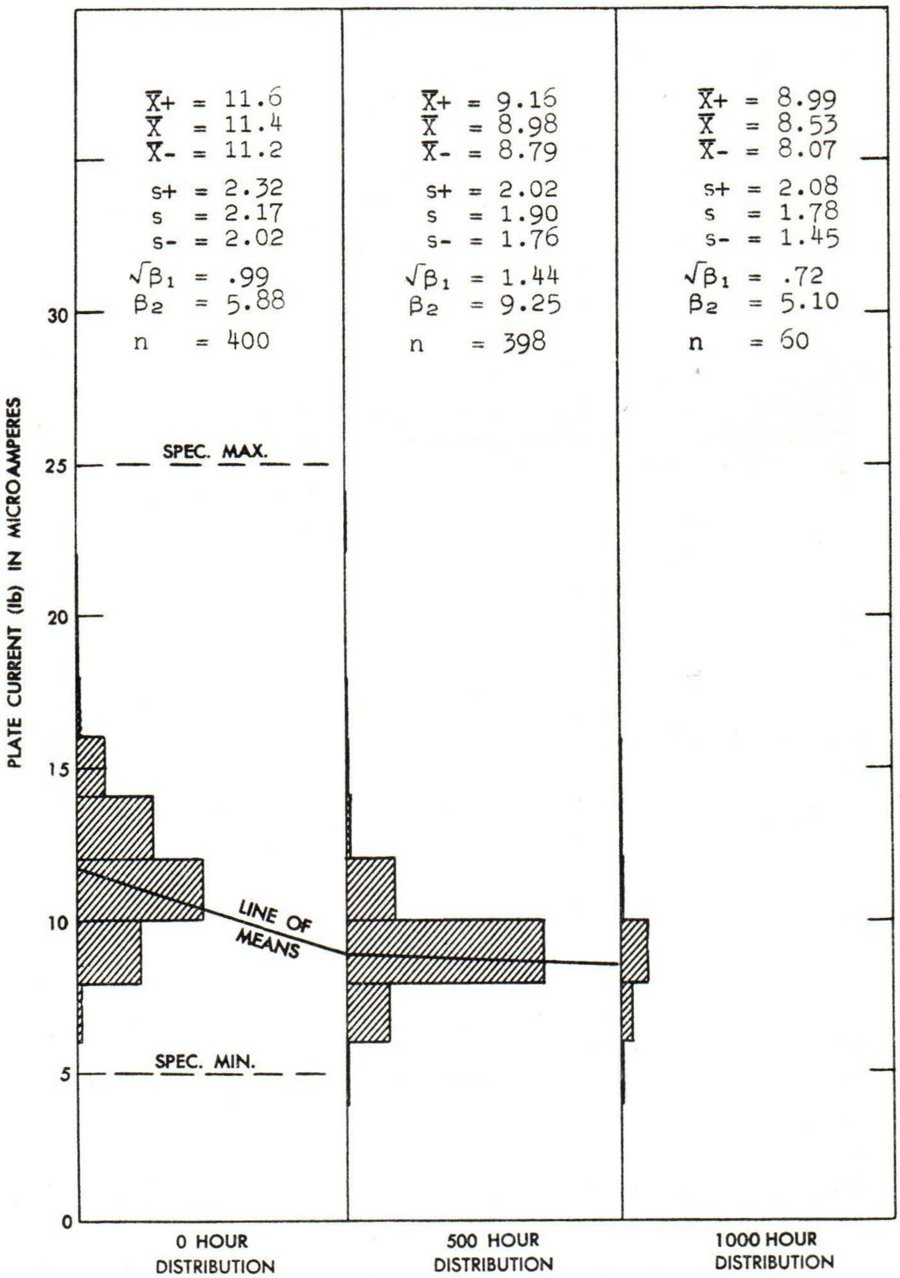


Figure 4-99. Distribution of Plate Current for JAN-5896.

PROPERTY BEHAVIOR FOR JAN-5896

The histograms and data for Operation Current of JAN-5896 are based upon 800 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/174C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

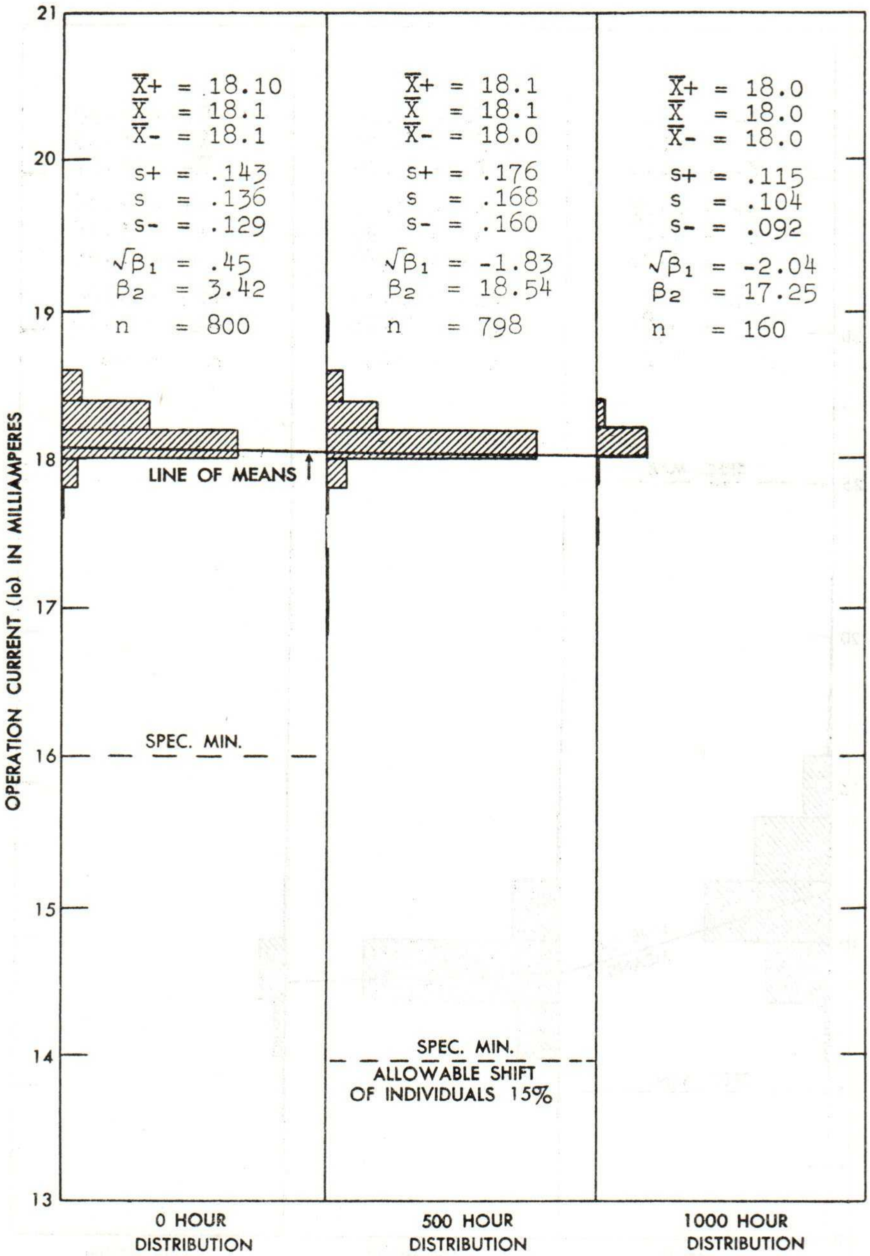


Figure 4-100. Distribution of Operation Current for JAN-5896.

PROPERTY BEHAVIOR FOR JAN-5896

The histograms and data for Emission Current of JAN-5896 are based upon 800 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/174C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

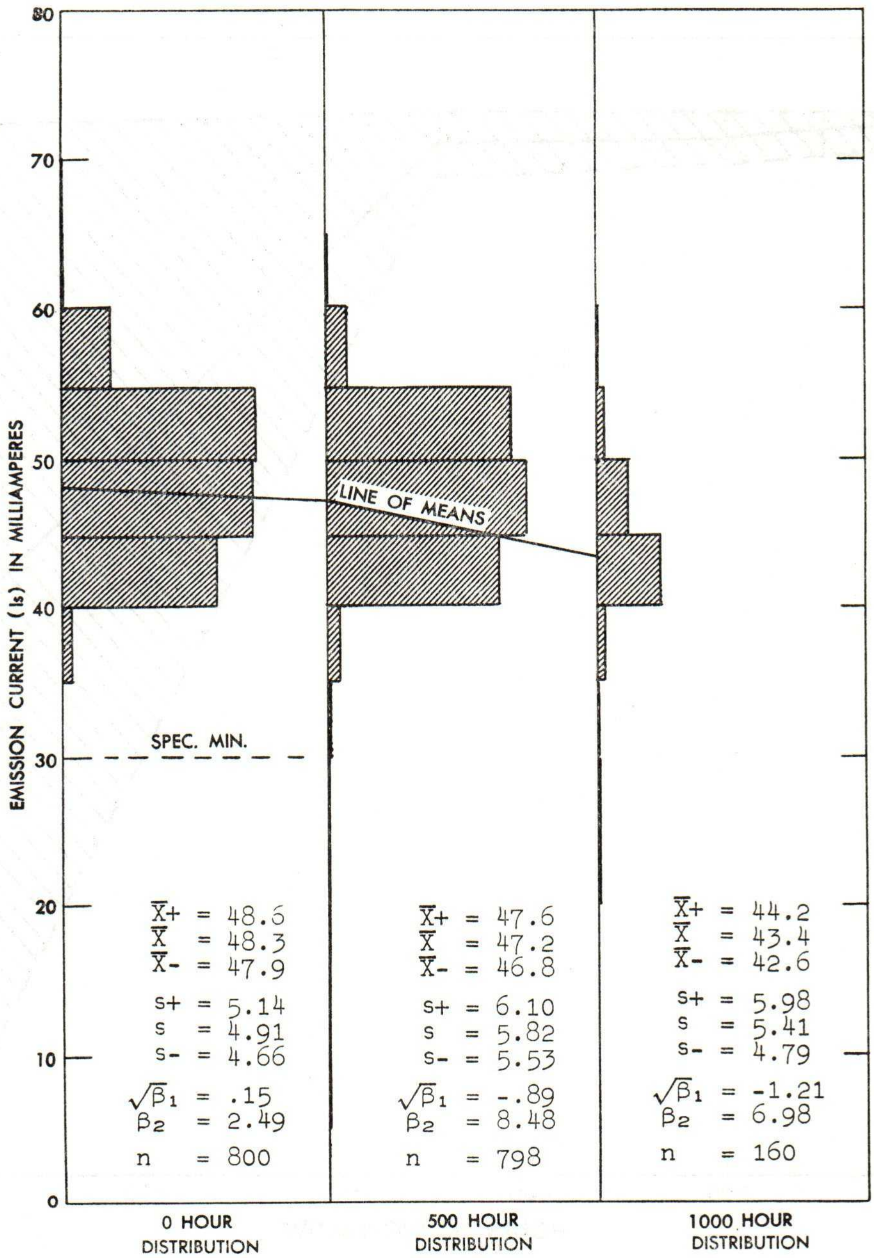


Figure 4-101. Distribution of Emission Current for JAN-5896.

PROPERTY BEHAVIOR FOR JAN-5896

This figure presents the inoperative probability of survival under MIL-E-1 specification life test conditions for tube type JAN-5896 during the production year 1956. This figure is derived from data supplied by two manufacturers, 2210 tubes with 15 failures occurring prior to 1000 hour test point.

The definition of "Inoperatives" coincides with that found in the appropriate paragraphs of MIL-E-1.

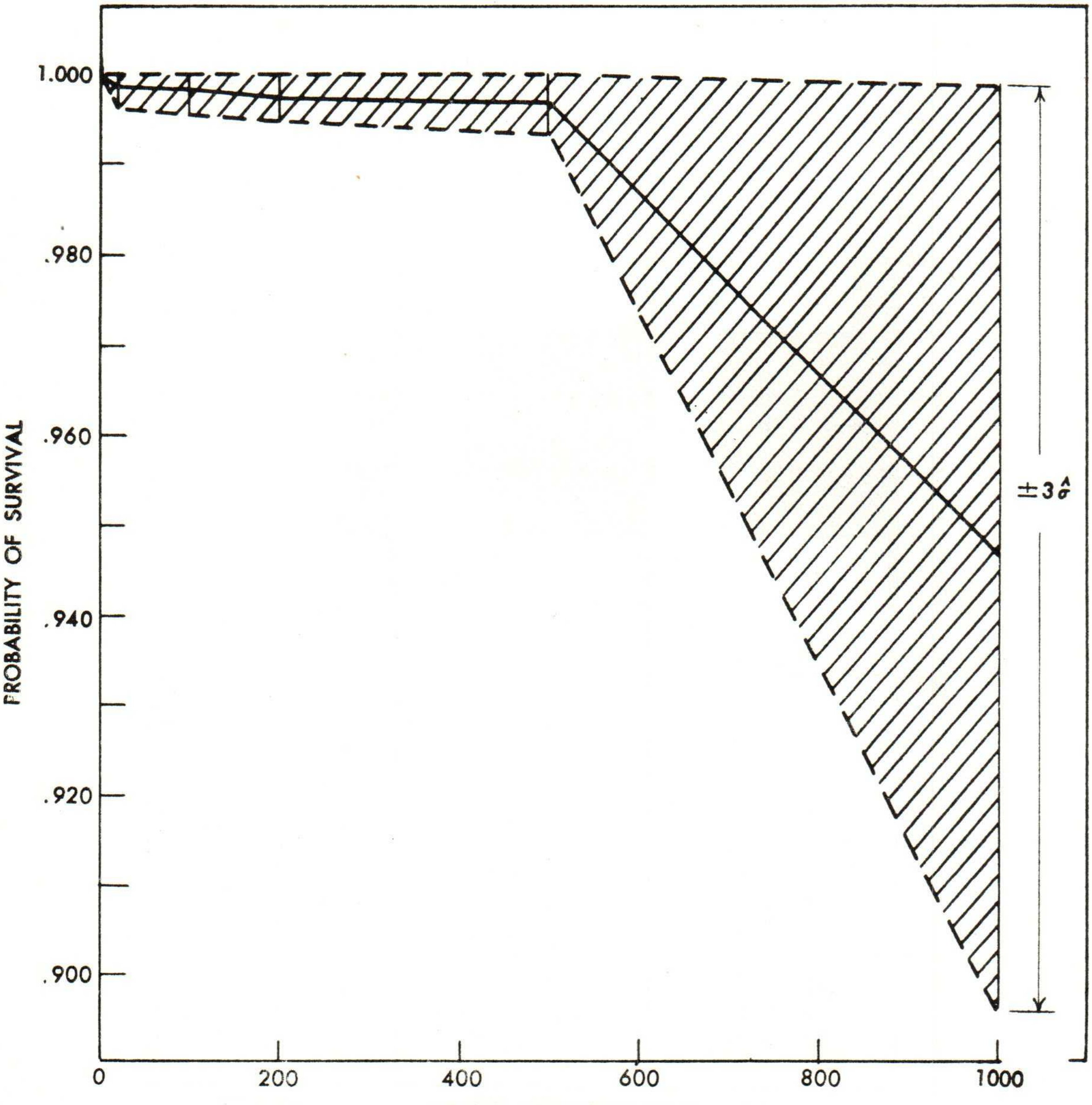


Figure 4-102. Probability of Survival for JAN-5896 Under MIL-E-1 Conditions.

PROPERTY BEHAVIOR FOR JAN-5899

The histograms and data for Plate Current of JAN-5899 are based upon 280 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/97C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

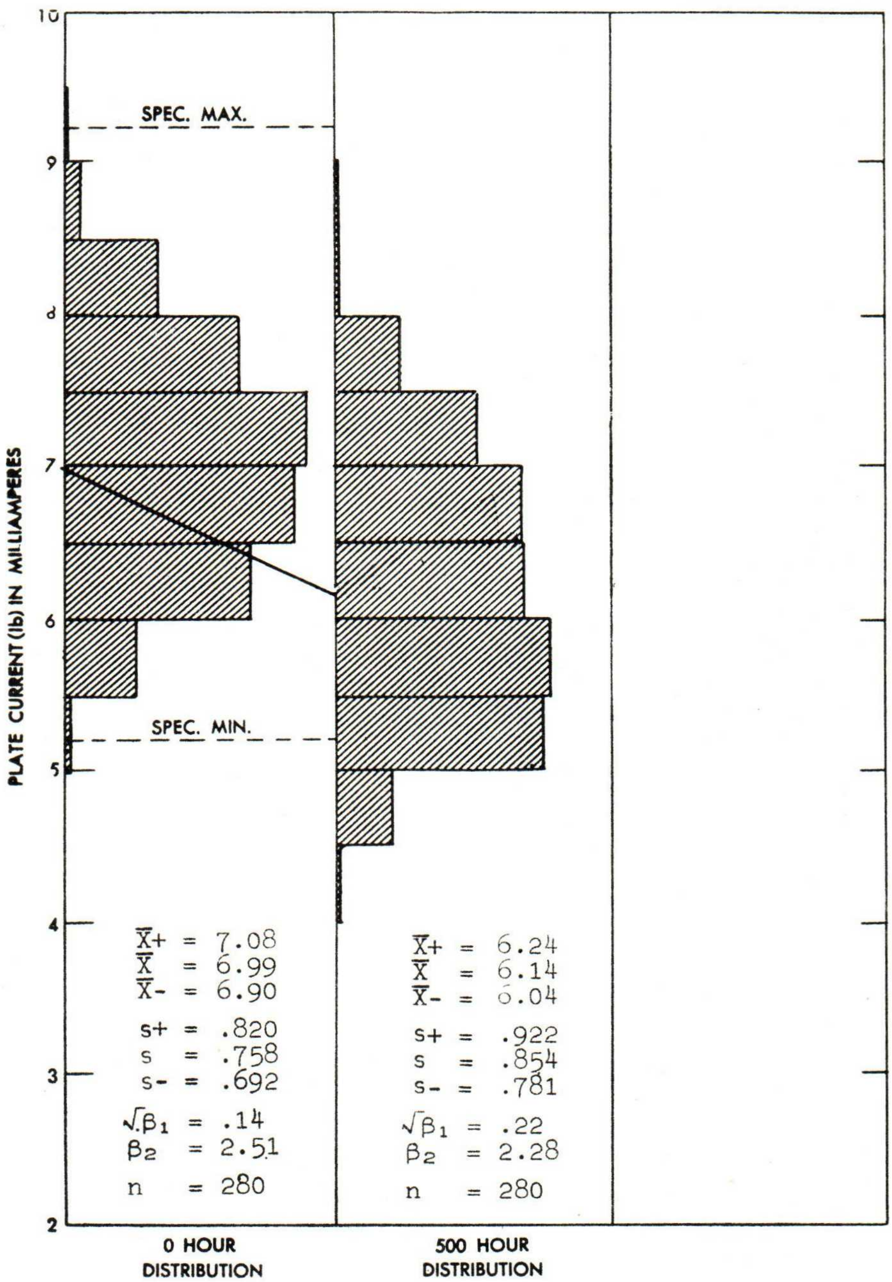


Figure 4-103. Distribution of Plate Current for JAN-5899.

