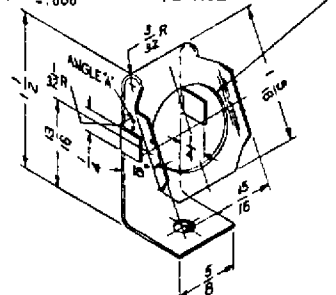




90° - ANGLE 'A' FOR LARGE TERMINAL
60° - " " " " SMALL "

.576^{+.005}_{-.000} HOLE FOR SMALL TERMINAL
.810^{+.007}_{-.000} " " " LARGE "



MATERIAL.
#25 B&S GA(.018) PHOSPHOR-BRONZE
SPRING TEMPER.

FIG. 4

CLASSIFICATION

The 1B22 vacuum tube is a hydrogen argon filled spark gap modulator tube. It is best suited for operation as a triggered gap in circuits similar to the one shown in Fig. 2. Two 1B22 tubes constitute the minimum number that can be operated as a triggered gap. More tubes in series may be used for higher voltages.

COUNTING

The mounting should be such that the tube when inserted will not be subject to excessive mechanical shock which would result in breakage of the glass bulb. Brackets of the type shown in Fig. 4 have been found to be satisfactory. The use of ordinary spring type fuse clips is not recommended.

The tube may be mounted in any position.

A free circulation of air around the bulb should be provided to assure proper cooling.

OPERATION AND CHARACTERISTICS

The characteristics of this tube are such that it will stand off voltages as high as 2700 volts and after having been broken down by a trigger pulse of the proper shape and amplitude will conduct currents of the order of 100 amperes for short intervals of time at a nominal repetition rate of 1000 pps.

The trigger pulse may take a number of different forms but a convenient and easily obtained type of pulse is a damped oscillation with a relatively high decrement. The fundamental frequency of such an oscillation may vary over a range of .1 to .5 megacycle. The form of the trigger pulse should be such that the logarithmic decrement lies between .3 and .7. If the maximum amplitude of the trigger pulse is 5 kv or more there is a possibility of ionizing both gaps thereby making lower starting voltages possible. If a unidirectional trigger pulse is used the starting voltages required are in general higher than in the case of the oscillatory type of pulse.

When the nominal trigger pulse is applied to the tubes in a circuit such as the one shown in Fig. 2 and the d-c voltage is raised continuously from zero the tubes will begin to operate when the d-c voltage reaches a maximum value of 2.5 kv. This is called the starting voltage. Conversely if the d-c voltage is set at 2.5 kv and the trigger amplitude is raised continuously from zero a normal pair of tubes will begin operation when or before the maximum trigger amplitude has reached 5000 volts. Hence it is necessary that the d-c power supply have regulation such that the no-load voltage applied to the tubes is at least 2.5 kv. This will assure that in the case of interruption of the trigger voltage, supply voltage or both, the tube will start upon return to normal conditions.

The circuit shown in Fig. 2 contains a resonance charging feature in that when the circuit is operating under proper conditions the peak voltage across the switching tubes is about twice the d-c supply voltage. If the resonant frequency of the charging choke and the network capacitance in series is $1/2$ the pulsing frequency, switching will take place at the peak of the first oscillation as shown in Fig. 3, the

NOTE: This tube is obsolete and manufacturing facilities are no longer available.

voltage across the gaps dropping to approximately 150 volts as the network energy is discharged into the load. The dashed curve shows the excursion of the voltage across the gaps if triggering should not take place. If the pulse forming network is matched to the load impedance only half the network voltage will appear across the load in the case of a square pulse. Hence with the doubling feature a voltage which approaches the d-c supply voltage appears at the load. In practical circuits the ratio of peak voltage across the load to d-c supply voltage may vary from .7 to .95.

Reverse current through the tubes arising from mismatch in the circuits or from other causes should be avoided since it will appreciably shorten tube life.

In some applications it may be required that several different repetition rates be used. In such case the resonant circuit may be designed for the highest required repetition rate and a charging diode inserted between the charging choke and the network. The diode permits the voltage to rise to its maximum value but prevents the normal drop in voltage which would occur if switching did not take place at the peak of the voltage wave. Hence any value of repetition rate lower than the resonance value may be used. It should be noted, however, that a very low value of total resistance in the dividing network across the spark gap tubes will cause the voltage to drop off with time despite the action of the diode, thus limiting the practical range and repetition rate.

The diode must have sufficient emission to pass the required charging current. Its plate to cathode impedance should be low because the drop in the diode must be compensated for by an increase in the voltage of the power supply. It and its filament or heater supply must have sufficient insulation to withstand the required peak and inverse voltages. The maximum peak inverse voltage to which the diode will be subjected is approximately the no load voltage of the d-c power supply.

In designing resonance charging circuits for use with spark gap tubes care should be taken to assure that the no-load d-c voltage does not exceed a value which will cause arcing after the first pulse. Since the second pulse will be doubled and since, in general, the condenser of the power supply filter will not yet have had time to discharge to its full load voltage the pulses immediately succeeding the first may be in excess of the maximum peak voltage rating of the gaps, thus causing circuit failure. This imposes a limitation on the capacitance of the final condenser in the power supply filter.

If the circuit is operating under normal conditions and the d-c supply voltage is raised, a point will be reached at which both gaps will pass over to a continuous arc. The maximum peak voltage above which this will occur is approximately 2.7 kv per gap.

In order to prevent damage to tubes or circuits if arcing occurs an overload relay in the d-c supply lead should be provided. This relay should be set to trip at about 100 milliamperes d-c and should remove the high voltage d-c when operated.

If under normal operating conditions the d-c supply voltage is lowered it will reach a value at which intermittent action will take place. Further reduction of the d-c voltage will cause cessation of operation. The point below which intermittent action takes place is called the minimum peak voltage. Its maximum value is 3.8 kv for any number of gaps in series provided rated trigger voltage is available at the spark gap tubes. This is true because with n gaps in series, n-1 gaps are broken down when the recommended trigger voltage is applied from the required circuit. Hence in any case only one gap remains to be broken down by the voltage on the pulse forming network.

The range of voltage between the minimum peak voltage and the maximum peak voltage is called the operating range. This is the range over which the spark gap tubes will operate satisfactorily provided circuit requirements are satisfied.

The two tube circuit shown in Fig. 2 will stand off approximately 5 kv. If it is desired to use higher voltages more spark gap tubes may be added in series.

It should be noted that when the number of gaps in series is increased the operating range is increased because while the maximum peak voltage is raised the minimum peak voltage remains the same as noted above. This is true only if the voltage is divided equally among the tubes and if sufficient peak trigger voltage is supplied to the junction points between spark gap tubes through individual coupling condensers.

In the interval between pulses when the network capacitance is being charged the trigger coupling condensers are also being charged through the resistors in the voltage dividing network. The charging currents to these condensers must flow through the resistors of the dividing network and unless the time constants of coupling condensers and dividing resistors are small as compared to the pulse interval the voltages appearing across the spark gap tubes will not be equal. This will result in the reduction of the upper limit of the range from its maximum value.

The circuit elements necessary for division of voltage during charging and for supply of trigger voltage to the junction points of the spark gap tubes cause loading of the trigger circuit. Since the trigger circuit is, in general, a high impedance this loading increases the difficulty of obtaining sufficient trigger voltage at the spark gap terminals. For this reason and due to the difficulty of obtaining voltage division at various pulse rates the use of more than four gaps in series is not recommended.

CHARACTERISTICS

*Max. peak voltage per gap at 1100 pps	2700 volts
Min. peak voltage for any number of gaps	3800 volts
Max. starting voltage	
(In 2 tube ckt. with 5 kv peak trigger voltage)	2500 volts d-c
**Peak trigger voltage	5000 volts
Nominal interelectrode capacitance	2.0 puf

RATINGS

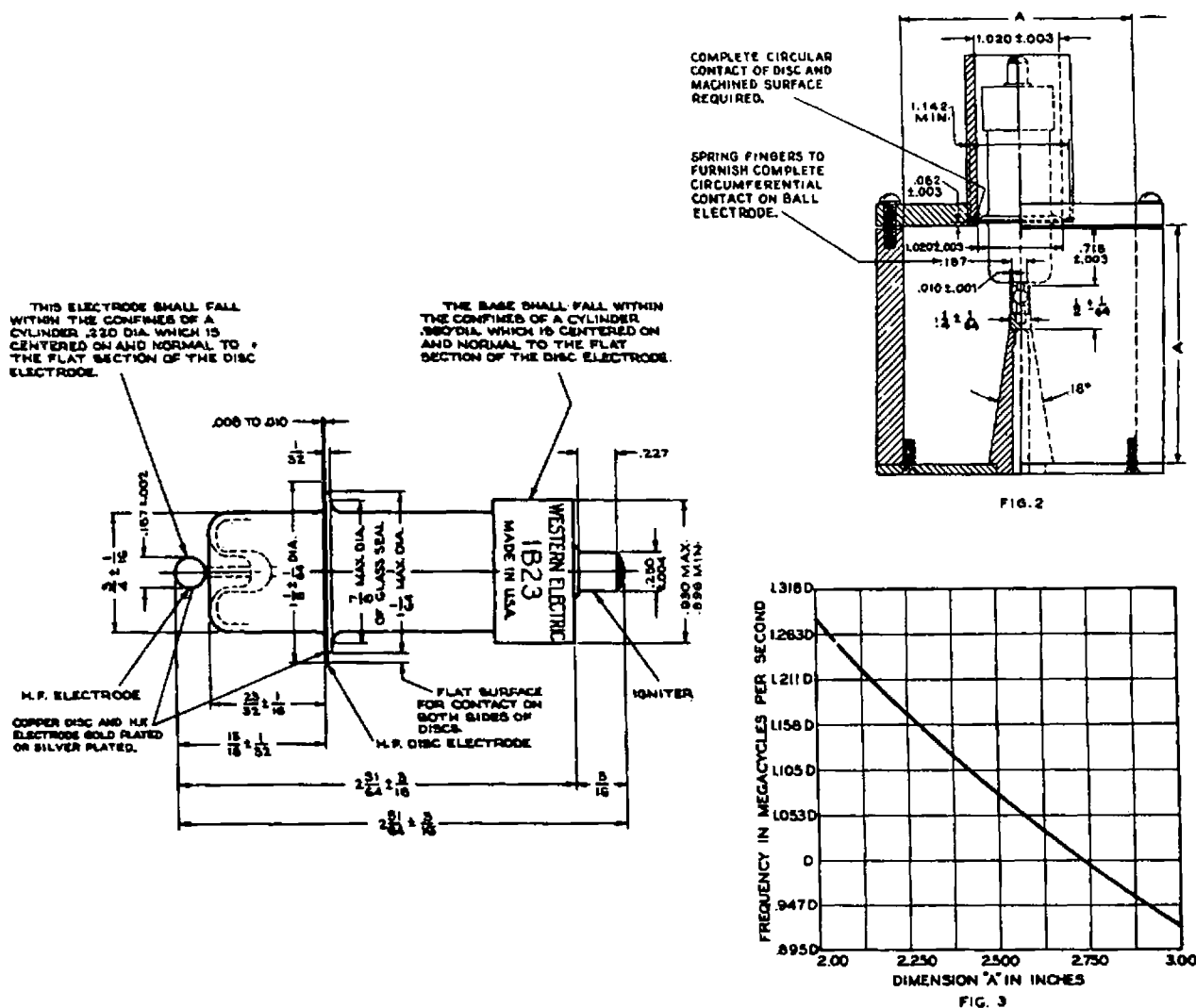
***Max. peak current	75 amperes
Max. average current	75 milliamperes
*Range of repetition rate	300-1600 pps
***Max. pulse duration	2.5 psec
Range of fundamental trigger frequency	0.1-0.5 mc

*When the pulse rate is increased from 1100 pps to 1600 pps the max. peak voltage must be reduced to 2500 volts.

**This is the trigger voltage at the tube terminals (without the spark gap tubes inserted) necessary for reliable operation. Reduction of peak trigger voltage will curtail range and increase starting voltage.

*** Tube life decreases as peak current or pulse length increases. Some sacrifice in tube life must be anticipated when maximum rated peak current and pulse duration are simultaneously applied.

TECHNICAL INFORMATION
WESTERN ELECTRIC 1B23 VACUUM TUBE



CLASSIFICATION

The 1B23 is a double-gap, gas-filled tube for use in pulsed systems employing a common antenna, particularly those operating at frequencies below 1.263D megacycles. The ultra-high frequency gap is formed by a disc electrode and a central rod electrode which terminates in a 3/16 in. diameter ball; the auxiliary gap is provided by an igniter electrode and the disc.

MOUNTINGS AND CONNECTIONS

The tube may be mounted in any position. It should be supported only through the electrical connections to the rod and disc electrodes. These connections should be made as shown in Fig. 2. When the tube is installed in the circuit the ball electrode must be gripped along a substantially continuous circle of contact with sufficient pressure to insure a low-resistance high-frequency contact. A clamping mechanism must be provided which will insure a continuous circle of contact between the disc and the machined surface of the cavity with sufficient pressure to produce a second low-resistance high-frequency connection. This mounting must not introduce stresses on the glass seal that will either destroy or weaken the seal by complete or partial separation of the copper from the glass. Contact to the cap terminal of the igniter electrode may be made by a quick release clip.

The igniter electrode current limiting resistor should be placed at the tube terminal in order to avoid oscillations within the tube.

AMBIENT TEMPERATURE

The 1B23 tube is intended for operation over the temperature range from -40°C to +100°C. Temperatures outside this range may cause mechanical failures. As noted below, under "Operation" the electrical behavior of the tube is also temperature dependent.

TONING

The tube is designed to operate at predetermined wave lengths to within $\pm 1\%$ in fixed dimension cavities over the .947D to 1.158D megacycle frequency range. The mean value of these frequencies, as a function of cavity size, is shown in Fig. 3. These data apply to tubes mounted in cavities of the type shown in Fig. 2. The correct dimensions for cavities used in service may depart from those shown because of the effects of the input and output coupling devices and because of the need for tuning adjustments. The

NOTE: This tube is obsolete and manufacturing facilities are no longer available.

total range of the provided tuning adjustment should exceed the desired tuning range of this system by 4% of the mean frequency in order to compensate for the permitted variation between individual tubes.

OPERATION

The tube may be operated as either a receiver disconnect switch or as a transmitter disconnect switch.

When used as a receiver disconnect switch, the tube and its associated circuit effectively disconnects the receiver from the system during the transmitting period. The isolation is not complete; the amount of leakage power, i.e. the transmitter power reaching the receiver, depends upon the design and the adjustment of the circuit and to a less extent upon the power of the transmitter. Changes in the circuit adjustment to decrease the leakage power (other than those necessary to match the impedances at the input to the tube circuit) will result in an increase in the low level loss which is introduced into the received signal path. The approximate relationship between the leakage power and the ultimate low level loss for matched input conditions is given by the expression:

$$P_r = \frac{V^2}{R} \frac{T}{1-T}, \text{ watts, where } V \text{ is the radio-frequency voltage drop across the tube gap, } R \text{ is the unloaded}$$

resonant impedance of the tube and cavity measured at the gap and T is the fraction of the received signal power which is passed through the gas tube circuit. The parameter V is nearly constant over a relatively large range in the gas tube power. For purposes of computation it may be assumed to be 100 volts. The low-level loss expressed in decibels ($10 \log \frac{1}{1-T}$) is normally adjusted to approximately 1.0 db.

Additional leakage power reaches the receiver as a result of direct coupling between the transmitter and the receiver. Some direct coupling occurs within the cavity itself through higher order transmission modes which do not excite the tube. The amount of this directly-coupled leakage power depends upon the size and shape of the cavity and the type and relative positioning of the input and output devices. It varies directly with the power of the transmitter and is normally of importance only in high power systems. The directly-coupled attenuation is usually of the order of 60 db unless special precautions are taken to increase it.

The recovery of the tube after the transmitting period is not instantaneous. The additional loss after the transmitting period varies with the ambient temperature from a few db at 20°C or higher to approximately 50 db at -40°C. At normal temperatures this loss decreases rapidly with time, returning to within 3 db of the ultimate low level loss value in approximately 2 microseconds.

The power dissipated in the tube during the transmitting period varies with the transmitter power, with the effectiveness of the tube circuit, and with the circuit adjustment. The approximate relationship

$$\text{is given by the expression: } P_g = \left[\frac{V^2 P}{R(1-T)} \right]^{1/2} \text{ watts, where } P \text{ is the transmitter output and } V, R, \text{ and } T$$

have the same meanings as before.

When used as a transmitter disconnect switch, the tube and its associated circuit effectively disconnect the transmitter from the circuit during the receiving period. Some low level loss is introduced so that of the received power only a definite fraction F of this will be directed toward the receiver. The power dissipated in the tube during the transmitting period varies with the circuit adjustment, being given

$$\text{by the expression: } P_g = \left[\frac{P V^2 F}{R(1-F)} \right]^{1/2}, \text{ watts, where the symbols have their previous meanings.}$$

CIRCUIT REQUIREMENTS

Since the unloaded resonant impedance R is a function of both the tube and cavity design, satisfactory operation can be obtained only with properly designed cavities. A measure of the quality of cavities of the same design can be made by measuring Q_0 the unloaded cavity Q . In general, cavities yielding Q_0 values less than 1500 will be unsatisfactory. If the Q_0 values for a cavity designed to have a maximum value of R has an unacceptably narrow band-width the cavity design should depart from the optimum in that direction which gives the highest value of R at the acceptable Q_0 value.

LIFE

The life expectancy of the tube will vary greatly with the power requirements which the system places on the tube, and on the value of the DC igniter current. The greater the current, the less the useful life.

STARTING DISCHARGE

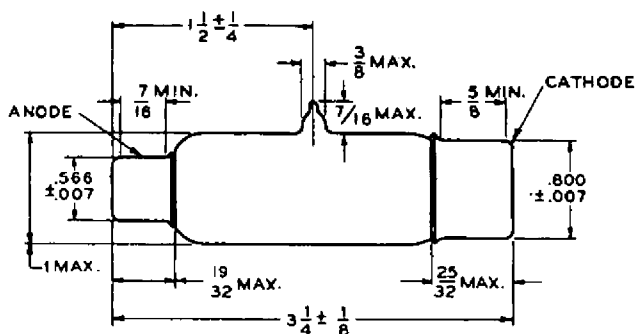
When the tube is used to protect receivers which may be damaged by a temporary overload, a continuous low current discharge must be maintained between the igniter and the adjacent copper disc. The igniter should be negative. A d-c source of 800 volts or more with a current limiting resistance of sufficient value to limit the discharge current to approximately 100µA is satisfactory. When the starting discharge is not required, no connection need be provided to the igniter.

RATING

For the tube mounted in the cavity shown in Fig. 2 with dimension A of 2.750 inches.

Operating frequency (D) $\pm 1\%$	As specified for the type
Minimum unloaded Q (Q_0)	1500
Maximum instantaneous dissipation	100 watts
Maximum average dissipation	1 watt
Approximate value of V , under conditions where the peak gas tube power is less than 100 watts (The parameter V increases gradually with temperature over the recommended operating range. Excessive values may be obtained at temperatures both above and below this range)	100 volts
Maximum igniter electrode strike voltage	800 volts dc
Maximum igniter electrode sustain voltage	500 volts dc
Minimum igniter electrode sustain voltage	300 volts dc
Maximum igniter electrode current (To be limited by series resistance)	0.1 milliamperes

TECHNICAL INFORMATION WESTERN ELECTRIC 1B29 VACUUM TUBE



THE TERMINALS OF THE COMPLETED TUBE SHALL BE CAPABLE OF BEING INSERTED SIMULTANEOUSLY INTO TWO COAXIAL CYLINDERS, THE CYLINDER FOR THE LARGE TERMINAL BEING .820 DIA. X 5/8 LONG AND THE CYLINDER FOR THE SMALL TERMINAL BEING .580 DIA. X 7/16 LONG.

FIG. 1

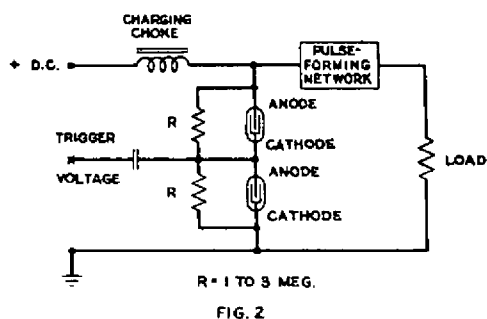


FIG. 2

	ANGLE "A"	HOLE "B"
FOR LARGE TERMINAL	90°	.810-.817
FOR SMALL TERMINAL	60°	.576-.581

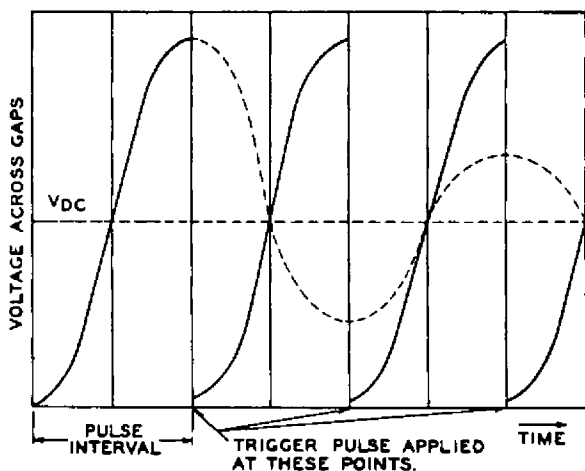
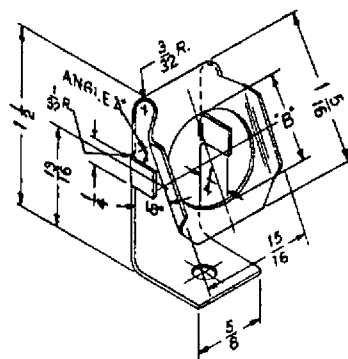


FIG. 3



MATERIAL:
#25 B&S GA. (018) PHOSPHOR-BRONZE
SPRING TEMPER.