PROPERTY BEHAVIOR FOR JAN-5899

The histograms and data for Screen Grid Current of JAN-5899 are based upon 280 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/97C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

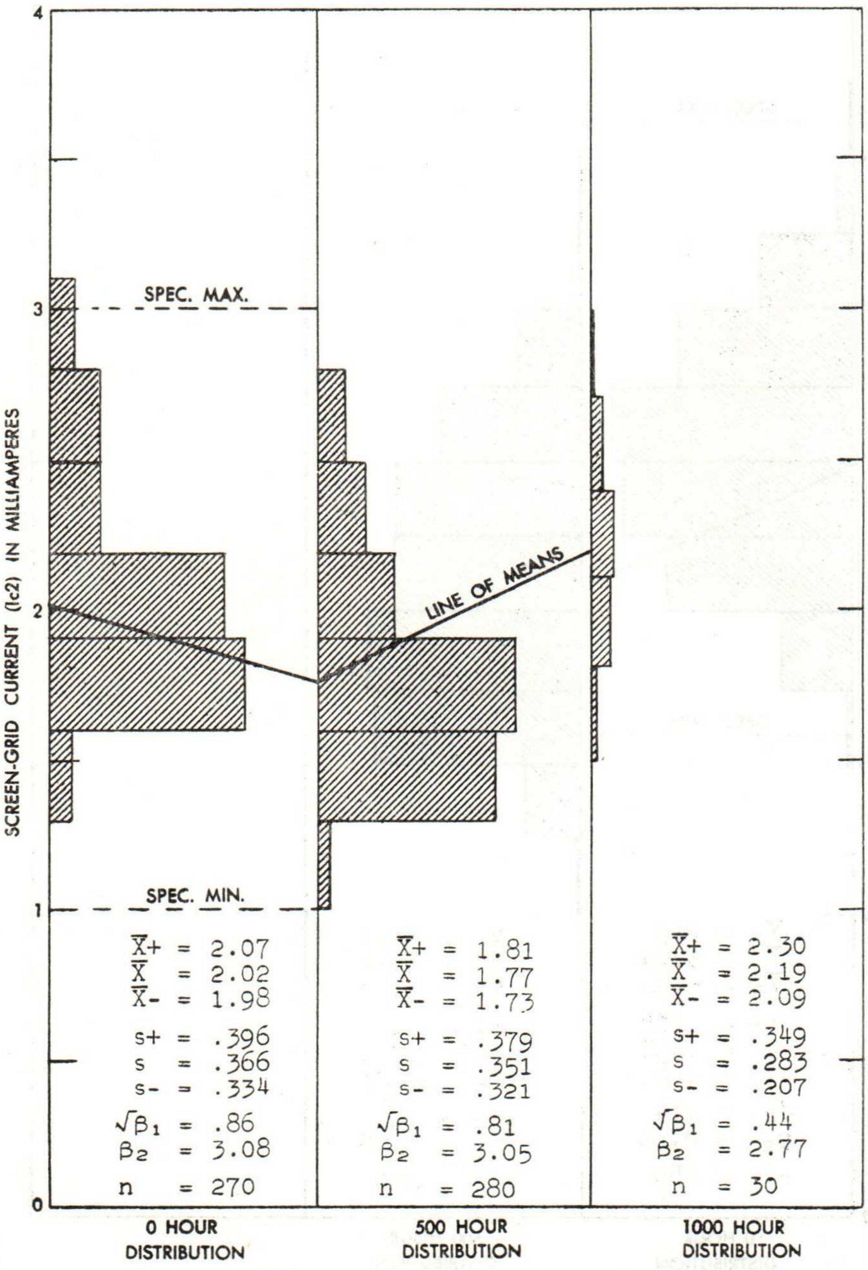


Figure 4-104. Distribution of Screen Grid Current for JAN-5899.

PROPERTY BEHAVIOR FOR JAN-5899

The histograms and data for Transconductance of JAN-5899 are based upon 380 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/97C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

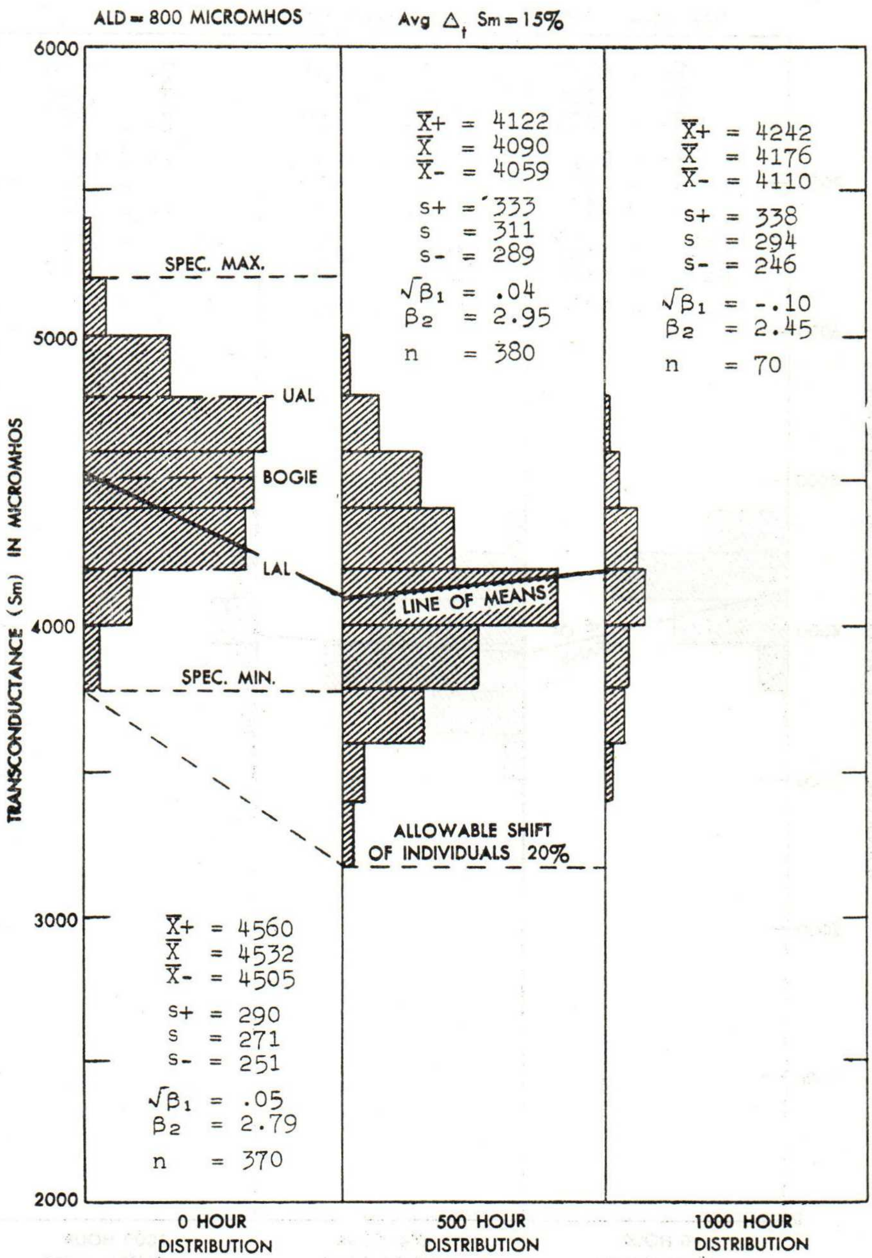


Figure 4-105. Distribution of Transconductance for JAN-5899.

PROPERTY BEHAVIOR FOR JAN-5899

The histograms and data for Reduced Ef Transconductance of JAN-5899 are based upon 380 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/97C dated 23 June 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

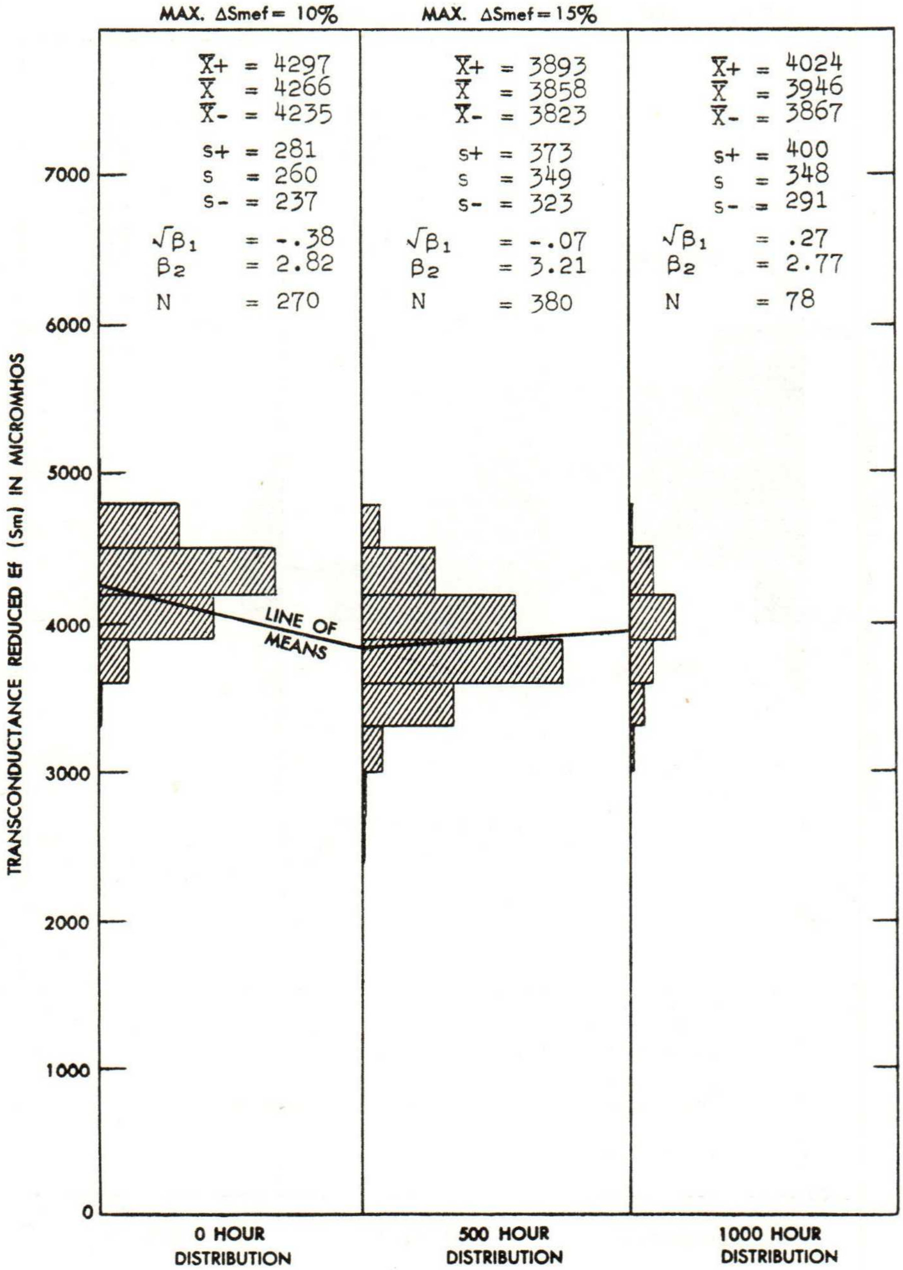


Figure 4-106. Distribution of Reduced Ef Transconductance for JAN-5899.

TYPICAL THERMAL BEHAVIOR OF JAN–5899

These typical curves have been obtained by experimental procedures performed on a small sample of JAN–5899 tubes. The specification ratings delineating a recommended or safe area of operation are shown. The effective environmental temperature was carefully detrmined for this particular experiment but there is considerable room for interpretation on an individual application basis.

Study of the chart should point out the fallacy of attempting operation beyond specification ratings by external reduction of the effective environmental temperature. This fallacy obtains because the plate temperature will most likely exceed the value which has been determined by the manufacturer as "safe" for this particular tube type.

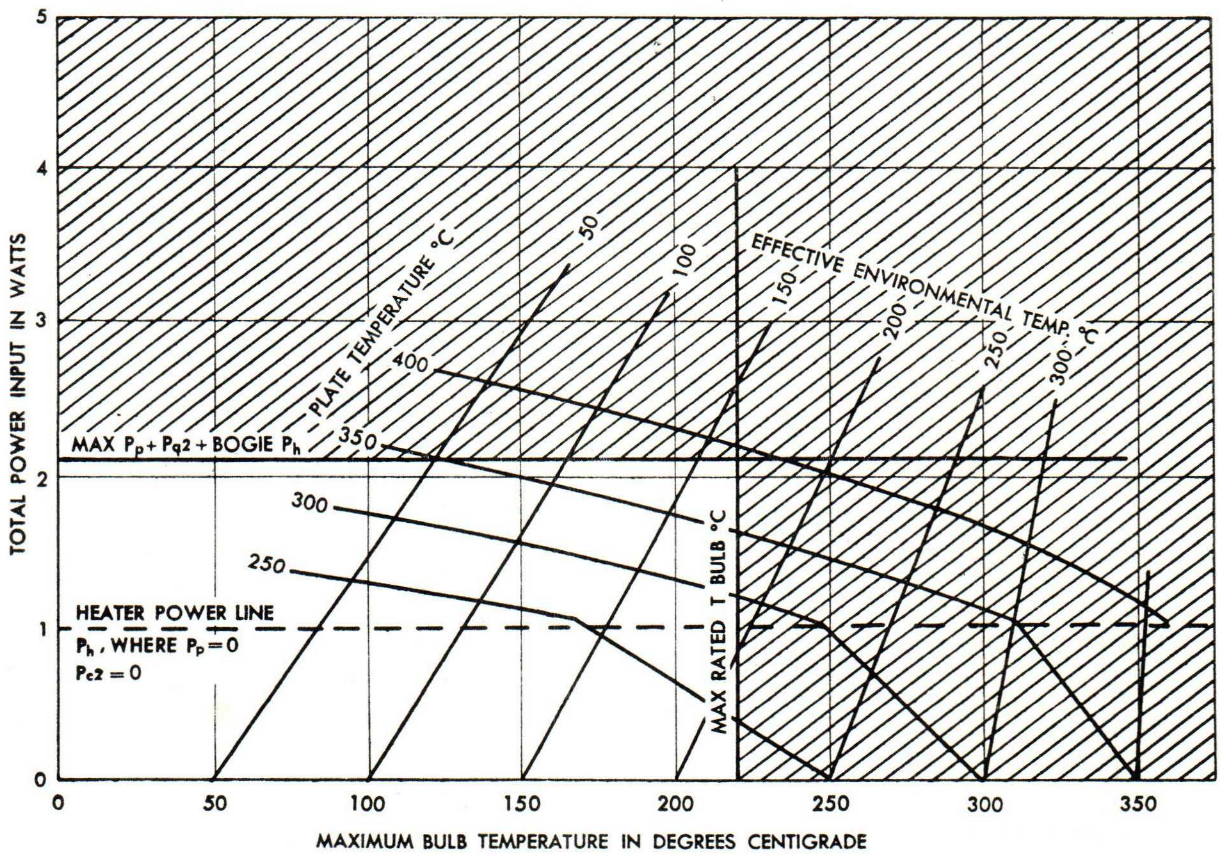


Figure 4-107. Typical Thermal Behavior for JAN-5899.

This figure presents the inoperative probability of survival under MIL-E-1 specification life test conditions for tube type JAN-5899 during the production year 1956. This figure is derived from data supplied by three manufacturers, 660 tubes with 7 failures occurring prior to 750 hour test point.

The definition of "Inoperatives" coincides with that found in the appropriate paragraphs of MIL-E-1.

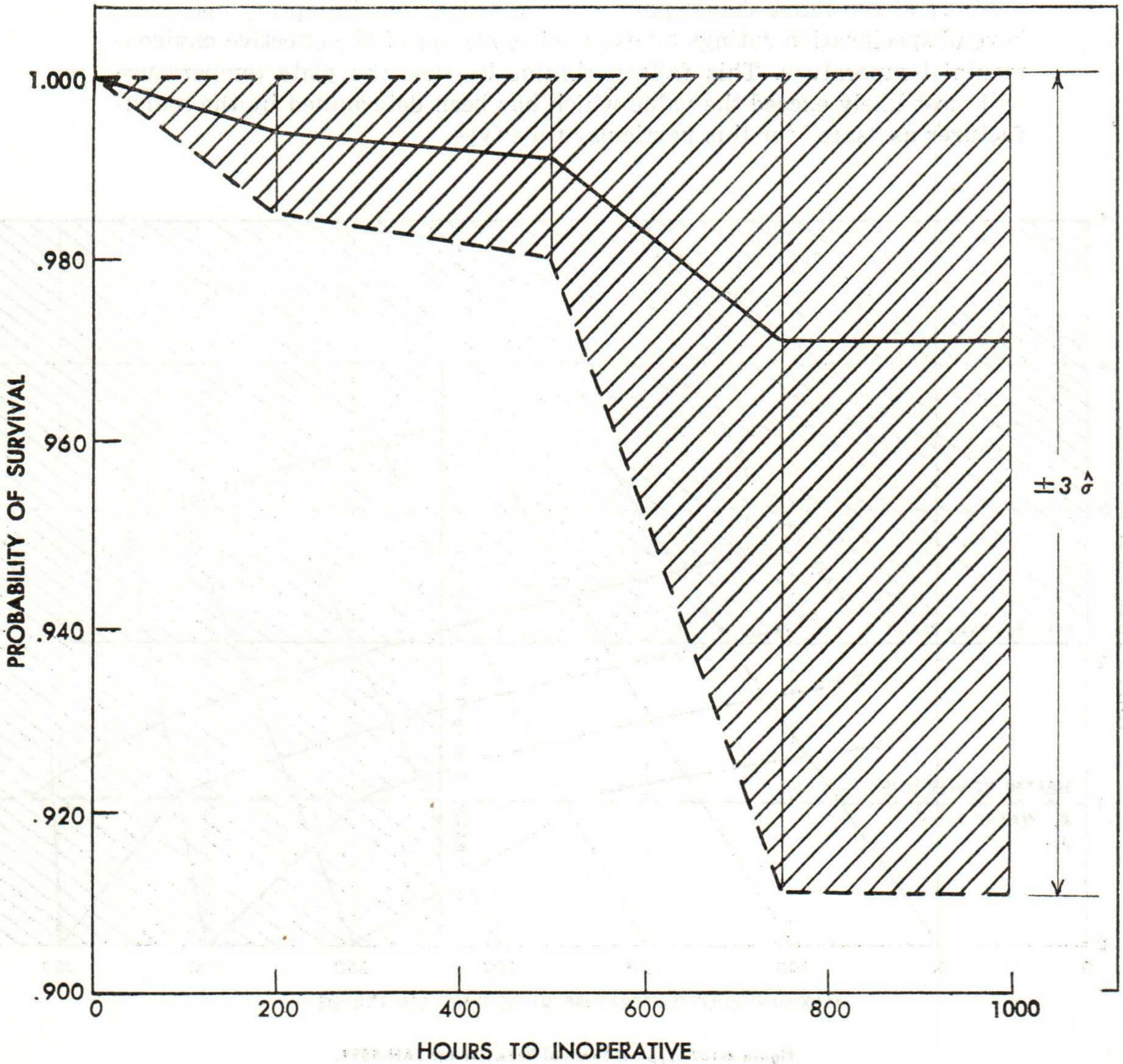


Figure 4-108. Probability of Survival for JAN-5899 Under MIL-E-1 Conditions.

PROPERTY BEHAVIOR FOR JAN-5902

The histograms and data for Plate Current of JAN-5902 are based upon 398 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/175C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

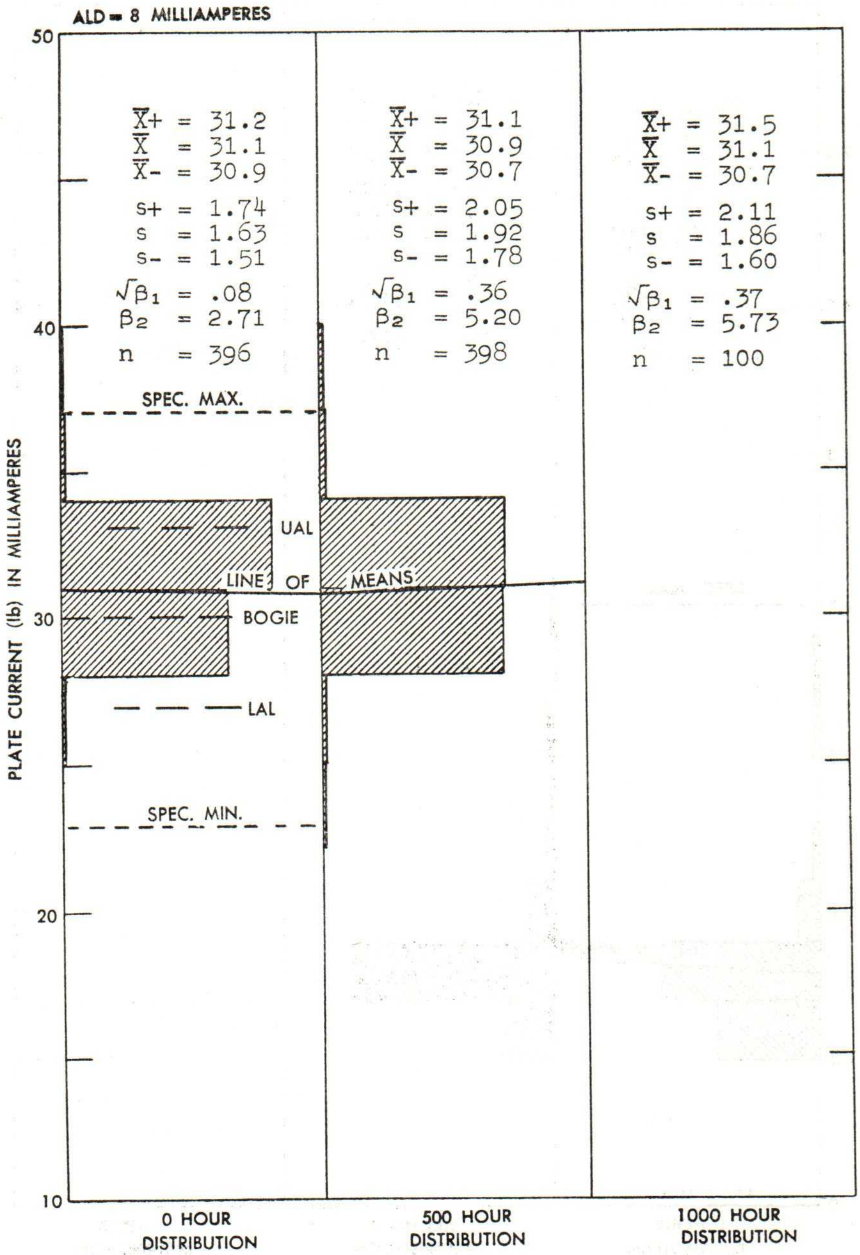


Figure 4-109. Distribution of Plate Current for JAN-5902.

PROPERTY BEHAVIOR FOR JAN–5902

The histograms and data for Screen Grid Current of JAN–5902 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/175C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

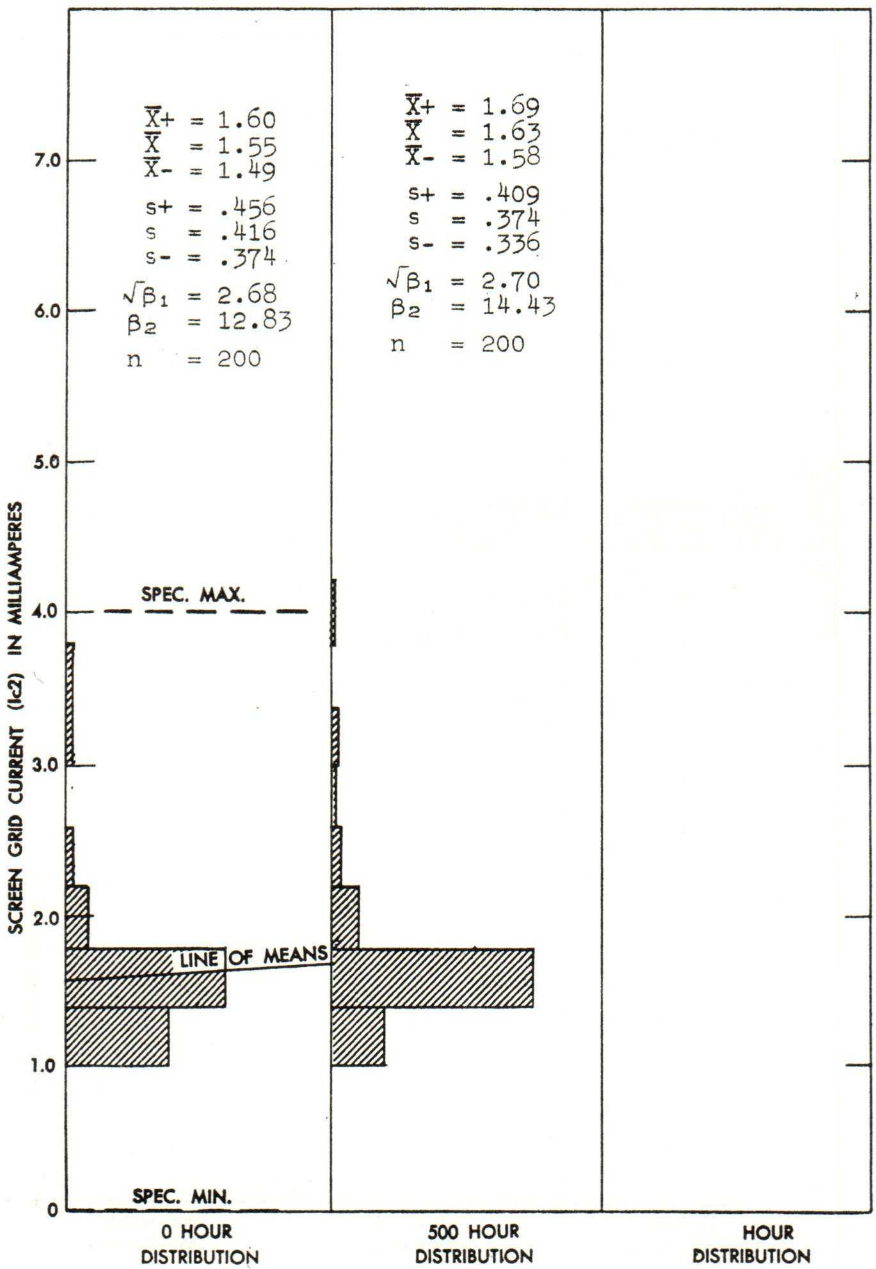


Figure 4-110. Distribution of Screen Grid Current for JAN-5902.

PROPERTY BEHAVIOR FOR JAN-5902

The histograms and data for Transconductance of JAN-5902 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/175C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

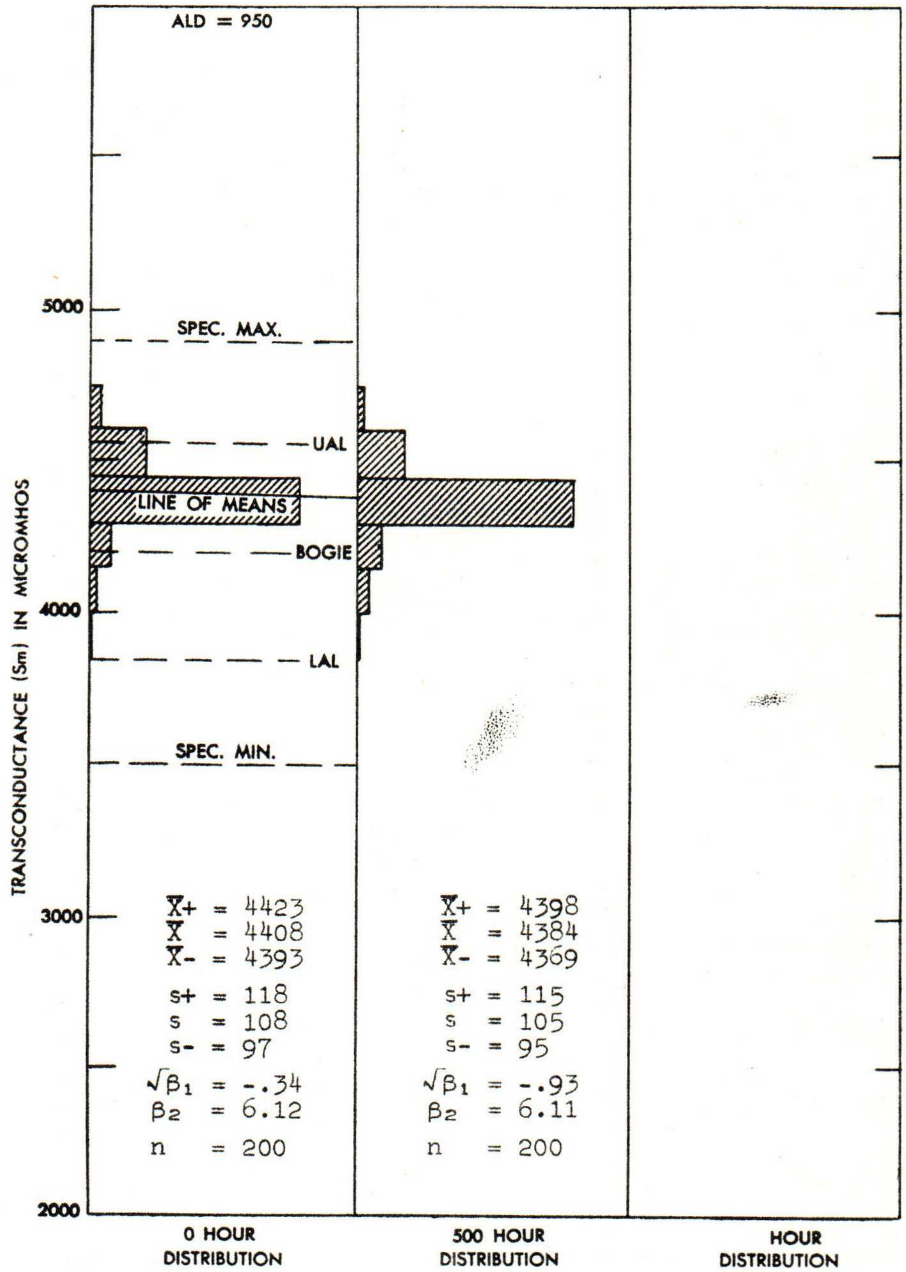


Figure 4-111. Distribution of Transconductance for JAN-5902.

PROPERTY BEHAVIOR FOR JAN-5902

The histograms and data for Power Output for JAN-5902 are based upon 478 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/175C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

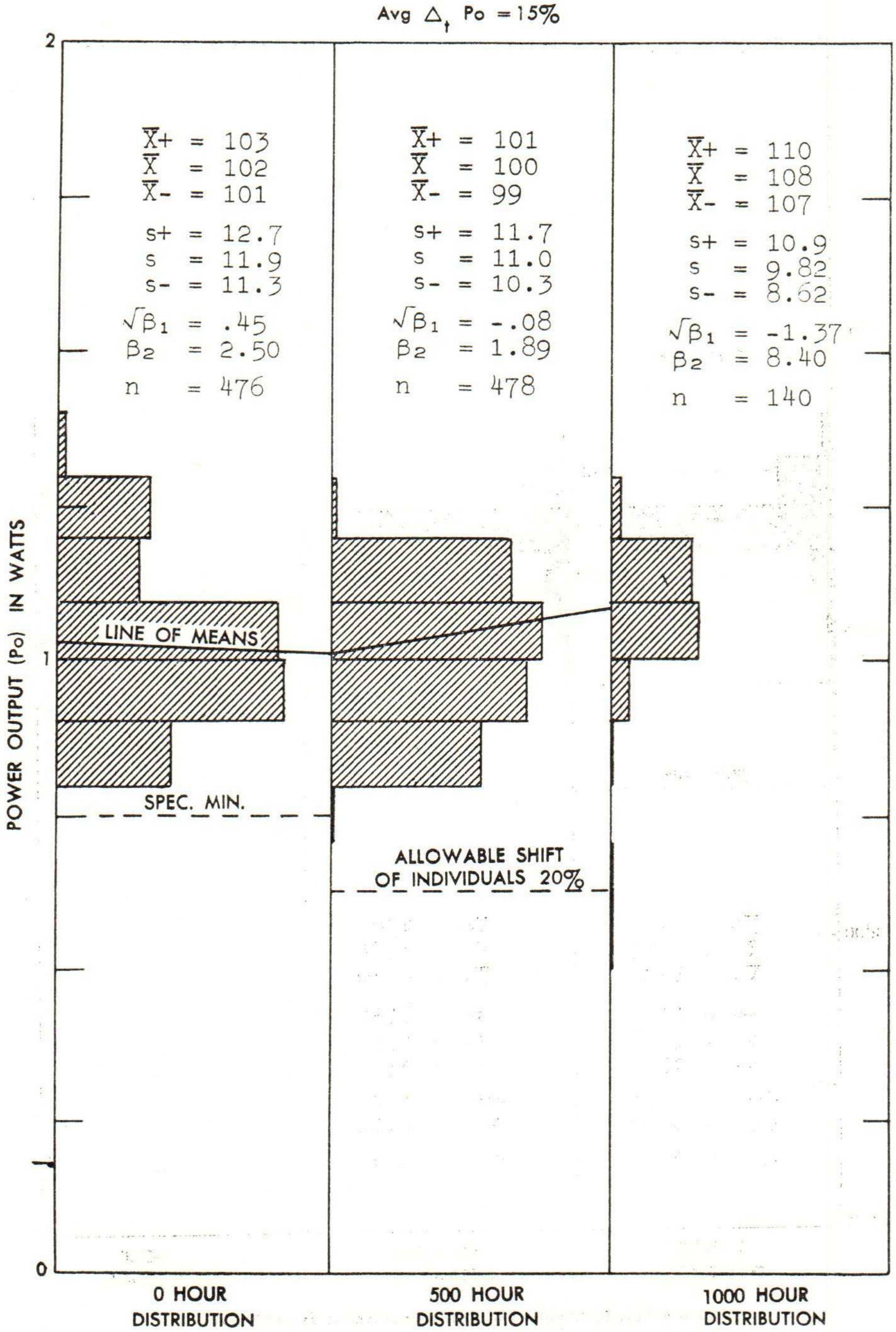


Figure 4-112. Distribution of Power Output for JAN-5902.

PROPERTY BEHAVIOR FOR JAN–5902

The histograms and data for Reduced Ef Power Output of JAN–5902 are based upon 478 tubes life-tested by three manufacturers of the type during the year 1956. The specification limits shown are taken from MIL–E–1/175C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

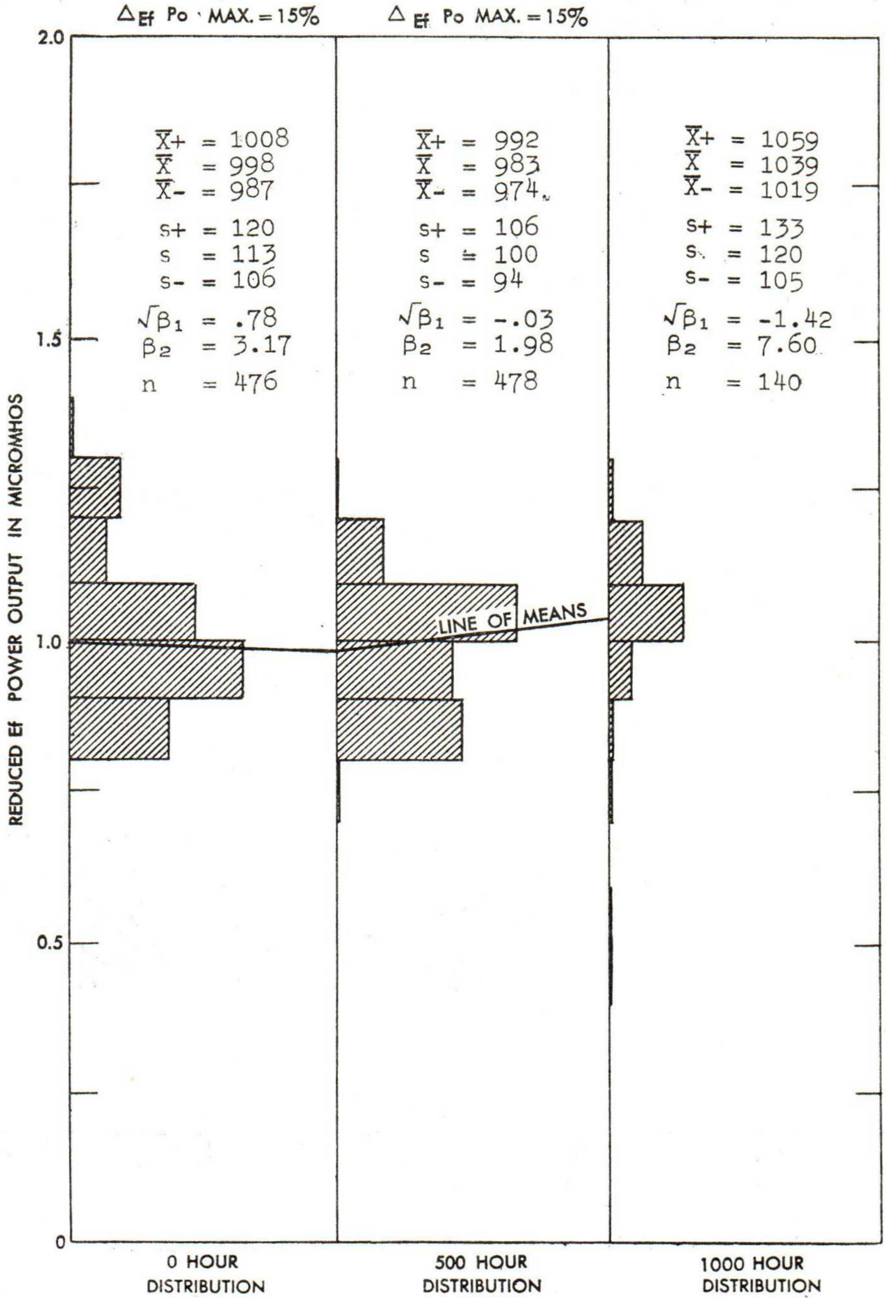


Figure 4-113. Distribution of Reduced Ef Power Output for JAN-5902.

This figure presents the inoperative probability of survival under MIL-E-1 specification life test conditions for tube type JAN-5902 during the production year 1956. This figure is derived from data supplied by three manufacturers, 1760 tubes with 7 failures occurring prior to 500 hour test point.

No field evidence is available to support the apparent infant mortality evidenced in these data.

The definition of "Inoperatives" coincides with that found in the appropriate paragraphs of MIL-E-1.

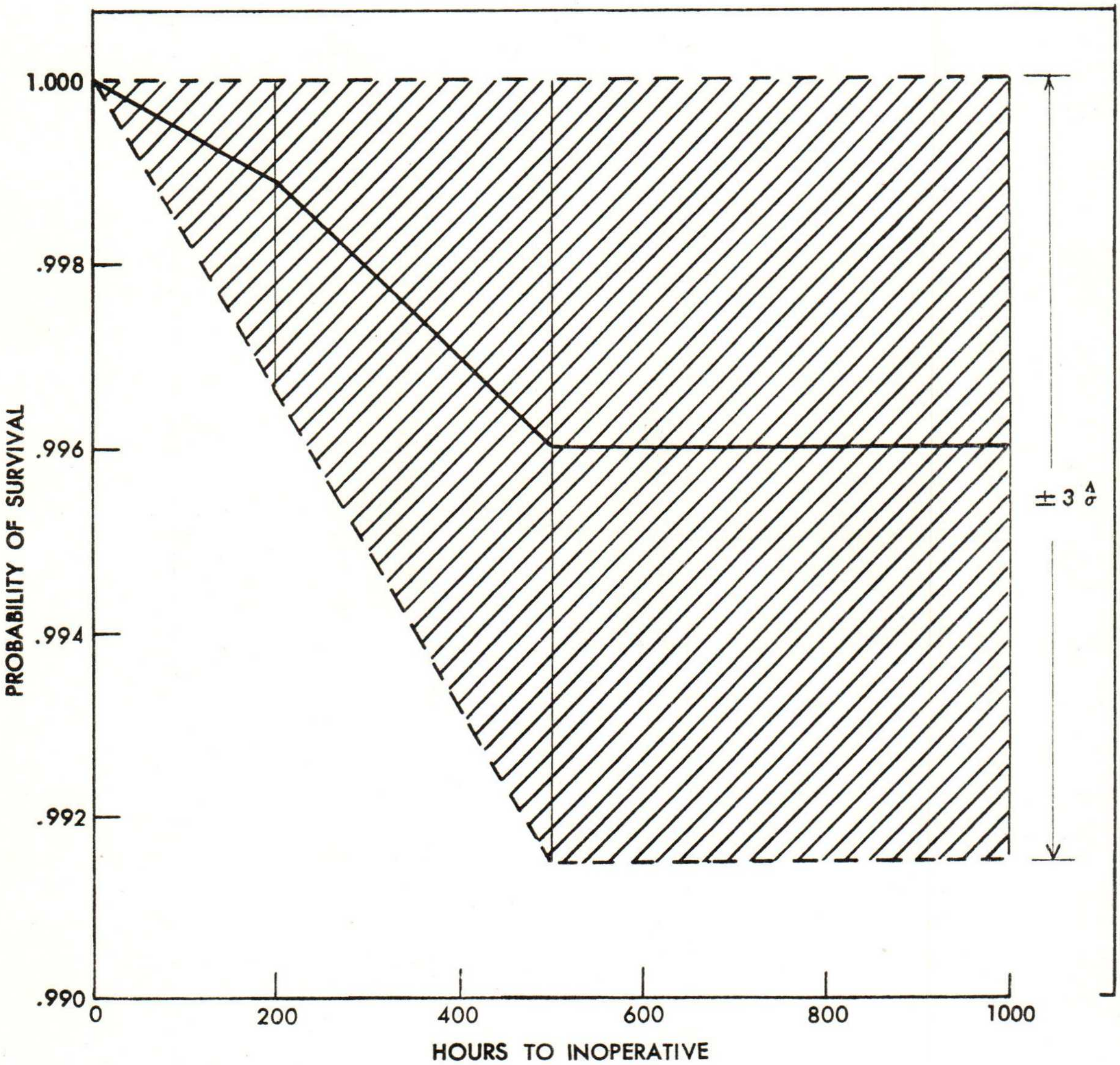


Figure 4-114. Probability of Survival for JAN-5902 Under MIL-E-1 Conditions.