FIG. 4

CLASSIFICATION

The 1B29 vacuum tube is a hydrogen argon filled spark gap modulator tube. It is best suited for operation as a triggered gap in circuits similar to the one shown in Fig. 2. Two 1B29 tubes constitute the minimum number that can be operated as a triggered gap. More tubes in series may be used for higher voltages.

MOUNTING

The mounting should be such that the tube when inserted will not be subject to excessive mechanical shock which would result in breakage of the glass bulb. Brackets of the type shown in Fig. 4 have been found to be satisfactory. The use of ordinary spring type fuse clips is not recommended.

The tube may be mounted in any position.

A free circulation of air around the tube should be provided to assure proper cooling.

OPERATION AND CHARACTERISTICS

The characteristics of this tube are such that it will stand off voltages as high as 1500 volts and after having been broken down by a trigger pulse of the proper shape and amplitude will conduct currents of the order of 30 amperes for short intervals of time at a nominal repetition rate of 2000 pps.

The trigger pulse may take a number of different forms but a convenient and easily obtained type of pulse is a damped oscillation with a relatively high decrement. The fundamental frequency of such an oscillation may vary over a range of .018 to .400 megacycles. If the maximum amplitude of the trigger pulse is 2.8 kv or more there is a possibility of ionizing both gaps thereby making lower starting voltages possible. If a unidirectional trigger pulse is used the starting voltages required are in general higher than in the case of the oscillatory type of pulse.

When the nominal trigger pulse is applied to the tubes in a circuit such as the one shown in Fig. 2 and the d-c voltage is raised continuously from zero the tubes will begin to operate when the d-c voltage reaches a maximum value of 1.9 kv. This is called the starting voltage. Hence it is necessary that the d-c power supply have regulation such that the no-load voltage applied to the tubes is at least 1.9 kv. This will assure that in the case of interruption of the trigger voltage, supply voltage or both, the tubes will start upon return to normal conditions.

The circuit shown in Fig. 2 contains a resonance charging feature in that when the circuit is operating under proper conditions the peak voltage across the switching tubes is about twice the d-c supply voltage. If the resonant frequency of the charging choke and the network capacitance in series is 1/2 the pulsing frequency, switching will take place at the peak of the first oscillation as shown in Fig. 3, the voltage across the gaps dropping to approximately 150 volts as the network energy is discharged into the

NOTE: This tube is obsolete and manufacturing facilities are no longer available.

load. The dashed curve shows the excursion of the voltage across the gaps if triggering should not take place. If the pulse forming network is matched to the load impedance only half the network voltage will appear across the load in the case of a square pulse. Hence with the doubling feature a voltage which approaches the d-c supply voltage appears at the load. In practical circuits the ratio of peak voltages across the load to d-c supply voltage may vary from .7 to .95.

Reverse current through the tubes arising from mismatch in the circuits or from other causes should be avoided since it will appreciably shorten tube life.

In some applications it may be required that several different repetition rates be used. In such case the resonant circuit may be designed for the highest required repetition rate and a charging diode inserted between the charging choke and the network. The diode permits the voltage to rise to its maximum value but prevents the normal drop in voltage which would occur if switching did not take place at the peak of the voltage wave. Hence any value of repetition rate lower than the resonance value may be used. It should be noted, however, that a very low value of total resistance in the dividing network across the spark gap tubes will cause the voltage to drop off with time despite the action of the diode, thus limiting the practical range and repetition rate.

The diode must have sufficient emission to pass the required charging current. Its plate to cathode impedance should be low because the drop in the diode must be compensated for by an increase in the voltage of the power supply. It and its filament or heater supply must have sufficient insulation to withstand the required peak and inverse voltages. The maximum peak inverse voltage to which the diode will be subjected is approximately the no load voltage of the d-c power supply.

In designing resonance charging circuits for use with spark gap tubes care should be taken to assure that the no-load d-c voltage does not exceed a value which will cause arcing after the first pulse. Since the second pulse will be doubled and since, in general, the condenser of the power supply filter will not yet have had time to discharge to its full load voltage the pulses immediately succeeding the first may be in excess of the maximum peak voltage rating of the gaps, thus causing circuit failure. For this reason the trigger voltage should be applied to the spark gap tubes before the d-c power supply voltage is turned on.

If the circuit is operating under normal conditions and the d-c supply voltage is raised, a point will be reached at which both gaps will pass over to a continuous arc. The maximum peak voltage above which this will occur is approximately 1.5 kv per gap.

In order to prevent damage to tubes or circuits if arcing occurs an overload relay in the d-c supply lead should be provided. This relay should be set to trip at about 60 milliamperes d-c and should remove the high voltage d-c when operated.

If under normal operating conditions the d-c supply voltage is lowered it will reach a value at which intermittent action will take place. Further reduction of the d-c voltage will cause cessation of operation. The point below which intermittent action takes place is called the minimum peak voltage. Its maximum value is 2.6 kv for any number of gaps in series provided rated trigger voltage is available at the spark gap tubes. This is true because with a gap in series, n-1 gaps are broken down when the recommended trigger voltage is applied from the required circuit. Hence in any case only one gap remains to be broken down by the voltage on the pulse forming network.

The range of voltage between the minimum peak voltage and the maximum peak voltage is called the operating range. This is the range over which the spark gap tubes will operate satisfactorily provided circuit requirements are satisfied.

The two tube circuit shown in Fig. 2 will stand off approximately 3 kv. If it is desired to use higher voltages more spark gap tubes may be added in series.

It should be noted that when the number of gaps in series is increased the operating range is increased because while the maximum peak voltage is raised the minimum peak voltage remains the same as noted above. This is true only if the voltage is divided equally among the tubes and if sufficient peak trigger voltage is supplied to the junction points between spark gap tubes through individual coupling condensers.

In the interval between pulses when the network capacitance is being charged the trigger coupling condensers are also being charged through the resistors in the voltage dividing network. The charging currents to these condensers must flow through the resistors of the dividing network and unless the time constants of coupling condensers and dividing resistors are small as compared to the pulse interval the voltages appearing across the spark gap tubes will not be equal. This will result in the reduction of the upper limit of the range from its maximum value.

The circuit elements necessary for division of voltage during charging and for supply of trigger voltage to the junction points of the spark gap tubes cause loading of the trigger circuit. Since the trigger circuit is, in general, a high impedance this loading increases the difficulty of obtaining sufficient trigger voltage at the spark gap terminals. For this reason and due to the difficulty of obtaining voltage division at various pulse rates the use of more than four gaps in series is not recommended.

RATINGS AND CHARACTERISTICS

	<u>Max.</u>	<u>Nominal</u>	<u>Minimum</u>
Peak voltage per gap	1.5 kv	1.4 kv	
Peak voltage for any number of gaps			2.6 kv
*Starting voltage	1.9 kv		
**Peak trigger voltage	3.5 kv	3.0 kv	2.7 kv
Fundamental trigger frequency	0.4 Mc		0.018 Mc
Peak current	30 A		20 A
Repetition rate	2100 pps		500 pps
Pulse duration	0.75 μ sec		0.4 μ sec
Inter-electrode capacitance		1.4 μ pf	

*In two tube circuit with 2.8 kv peak trigger voltage.

**This is the trigger voltage at the tube sockets with the spark gap tubes removed but with equivalent capacitances substituted.

TYPE DESIGNATION REGISTRATION

Manufacturer: Western Electric Company
Manufacturer's Type No.: 1391XK
JETEC Type No.: 1B31

The 1B31 is a hydrogen-argon filled spark gap modulator tube for use in pulse modulator applications. Two or more tubes may be used in series as a pulse triggered switch to actuate release of energy previously stored in a pulse shaping network.

Ratings

	<u>Min.</u>	<u>Max.</u>
Peak Voltage per Gap*	---	4.6 kilovolts
Peak Current*	30	300 amperes
Pulse Repetition Rate*	200	1600 pulses/sec.
Pulse Duration	.25	5.0 microseconds

Mechanical Data

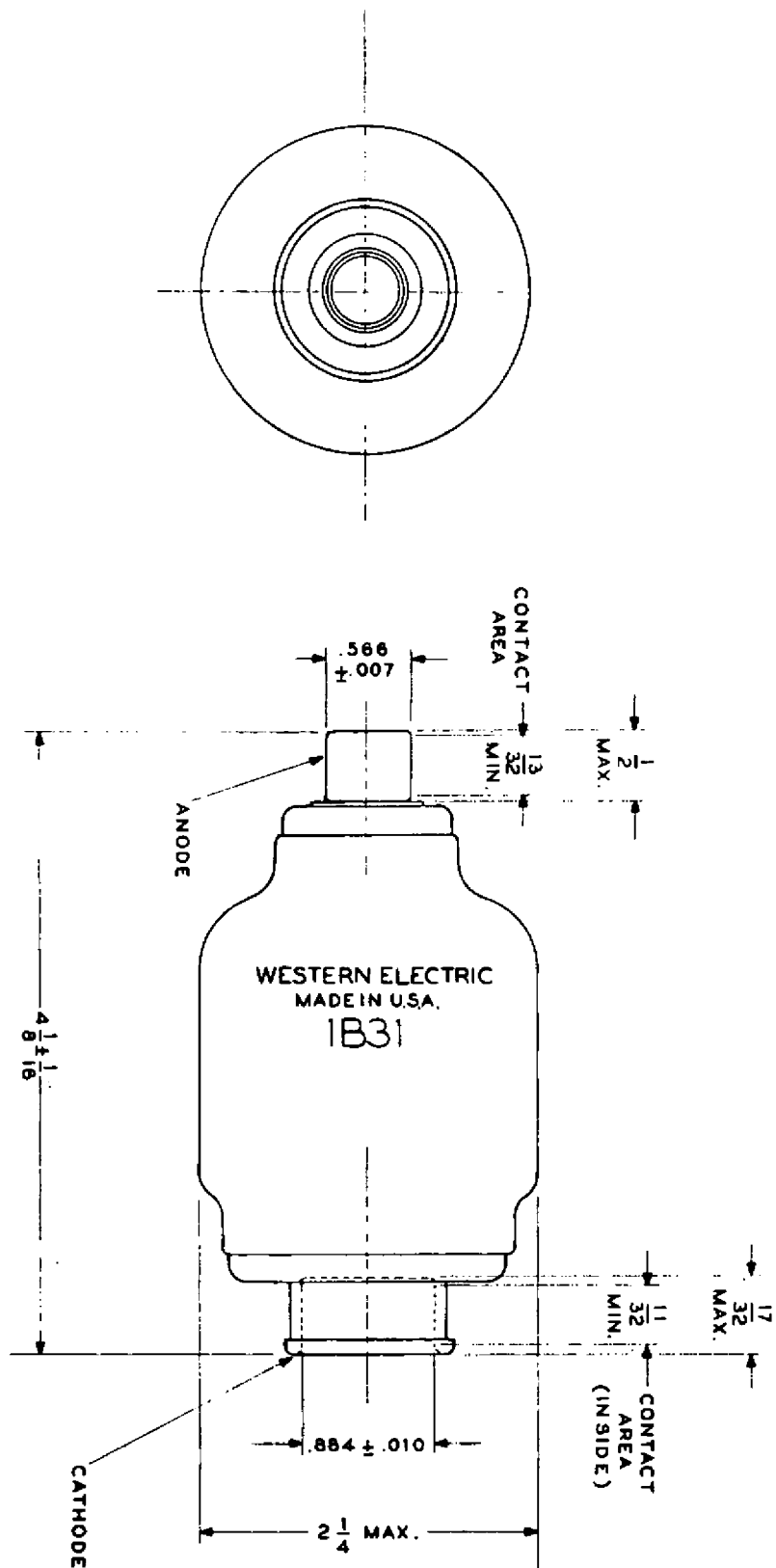
Mounting Position	Any
Dimensions	See attached outline.

* Maximum Ratings do not apply simultaneously.

NOTE: This tube is obsolete and manufacturing facilities are no longer available.

NOTE

THE BULB SHALL NOT BE ECCENTRIC BY MORE THAN $\frac{3}{64}$ AND THE CONTACT SURFACE OF THE TERMINALS BY MORE THAN $\frac{1}{32}$ FROM A & THROUGH THE CENTER OF THE END OF THE ANODE AND CATHODE TERMINALS.



TECHNICAL INFORMATION
WESTERN ELECTRIC 1B42 VACUUM TUBE

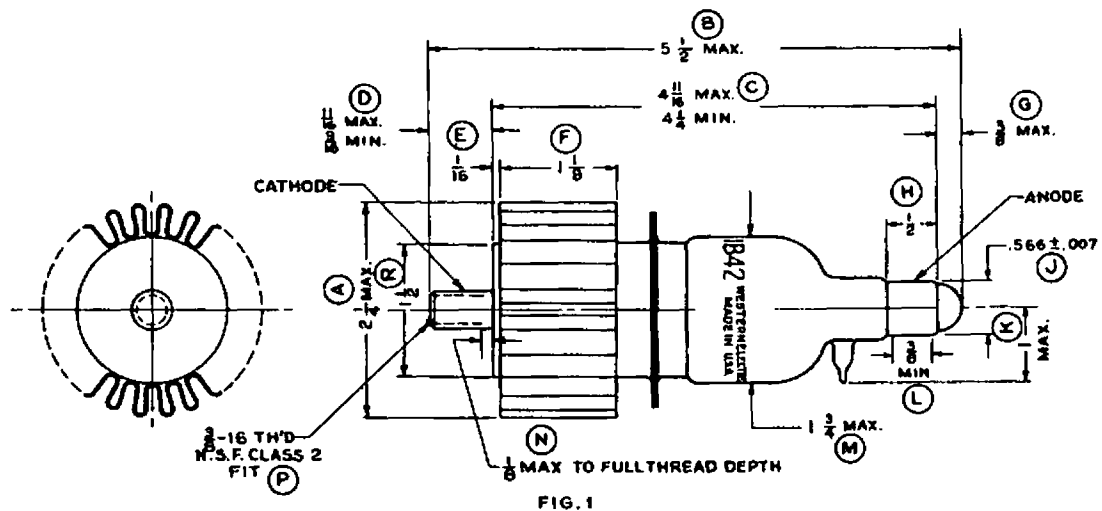


FIG. 1

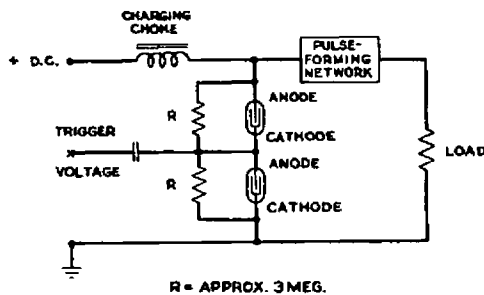


FIG. 2

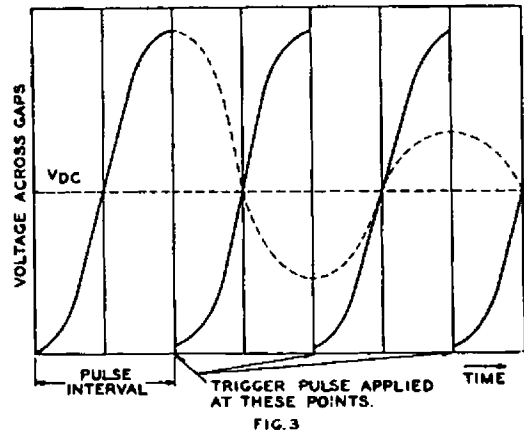


FIG. 3

CLASSIFICATION

The 1B42 vacuum tube is a hydrogen argon filled spark gap modulator tube with a mercury sponge cathode. It is best suited for operation as a triggered gap in circuits similar to the one shown in Figure 2. Two or more 1B42 tubes may be used in series in this type of circuit.

MOUNTING AND COOLING

The tube should be mounted in a vertical position with the cathode end down, and should be firmly supported by the stud at the cathode end. The axis of the tube should not deviate more than 30° from the vertical during operation.

Connection to the anode terminal should be made with a flexible lead so that no strain is placed upon the terminal.

The temperature of the metal adjacent to the cathode terminal must not exceed 150°C, a condition which requires free circulation of air through the radiator fins. Under conditions of very high dissipation within the tube or high ambient temperature it may be necessary to use forced air cooling, in which case the air should be directed over the radiator fins, and prevented as much as possible from cooling the glass portion of the tube.

OPERATION AND CHARACTERISTICS

The characteristics of this tube are such that it will stand off voltages as high as 5700 volts and after having been broken down by a trigger pulse of the proper shape and amplitude will conduct currents up to 300 amperes for short intervals of time at repetition rates from 160 pps to 1600 pps.

The trigger pulse may take a number of different forms but a convenient and easily obtained type of pulse is a damped oscillation with a relatively high decrement. The fundamental frequency of such an oscillation may vary over a range of 0.1 to 0.5 megacycles. If the maximum amplitude of the trigger pulse is 10.0 kv or more for a two tube circuit or 15.0 kv or more for a three tube circuit there is possibility of ionizing all the gaps simultaneously thereby making lower starting voltages possible. If a unidirectional trigger pulse is used, the starting voltages required are in general higher than in the case of the oscillatory type of pulse. When the nominal trigger pulse is applied to the tubes in a circuit such as the one shown in Figure 2 and the d-c voltage raised continuously from zero, the tube will begin to operate when the d-c voltage reaches a maximum value of 8.5kVdc for a two tube circuit and a maximum value of 8.5kVdc for a three tube circuit. These values are called the starting voltages. Hence it is necessary that the d-c power supply have regulation such

NOTE: This tube is obsolete and manufacturing facilities are no longer available.

that the no-load voltage applied to the tubes is at least 6.5 kVdc for a two tube circuit and at least 8.5 kVdc for a three tube circuit. This will assure that in the case of interruption of the trigger voltage, supply voltage or both, the tubes will start upon return to normal conditions.

The circuit shown in Figure 2 contains a resonance charging feature in that when the circuit is operating under proper conditions the peak voltage across the switching tubes is about twice the d-c supply voltage. If the resonant frequency of the charging choke and the network capacitance in series is 1/2 the pulsing frequency, switching will take place at the peak of the first oscillation as shown in Figure 3, the voltage across the gaps dropping to approximately 150 volts as the network energy is discharged into the load. The dashed curve shows the excursion of the voltage across the gaps if triggering should not take place. When the pulse forming network is matched to the load impedance only half the network voltage will appear across the load in the case of a square pulse. Hence with the doubling feature a voltage which approaches the d-c supply voltage appears at the load. In practical circuits the ratio of peak voltages across the load to d-c supply voltage may vary from .7 to .95.

In some applications several different repetition rates may be required. If such is the case the resonant circuit may be designed for the lowest required repetition rate. Then as the repetition rate is increased above the resonant value the voltage across the gaps will not build up each cycle as shown in Figure 3 but will instead, build up more nearly linearly. This is due to the fact that the current flowing in the charging inductance at the beginning of each charging cycle is no longer zero as in the case of resonance charging but has an appreciable value. The initial rate of rise of voltage across the network capacitance is then proportional to this initial value of charging current. When the repetition rate is several times that necessary for resonance, the charging current is practically d-c and the rate of rise of the condenser voltage is practically constant. For this reason this type of operation is termed "linear charging". Just as in the case of resonance charging the peak value of the voltage across the gaps just before triggering is approximately twice the d-c supply voltage.

The use of diode charging in which a diode is connected in series with the charging inductance in order to hold the voltage of the network at its maximum value for a considerable time before the gaps are triggered is not recommended. The reason for this is that the 1B42 spark gap tube is not designed to hold off steady voltages but only to hold off voltages of the wave form produced by resonant or linear charging circuits.

When using spark gap tubes in resonance charging circuits the trigger voltage should be applied to the spark gap tubes before the d-c power supply is turned on. This prevents the doubling of a very high no-load voltage of the power supply which might occur during the initial pulses.

If the circuit is operating under normal conditions and the d-c supply voltage is raised, a point will be reached at which both gaps will pass over to a continuous arc. The maximum peak voltage above which this will occur is approximately 5.7 kv per gap. For repetition rates above 1200 pps or peak currents above 200 amperes, the maximum peak voltage per gap should not exceed 5.0 kv.

In order to prevent damage to tubes or circuits if arcing occurs, an overload relay in the d-c supply lead should be provided. This relay should be set to trip at about 50% greater than normal current and should interrupt the primary circuit of the high voltage d-c supply when operated.

If under normal conditions the d-c supply voltage is lowered it will reach a value at which intermittent action will take place. The point below which intermittent action takes place is called the minimum peak voltage. Its maximum value is 9.0 kv for a two gap circuit and 10.5 kv for a three gap circuit.

The range of voltage between the minimum peak voltage and the maximum peak voltage is called the operating range. As is evident from the above, this range is greater for a three gap circuit than for a two gap circuit. The full operating range may be obtained only when the voltage is divided equally among the gaps and when sufficient trigger voltage is supplied to the junction points between the spark gap tubes through individual coupling condensers.

In the interval between pulses when the network capacitance is being charged, the trigger coupling condensers are also being charged through the resistors in the voltage dividing network. The charging currents to these condensers must flow through the resistors in the voltage dividing network and unless the time constants of the coupling condensers and dividing resistors are properly selected, the voltages appearing across the spark gap tubes will be unequal. This will result in the reduction of the upper limit of the operating range for the 1B42 tubes from the maximum value.

If the load is not properly matched to the pulse shaping network, a small amount of reverse current may flow through the tube immediately following each main forward current pulse. Or if the load occasionally "arcs over", then large amounts of reverse current may flow during those periods. Either operating condition will materially shorten the life of the tubes. The inverse current pulse following the main forward current pulse should not exceed five amperes peak nor last for longer than the forward pulse duration.