PROPERTY BEHAVIOR FOR JAN-6005/6AQ5W

The histograms and data for Plate Current of JAN-6005/6AQ5W are based upon 200 life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/13A dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

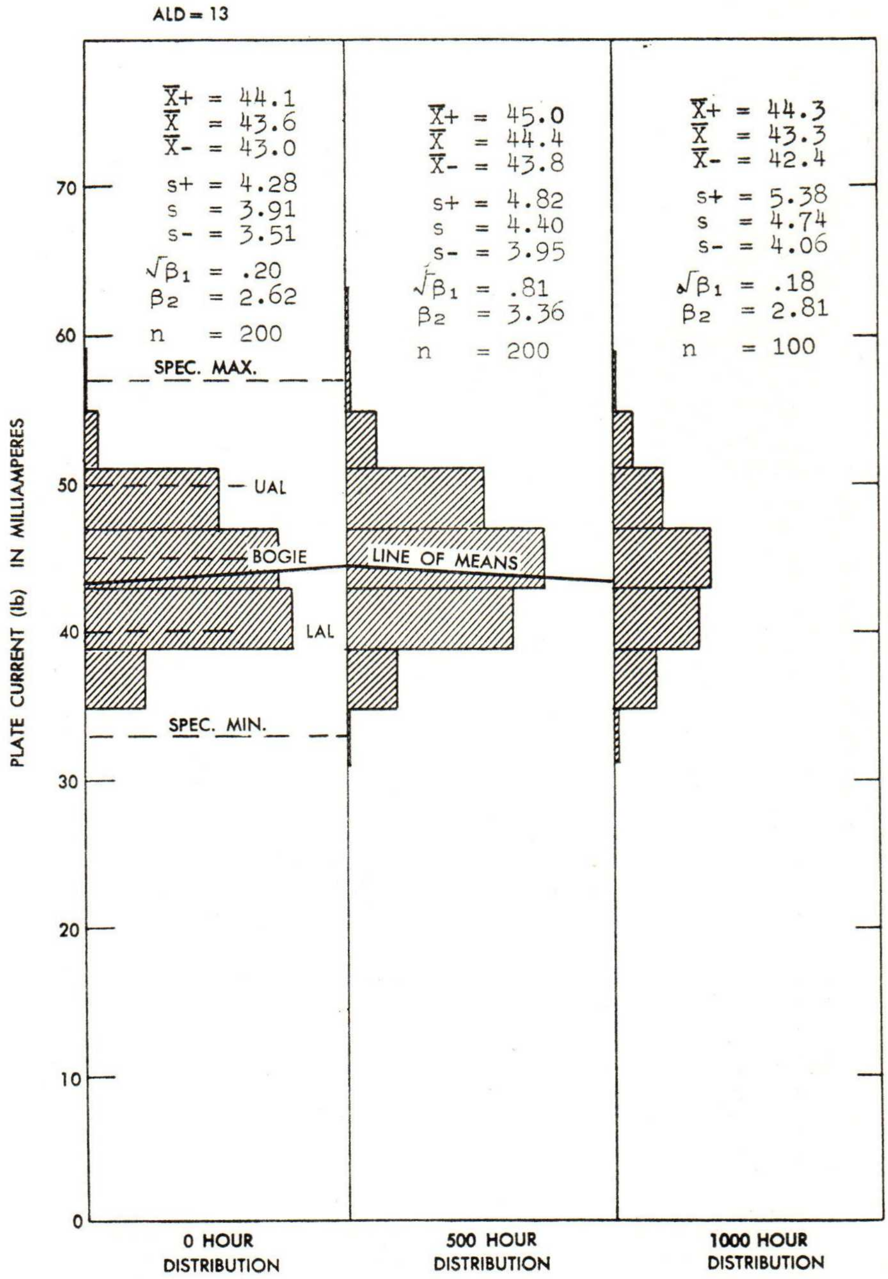


Figure 4-115. Distribution of Plate Current for JAN-6005/6AQ5W.

PROPERTY BEHAVIOR FOR JAN-6005/6AQ5W

The histograms and data for Power Output of JAN-6005/6AQ5W are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/13A dated 20 May 1953. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

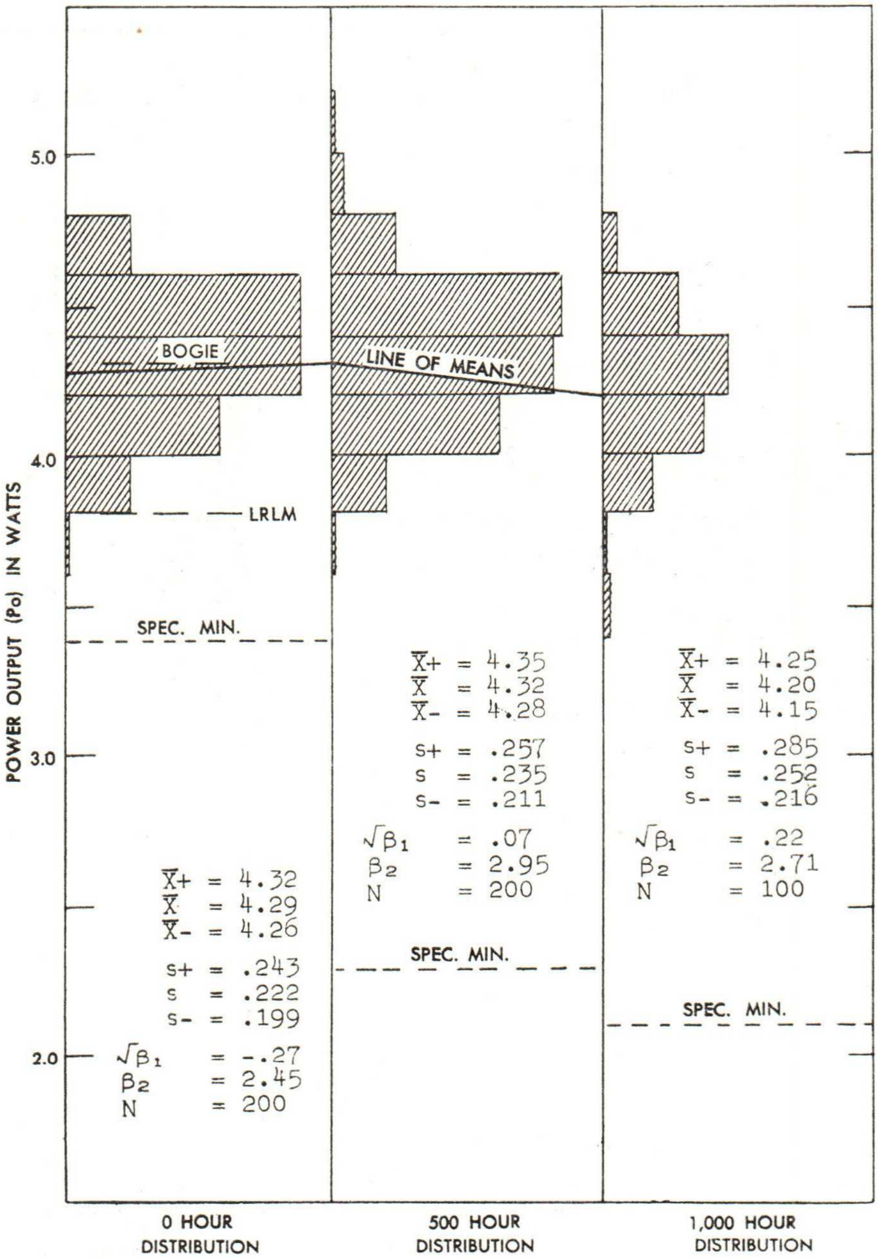


Figure 4-116. Distributions of Power Output for JAN-6005/6AQ5W.

TYPICAL THERMAL BEHAVIOR OF JAN–6005/6AQ5W

This data was withdrawn from a sizeable sample of tubes operating under MIL–E–1 test conditions in the absence of any tube shield. It shows that at elevated environmental temperatures it is possible to exceed the maximum rated bulb temperature in every case. Attention of the designer is directed to the term effective environmental temperature. The effective environment seen by an electron tube is difficult to define, particularly with the presence or absence of ventilation, air circulation, liquid cooling, and shielding devices. It must be noted, however, that for a given total dissipation within the tube, the bulb temperature under bare bulb conditions will give a good indication of the effective environment.

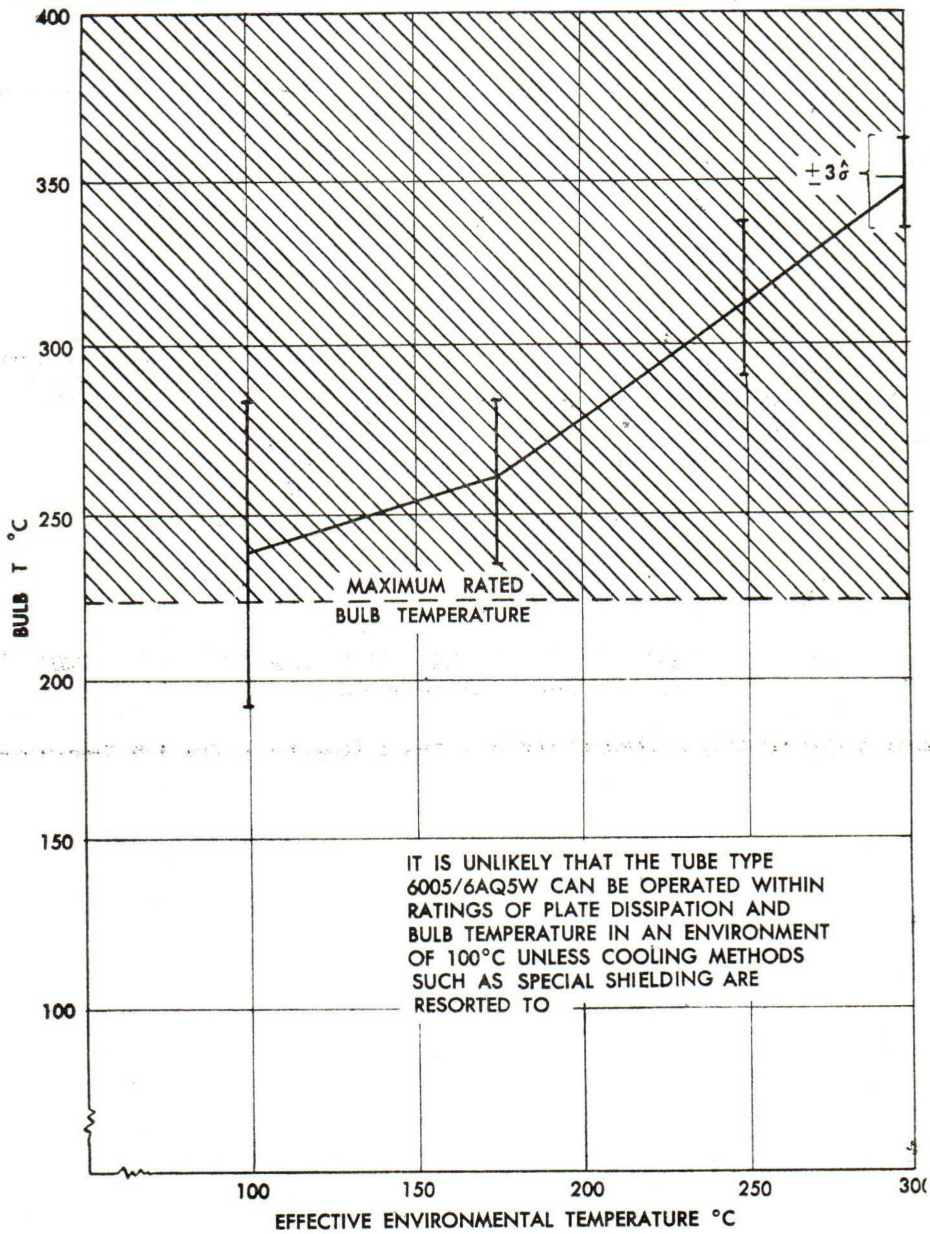


Figure 4-117. Typical Thermal Behavior for JAN-6005/6AQ5W.

TYPICAL RELIABILITY OF JAN-6005/6AQ5W IN GROUND EQUIPMENT AT TWO BULB TEMPERATURES

A field test of 24 JAN-6005/6AQ5W tubes in ground equipment in the circuit shown revealed that a considerable increases in lifetime as well as a change in the failure pattern was detected when cooling methods were used in 12 of the associated sockets.

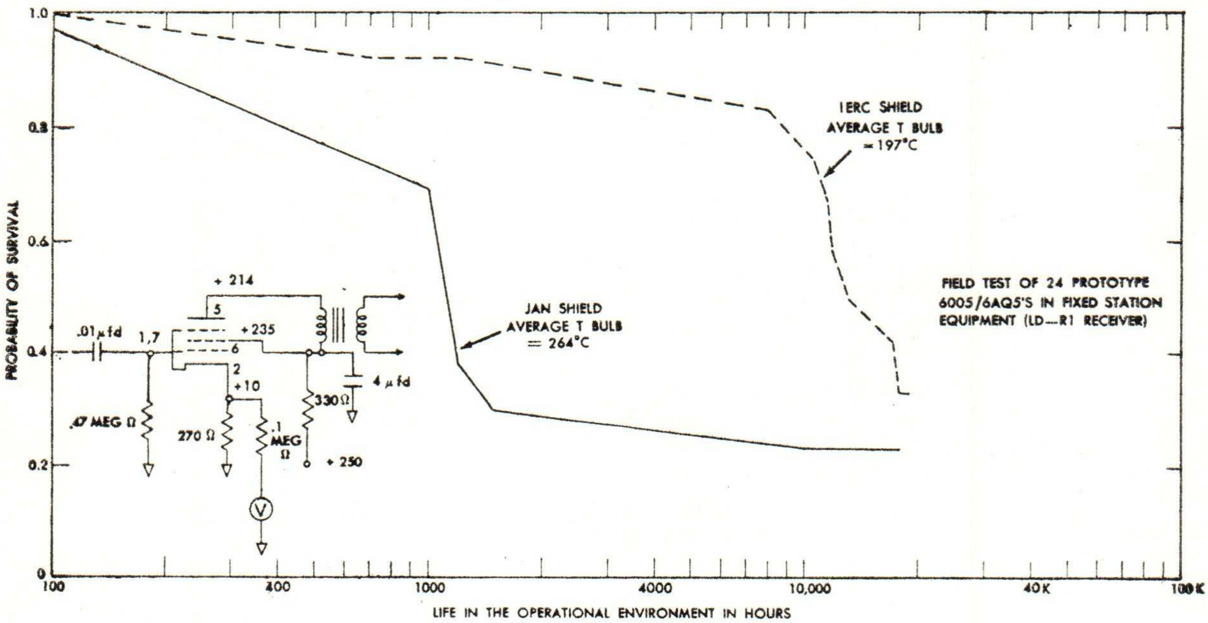


Figure 4-118. Typical Reliability of JAN-6005/6AQ5W in Ground Equipment at Two Bulb Temperatures

PROPER BEHAVIOR FOR JAN-6021

The histograms and data for Plate Current of JAN-6021 are based upon 797 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/188B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

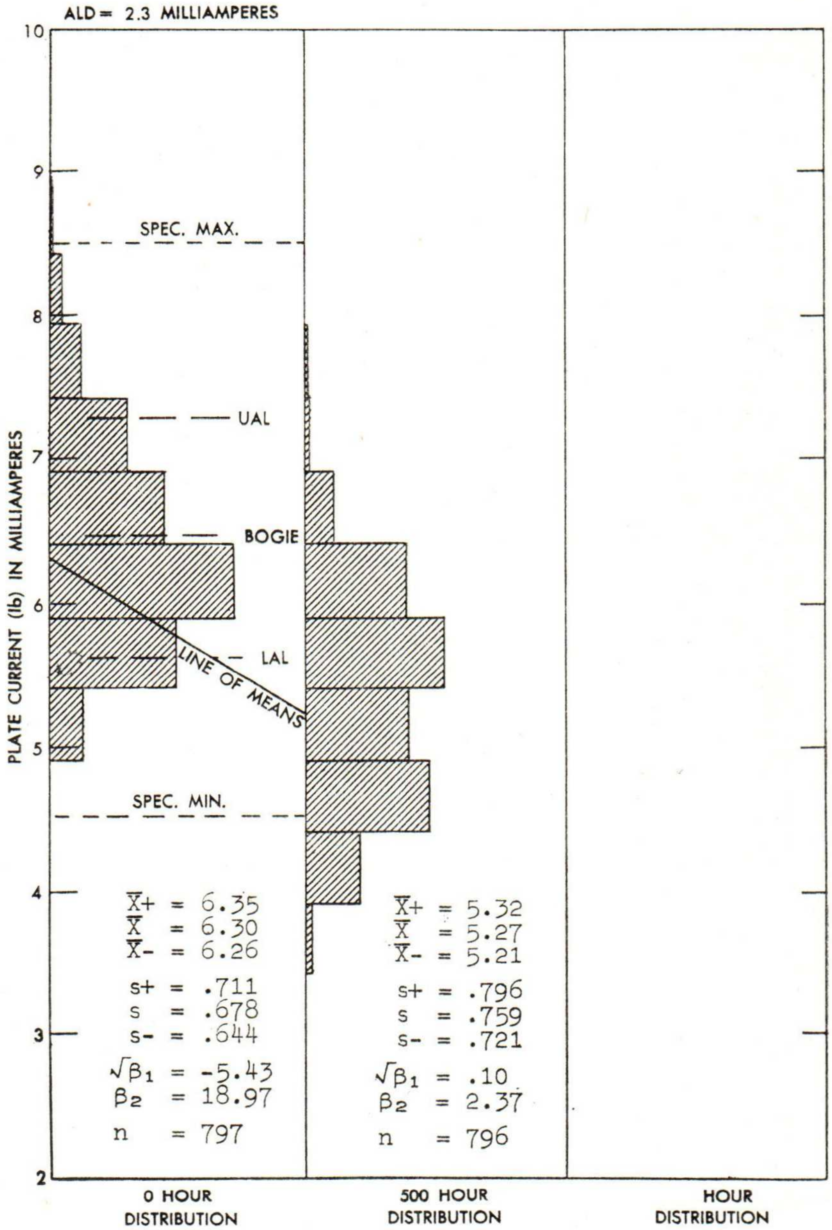


Figure 4-119. Distribution of Plate Current for JAN-6021.

PROPER BEHAVIOR FOR JAN-6021

The histograms and data for Transconductance of JAN-6021 are based upon 796 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/188B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

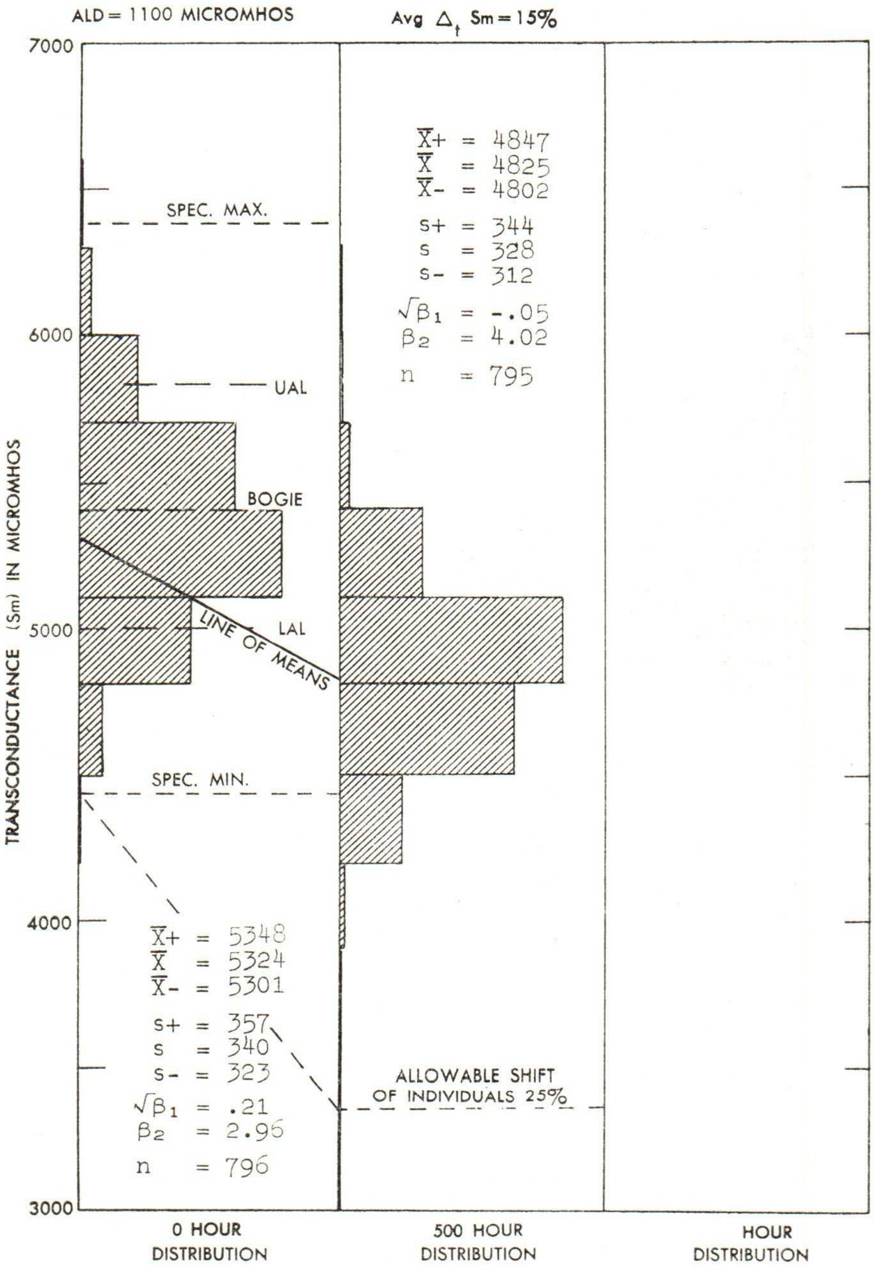


Figure 4-120. Distribution of Transconductance for JAN-6021.

PROPER BEHAVIOR FOR JAN-6021

The histograms and data for Reduced Ef Transconductance of JAN-6021 are based upon 796 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/188B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

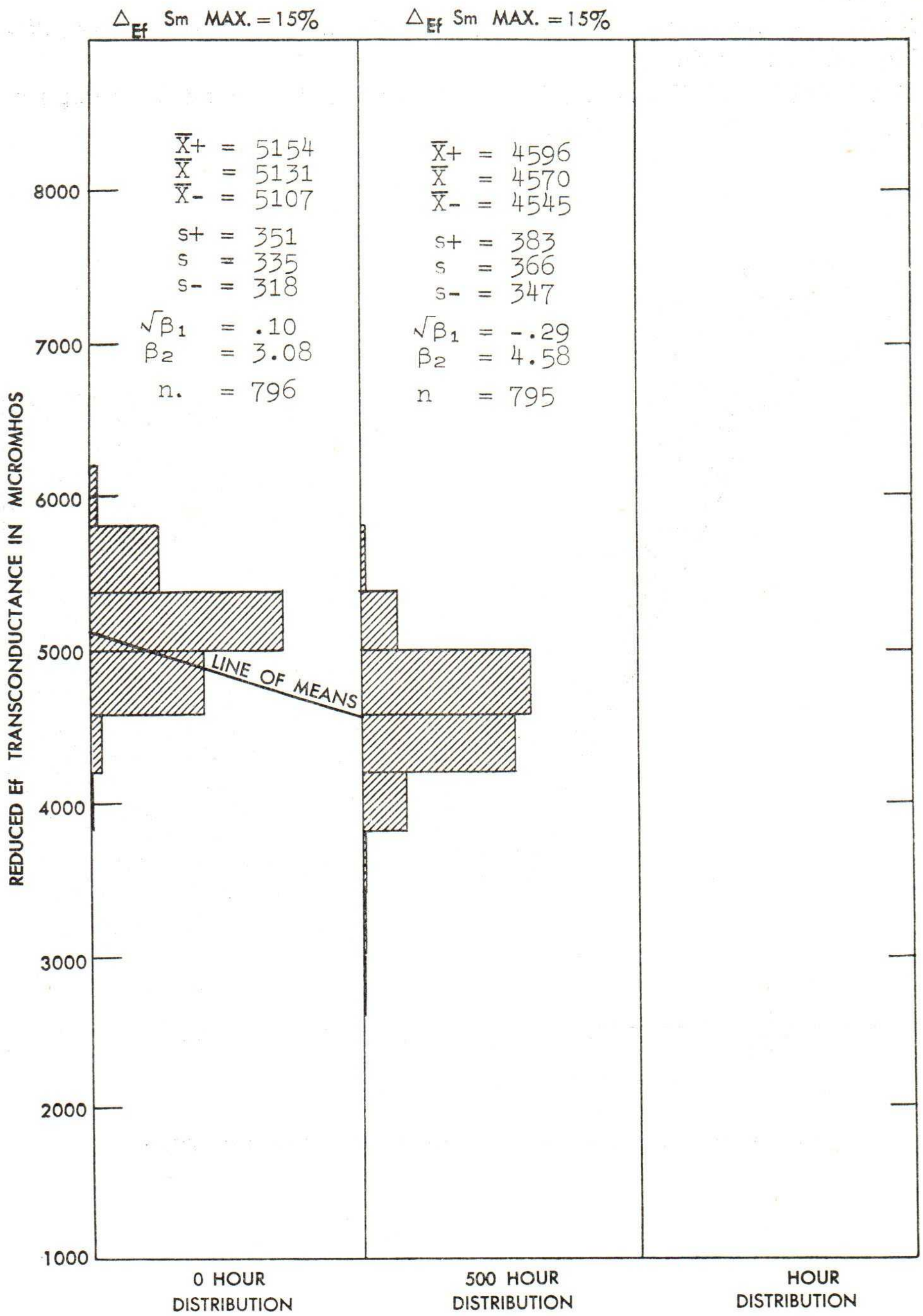


Figure 4-121. Distribution of Reduced Ef Transconductance for JAN-6021.

This figure presents the inoperative probability of survival under MIL-E-1 specification life test conditions for tube type JAN-6021 during the production year 1956. This figure is derived from data supplied by two manufacturers, 1640 tubes with 18 failures occurring prior to 500 hour test point.

No field evidence is available to support the apparent infant mortality evidenced in these data.

The definition of "Inoperative" coincides with that found in the appropriate paragraphs of MIL-E-1.

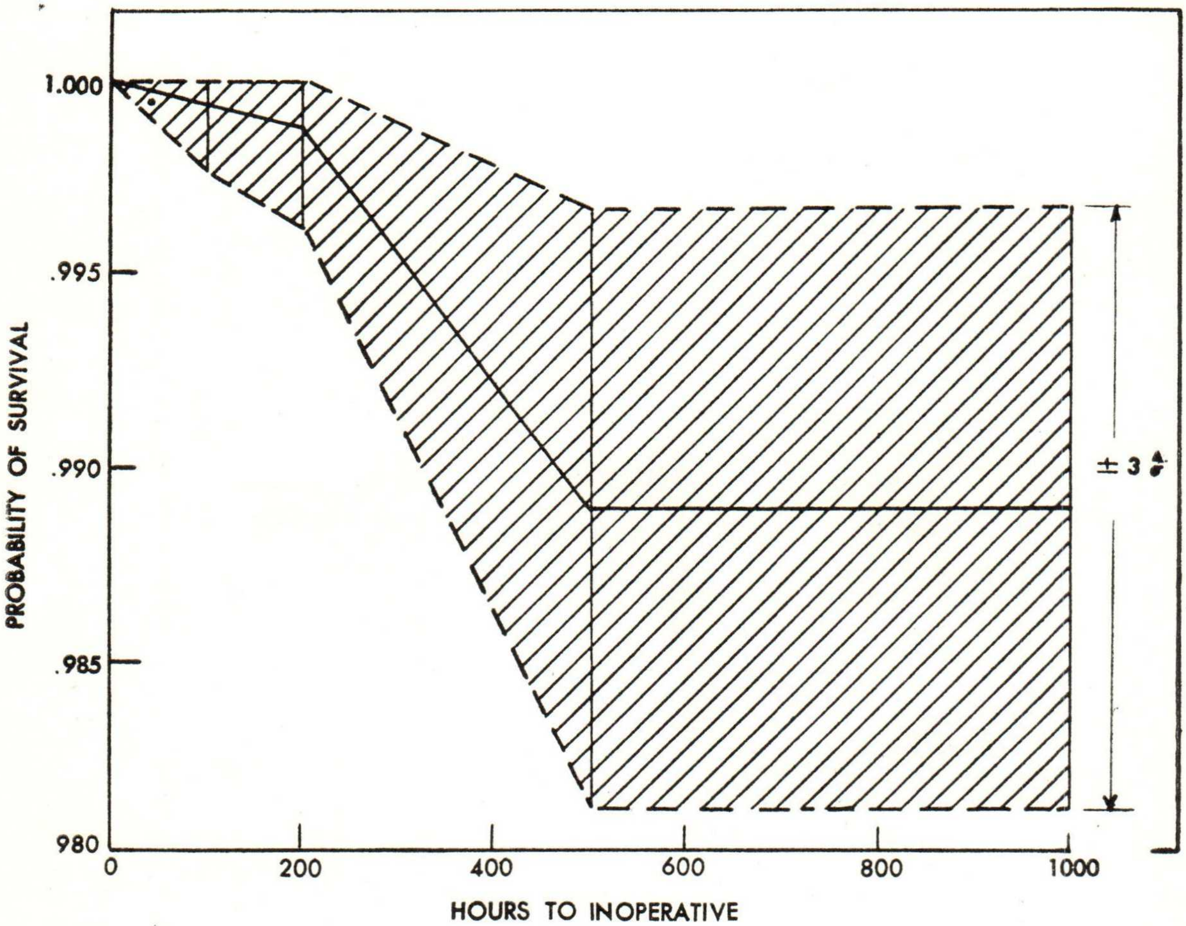


Figure 4-122. Probability of Survival for JAN-6021 Under MIL-E-1 Conditions.

PROPERTY BEHAVIOR FOR JAN-6080WA

The histograms and data for Transconductance of JAN-6080WA are based upon 400 tubes life-tested by two manufacturers of the type during the year 1956. The specification limits shown are taken from MIL-E-1/510B dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

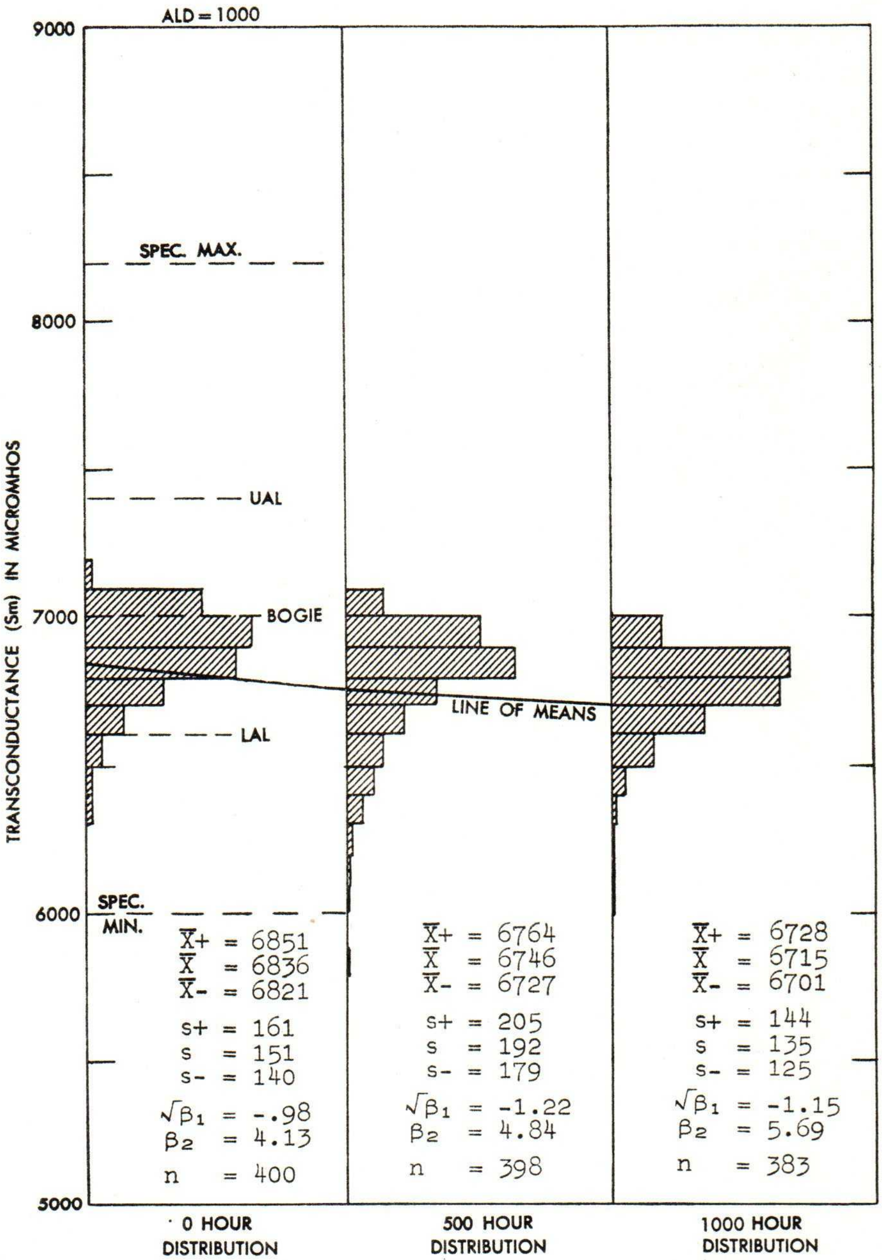


Figure 4-123. Distribution of Transconductance for JAN-6080WA.

PROPERTY BEHAVIOR FOR JAN-6080WA

The histograms and data for Reduced Ef Transconductance of JAN-6080WA are based upon 479 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/510B dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

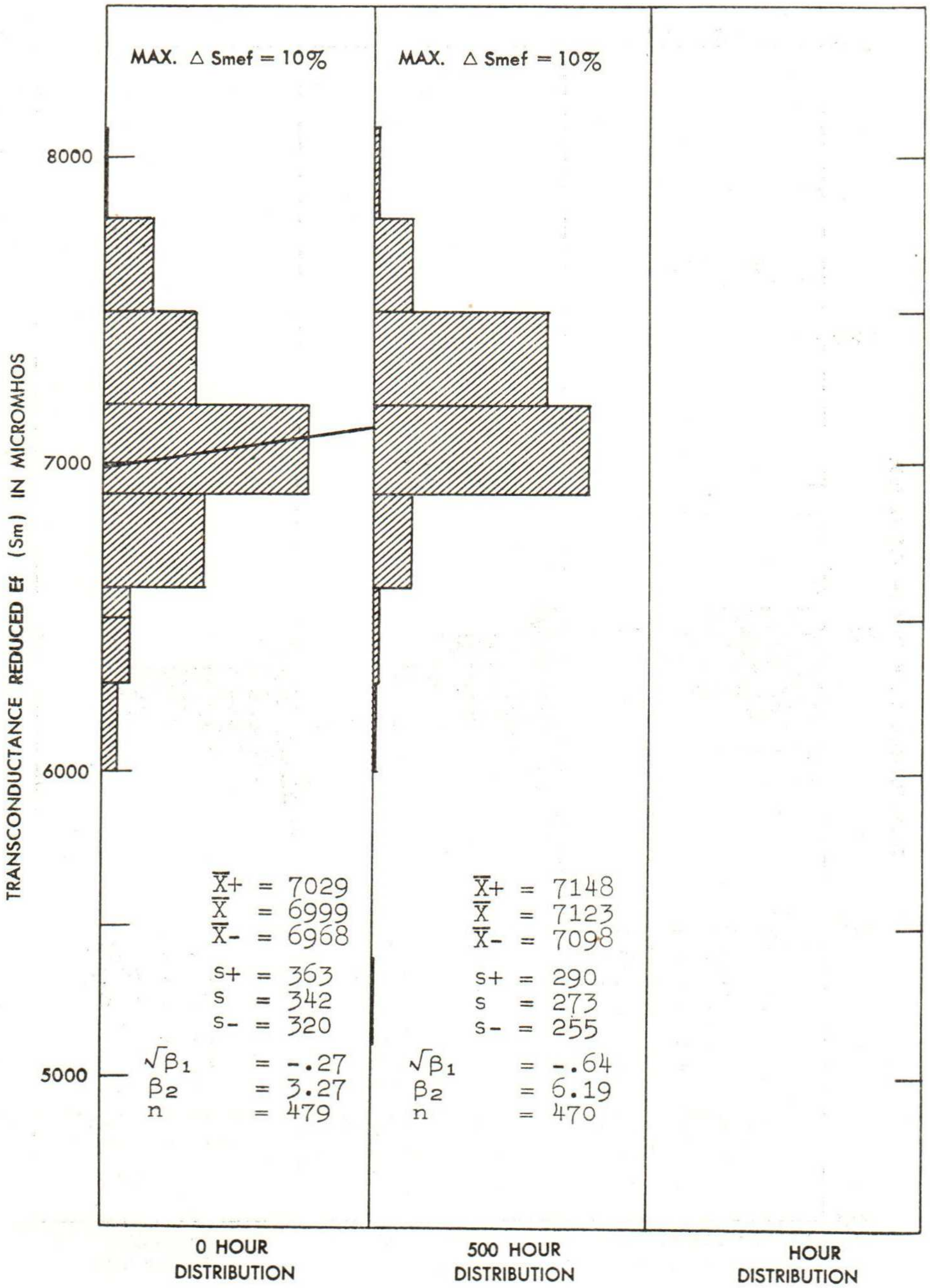


Figure 4-124. Distribution of Reduced Ef Transconductance for JAN-6080WA.

ZERO HOUR AMPLIFICATION FACTOR OF THE JAN-6080WA

This data has been withdrawn from information furnished by one manufacturer of the type.