RATINGS AND CHARACTERISTICS

	Max.	Nom.	Min.
*Peak voltage per gap	5.7 kv	5.0 kv	-
**Peak voltage across two gaps	-	-	9.0 kv
**Peak voltage across three gaps	-	-	10.5 kv
*Starting voltage for two gaps	6.5 kVdc	-	-
*Starting voltage for three gaps	8.5 kVdc	-	-
‡Trigger voltage for two gaps	-	10.0 kv	8.0 kv
‡Trigger voltage for three gaps	-	15.0 kv	13.0 kv
Trigger frequency	0.5 Mc	-	0.1 Mc
*Peak current	300 a	-	80 a
*Repetition rate	1500 pps	-	160 pps
Pulse duration	6.1 us	-	0.25 us
Duty cycle	0.0012	-	-
Product of repetition rate and peak current	3×10^5	-	-
Coulombs per pulse	0.00128	-	-
Average current	0.250 A	-	-
†Inverse current	-	-	-
Temperature	150 °C	-	-40 °C

*The maximum peak voltage per gap must be reduced to 5.0 kv for repetition rates above 1200 pps or peak currents above 200 amperes. Prefiring may take place during the first three minutes of operation.

**The values of minimum peak voltage and starting voltage are based on a minimum value for the trigger voltage of 10.0 kv for a two tube circuit and a minimum value of 15.0 kv for a three tube circuit.

‡This is the trigger voltage at the tube sockets with the spark gap tubes removed but with equivalent capacitances substituted.

†The inverse current pulse following the main current pulse should not exceed 5 amperes peak nor last for longer than the forward pulse duration.

TYPE DESIGNATION REGISTRATION

Manufacturer: Western Electric Company
Manufacturers Type No.: 1487
JETEC Type No.: 2A21

The 2A21 Ballast Lamp is a tube designed to maintain a relatively constant current over a specified operating voltage.

MAXIMUM RATINGS, ABSOLUTE VALUES

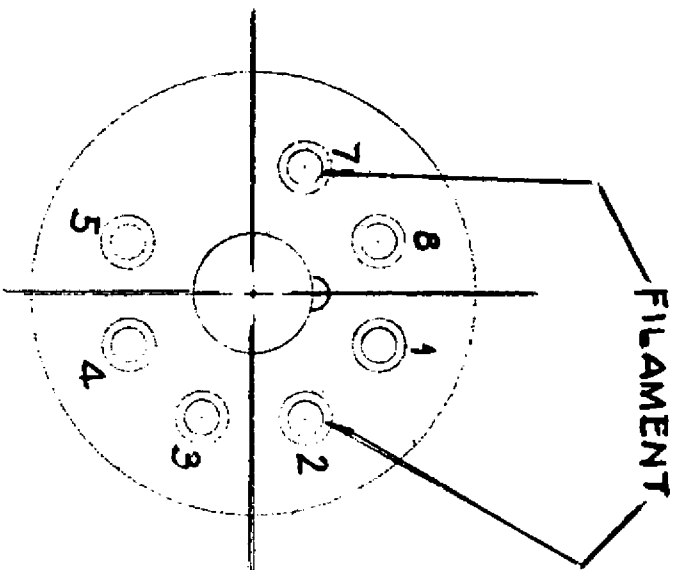
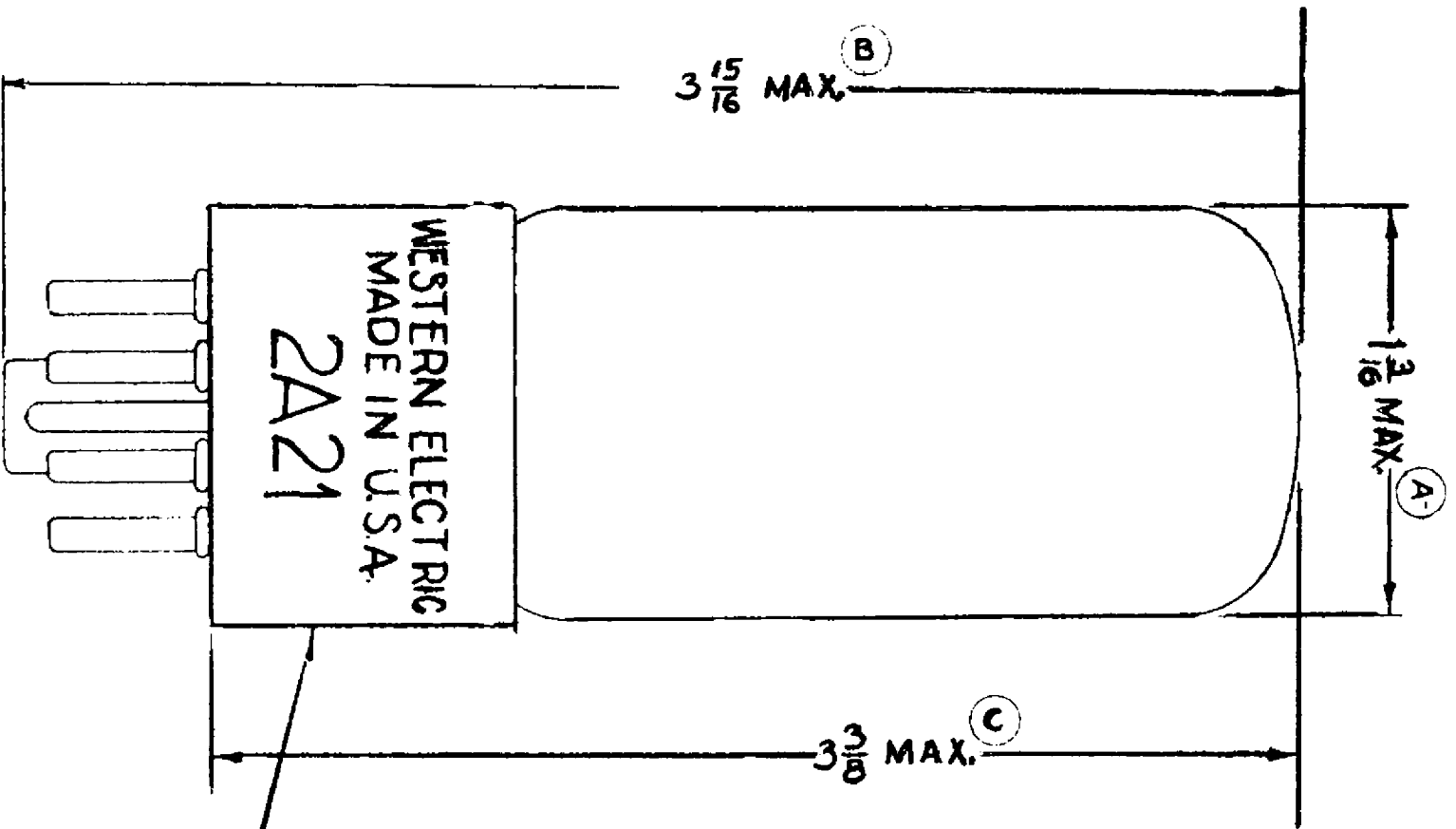
Current	1.035 amperes
Current Limit	.955 to 1.035 amperes
Voltage Limit	6.5 to 9.5 volts
Ambient Temperature Range	-30 to +85° centigrade

ELECTRICAL DATA

	<u>Min.</u>	<u>Bogey</u>	<u>Max.</u>
Mean Regulating Current	.980	.995	1.010 amperes

MECHANICAL DATA

Type of Cooling	Convection
Mounting Position	Vertical, base end down



BOTTOM VIEW

B7-2 SMALL SHELL OCTAL BASE PER RMA SP 146A
TO MEET REQUIREMENTS OF PIN GAUGE 688-1 PER
RMA SP 147-A

TYPE DESIGNATION REGISTRATION

Manufacturer: Western Electric Company
Manufacturer's Type No.: 1472 (D-170930)
JETEC Type No.: 2A22

The 2A22 Ballast Lamp is a tube designed to maintain a relatively constant current over a specified operating voltage.

Maximum Ratings, Absolute Values

Current*	1.70 Amperes
Current Limits*	1.50 to 1.70 Amperes
Voltage Limit	3.0 to 8.0 Volts
Ambient Temperature Range*	--

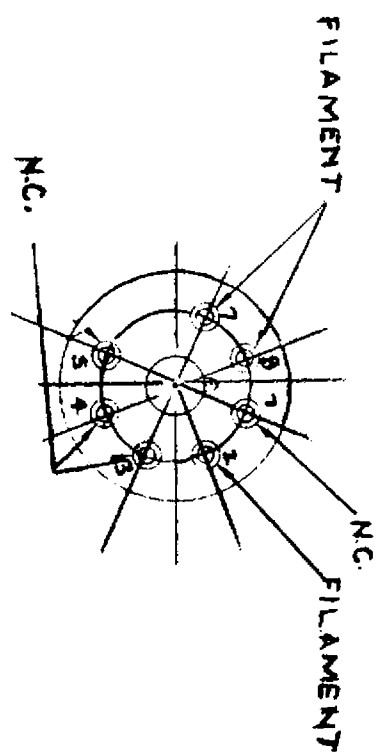
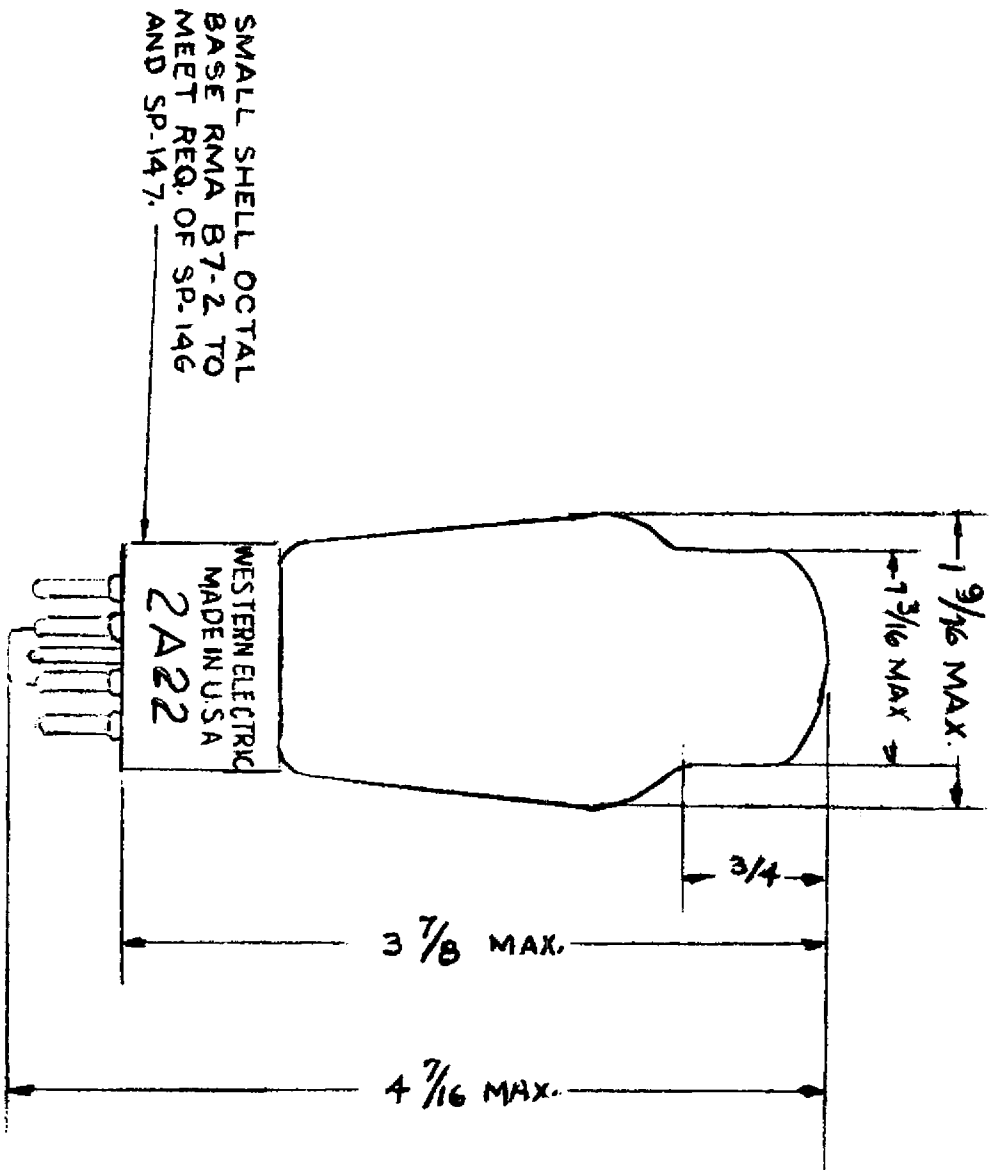
<u>Electrical Data</u>	<u>Min.</u>	<u>Bogey</u>	<u>Max.</u>
Mean Regulating Current	1.50	1.60	1.70 Amperes

Mechanical Data

Type of Cooling	Connection
Mounting Position	Vertical, Base End Down

* These current limits are for operation in free circulating air at 25 C. The tube may be operated in ambients as high as + 85 C with some variation from these limits.

NOTE: This Ballast Lamp is obsolete and manufacturing facilities are no longer available.



TECHNICAL INFORMATION
WESTERN ELECTRIC 2J51 VACUUM TUBE

ISSUE 2 12-28-45

PRINTED IN U.S.A.



NOTE: THIS SHEET DOES NOT IMPLY
COMMERCIAL AVAILABILITY OF
THE TUBE.

FIGURE 1 NOTES

NOTE 1

TO INCREASE FREQUENCY, DRIVE THIS END OF WORM SHAFT IN COUNTERCLOCKWISE DIRECTION.
COMPLETE FREQUENCY RANGE COVERED IN APPROX. 125 TURNS.
THE TUNING MECHANISM SHALL OPERATE SMOOTHLY OVER THE ENTIRE MECHANICAL RANGE WHEN SUBJECTED TO TORQUE OF 1 1/2 INCH-POUNDS APPLIED AT THE WORM SHAFT.
IN EQUIPMENT NO LESS THAN 1 1/2 INCH-POUNDS NOR MORE THAN 2 1/2 INCH POUNDS SHALL BE APPLIED AT DRIVE SHAFT.
THE GEAR AND WORM THREADS MUST BE FREE FROM CORROSION, PAINT AND OTHER IMPERFECTIONS.

NOTE 2 WARNING

MAINTAIN MIN. 2 INCHES CLEARANCE BETWEEN THIS MAGNET, & MAGNETIC MATERIALS (MAGNETS, STEEL TOOLS, PLATES, ETC.)

NOTE 3

FOUR .193 $\pm$.003"DIA. HOLES. 7/32" MIN. CLEARANCE AROUND FOUR HOLES AT BASE PLATE. THIS CLEARANCE TO BE FREE FROM BLACK FINISH.

NOTE 4

FOUR MAGNET SHUNTS
FOR NUMBER OF MAGNET SHUNTS TO BE RETAINED SEE TECHNICAL INFORMATION.
TO REMOVE SURPLUS, GRIP FIRMLY AT TABS WITH SUITABLE PLIERS AND PULL AWAY FROM TUBE.

NOTE 5

ANY PORTION OF THE ASSEMBLY EXTENDING BELOW THIS SURFACE SHALL BE WITHIN A 1-7/64" RADIUS ON THE TRUE CENTER OF THE PLATE.

NOTE 6

ALL JOINTS IN THE WAVE GUIDE ASSEMBLY SHALL BE VACUUM TIGHT SO THAT THE WAVE GUIDE FLANGE MAY BE USED TO PROVIDE A HERMETIC SEAL AT SURFACE (F) (SEE TEST SPEC.)

NOTE 7

THE $\pm .020$ " TOLERANCE OF .281" DIMENSION INCLUDES ANGULAR AS WELL AS LATERAL DEVIATIONS OF THE SURFACE.

NOTE 8

THESE DIMENSIONS DEFINE RELATION OF SURFACE (F) TO RESPECTIVE HOLES.

NOTE 9

THIS COUNTERSINK SHALL BE CAPABLE OF ACCEPTING A CONE HAVING A 60° INCLUDED ANGLE AND A BASE DIAMETER OF .234" AND SHALL REJECT A SIMILAR CONE HAVING A BASE DIAMETER OF .254".

NOTE 10

WITH 1/16" SEAT RESTING ON A PLANE SURFACE, THE FLATNESS OF THE SEAT SHALL BE SUCH THAT A .010" THICKNESS GAUGE 1/8" WIDE SHALL NOT PASS UNDER.

NOTE 11

HEXHEAD BANANA PIN JACK 19/32" LONG HOLE .169 $\pm$.005"DIA.

NOTE 12

THE JACK HOLES SHALL BE WITHIN A RADIUS OF .023" OF THE SPECIFIED LOCATION BUT SHALL BE SPACED .500" $\pm$.010" WITH RESPECT TO EACH OTHER. THE CENTERLINES OF THE JACK HOLES SHALL BE PERPENDICULAR TO MOUNTING PLATE WITHIN 3°.

NOTE 13

THIS DIAMETER SHALL BE CONCENTRIC WITH OPENING IN WAVE GUIDE WITHIN .010".

NOTE 14

"C" INDICATES ADJACENT JACK IS THE COMMON HEATER-CATHODE CONNECTION.

NOTE 15

ALL METAL SURFACES COVERED BY BLACK FINISH EXCEPT SURFACES (D) AND (F), DRIVE AND STOP MECHANISM (X), SURFACE AROUND HOLES AS SPECIFIED IN NOTE 3, PARTS ASSOCIATED WITH GLASS INSULATOR (L), AND SHUNTS.

NOTE 16

IT SHALL BE POSSIBLE FOR A SLEEVE .195" I.D. X .406" O.D. X 1" LONG TO PASS OVER ENDS OF SHAFT TO FACE OF WORM BRACKET.

NOTE 17

BLACK FINISH MAY BE OMITTED FROM THE EDGES AND BACK OF WAVE GUIDE.

NOTE 18

THIS DIAMETER SHALL BE CONCENTRIC WITH THE DIAMETER OF THE FLANGE WITHIN .005".

NOTE 19

ON GOVERNMENT ORDERS THE INITIAL ISSUE OF THIS DRAWING AND ALL SUBSEQUENT CHANGES ARE SUBJECT TO APPROVAL BY THE SERVICES.

NOTE 20

THE OPENING IN THE WAVE GUIDE SHALL BE ENCLOSED BY A DUST COVER WHEN THE TUBE IS NOT IN USE.

NOTE 21

NUMBER APPEARING ON GENEVA INDICATES THE NUMBER OF REVOLUTIONS OF HELICAL GEAR.

WITH THE GENEVA AND GEAR SET AT 3 AND ZERO RESPECTIVELY THE FREQUENCY OF THE TUBE IS 9000 $\pm$ 25 MC UNDER OSCILLATION 3 ON TEST SPECIFICATION LTP-16802.

NOTE 22

SOLDERED JOINTS IN BASE PLATE WITHIN THIS DIA. SHALL BE VACUUM TIGHT SO THAT BASE PLATE MAY BE USED TO PROVIDE A HERMETIC SEAL.

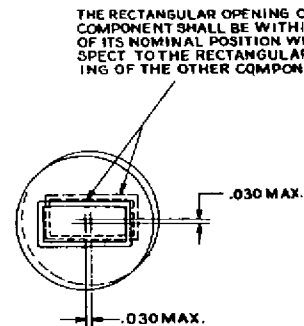
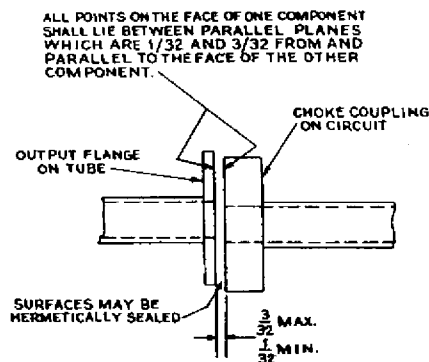


FIG. 2

CLASSIFICATION

The 2J51 vacuum tube is a magnetron oscillator the frequency of which is determined by internal resonant circuits. The frequency may be varied by an external adjustment over a range of 8500 to 9600 megacycles. The tube is designed for the generation of peak power up to 80 kilowatts under conditions of pulsed operation. It has an equi-potential cathode with a 6.3 volt, 1.0 ampere heater.

The output circuit is designed so that the tube, when loaded by a matched waveguide, will operate at a fairly uniform level of power and frequency pulling over the band. The tube is equipped with permanent magnets to supply the maximum field required for operation. Four magnetic shunts are provided to adjust the strength of the field downward. If not required, these shunts should be removed before the tube is installed. Forced air cooling is required for normal operation.

DIMENSIONS, MOUNTING AND CONNECTIONS

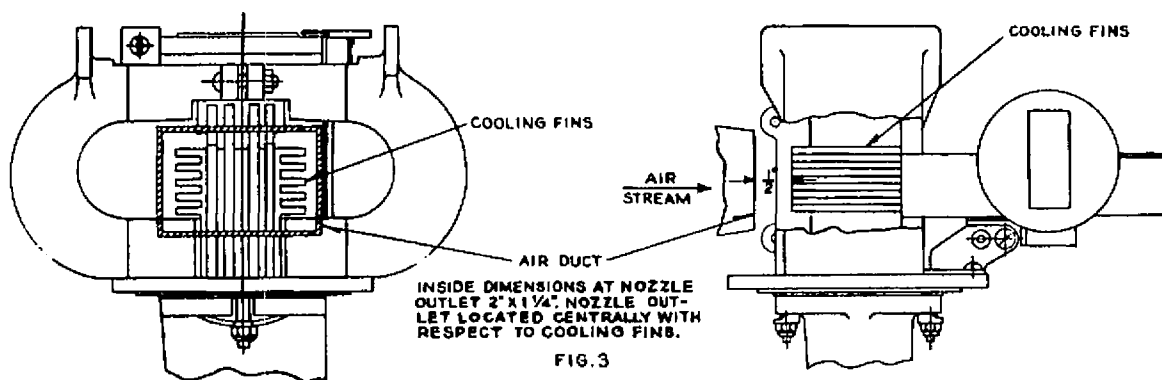
Figure 1 shows the principal external dimensions and the arrangement of heater, cathode and output leads. One end of the heater is connected to the cathode internally. Since this cathode lead is pulsed at high voltage the input connections must be adequately isolated. The connections should be flexibly mounted.