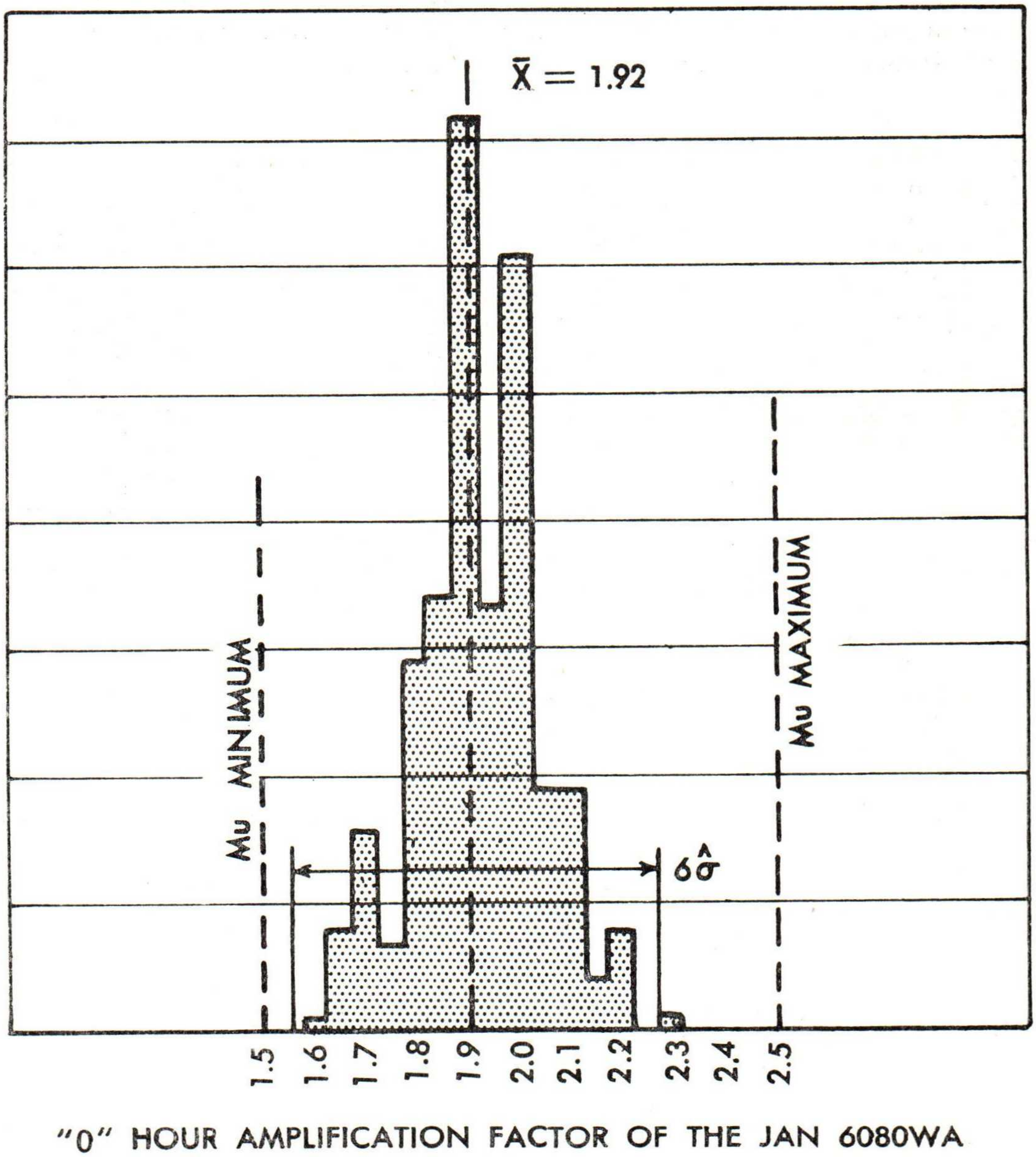


Figure 4-125. Zero Hour Amplification Factor of the JAN-6080WA.

TYPICAL THERMAL BEHAVIOR OF JAN-6080WA

This figure represents data from a sample of three tubes tested under rated heater voltage with plate dissipation varying as shown. The lines describing the behavior are the regression line and tolerance limits obtained by the techniques described in Part II.

It is apparent from the figure that in order to operate JAN-6080WA within bulb temperature ratings while at or near maximum rated plate dissipation, drastic cooling techniques are required.

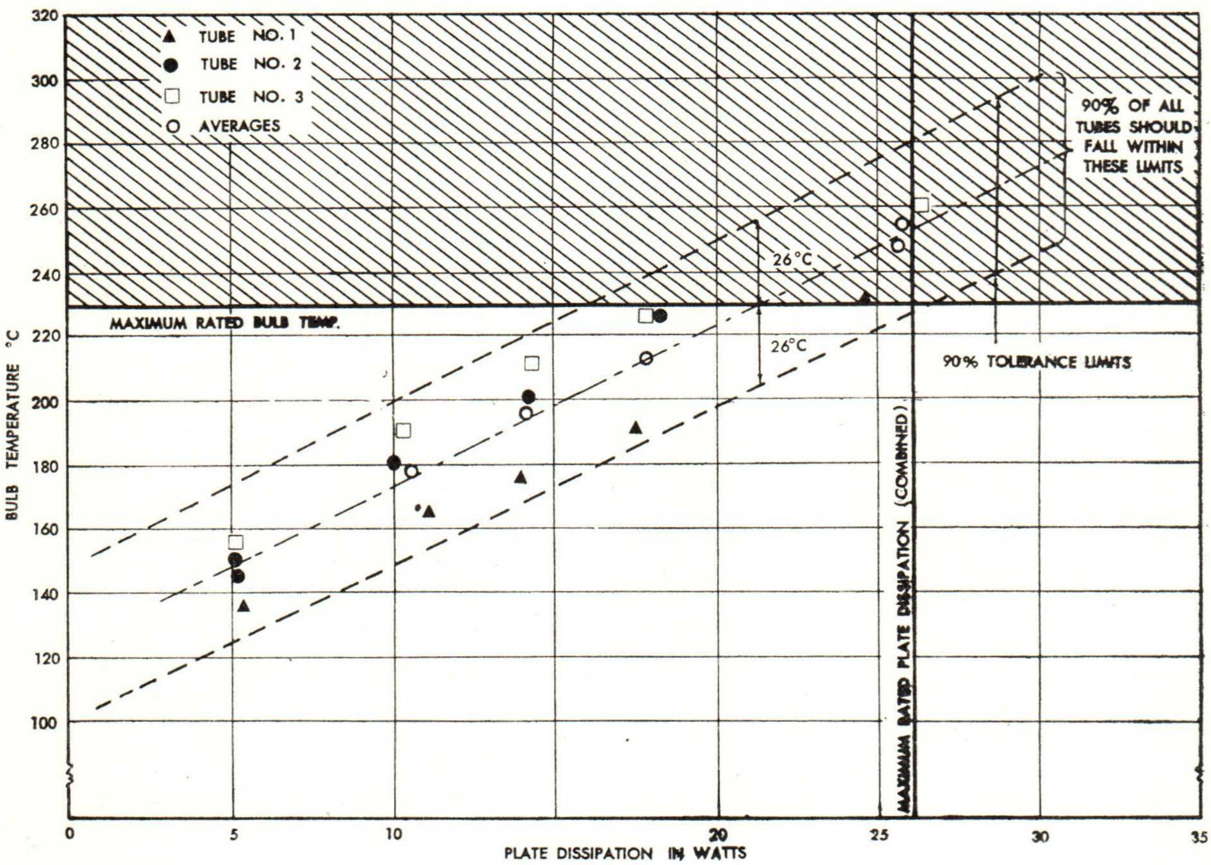


Figure 4-126. Typical Thermal Behavior of JAN-6080WA.

PROPERTY BEHAVIOR FOR JAN-6088

The histograms and data for Plate Current of JAN-6088 are based upon 55 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/694 dated 3 May 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

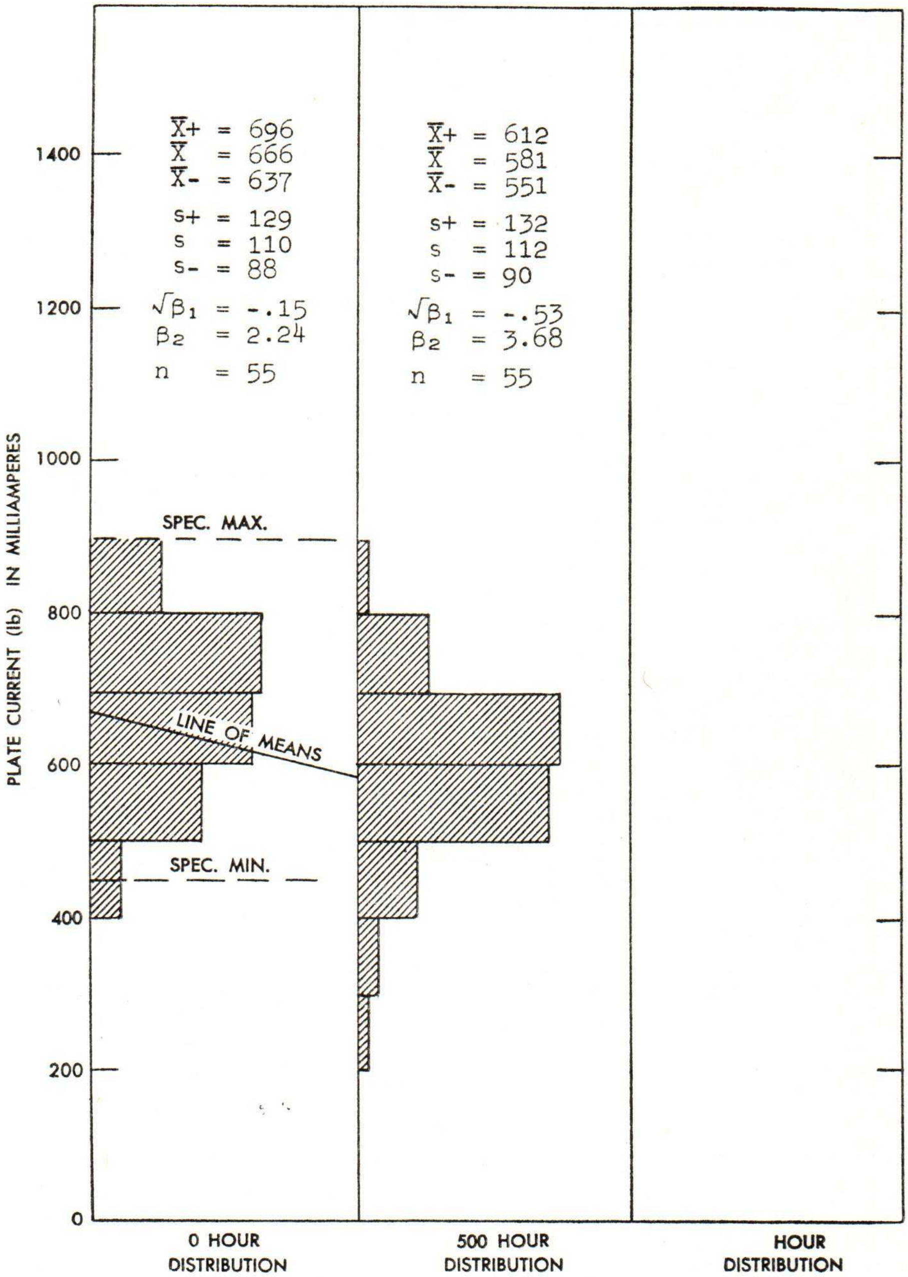


Figure 4-127. Distribution of Plate Current for JAN-6088.

PROPERTY BEHAVIOR FOR JAN-6088

The histograms and data for Screen Grid Current of JAN-6088 are based upon 55 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/694 dated 3 May 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

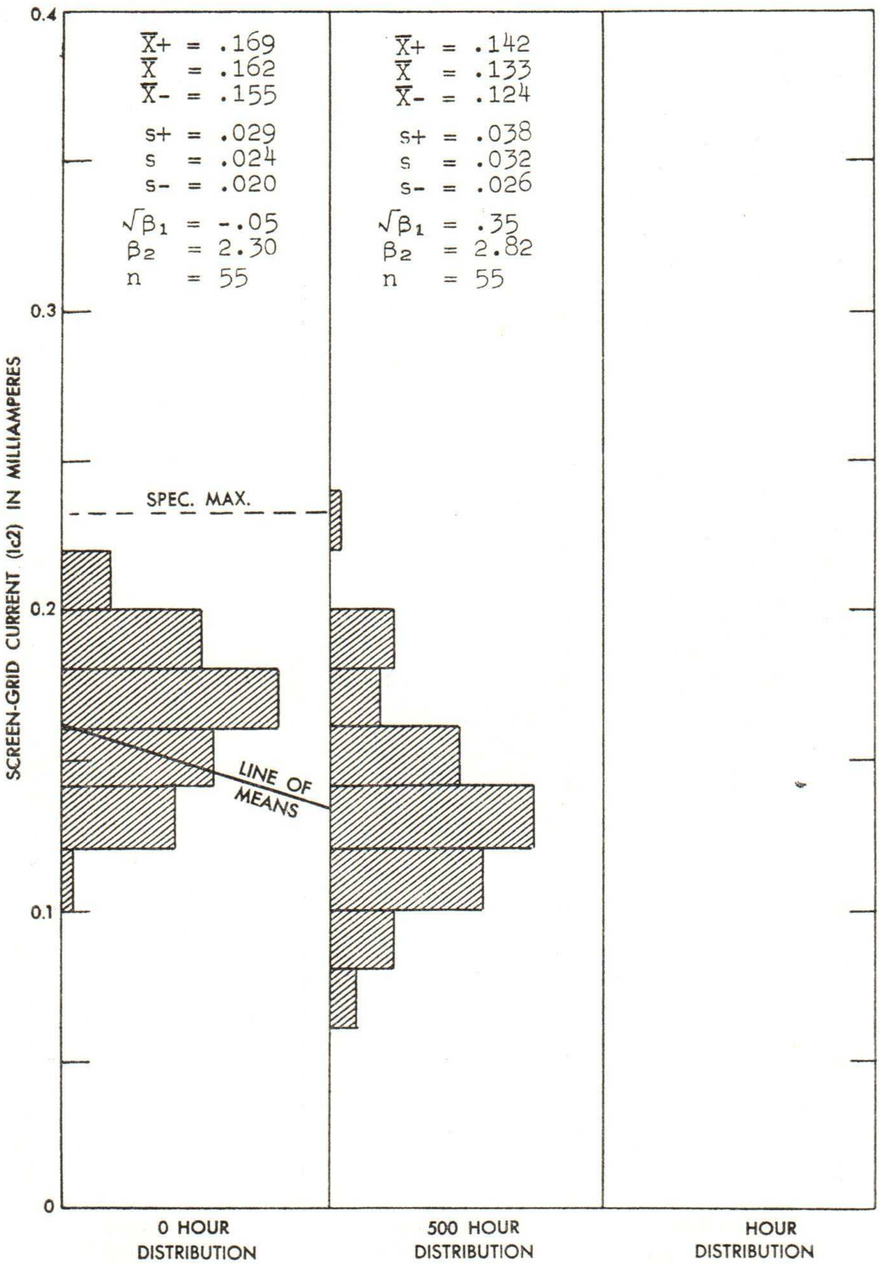


Figure 4-128. Distribution of Screen Grid Current for JAN-6088.

PROPERTY BEHAVIOR FOR JAN-6088

The histograms and data for Transconductance of JAN-6088 are based upon 55 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/694 dated 3 May 1954. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

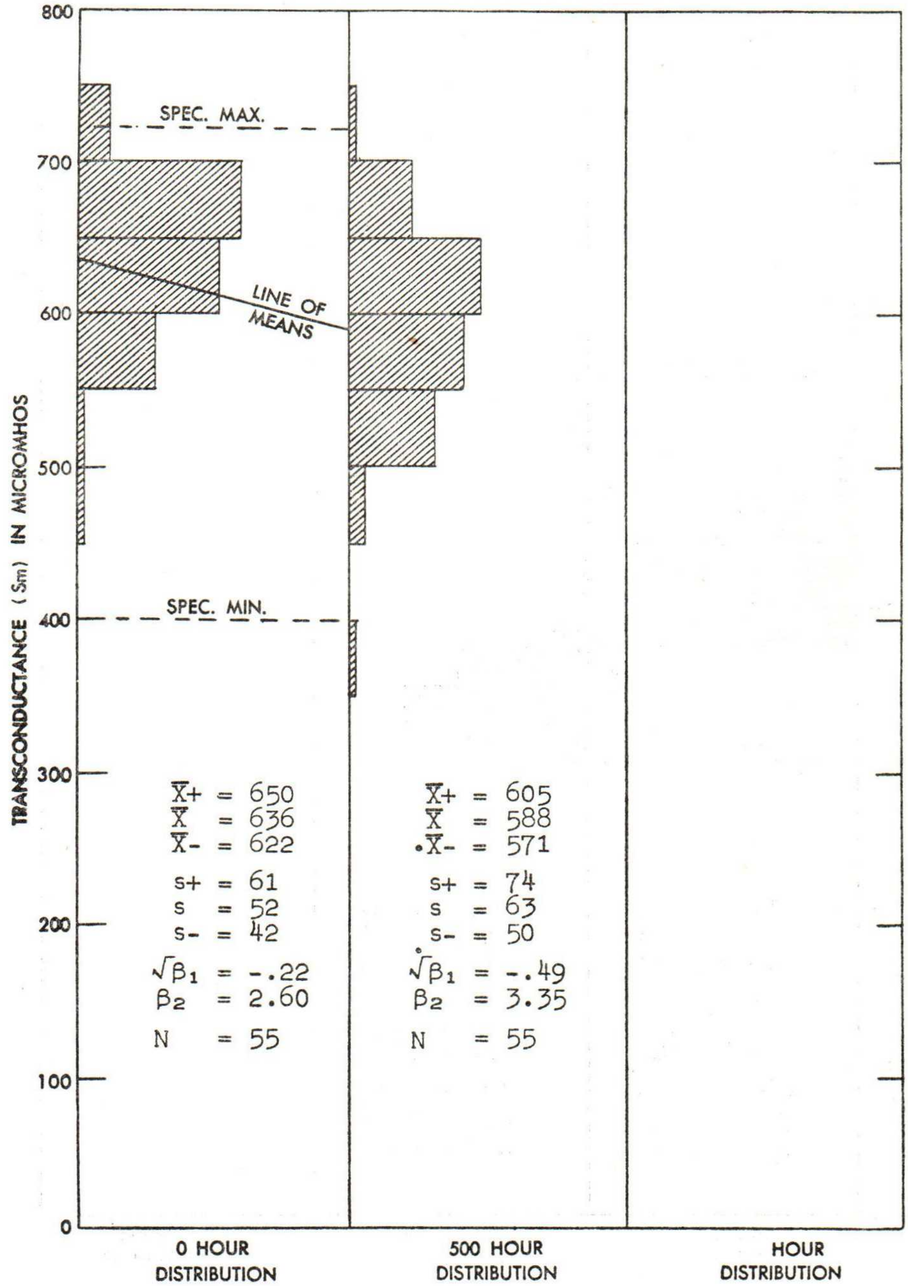


Figure 4-129. Distribution of Transconductance for JAN-6088.

PROPERTY BEHAVIOR FOR JAN–6111

The histograms and data for Plate Current of JAN–6111 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/189B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

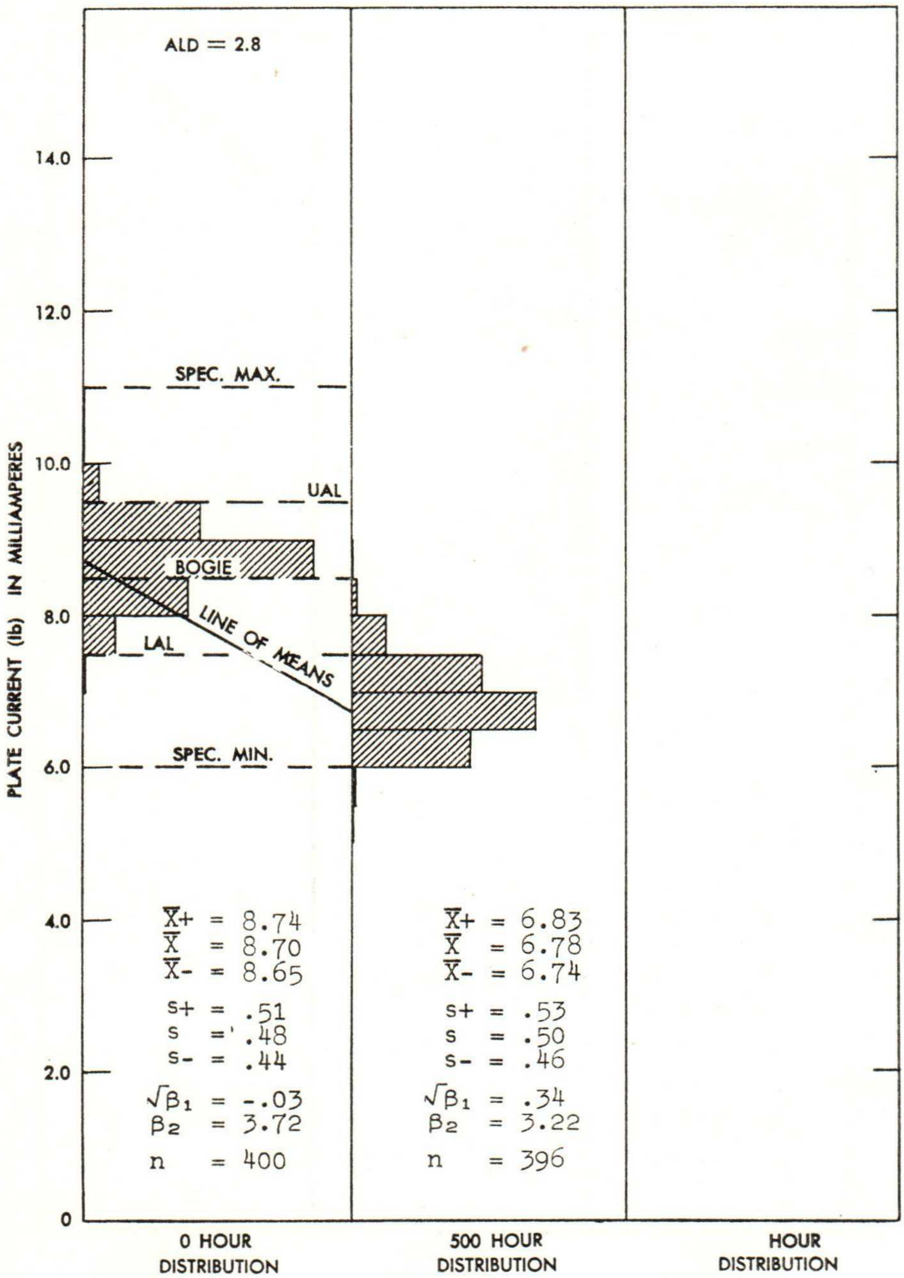


Figure 4-130. Distribution of Plate Current for JAN-6111.