The tube should be mounted only from the circular flange to which the glass protective boot is attached but may be operated in any orientation. The flange has a circular bead to facilitate pressurizing. No direct connection is made to the output circuit of the tube. Figure 2 shows the output coupling and gives limits controlling the placement of the components.

Care should be exercised in the handling of the tube. The tube envelope is soft copper and may be easily distorted. Distortion may result in loss of vacuum or impairment of electrical characteristics. The warning note on the magnets should be heeded. No more than the maximum torque as specified in Note 1 of Figure 1 should be applied to the tuning mechanism.

COOLING

The temperature of the tube envelope must not exceed 150°C. Failure to provide adequate cooling will adversely affect the life of the tube. The rate of air circulation required will depend upon total dissipation and the efficiency of heat interchange between the tube structure and circulated air. A blower delivering 50 cubic feet of air per minute directed at the point indicated in Figure 3 and uniformly distributed over the cooling fins provides adequate cooling under conditions of maximum value of average power input when the ambient conditions are 50°C temperature and 760 mm. Hg. pressure.



PULSE CHARACTERISTICS

In pulsed operation the tube is energized a small fraction of the time (Duty Cycle) by applied voltage pulses of not more than a few microseconds duration. Frequency modulation in the tube may result from: pulses of varying amplitude; pulses with superimposed ripple; or pulses for which the time of rise or time of fall, or both, occupy too great a portion of the pulse duration. On the other hand, misfiring, or missing lines in the spectrum may result from pulses for which the time of rise is too short, a condition especially likely to occur when the pulse duration is a small fraction of a microsecond. The time of rise of the resulting current pulse should be not less than 0.1 usec.

For operation near the maximum rated pulse power, it is essential that the input circuit be so designed that the energy per pulse delivered to the tube, if sparking occurs, cannot greatly exceed the normal energy per pulse. Pulsers of the discharging network type usually satisfy this requirement.

OPERATION

Prior to application of high voltage, the cathode should be heated at $E_f = 6.3 \pm 10$ per cent for not less than one minute. During high voltage pulsed operation the heater voltage should be varied with input power approximately in accordance with the formula:

$$R_f = 6.3 \sqrt{1 - \frac{P_i}{150}}$$

with $R_f = 0$ for all values of P_i greater than 150. The heater should be protected against input pulse power by an appropriate filter.

A new tube may exhibit initial instability. This is most likely to occur with pulses of long duration and high peak power, and is progressively less severe for shorter pulses and lower peak power. A few minutes of operation is usually sufficient to obtain stable operation.

The initial values of frequency and power output differ slightly from those measured under conditions of thermal equilibrium. Also, an adjustment of the tuning mechanism during operation disturbs the thermal equilibrium so that the frequency does not immediately assume its steady state value for that setting. The thermal drift is about 75 per cent completed within one minute. Its magnitude, in megacycles per megacycle of tuning adjustment varies from about 0.01 at the low frequency end of the range to about 0.06 at the high frequency end.

OPERATING CHARACTERISTICS

Figure 4 shows the frequency and power output at constant I_b of an average tube operating at mid-band frequency as functions of the load impedance presented at the output flange of the tube. In this diagram standing wave ratio contours are concentric circles, the center of the circles representing a matched line. The circles for s.w.r. = 1.5 is shown. The contours of constant power output and constant frequency remain very similar as the tube is tuned mechanically over the range. They rotate, however, with respect to the impedance diagram, making about one full clockwise rotation between maximum and minimum frequency adjustments.

Figure 5 shows average power output, pulse voltage and pulling factor as functions of frequency under conditions of maximum magnetic field and 14 milliamperes average current. Efficiency is reduced progressively as the magnetic field is reduced by means of the shunts. The dynamic impedance of a typical tube is approximately 150 ohms, and is slightly dependent upon the operating point, accordingly, the threshold voltage is about 2 kv less than the pulse voltage corresponding to a pulse current of 14 amperes.

The performance data given below are based upon typical sets of conditions at midband frequency. Variations can be expected with different tubes and in different systems.

	<u>NO SHUNT</u>	<u>MAGNETIC FIELD</u>	<u>TWO SHUNTS</u>
Pulse Current (Amperes)	14.0		12.0
Average Current (Milliamperes)	14.0		12.0
Pulse Voltage (Kilovolts)	14.3		12.0
Peak Power Input (Kilowatts)	200		144
Peak Power Output (Kilowatts)	60		40

RATINGS

These ratings apply to each quantity independently. They do not form a set of values at which the tube can operate.

	<u>MAX.</u>	<u>MIN.</u>	<u>UNIT</u>
Heater Voltage (R_f)	7.0		Volt
Pulse Current (I_b)	16.0	6.0	Ampere
Peak Power Input (p_i)	260		Kilowatt
Average Power Input (P_i)	230		Watt
Duty Cycle	.0012		
Pulse Duration	6.0		Microsecond
Total Time of Oscillation in Any 100 us Interval	6.0		Microsecond
Anode Temperature	150		°C
<u>*TUNING RANGE</u>	9600	8500	Mc/sec

*Voltage varies approximately 11% over the frequency band. Adjustment must be made when the tube is tuned so that current remains within ratings.

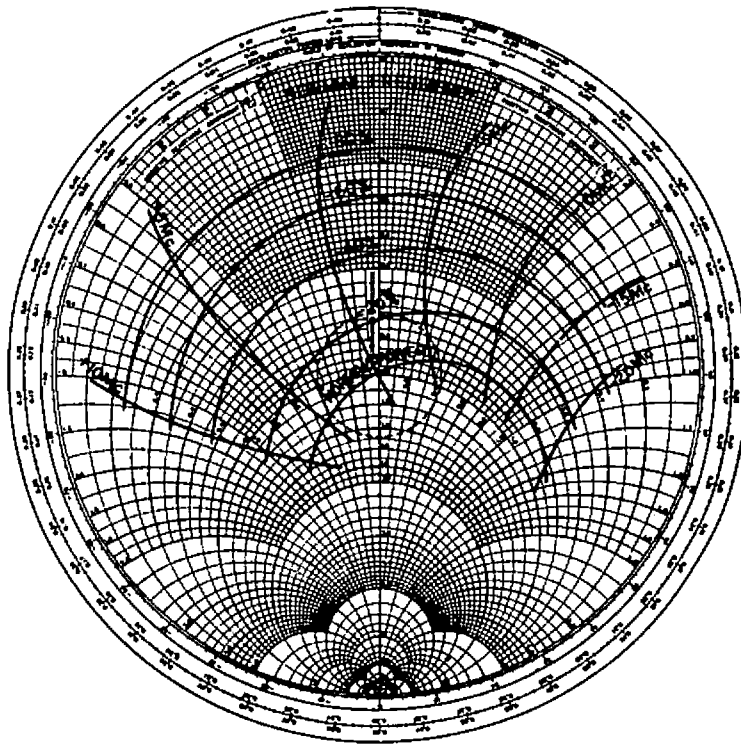


FIG. 4

AVERAGE CHARACTERISTICS
OF
2J51 MAGNETRONS

CONDITIONS: $I_b = 14 \text{ ma.}$, $t_p = 10^{-6} \text{ sec.}$, P.P.S. = 1000

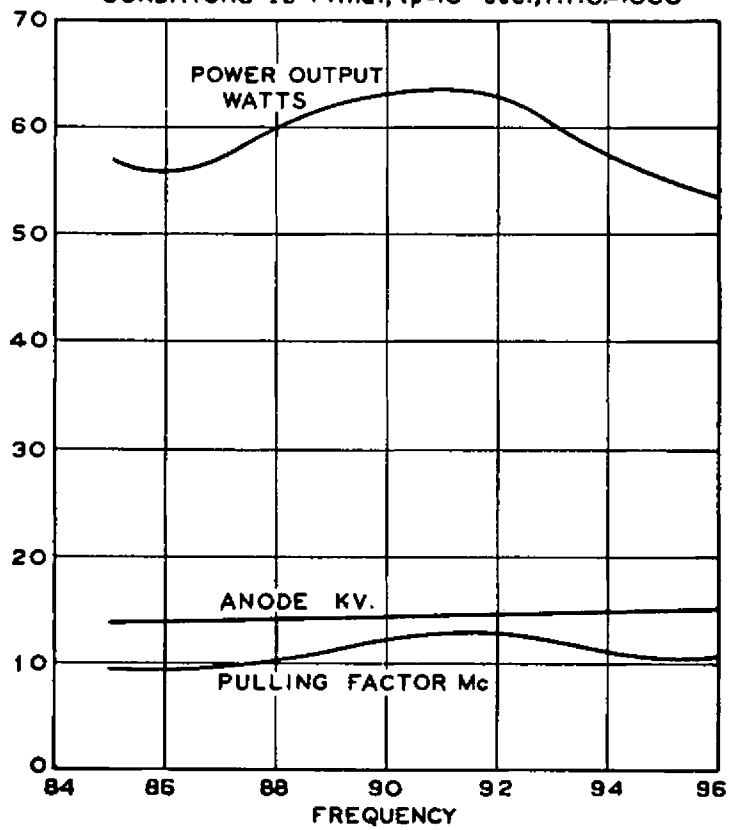
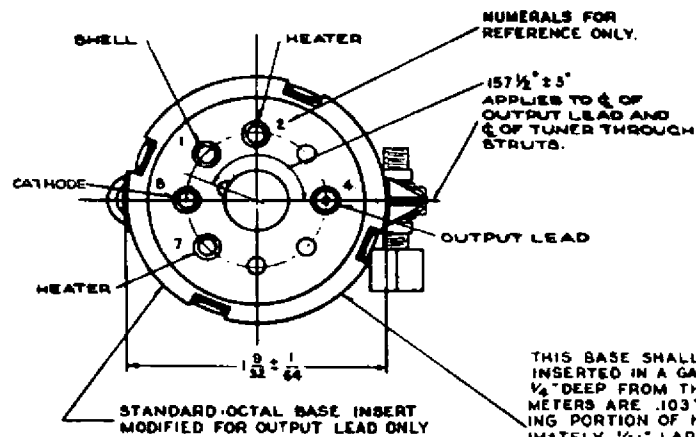


FIG. 5

WESTERN ELECTRIC 2K25 [REDACTED] ELECTRON TUBE

The information contained herein is tentative.

2K25
OSCILLATOR
UHF



Western Electric

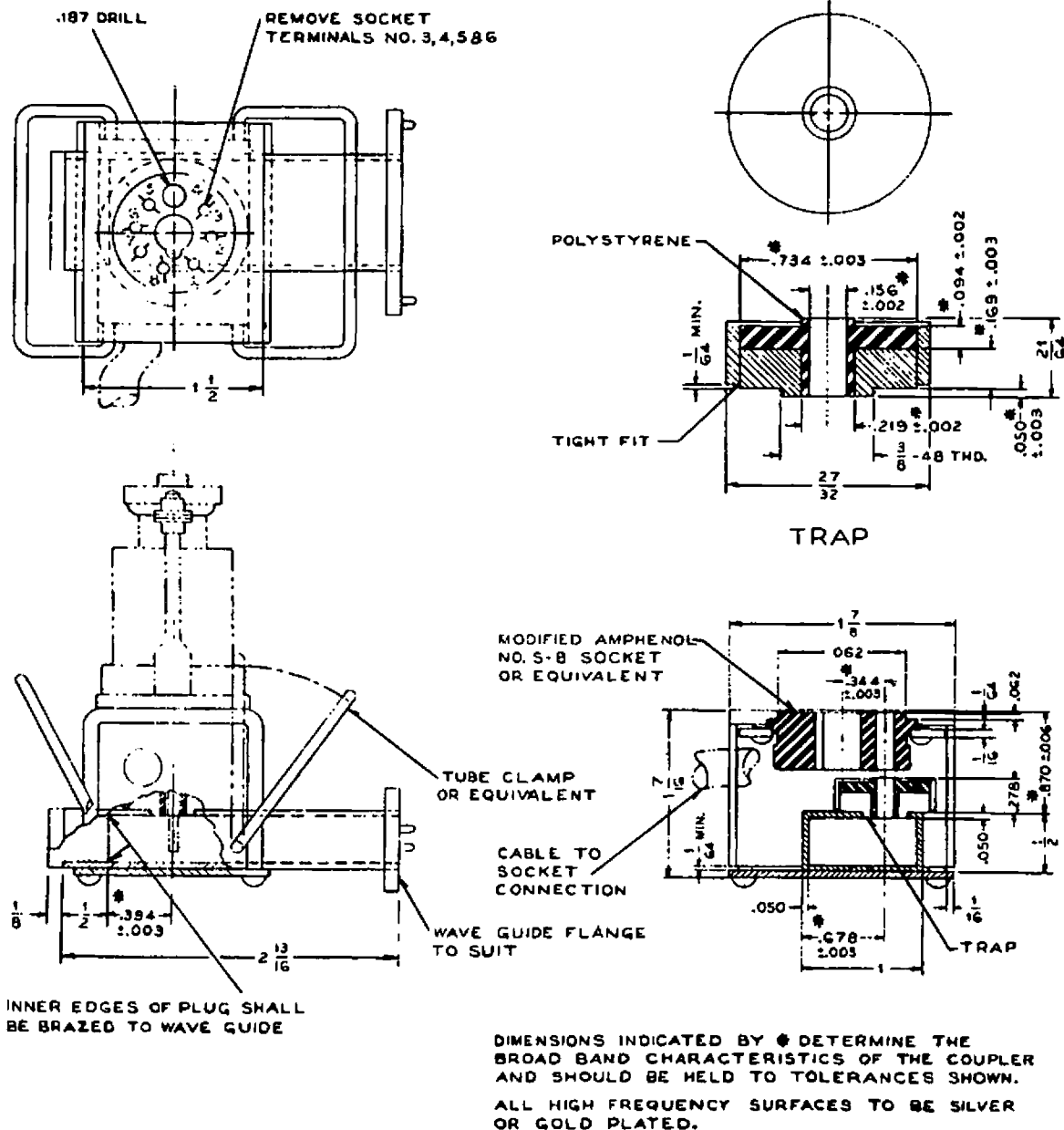


FIG. 1

CLASSIFICATION

The 2K25/0000-10 electron tube is an ultra high frequency oscillator in which the resonant circuit and means of tuning are integral with the tube. It has been developed for operation within a frequency range of 8500 to 9660 megacycles per second.

INSTALLATION

This tube employs a modified intermediate octal wafer type base with the No. 4 pin removed and the hole drilled to allow the coaxial output line to pass through. The output line has been designed for direct coupling with a suitable wave guide. The central conductor of the coaxial line projects beyond the outer conductor to serve as an antenna when the coaxial is projected through the wall of the guide. For best operating conditions, the full length of the antenna should be inside of the wave guide wall. The polystyrene insulator should be kept clean to avoid power loss in a conducting surface film. The tube may be mounted either in a horizontal or vertical position. For proper operation the tube socket mount should be rigidly fastened to the wave guide. The No. 4 hole in the socket, which is drilled to admit the coaxial output line, should be in alignment with the entrance hole in the wave guide wall. Tubes should be fastened rigidly to the socket mounting by clamping at the base and adjacent platform only. The tube must not be clamped above the shoulder of the platform which is located .365" $\pm$.035" above the bottom surface of the base.

The inner and outer conductors of the coaxial output line are at the same potential as the resonator. The resonator may be operated at a potential other than that of the wave guide if a suitable by-pass condenser or choke coupling is provided between the coaxial and the wave guide.

The radio frequency properties of the tube are specified when the tube is mounted in the broadband coupling unit shown in Figure 1 and this unit is coupled to a load which presents a standing wave not exceeding .8 db at the coupler. Unless otherwise stated all characteristics discussed refer to operation in this coupler and for comparable results an equivalent unit should be employed. The coupler incorporates a choke to provide a radio frequency connection between the wave guide and tube coaxial while permitting d-c isolation.

Since the frequency is a function of the repeller and resonator voltages it is very important in many applications to shield and by-pass the leads carrying these voltages as close to the tube as possible in order to avoid modulation of the tube output by extraneous voltages.

HEATER RATING

Heater voltage	5.8 volts min. 6.8 volts max.
Nominal heater current	0.44 ampere

The heater element of this tube is designed to operate on a voltage basis and it should be operated at as near to 6.3 volts as practicable.

OPERATING CONDITIONS AND CHARACTERISTICS

	Normal	Absolute Maximum
Heater voltage (Ef)	6.3	6.5 volts
Potential difference between heater and cathode	0	± 45 volts
Resonator voltage (Ers)	300	330 volts
Cathode current (Ik)	22	35 milliamperes
Repeller voltage (ER) range	-20 to -300	-350 volts
Ambient temperature	-	110°C*

* This is the temperature surrounding the bulb proper. The temperature of the coaxial line below the base must not exceed 90°C.

Unless otherwise specified all data given hereafter are for normal operating conditions in the coupling shown on the outline drawing.

The life of the tube will depend on the operating conditions. Operation above the normal conditions will decrease the useful life.

In equipment design it is sometimes necessary to know the expected manufacturing distribution of cathode current. This is shown in Figure 2.

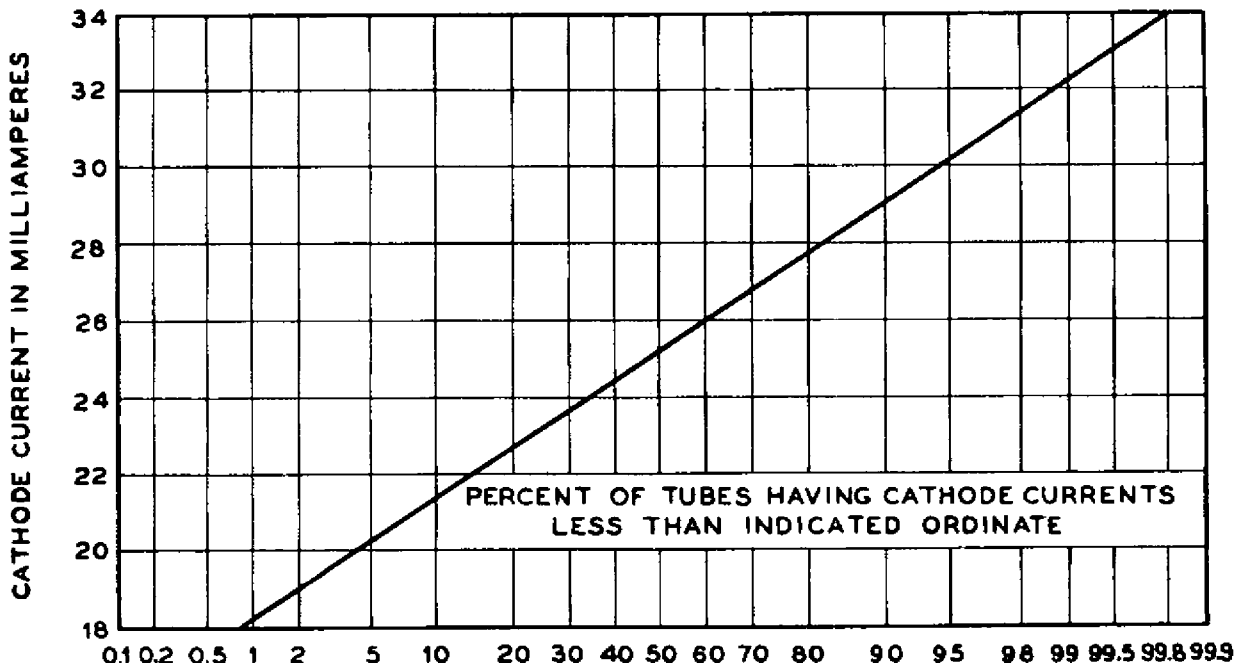


FIG. 2

MECHANICAL TUNING ADJUSTMENT

The mechanical tuning mechanism and flexible diaphragm have been designed to afford an occasional adjustment of frequency. It is not intended for use where continual or frequent adjustment is required.

When putting a tube into service, the tube should be mechanically tuned to the frequency desired. The bows should then be flexed a number of times to relax the strains in the system. By decreasing the flexing successively from a maximum of one full turn to zero in 8 or 10 flexes, the desired frequency will be found to be essentially stable.

REPELLER VOLTAGE CHARACTERISTICS

The same frequency of oscillation may be obtained at several repeller voltages when all other conditions are kept fixed including the tuning of the resonator. Each of these correspond to a different number of cycles of drift in the repeller space. These characteristics are illustrated in Figure 3 which shows approximately the relative output as a function of the repeller voltage for various mean resonator frequencies obtained by mechanical tuning. Fig. 3 also gives approximate information concerning the range of repeller voltage over which oscillation occurs in the various modes and the voltage separation between the modes. It is recommended that for most applications as a local oscillator, the mode designated A should be used, since the coupling unit was designed specifically for this mode and the test specifications were so written to ensure the properties of this mode. The two dashed lines in Figure 3 show the probable range of repeller voltages required to produce maximum power output in mode A that may be expected due to production variations. The middle curve shows the variation of repeller voltages with frequency for a typical tube.

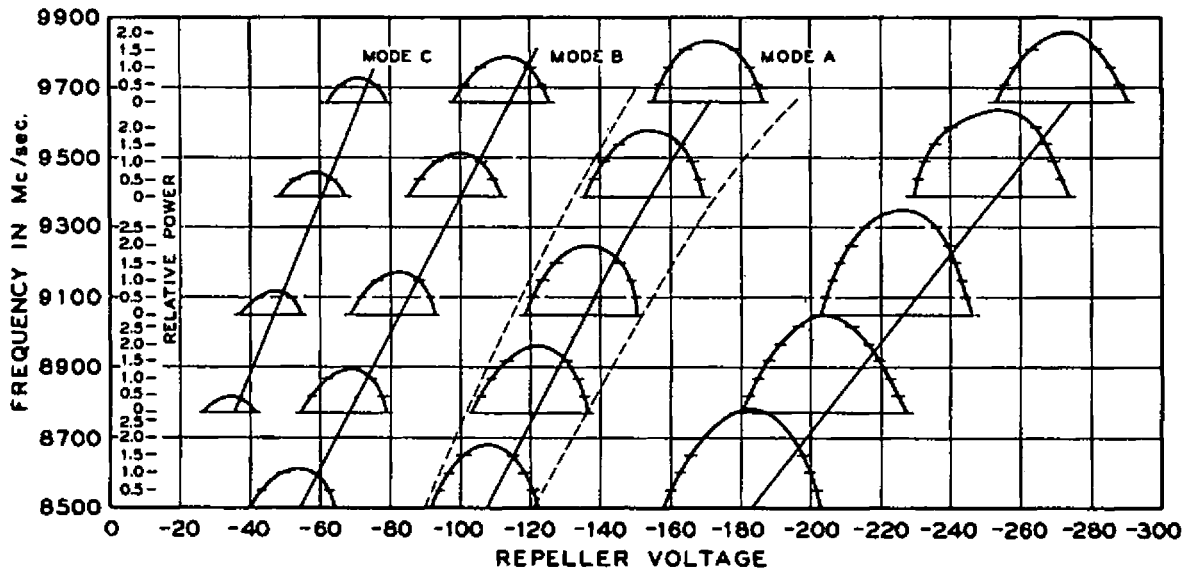


FIG. 3

POWER OUTPUT

The power output characteristics for a tube oscillating in mode A and operating into a load presenting a unity standing wave ratio are shown in Figure 4 as a function of frequency. The dashed curves on either side of the power frequency curve indicate the probable variation to be expected. The test specification requires that a tube oscillating in mode A shall give not less than 20 milliwatts throughout the frequency range. The specification also requires that at 9370 Mc the power for operation in mode B of Figure 3 shall not be less than 15 milliwatts and for mode C not less than 3 milliwatts. The specifications for modes B and C are made for special applications and the use of these modes for normal service is not recommended.

ELECTRONIC TUNING

The frequency of oscillators of this type may be varied over a limited range by variations of the repeller voltage.

The amount of electronic tuning as well as the rate of change of frequency with repeller voltage is a function of the resonator voltage and the loading. Data presented here are applicable when the tube is coupled to a matched load in the recommended coupling and the resonator voltage is normal (300 V).

Figure 5 shows the range of electronic tuning as a function of maximum power frequency. Both the tuning between half power and 2.5% power points are shown. The dashed lines above and below each of the curves indicates the probable variation to be expected.

The effect on tuning ranges and power output caused by using other values of resonator voltages is shown in Figure 6.

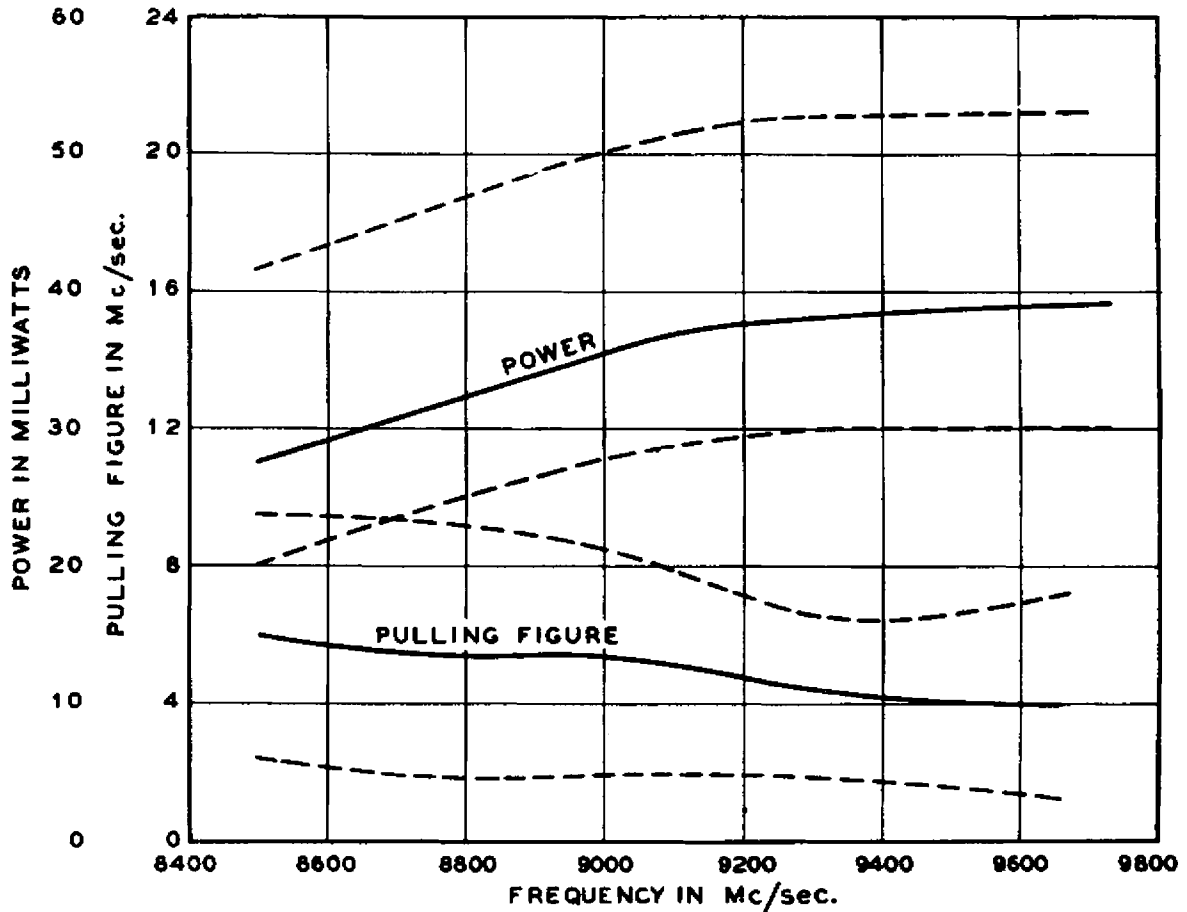


FIG. 4

OUTPUT IMPEDANCE CHARACTERISTICS

It is not possible because of space limitations to illustrate the behavior of the oscillators as the impedance is varied for frequencies throughout the band. However, a typical impedance diagram taken at 9375 Mc on a tube of average characteristics is shown in Figure 7. With a matched load presented to the coupler, the repeller voltage was adjusted for maximum power. All voltages were held fixed while various impedances were presented to the tube. The solid lines are loci of constant power and the dotted are loci of constant frequency differences from the frequency for a matched load. The impedance plane of reference is a plane in the wave guide perpendicular to the axis and including the tube antenna.

It will be observed that the oscillator is not coupled to give maximum power output. This is a design feature of the tube and coupling and provides a margin of safety against over coupling and the possible resulting loss of oscillation. It may be observed by examining Figure 7 that wide variations in the power output of the tubes can be caused by changes in the load impedance and that sufficient over-loading can cause the tube to stop oscillating. If the load is frequency sensitive, over-loading may occur over a portion of the normal electronic tuning range and as a result there will be no output in that region.

It is specified that the tube shall operate at 9370 Mc without a discontinuity in the center of the mode for a load having a standing wave ratio with an amplitude of 8 db or less and any phase position measured in the wave guide at the coupling. The minimum amplitude of standing wave ratio that will cause such a discontinuity is called the "sink margin". Figure 8 shows the variation of the sink margin over the frequency band. A reduction in resonator voltage will usually decrease the sink margin. For example a reduction from 300 V to 250 V applied to the resonator will reduce the sink margin an average of 11%.

Another important output impedance characteristic is the change in operating frequency with change in loading. This is customarily expressed in terms of the pulling figure which is defined as the maximum difference in frequencies produced when a mismatch measured at the coupler to have an absolute reflection coefficient of 0.2 is varied through 360°. All operating voltages are held fixed during this test. The expected range of pulling figures is presented as a function of frequency in Figure 4.

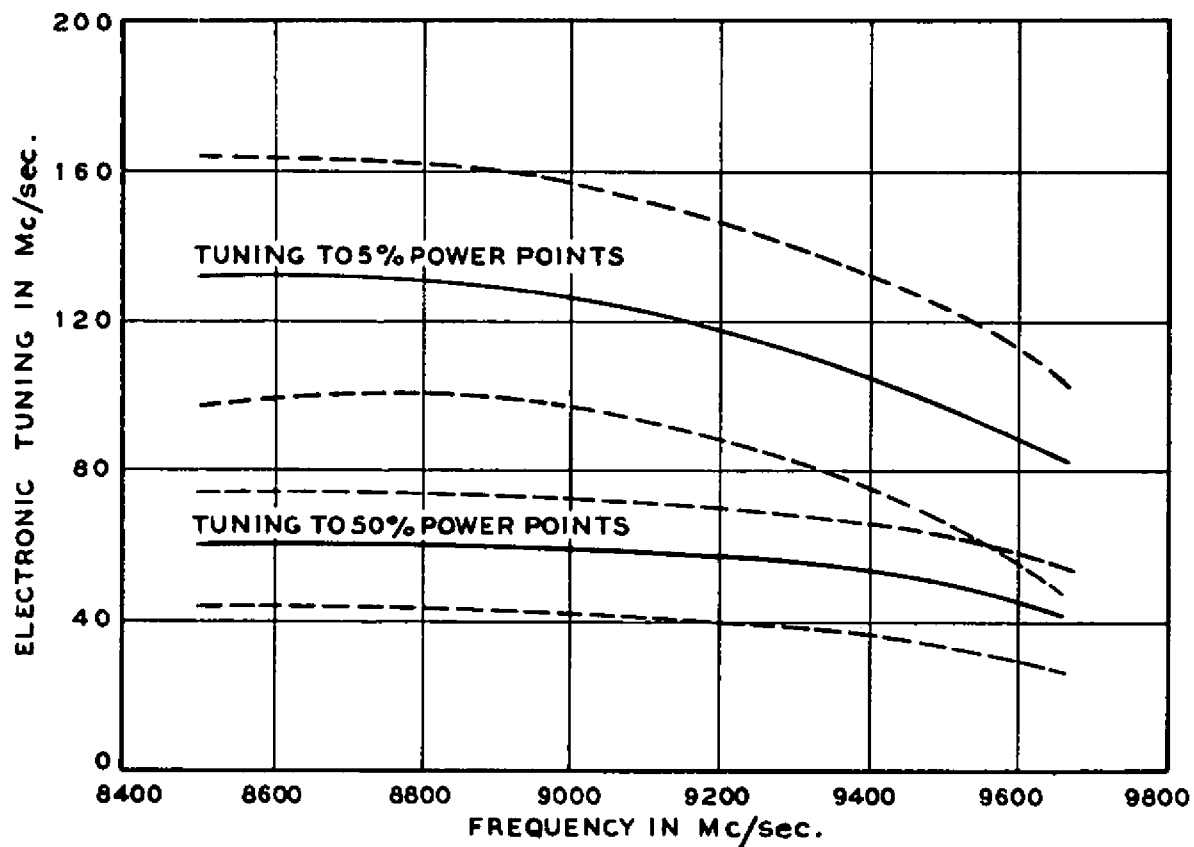


FIG.5

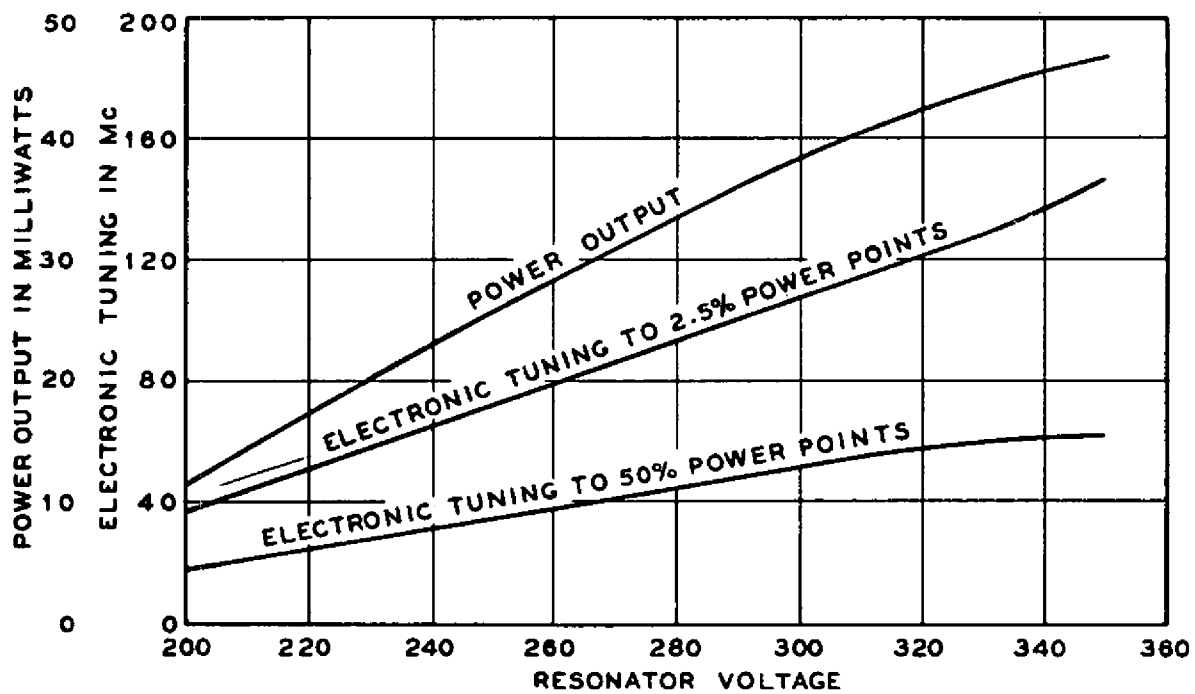


FIG.6

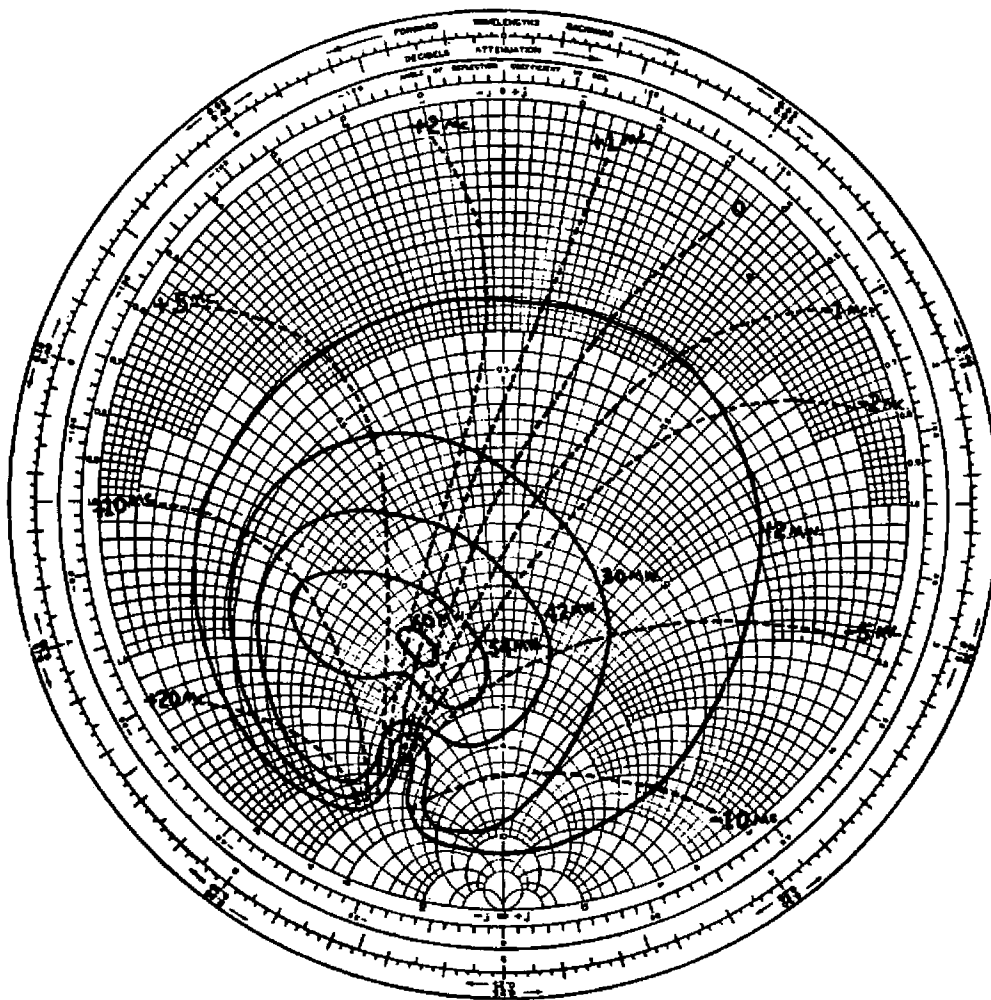


FIG. 7

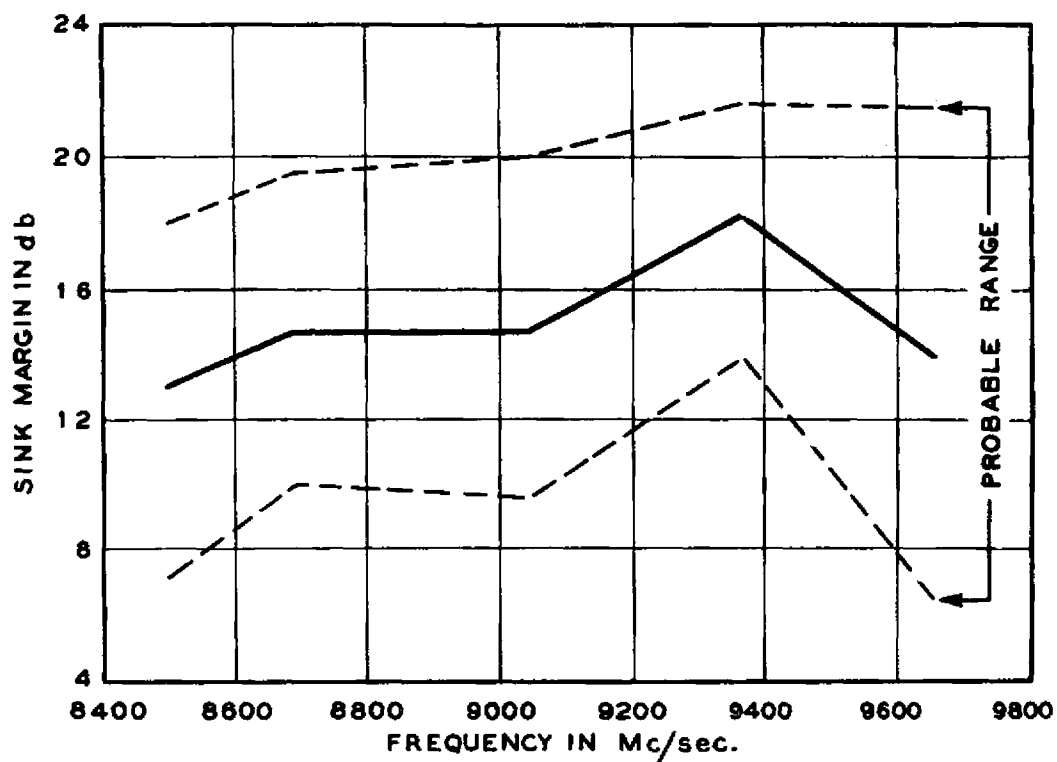


FIG. 8

TEMPERATURE COEFFICIENT

The materials used in mechanical tuning mechanism have been especially selected so that their thermal expansion and heat conduction coefficients will balance with those of the other parts of the tube to produce a desirable ambient temperature coefficient. This coefficient lies between 0 and $-0.20 \text{ Mc/s/}^{\circ}\text{C}$.

The tube should be operated either in still air or in uniform drafts since varying drafts playing on the tube will produce fluctuations in the oscillating frequencies.

The tube will oscillate at a frequency with 5 Mc/sec of the equilibrium value approximately 6 minutes after power is applied, provided the tube is in still air having an ambient temperature that is nearly constant.

AFFECT OF ATMOSPHERIC PRESSURE ON FREQUENCY

The frequency of oscillation of the tube is affected by atmospheric pressure. The variation of the frequency with altitude for constant ambient temperature is shown in Figure 9, thermal effects will superimpose upon this variation.

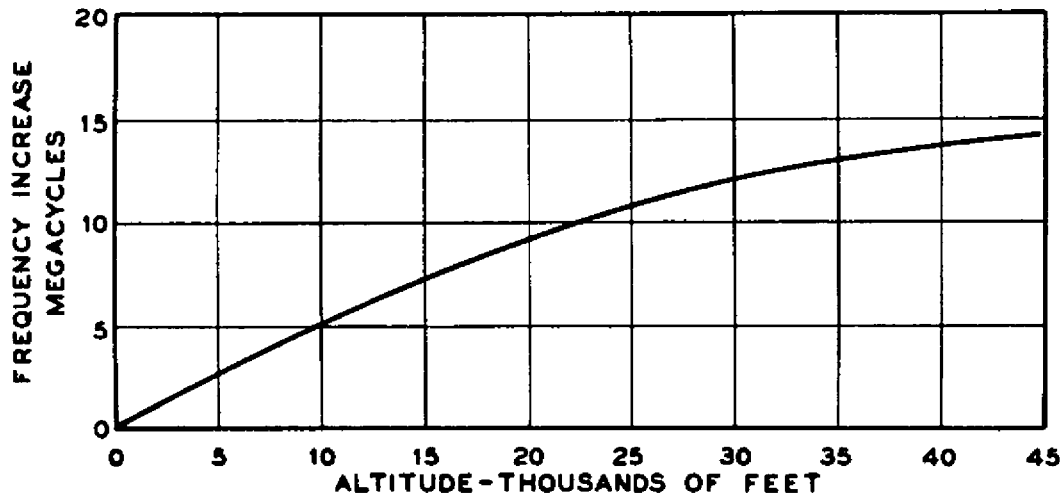


FIG. 9

PULSED OPERATION

This tube may be pulse operated for use in test equipment. Successful operation has been achieved by setting the repeller voltage at a value such that sustained oscillation does not occur. A square wave pulse is then applied which drives the repeller sufficiently positive or negative to reach the oscillating conditions. To obtain a square wave output the drive should not exceed the value to reach the optimum power output condition. The resonator voltage is held fixed.