PROPERTY BEHAVIOR FOR JAN-6111

The histograms and data for Transconductance of JAN-6111 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/189B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

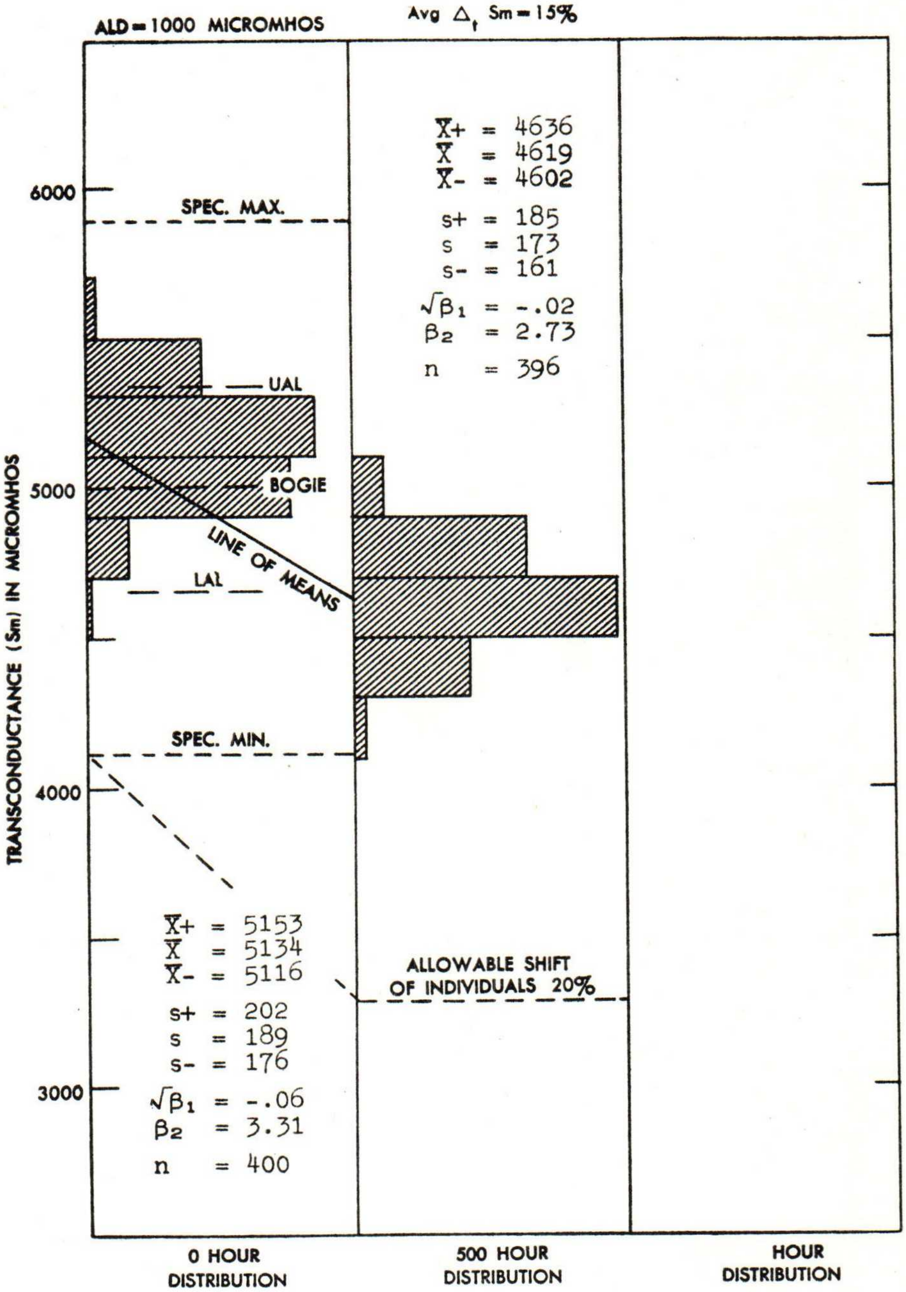


Figure 4-131. Distribution of Transconductance for JAN-6111.

PROPERTY BEHAVIOR FOR JAN-6111

The histograms and data for Reduced Ef Transconductance of JAN-6111 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/189B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

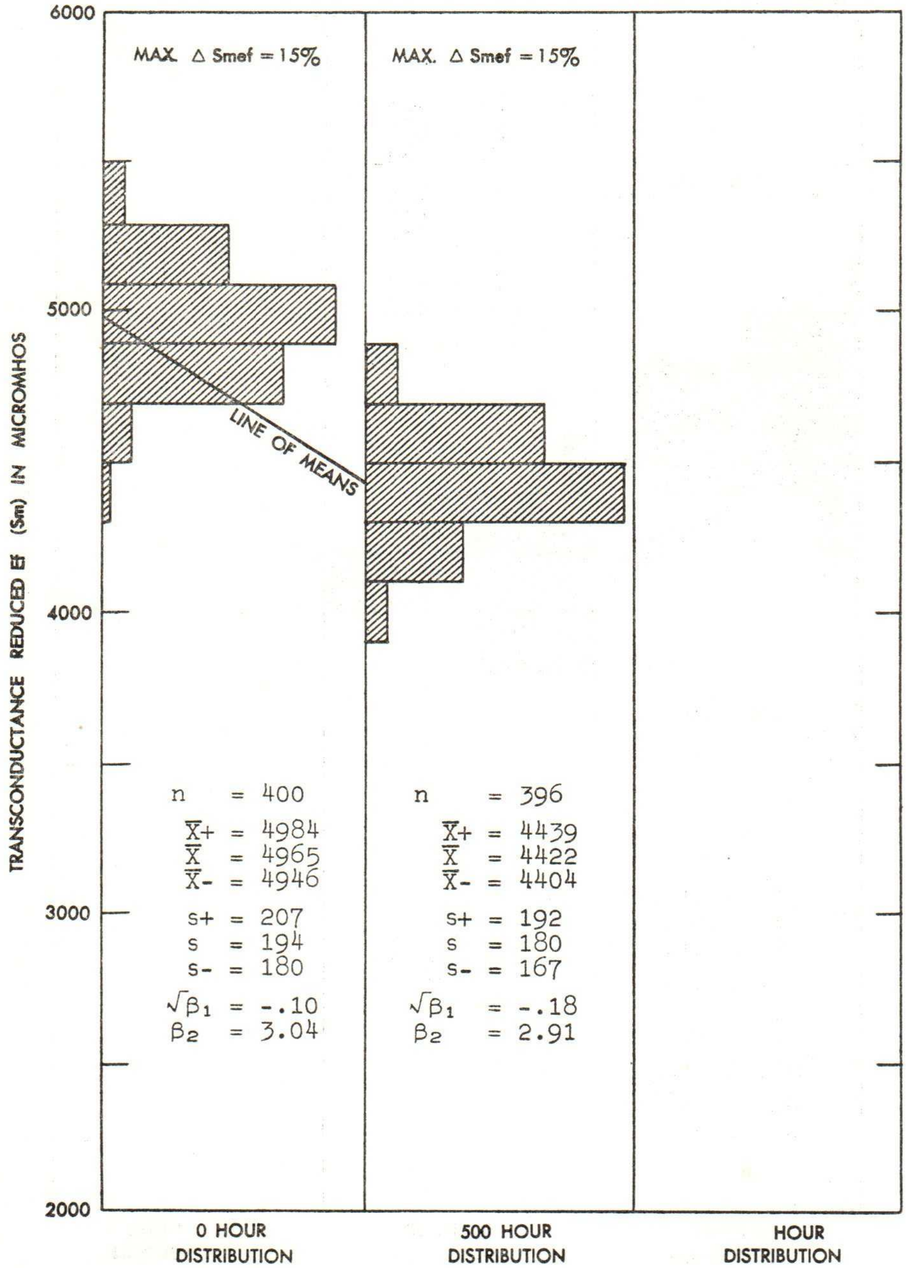


Figure 4-132. Distribution of Reduced Ef Transconductance for JAN-6111.

PROPERTY BEHAVIOR FOR JAN-6111

The histograms and data for Emission of JAN-6111 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/189B dated 23 August 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

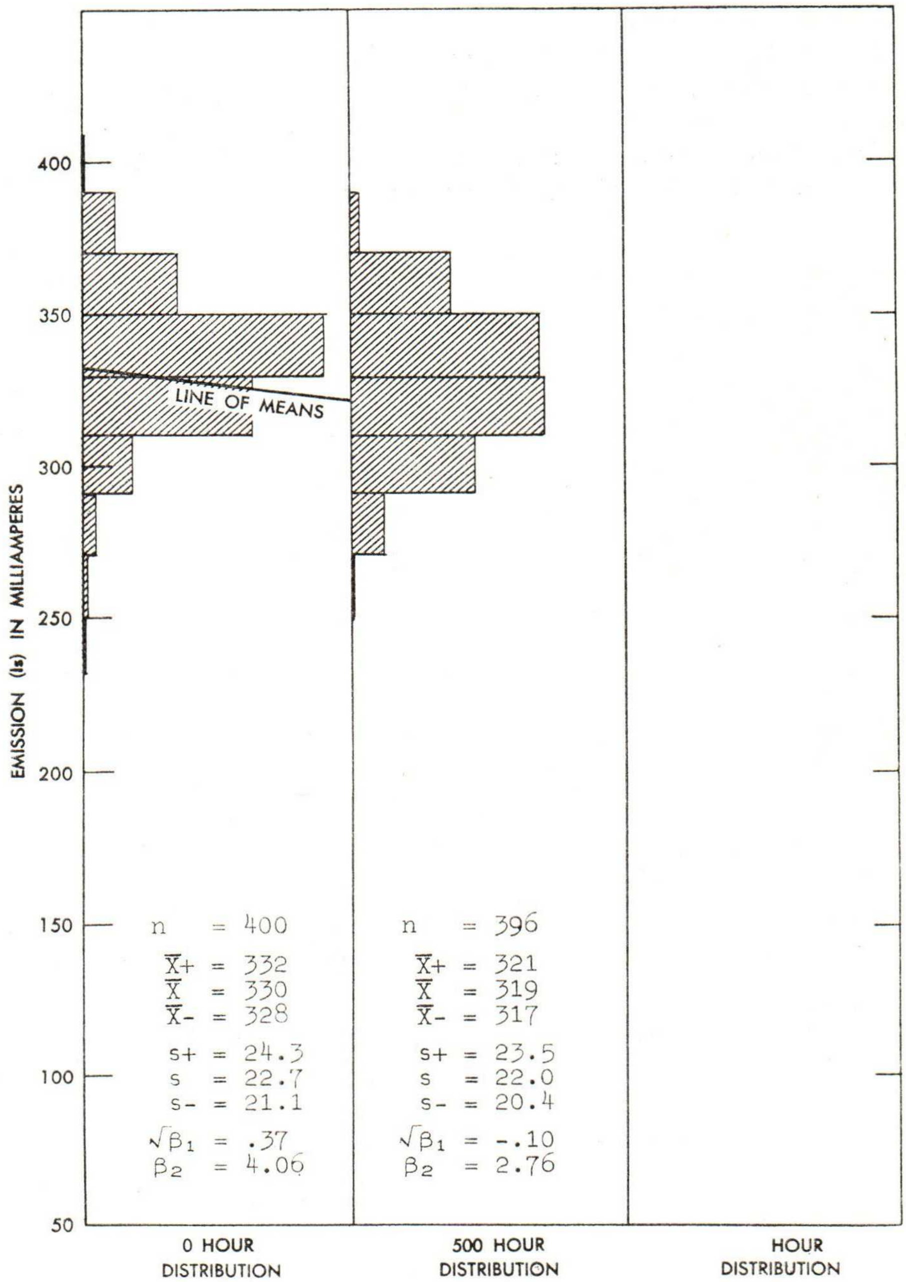


Figure 4-133. Distribution of Emission for JAN-6111.

TYPICAL THERMAL BEHAVIOR FOR JAN-6111

These typical curves have been obtained by experimental procedures performed on a small sample of JAN-6111 tubes. The specification ratings delineating a recommended or safe area of operation are shown. The effective environmental temperature was carefully determined for this particular experiment but there is considerable room for interpretation on an individual application basis.

Study of the chart should point out the fallacy of attempting operation beyond specification ratings by external reduction of the effective environmental temperature. This fallacy obtains because the plate temperature will most likely exceed the value which has been determined by the manufacturer as "safe" for this particular tube type.

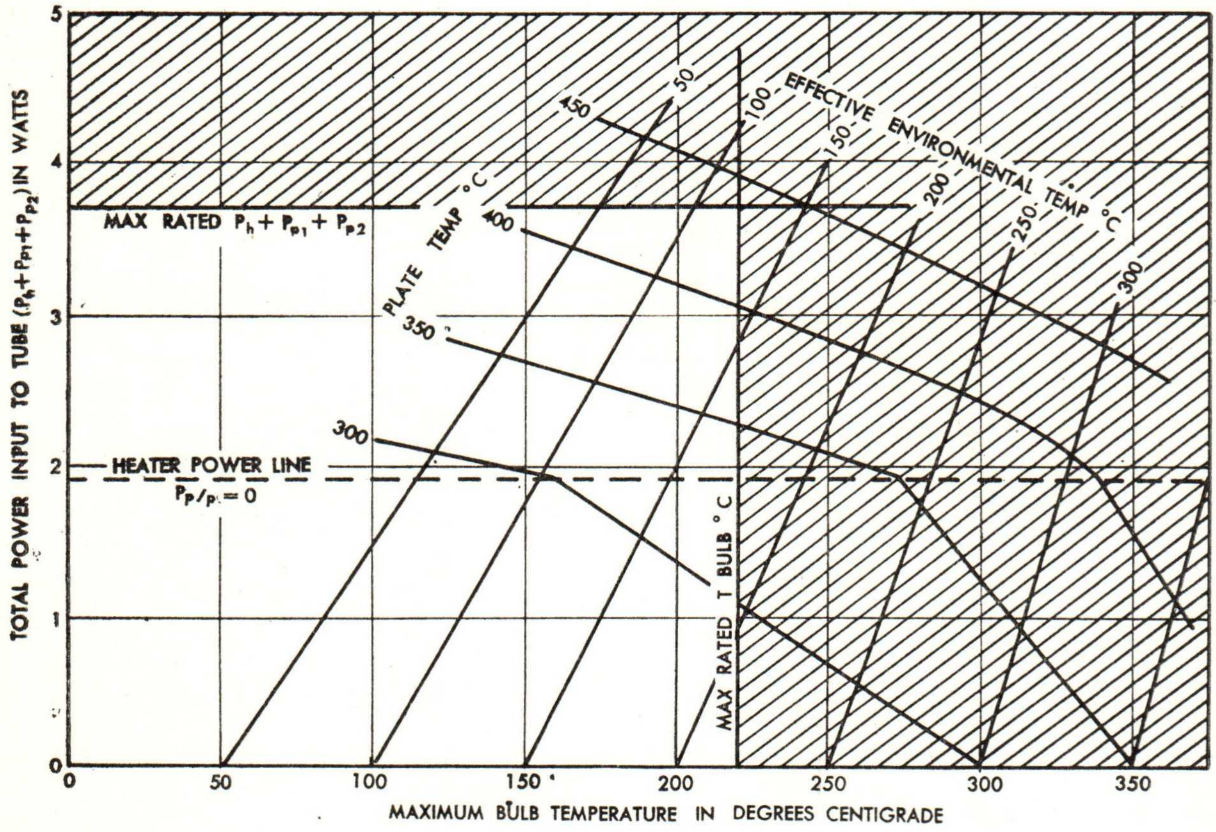


Figure 4-134. Typical Thermal Behavior for JAN-6111.

PROPERTY BEHAVIOR FOR JAN–6112

The histograms and data for Plate Current of JAN–6112 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL–E–1/190C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

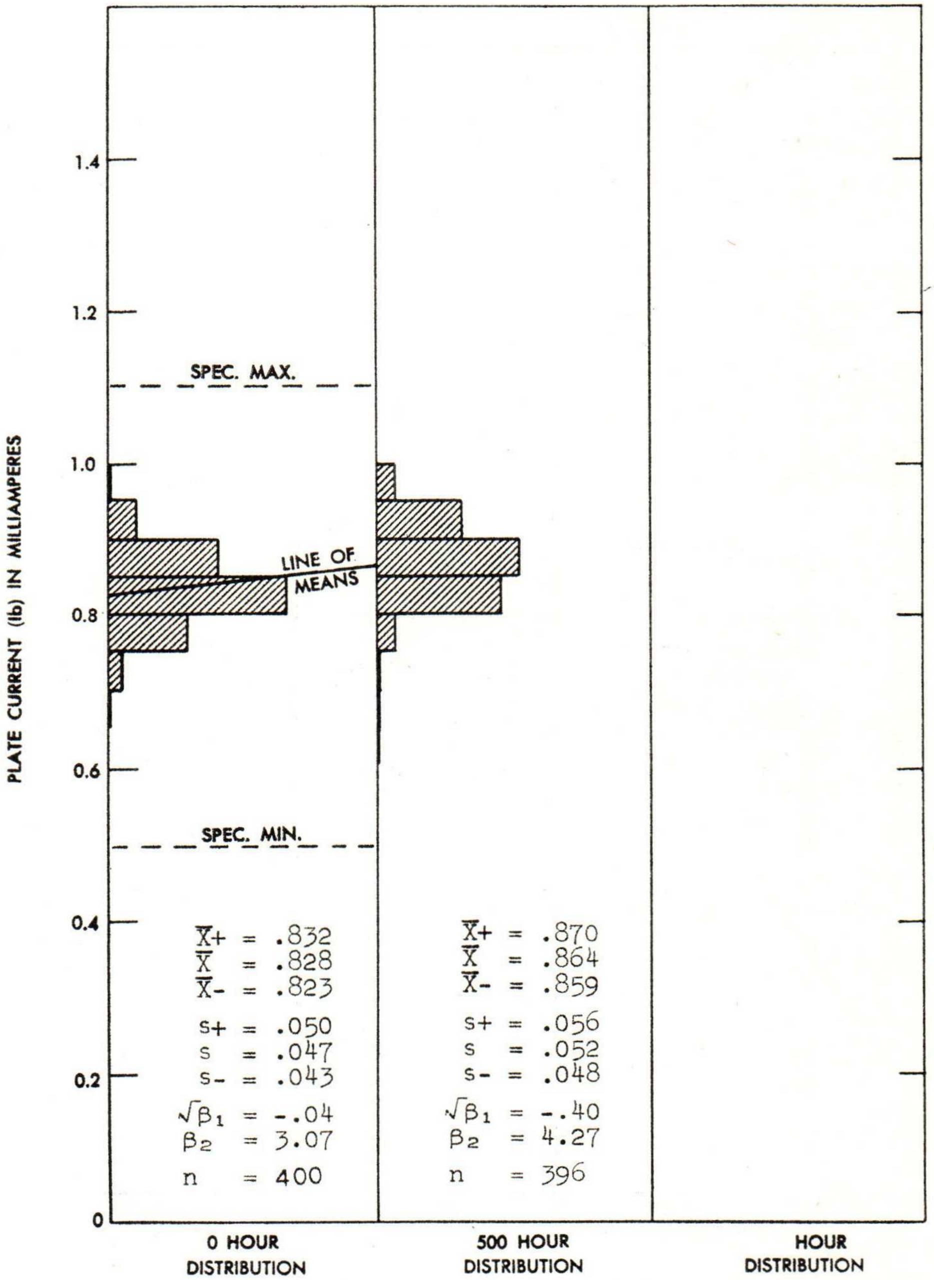


Figure 4-135. Distribution of Plate Current for JAN-6112.