Successful operation has also been obtained by setting the resonator cathode voltage at a value such that sustained oscillation does not occur. A square wave pulse is then applied to drive the cathode sufficiently negative to provide the operating condition. The repeller cathode voltage is set to provide the optimum condition with the square wave applied. For this latter method a greater peak resonator voltage is allowable than for steady operation but the power input to the tube should not exceed that for the maximum rating. If the tube is switched from CW operation to pulse operation at the same peak input, a frequency shift will result from thermal effects. The amount of this shift will depend upon the duty cycle, and for the extreme case of the very short duty cycle may be in the order of 10 Mc. For this reason the first method of operation is sometimes preferred.

The interelectrode capacitances which may be of importance in pulse operation are as follows:

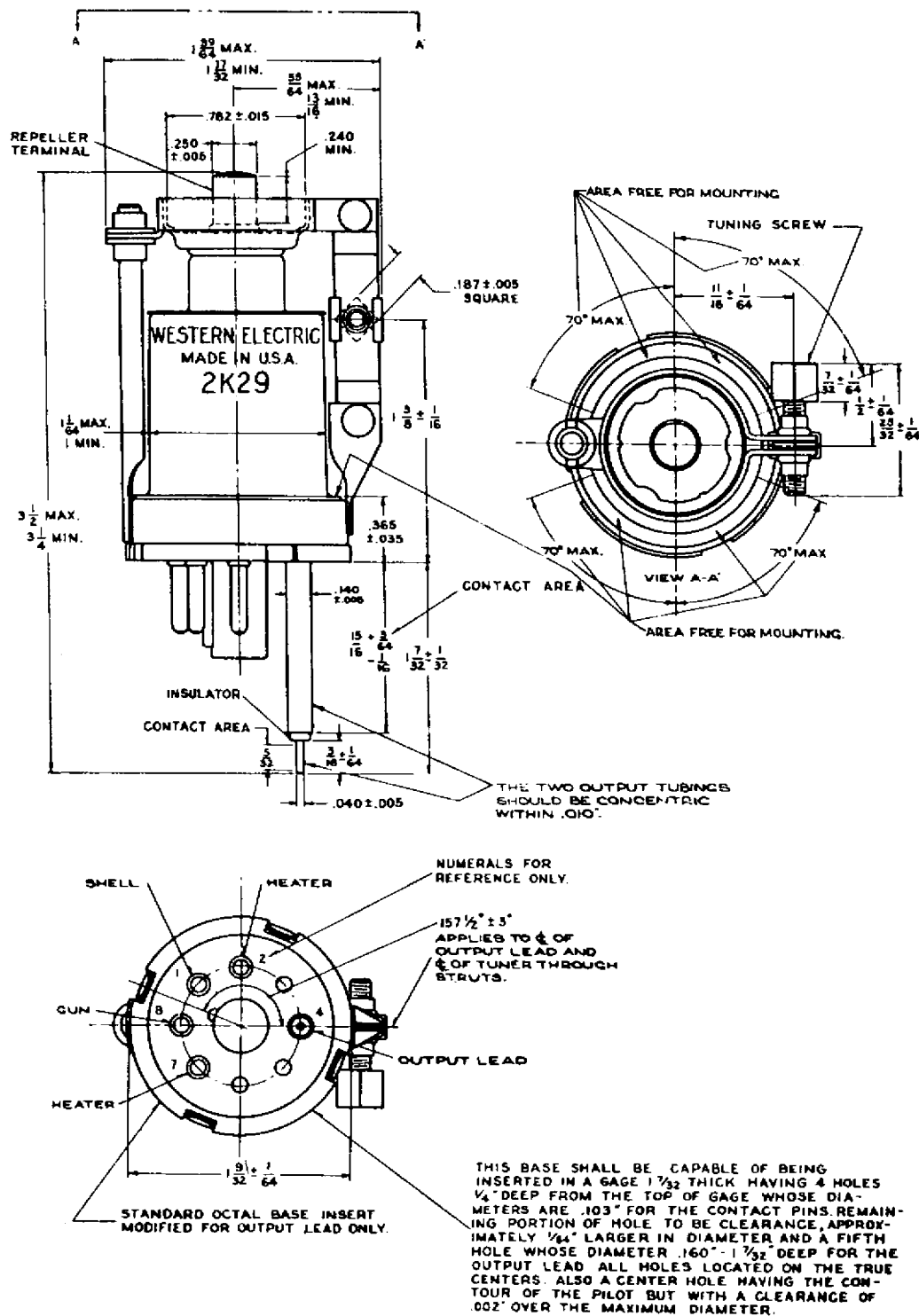
Repeller to resonator	3.0 mmf
Cathode to resonator (heater tied to cathode)	8.0 mmf
Heater to cathode	3.0 mmf

TECHNICAL INFORMATION WESTERN ELECTRIC 2K29 VACUUM TUBE

Note:

The information contained herein is tentative.

It is recommended that proposed operating conditions for specific applications be discussed with Department 1400 of the Bell Telephone Laboratories.



NOTE: THIS SHEET DOES NOT IMPLY
COMMERCIAL AVAILABILITY OF
THE TUBE.

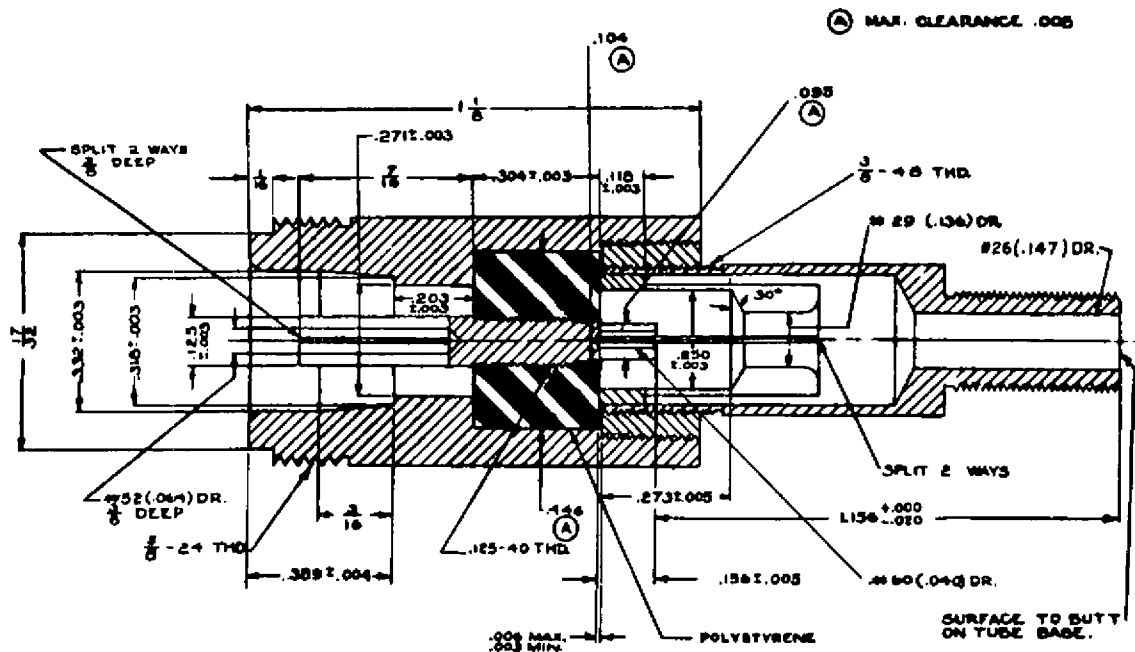


FIG. 1

ALL METAL PARTS BRASS SILVER PLATED 25 M.S.I

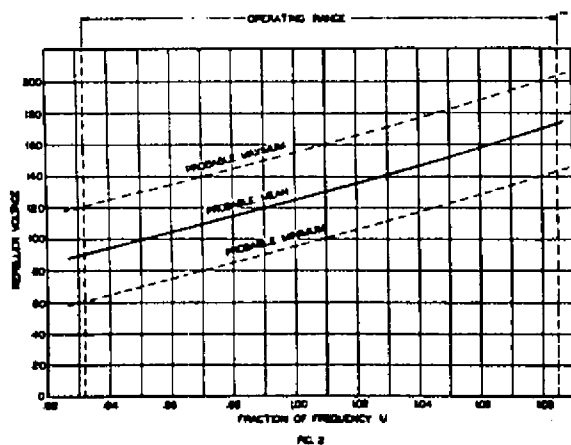


FIG. 2

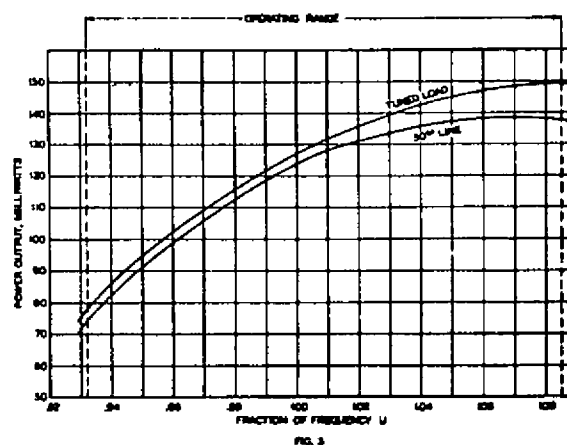


FIG. 3

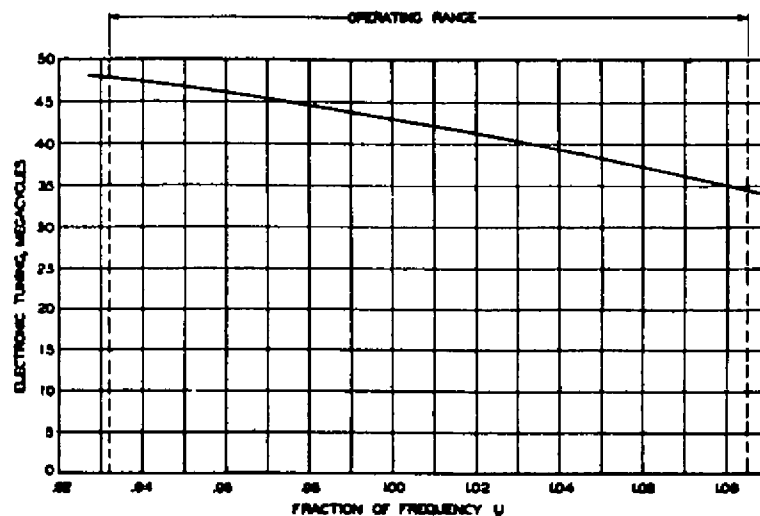


FIG. 4

CLASSIFICATION

The 2K29 vacuum tube is an ultra high frequency oscillator of the reflex type. The resonant circuit is contained within the tube. Means for mechanically tuning the resonant circuit are provided by the bow arrangement integral with each tube. Motion of the tuning bow produces motion of a diaphragm which forms one of the cavity walls. The tube has been developed for operation within a frequency range of 0.931 U to 1.065 U where U is the midpoint of the S_w Frequency band.

MOUNTING

This tube employs a modified intermediate octal wafer type base with the number four pin removed and the hole enlarged to allow the coaxial output line to pass through. The output line has been designed for direct mechanical connection to a suitable coaxial coupling. The polystyrene insulator should be kept clean to avoid power loss in a conducting surface film. The tube may be mounted in either a horizontal or vertical position. The number four pin of the socket must be enlarged to pass the coaxial output line. The coaxial coupling should not depend upon the tube coaxial output line for mechanical support. Care should be taken to insure that the coaxial coupling is in alignment with the tube coaxial output line. The tube should be fastened rigidly to the socket mounting by clamping at the base and adjacent platform only. The tube must not be clamped above the shoulder of the platform which is located .365" ± .035" above the bottom surface of the base.

OPERATING CONDITIONS AND CHARACTERISTICS FOR CONTINUOUS OPERATION

	Normal	Absolute Maximum
Heater voltage	6.3	6.3 ±8% volts
Heater current	0.44	amperes
Potential difference between heater and cathode	0	±45 volts
Resonator voltage	300	330 volts
Cathode current	22	35 milliamperes
Repeller voltage range	-20 to -300	-350 volts
Ambient temperature		110°C *

* This is the temperature surrounding the bulb proper. The temperature of the coaxial line below the base must not exceed 75°C.

The life of the 2K29 type tube will depend upon the operating conditions. Operation above the normal conditions will decrease the useful life.

The Heater should be operated at as near as possible to the normal value of 6.3 volts.

The inner and outer conductors of the coaxial output line are at the same potential as the resonator. The resonator may be operated at a potential other than that of the coaxial line if suitable by-pass condensers are provided in the coupler.

MECHANICAL TUNING ADJUSTMENT

The mechanical tuning mechanism and flexible diaphragm has been designed to afford an occasional adjustment of frequency. It is not intended for use where continual or frequent adjustment is required.

When putting a tube into service, adjustment to the correct frequency is made by manipulation of the bow and repeller voltage. The bow should then be flexed a number of times to relax the strains in the system. By decreasing the flexing successively from a maximum of one full turn to zero in 8 or 10 flexes, the desired frequency will be found to be essentially stable.

REPELLER VOLTAGE RANGE

Oscillating conditions may be obtained in a given tube at a number of different repeller voltages. Only one mode is recommended. This mode will be found in the repeller voltage ranges shown between the broken lines of Fig. 2. A typical curve is given as a solid line.

POWER OUTPUT

Curves for power output as a function of frequency are given in Fig. 3. The upper curve gives the power output measured into an adjustable load. This curve is approximately average for pre-production tubes made to date. The curve immediately below this curve gives the power output into a fixed load. Here the tube coupled through a connector, details of which are shown in Fig. 1, is worked into a 50 ohm resistive load. The load consists of a section of 50 ohm lossy line operating into a load adjusted to 50 ohms at the frequency of measurement. The coupler is designed to couple to a (Neill) fitting D-163446 (CW-49288).

The critical dimensions in the coupler of Fig. 1 are given therein. This coupler maintains an impedance of essentially 50 ohms throughout its length. The coupler may be made with or without by-pass condensers. These condensers are not illustrated in the unit shown. If desired, they should be designed to maintain the 50 ohm impedance.

The lowest curve shown in Fig. 3 is the probable minimum power which will be found in any tube using the coupler of Fig. 1.

ELECTRONIC TUNING

The frequency of oscillators of the 2K29 type may be varied over a restricted range by small variations in the repeller voltage. In order to make use of this characteristic, special design features have been incorporated to minimize a type of discontinuity in the electronic tuning characteristic which has been labeled electronic tuning hysteresis. In system uses where the electronic tuning feature, defined below, is used for frequency control a maximum of electronic tuning is desired. The 2K29 has been designed to provide an essentially uniform electronic tuning characteristic over the operating frequency range.

Electronic tuning characteristics for the 2K29 tube are given in Fig. 4. The results are obtained while working the tube into a tunable load adjusted for maximum power output. The electronic tuning range is here expressed in terms of the number of megacycles between two repeller voltages at which the power is 1/2 the maximum value for the given nominal wavelength. The results of measuring the electronic tuning range using the fixed load defined by the coupler of Fig. 1 and a 50 ohm line are coincident within 5% of the values given for the tunable load measurements.

There are two to three repeller-cathode voltages for which these tubes will oscillate when the resonator voltage is 300 volts. In order to minimize hysteresis from the electronic tuning characteristic it is necessary to restrict the operation to the mode for which data were given in Figs. 1 and 2. The amount of electronic tuning and its variation with the repeller-cathode voltage depend upon the type of load and strength of coupling to the load. It is important in operation of the tube in applications where the maximum electronic tuning range is required that the load should be essentially resistive. A highly reactive load will markedly decrease the available electronic tuning range. It is undesirable to adjust the r.f. output of the oscillator by changing the resonator voltage since the electronic tuning range decreases more rapidly than the power output as the resonator voltage is decreased and the electrical tuning performance is likely to suffer.

TEMPERATURE COEFFICIENT

The materials used in the mechanical tuning mechanism have been especially selected so that their thermal expansion and heat conduction coefficients will cooperate with those of the other parts of the tube to produce a desirable temperature coefficient. The coefficient for the 2K29 tube lies between +0.05 and -0.10 megacycles per degree centigrade.

The tube should be operated in either still air or in a uniform draft since varying drafts playing on the tube will produce fluctuations in the oscillating frequency.

PULSED OPERATION

This tube may be pulse operated for use in test equipment. Successful operation has been achieved by setting the resonator voltage at a value such that sustained oscillation does not occur. A square wave pulse is then applied which drives the cathode negative sufficiently to provide the oscillating condition. The repeller-cathode voltage is set to provide the optimum condition with the square wave applied. In pulsed operation a greater resonator potential is allowable than in steady operation, but the power input to the tube should not exceed that for the maximum rating.

TYPE 342A

WATER COOLED TRIODE

RELEASE NO. 405

APRIL 30, 1945

Filament—Tungsten

Filament voltage.....	20.0 volts, a.c.
Nominal filament current.....	67.0 amperes
Average thermionic emission.....	10.0 amperes

Average Direct Interelectrode Capacitances

Plate to grid.....	27 $\mu\text{f.}$
Grid to filament.....	19 $\mu\text{f.}$
Plate to filament.....	2.5 $\mu\text{f.}$

Average Characteristics at plate voltage of 15,000 and plate current of 1.30 amperes.

Amplification factor.....	40
Plate resistance.....	5860 ohms
Grid to plate transconductance.....	6820 micromhos

Operation**Maximum Ratings**

Max. direct plate voltage.....	20,000 volts
Max. direct plate current.....	2.5 amperes
Max. plate dissipation.....	25,000 watts
Max. grid dissipation.....	400 watts
Max. r-f grid current.....	40 amperes
Max. frequency for the above ratings.....	4 megacycles
Max. plate voltage for upper frequency limit of 16 Mc.....	10,000 volts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage.....	15,000	12,500 volts
Grid bias.....	-200	-160 volts
Direct plate current per tube		
No drive.....	0.40	0.35 ampere
Max. drive.....	1.6	1.6 amperes
Plate dissipation, per tube.....	9,000	7,200 watts
Load resistance, plate-to-plate.....	9,600	7,680 ohms
Load resistance, per tube.....	2,400	1,920 ohms
Approximate maximum output—2 tubes.....	30,000	24,000 watts
Recommended power for driving stage.....	1,000	1,000 watts

Class B Radio-Frequency Amplifier

Direct plate voltage.....	18,000	12,500 volts
Direct plate current for carrier conditions.....	1.4	1.4 amperes
Grid bias.....	-450	-300 volts
Approx. carrier watts for use with 100% modulation	8,500	5,800 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage.....	18,000	15,000 volts
Direct plate current.....	2.5	2.5 amperes
Grid bias.....	-675 to -900	-550 to -750 volts
Nominal power output.....	30,000	25,000 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage.....	12,500	10,000 volts
Direct plate current.....	1.2	1.5 amperes
Grid bias.....	-600	-500 volts
Max. direct grid current.....	250	250 milliamperes
Nominal carrier power output.....	10,000	10,000 watts

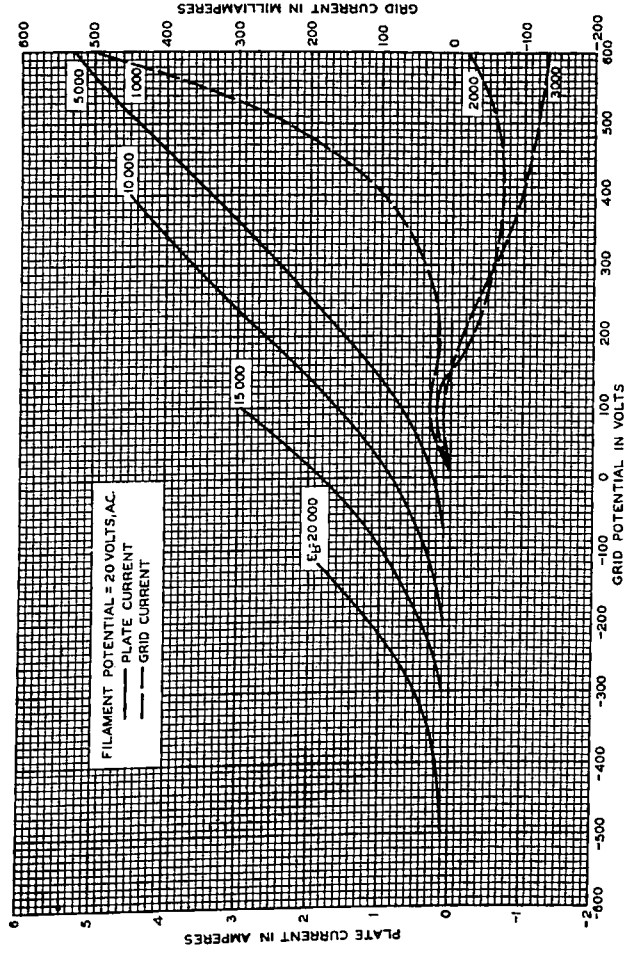


FIG. 2

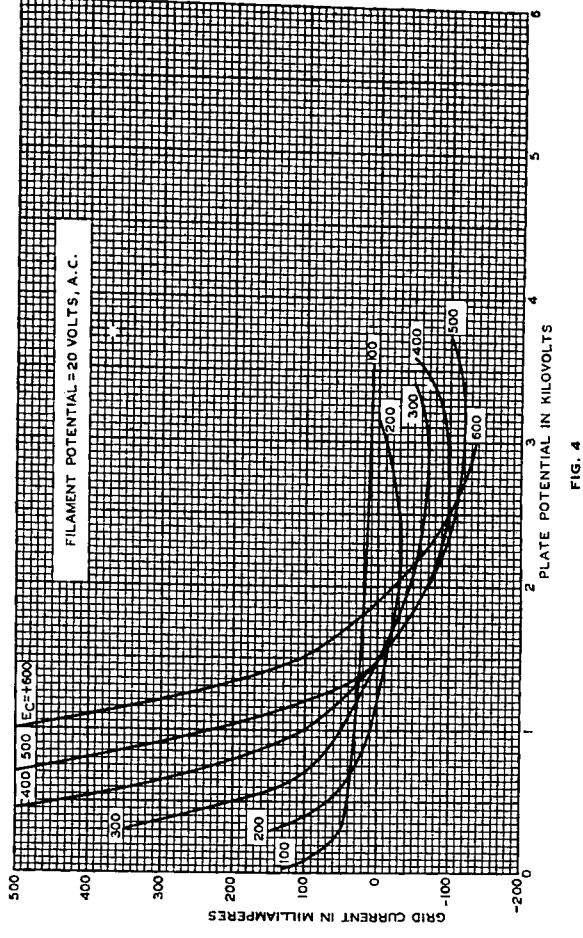


FIG. 4

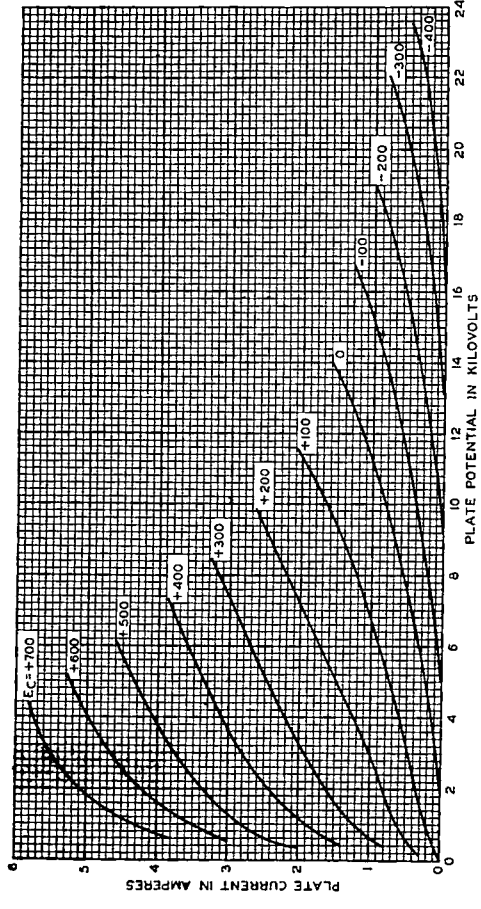


FIG. 3

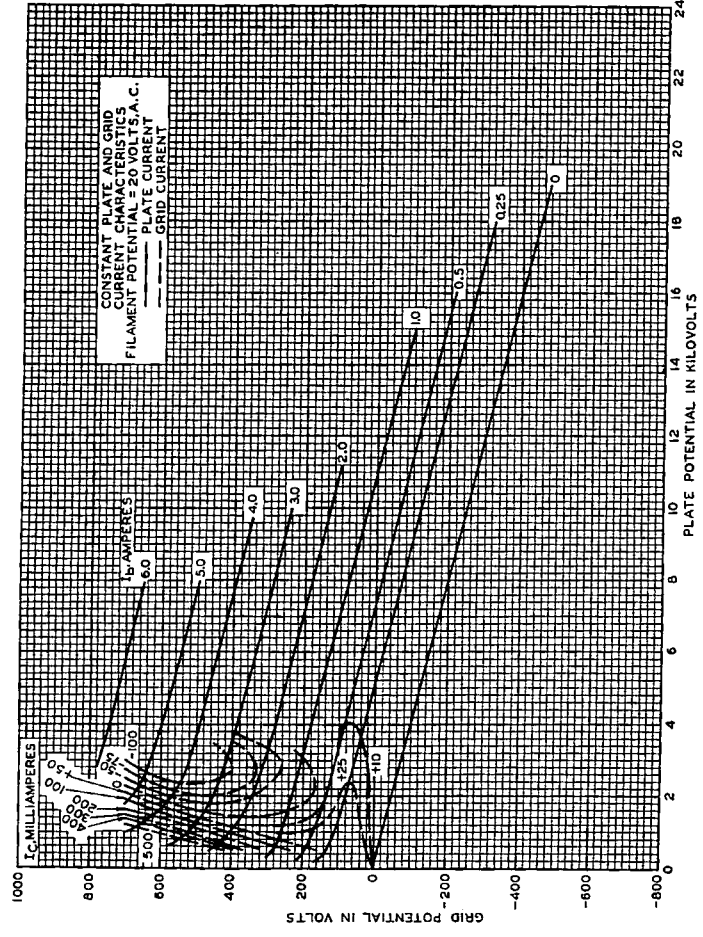
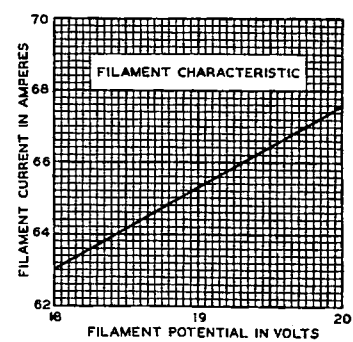
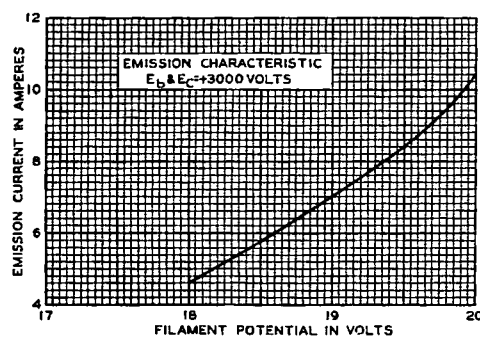
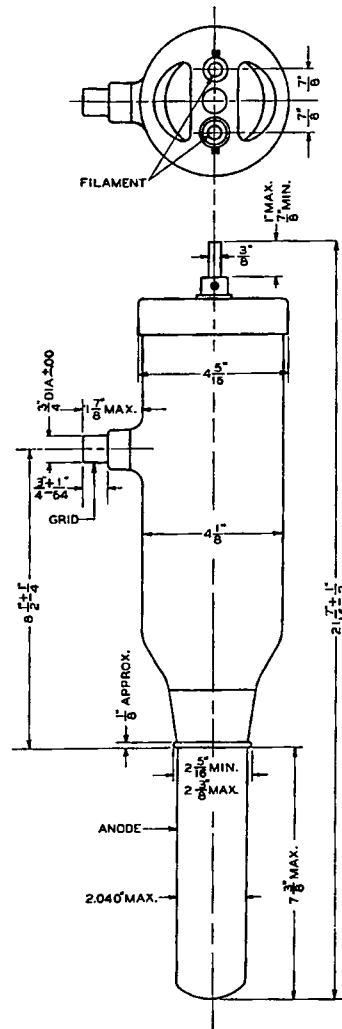


FIG. 5

TYPE 342 A



RADIO MANUFACTURERS ASSOCIATION ENGINEERING DEPARTMENT

TYPE 5649

REFLEX KLYSTRON

RMA DATA BUREAU
90 WEST STREET
NEW YORK 6, N. Y.



GENERAL CHARACTERISTICS

Reflex Oscillator
Internal Cavity

ELECTRICAL CHARACTERISTICS

Heater Voltage	6.3 volts
Heater Current	450 milliamperes
Maximum Frequency	1460 MC
Minimum Frequency	1310 MC

MAXIMUM RATINGS (Absolute Values)

C. W. OPERATION

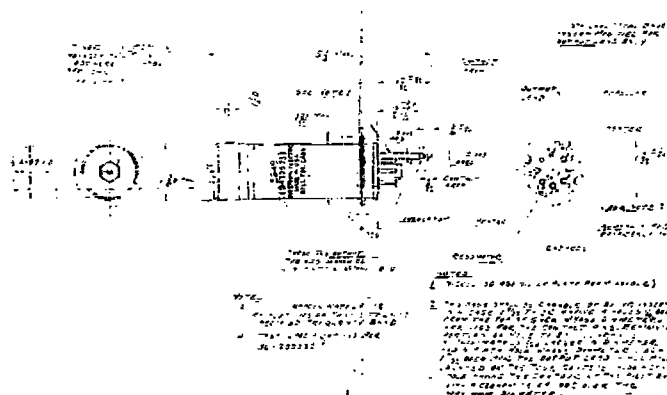
Resonator Voltage	250 volts
Resonator Current	50 milliamperes
Reflector Voltage	-350 volts
Heater-Cathode Voltage (Peak)	(+45 volts -45 volts)
Shell Temperature	130 centigrade

MECHANICAL INFORMATION

Type of Cathode	Coated Unipotential
Base and Physical Specifications	- See Outline Drawing BL-276069
Base Connection	" " " BL-276069
Mounting Data	May be mounted in any position

TYPICAL OPERATION (C.W.)

Frequency	1380 MC
Resonator Voltage	225 volts
Resonator Current	40 milliamperes
Reflector Voltage	-135 volts
Reflector Current	Less than 7 microamperes
Mode Number	150 volts
Electronic Tuning;	
Frequency Variation (E_r range -115 to -155)	6.5 MC
Modulation Sensitivity	0.16 MC/volt
Average Power Output	170 milliwatts



RADIO MANUFACTURERS ASSOCIATION

ENGINEERING DEPARTMENT



GENERAL CHARACTERISTICS

Reflex Oscillator
Internal Cavity

TYPE 5650

REFLEX KLYSTRON

RMA DATA BUREAU
90 WEST STREET
NEW YORK 6, N. Y.

ELECTRICAL CHARACTERISTICS

Heater Voltage	6.3 volts
Heater Current	450 milliamperes
Maximum Frequency	1390 MC
Minimum Frequency	1245 MC

MAXIMUM RATINGS

Resonator Voltage	250 volts
Resonator Current	50 milliamperes
Reflector Voltage	-350 volts
Heater-Cathode Voltage (peak)	(+45 volts (-45 volts
Shell Temperature	130 centigrade

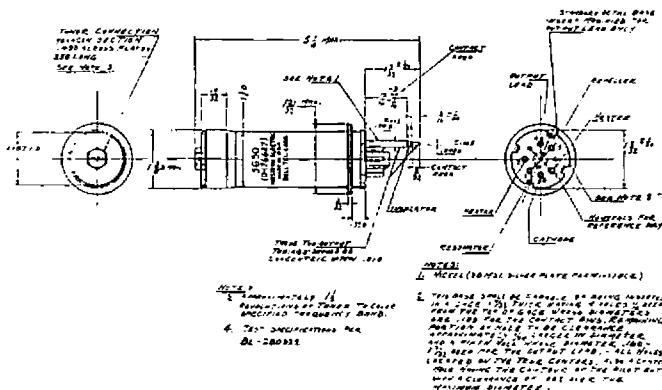
C. W. OPERATION

MECHANICAL INFORMATION

Type of Cathode	Coated Unipotential
Base and Physical Dimensions -	See outline Drawing BL-277337
Base Connections	" " " BL-277337
Mounting Data	May be mounted in any position

TYPICAL OPERATION (C.W.)

Frequency	1320 MC
Resonator Voltage	225 volts
Resonator Current	40 milliamperes
Reflector Voltage	-120 volts
Reflector Current	Less than 7 microamperes
Mode Number	150 volts
Electronic Tuning;	
Frequency Variation(E_R range-100 to -140)	5.5 MC
Modulation Sensitivity	0.14 MC/volt
Average Power Output	165 milliwatts



REGISTRATION DATA

WESTERN ELECTRIC 5780 MAGNETRON

DESCRIPTION

The 5780 is an integral magnet type tunable magnetron intended for service as a pulsed oscillator capable of operating over a frequency range of 8500 to 9600 megacycles per second. The peak power output is approximately 250 kilowatts and the tube is forced air-cooled.

GENERAL ELECTRICAL DATA

Pre-heat Heater Voltage	20 volts
Pre-heat Heater Current (at 20 volts)	4 ± 0.4 amperes
Minimum Pre-heat Time	180 secs
Heater Cold Resistance	0.5 ohms
Anode-Cathode Capacitance	14 ± 1.5 μmf

MAXIMUM RATINGS, Absolute Values

Heater Voltage	22 volts
Heater Current	4.5 amperes
Heater Surge Current	16.0 amperes
Peak Anode Voltage	40 kv
Peak Anode Current	36 amperes
Average Power Input	600 watts
Duty Cycle	.001
Pulse Duration	0.30 usec.
Rate of Rise of Anode Voltage	300 kv/usec.
Anode Temperature	100°C

GENERAL MECHANICAL DATA

Mounting Position	May be mounted in any position - see 4 hole mounting plate in Fig. 1.
Net Weight	16 pounds
Cooling Data	
To limit rise in body temperature to 50°C for a dissipation of 450 watts	20 cfm
Coupling Between Tube and Load	Waveguide Choke
Input Connection	See Footnote A
Output Connection	See Footnote B

The output section is coupled to RG-51/U waveguide by means of a standard waveguide flange.

Note A: The coaxial cathode input connector shall utilize a heater shunt capacitor in close proximity to the cathode input terminal so as to minimize voltage surges which could damage the heater. See Figure 1.

Note B: A connection has been provided to the "arc quencher" wire, by means of a standard grid cap. When wired into the appropriate voltage supply and relay circuitry an arc across the output window, caused by RF voltage breakdown in the waveguide load, can be extinguished by automatically turning off the applied pulse voltage momentarily. The effect of the quencher is to protect the output window from "suck in" when such an arc is permitted to run.

TYPICAL OPERATING CONDITIONS

Frequency	8500 to 9600 Mc
Peak Anode Voltage	
At 8500 Mc	33 ± 1 KV
At 9600 Mc	35 ± 1 KV
Pulling Factor (VSWR 1.5/1)	16 Mc

TYPICAL OPERATION

#	Ef V	If A	Ib mA	epy kv	Pi W	Du	tp μsec.	rrv kv/μs
1.	13.0	3.1	9.5	36	340	.00033	0.24	200
2.	14.5	3.4	4.9	36	175	.00020	0.20	210
3.	11.0	2.3	14.5	36	520	.00072	0.18	160

The data on lines #1, #2 and #3, shown under "Typical Operation" caption, each constitute a satisfactory set of simultaneous operating conditions. Fig. 2 shows typical satisfactory pulse shapes for these, observed when using a Line Type Modulator.

OPERATING DATA

These data are embodied in the following set of figures. A family of curves are shown which represent the spread in range of the tube as manufactured. Data involving VSWR have been carried beyond the 1.5 test value for information purposes only.

Figure 3 This is a plot of required filament current and anode cooling air versus applied average anode power input.

These data were taken under single and simple multiple pulse conditions and it is anticipated that some deviation may occur when complex multiple group pulse conditions are employed.

Figure 4 This is a plot of tuning dial reading versus frequency. It is assumed that thermal equilibrium has been obtained at each of the calibrated points.

Figure 5 This is a plot of both applied peak anode voltage and overall operating efficiency versus peak anode current. The recommended operating range of voltage, current, and efficiency are indicated as a guide within which satisfactory operation is expected. These data were taken at 9100 mc. For lower frequencies the spread will decrease, for high frequencies the spread will increase.

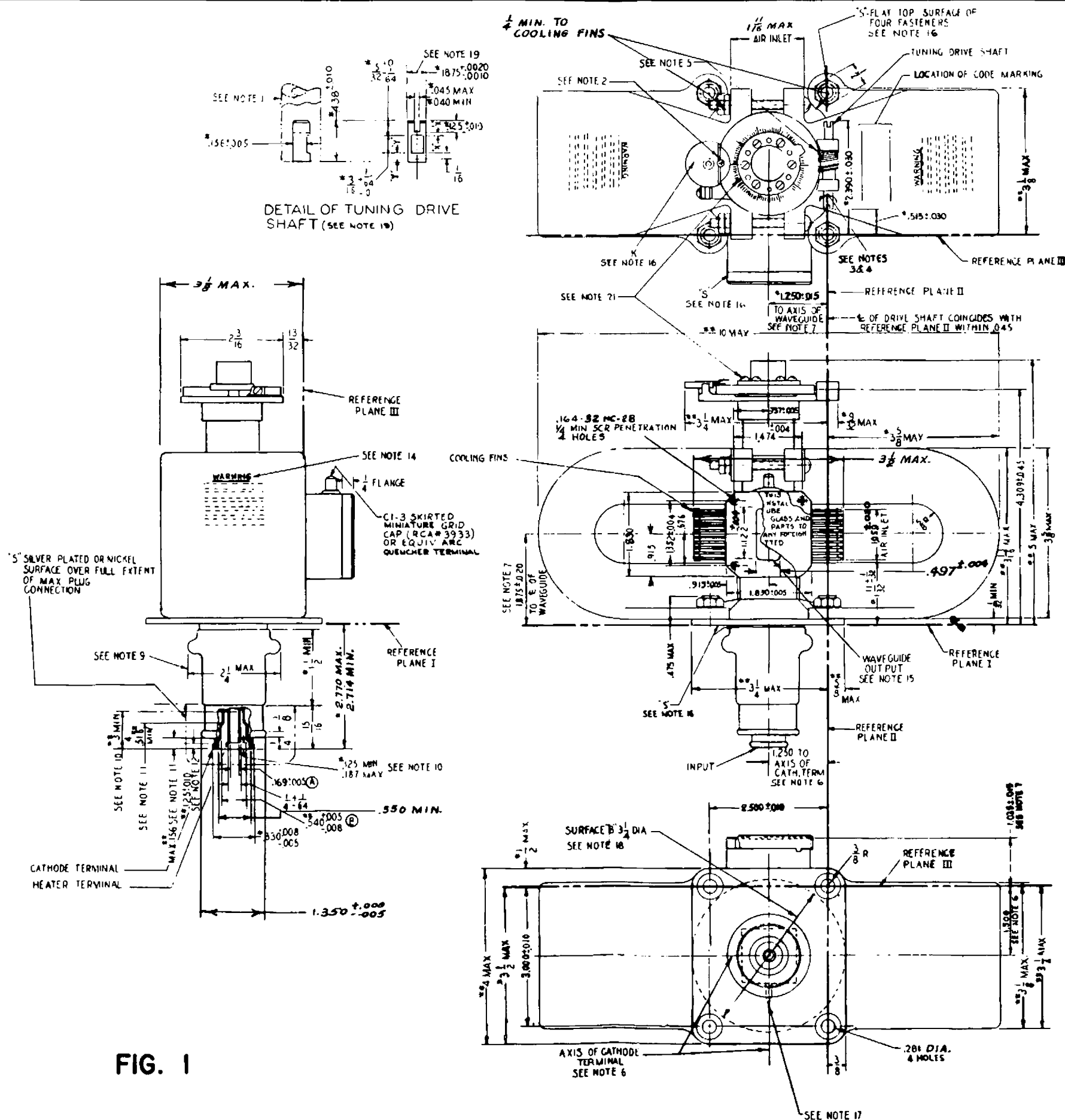
Figure 6 This is a plot of percent of power output change from matched load conditions one can obtain by varying the phase of a 1.5 and a 2 VSWR from sink to anti-sink.

The nominal match curve is obtained relative to the frequency tuning band by equating the output at each frequency point against the power output at 8500 mc. Therefore the change due to load mismatch and phase is that difference between the nominal line and the appropriate sink or anti-sink line at any associated frequency point.

Figure 7 This is a plot of frequency pulling relative to VSWR and represents the greatest variations wherever encountered in the full frequency tuning band.

Figure 8 This is a plot of "phase of sink" vs frequency.

Figure 9 This is a plot of long line relationships vs line length for the specific case of 16 mc pulling which is the 5780 maximum specification limit.



- Notes:
1. A sleeve .195 I.D. X .06 O.D. X 1 inch long shall pass over ends of drive shaft as far as face of worm bracket.
 2. The number on the Geneva appearing through the hole in the Geneva cover indicates complete revolutions of the gear from zero to six. The number on the gear is to be read directly opposite hole position in the Geneva cover. The tube is to be adjusted that with the Geneva set at "0" the upper frequency limit occurs between 0.5 and 2.5 on the gear setting. To obtain the correct value it is necessary to operate the tube for at least 20 minutes under oscillator at full input per FCC-59).
 3. The frequency increases when drive shaft is driven in direction indicated by arrow shown in top view.
 4. Complete frequency range is covered in not more than 180 nor less than 150 turns of drive shaft.
 5. The tuning mechanism shall operate smoothly over the entire mechanical range when subjected to torque of 6 inch ounces max. applied at the drive shaft. In equipment, no less than 6 inch ounces nor more than 3 inch-pounds shall be applied at drive shaft.
 6. The axis of the cathode terminal shall be within a radius of $3/64$ of specified location.
- Note 7 Applies.
7. The limits on location of waveguide output and cathode terminal include angular as well as lateral deviations.
 8. With a pressure of 30 PSI applied at the waveguide output the leak rate of the external choke and the arc suppressor shall not exceed 0.1 cubic inches per minute.
 9. Any portion of the assembly extending below reference plane 1 shall be within a $1-3/16$ inch radius of the specified axis of the input.
 10. Three dimensions define the extremities of the cylindrical section given by the "A" dimension.
 11. These dimensions define the extremities of the cylindrical section given by the "B" dimension.
 12. No clamping means to bear beyond this dimension.
 13. The heater terminal shall be concentric with the cathode terminal within .010.
14. Warning
- Maintain minimum clearance of 2 inches between this magnet and magnetic materials. (Magnets, Steel tools, plates, etc.).
15. The opening of the waveguide shall be enclosed by a dust cover when tube is not in use.
 16. All metal surfaces covered by gray finish except those marked S and drive and stop mechanism (K).
 17. Exhaust ventilation cover shall not extend beyond plane of defined by mounting plate edge.
 18. With the $3-1/4$ dia. resting on a plane surface, coincident with reference plane 1. A .010 gauge $1/8$ wide shall not enter any arc of the base plate outside the $3-1/4$ dia. shall be within .010 of the plane surface.
 19. The $.1875 \pm .002$ dia. does not necessarily apply to the part of the tuning drive shaft between the slot and the keyway designated "Y-Y", and to the $1/16$ wide strip adjacent to the keyway towards the middle of the shaft designated "Y-Y". These parts of the shaft may be slightly less than the $.1875 \pm .002$ dia. to obtain better deburring, but may not be larger than the $.1875 \pm .002$ diameter.
 20. Dimensions with a single asterisk (*) denote design test. Dimensions with a double asterisk (**) denote qualification approval.
 21. Geneva stop + RH Brass machine screws are optional.