PROPERTY BEHAVIOR FOR JAN-6112

The histograms and data for Transconductance of JAN-6112 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/190C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

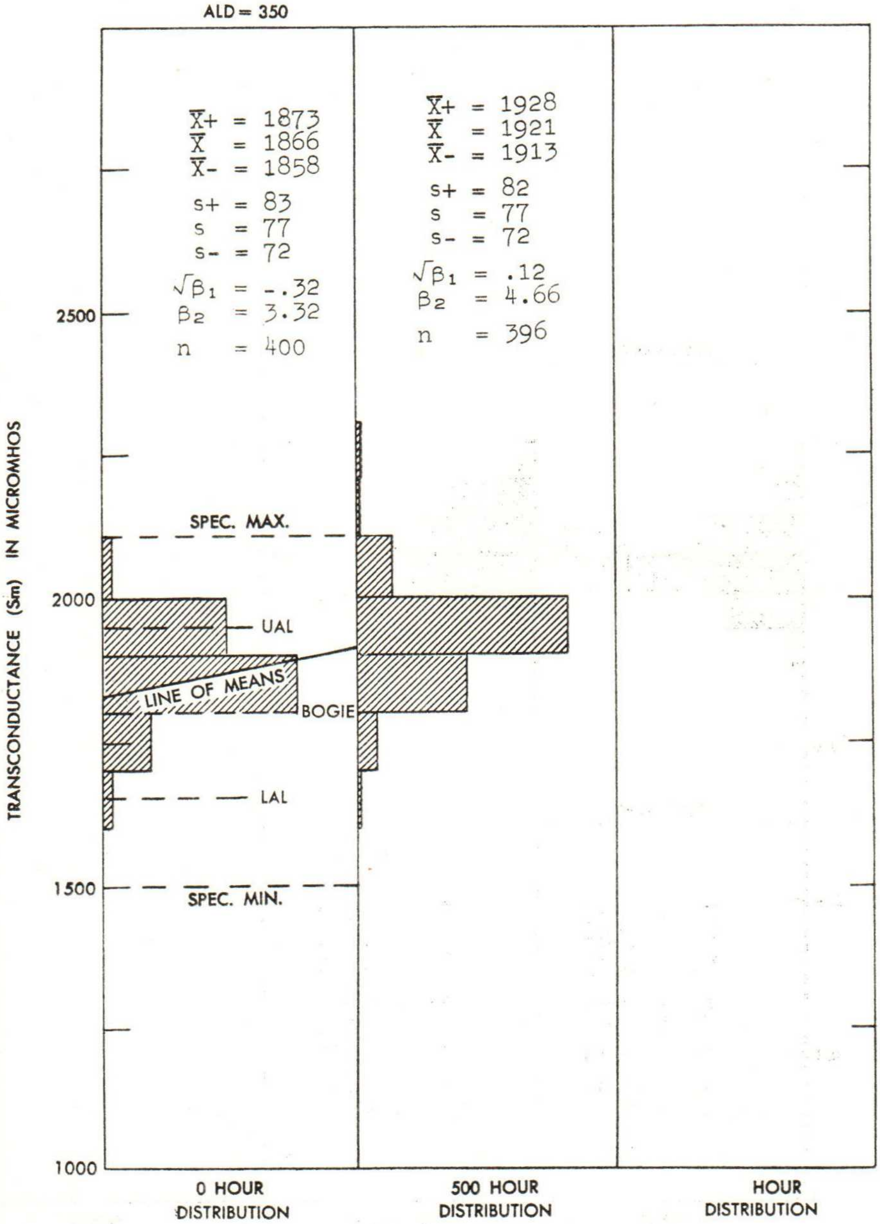


Figure 4-136. Distribution of Transconductance for JAN-6112.

PROPERTY BEHAVIOR FOR JAN-6112

The histograms and data for Reduced Ef Transconductance of JAN-6112 are based upon 400 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/190C dated 14 May 1956. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

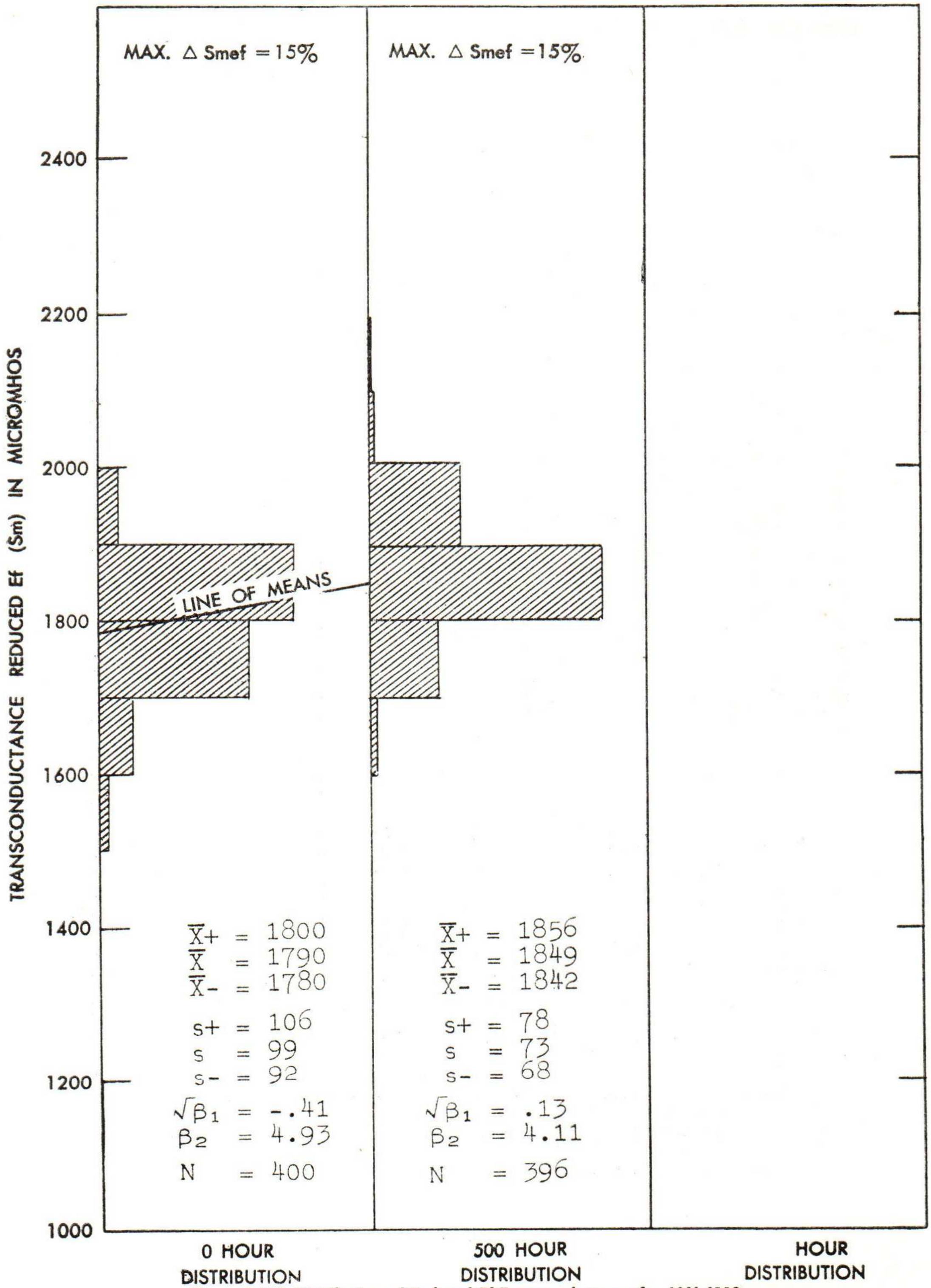


Figure 4-137. Distribution of Reduced Ef Transconductance for JAN-6112.

PROPERTY BEHAVIOR FOR JAN-6533

This histograms and data for Plate Current of JAN-6533 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/975 dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

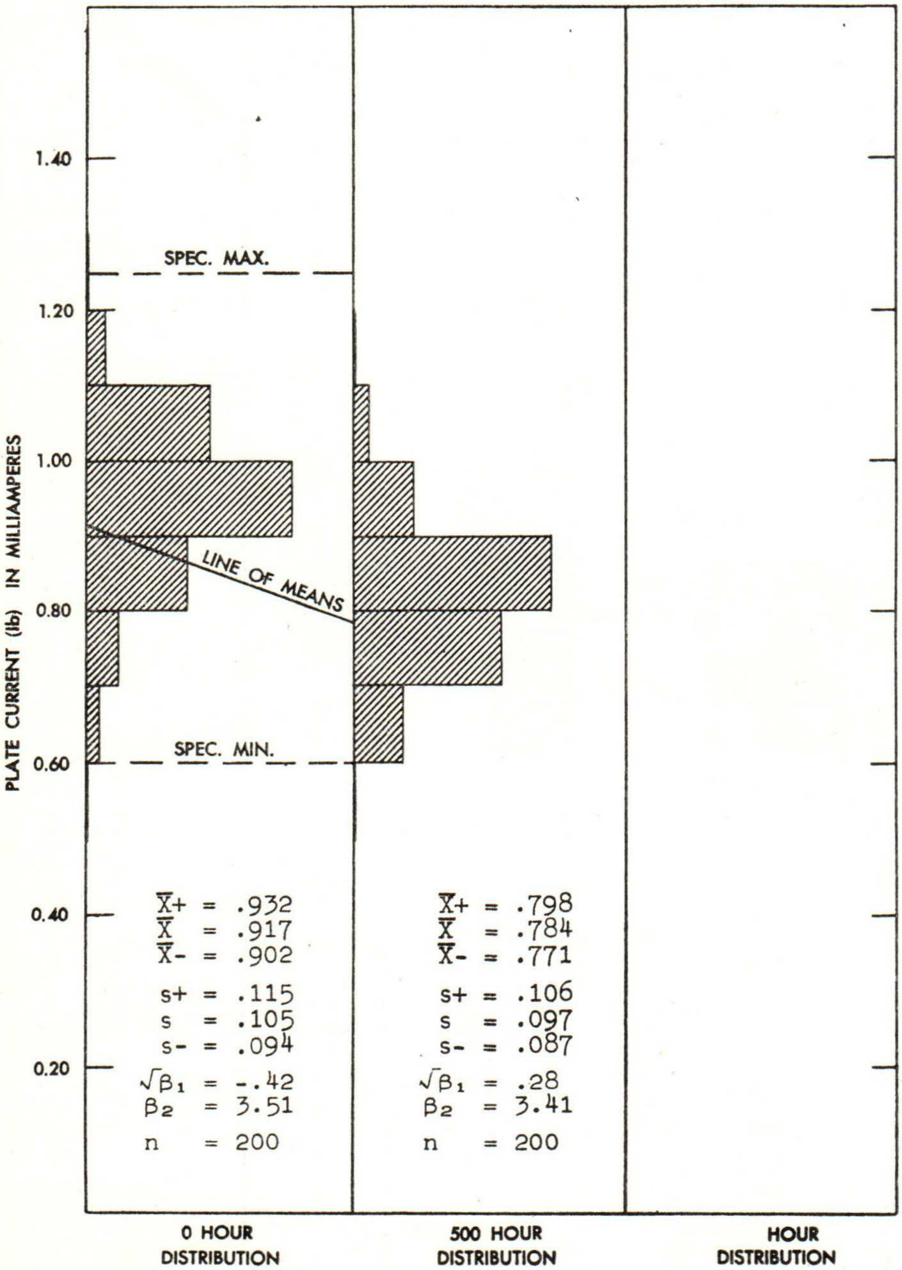


Figure 4-138. Distribution of Plate Current for JAN-6533.

PROPERTY BEHAVIOR FOR JAN-6533

The histograms and data for Transconductance of JAN-6533 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/975 dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

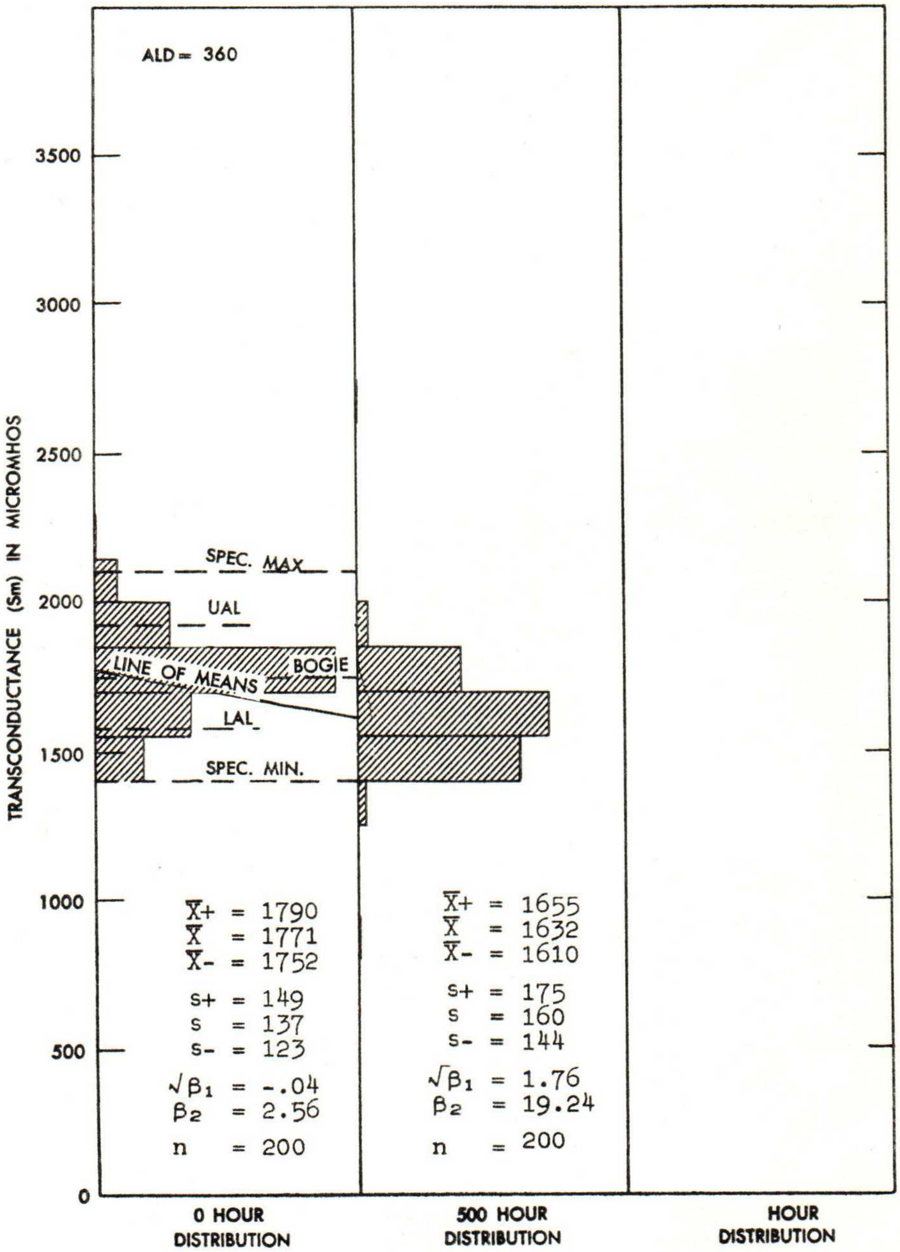


Figure 4-139. Distribution of Transconductance for JAN-6533.

PROPERTY BEHAVIOR FOR JAN-6533

The histograms and data for Reduced Ef Transconductance of JAN-6533 are based upon 200 tubes life-tested by one manufacturer of the type during the year 1956. The specification limits shown are taken from MIL-E-1/975 dated 5 December 1955. Only data from lots accepted by the specification is used. Each distribution curve includes data from all tubes still operative at the time associated with that curve.

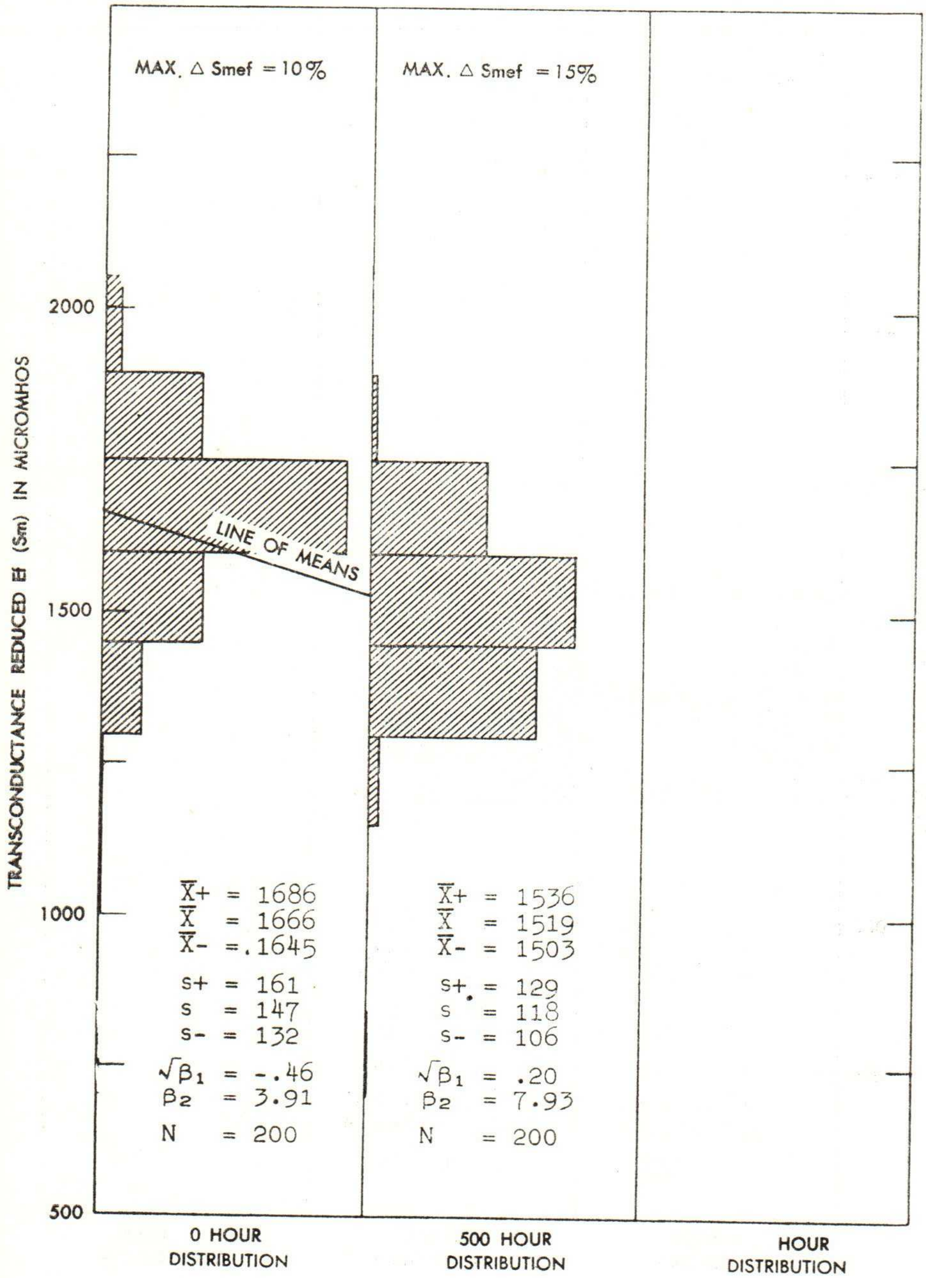


Figure 4-140. Distribution of Reduced Ef Transconductance for JAN-6533.

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