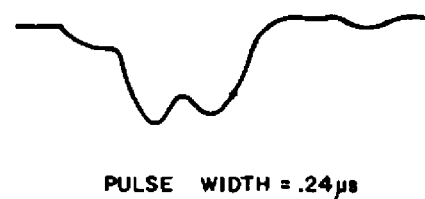
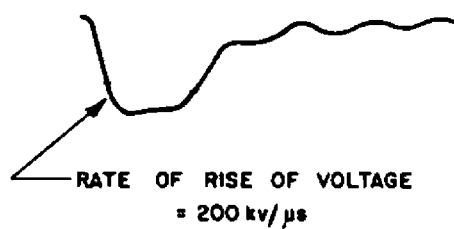
TOLERANCE UNLESS OTHERWISE INDICATED
FRACTIONAL $\pm \frac{1}{16}$
DECIMAL $\pm .005$

TYPICAL 5780 PULSES

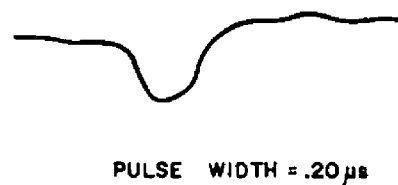
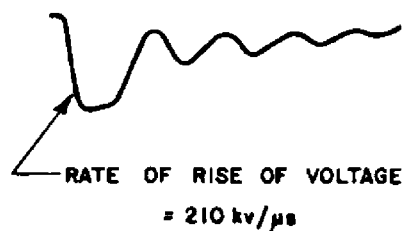
ANODE VOLTAGE

ANODE CURRENT

TYPICAL OPERATION #1



TYPICAL OPERATION #2



TYPICAL OPERATION #3

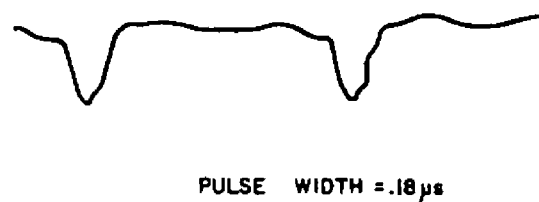
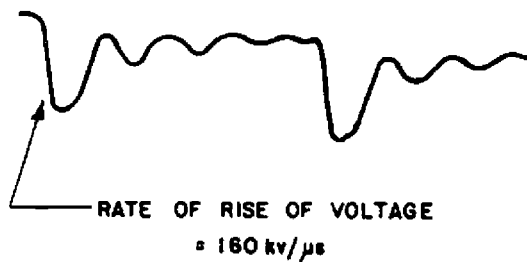


FIG. 2

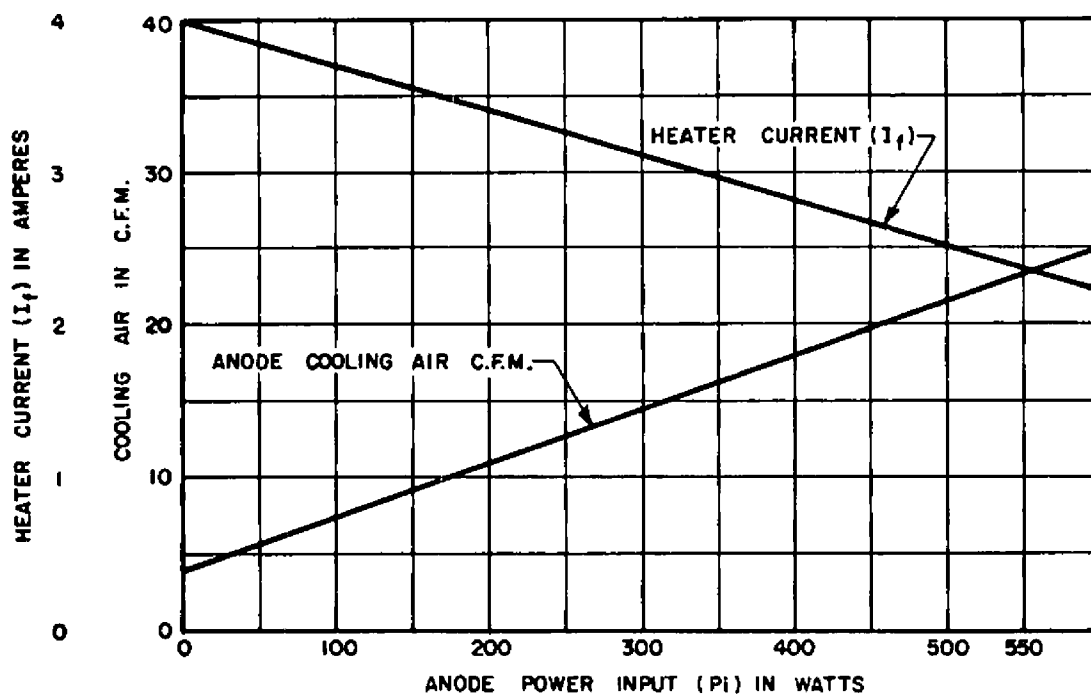


FIG. 3

NOTE: The air cooling information plotted in Figure 3 above is based on a maximum rise in magnetron body temperature of 50°C above a maximum ambient of 50°C with an anode dissipation of 450 watts.

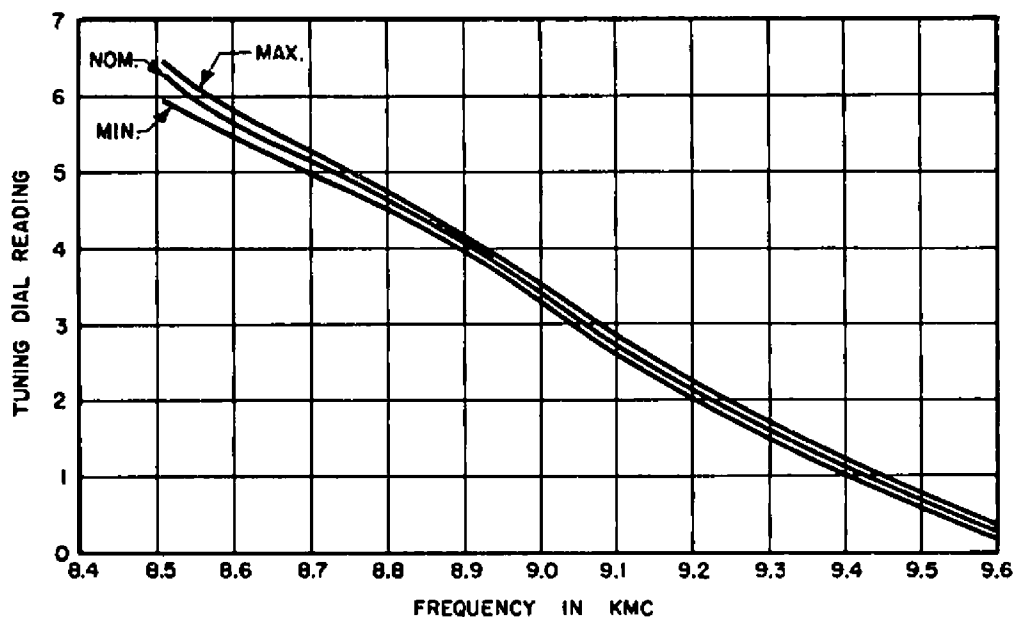


FIG. 4

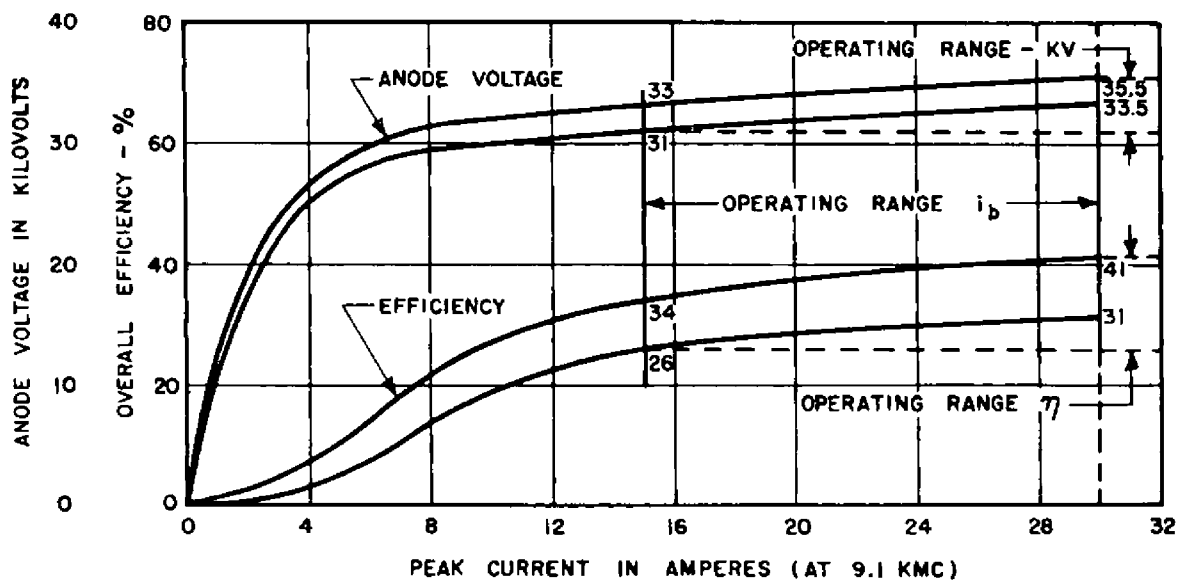


FIG. 5

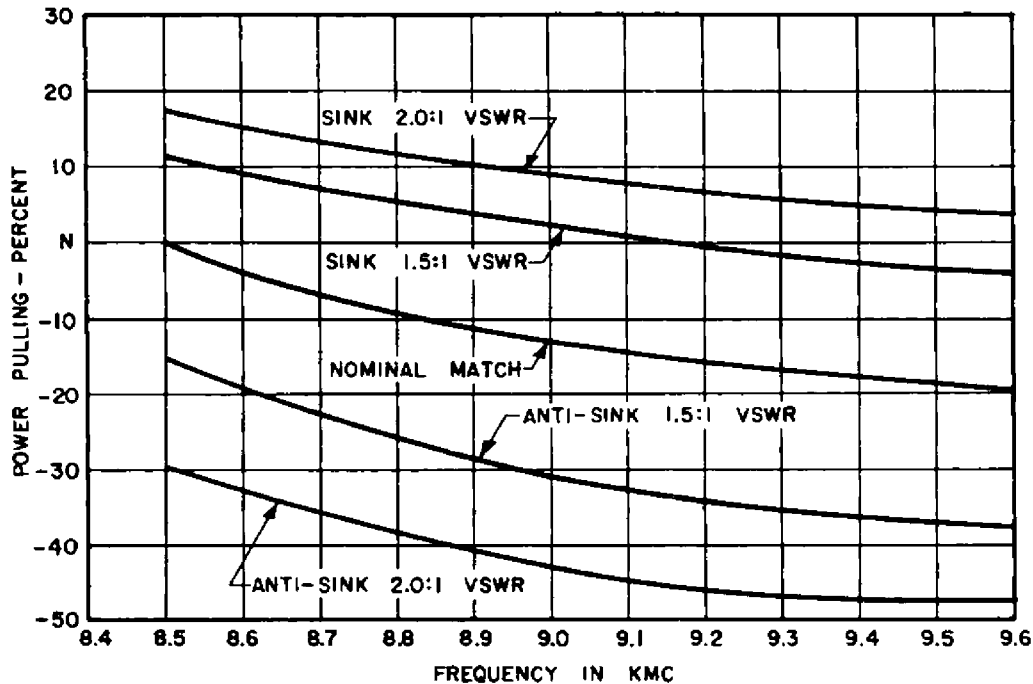


FIG. 6

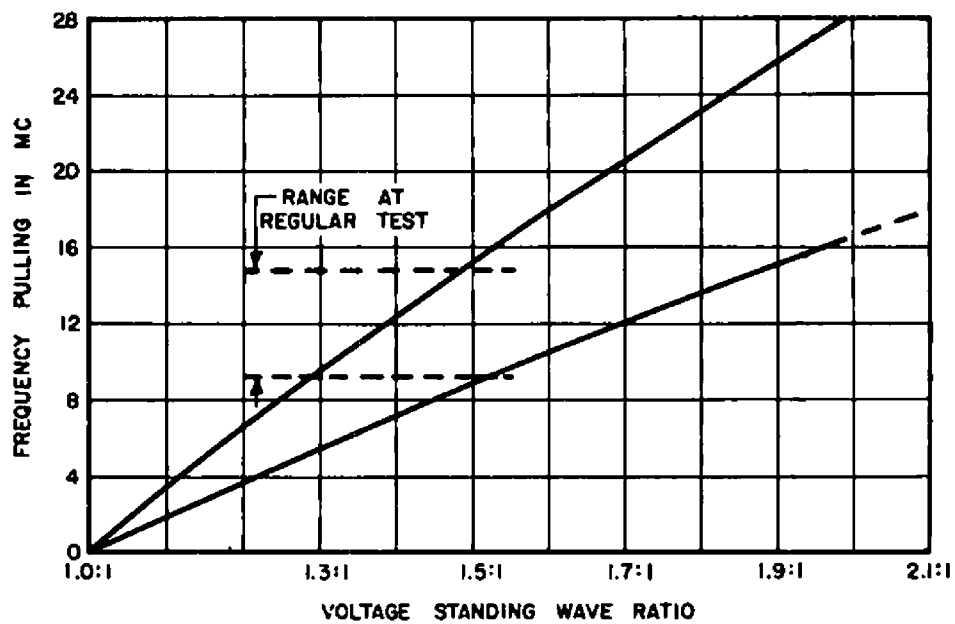


FIG. 7

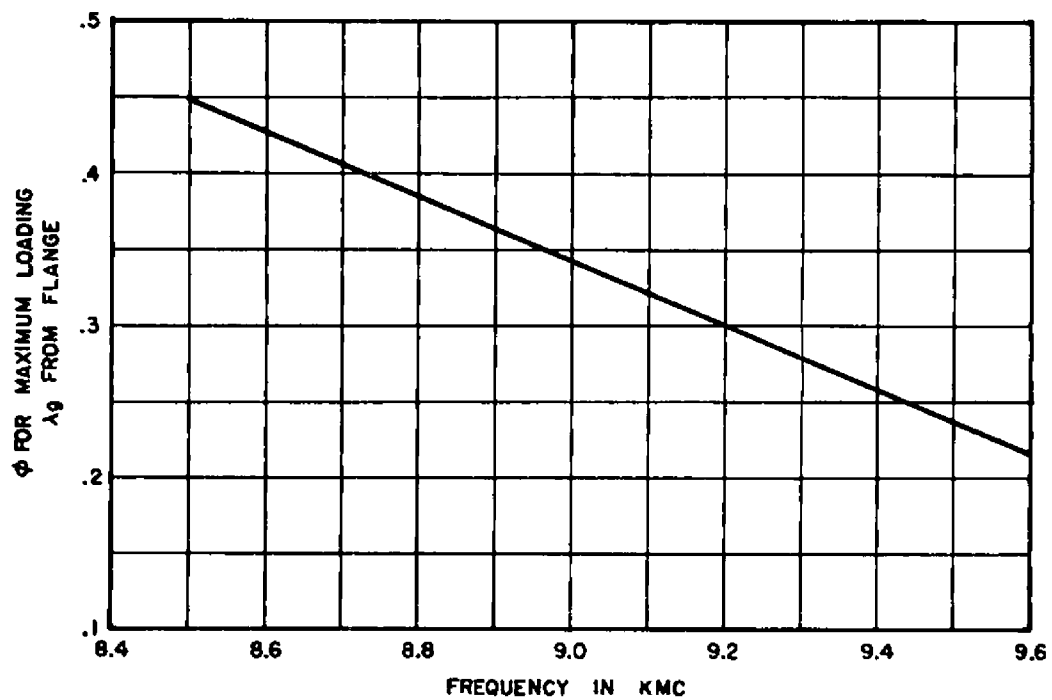


FIG. 8

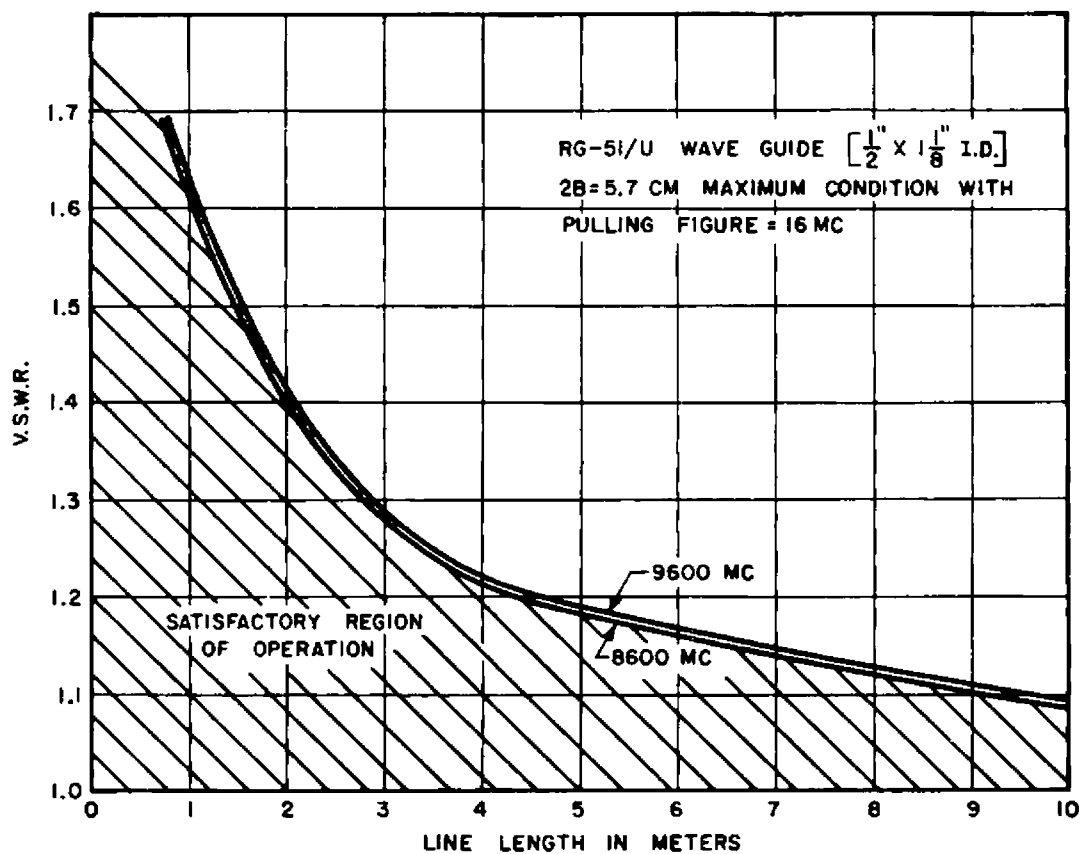


FIG. 9

REGISTRATION DATA

WESTERN ELECTRIC 5795 MAGNETRON

DESCRIPTION

The 5795 is an integral magnet type tunable magnetron intended for service as a pulsed oscillator capable of operating over a frequency range of 3100 to 3500 megacycles per second. The peak power output is approximately 1000 kilowatts and the tube is forced-air cooled.

GENERAL ELECTRICAL DATA

Pre-heat Heater Voltage	107± 7 volts
Pre-heat Heater Current (at 107 volts)	3.65± 0.35 amperes
Minimum Pre-heat Time	600 secs
Heater Cold Resistance	3.2 ohms

RATINGS, Absolute Values

Heater Voltage (Maximum)	120 volts
Pre-heat Time (Minimum)	240 seconds
Heater Surge Current (Maximum)	17 amperes
Peak Anode Voltage (Maximum)	50 kilovolts
Peak Anode Current (Maximum)	50 amperes
Average Power Input (Maximum)	5 kilowatts
Duty Cycle (Maximum)	.0022
Pulse Duration (Maximum)	1.5 μsec.
Rate of Rise of Anode Voltage (Maximum)	220 kv/μsec.
Anode Temperature (Maximum)	110° C

GENERAL MECHANICAL DATA

Recommended Mounting Position	Output vertical facing up.
Net Weight	65 pounds
Coupling Between Tube and Load	Waveguide Flange
Input Connection	See Footnote A
Output Connection	See Footnote B

The output section is coupled to RG-48/U waveguide by means of the choke coupling shown on Fig. 9.

Note A: The coaxial input connector shall utilize a heater shunt capacitor in close proximity to the cathode input terminal so as to minimize voltage surges which could damage the heater. The input connector must have provision for cooling the cathode with an air flow of $4\text{-}3/4" \pm 1/2$ c.f.m.

Note B: Provision should be made externally and in close proximity to the magnetron output window for an "arc quencher", which should be wired into the appropriate voltage supply and relay circuitry, so that an arc across the output window, caused by R.F. voltage breakdown in the waveguide load, can be extinguished by automatically turning off the applied pulse voltage momentarily. The effect of the quencher is to protect the output window from "suck in" when such an arc is permitted to run.

TYPICAL OPERATING CONDITIONS

	<u>Ef</u> <u>V</u>	<u>If</u> <u>A</u>	<u>Ib</u> <u>mA</u>	<u>epy</u> <u>kv</u>	<u>Pi</u> <u>Kw</u>	<u>Du</u>	<u>tp</u> <u>usec.</u>	<u>rrv</u> <u>kv/us</u>
#1	40	2.5	90	45	4.0	.002	1.33	150
#2	65	2.7	60	45	2.6	.00133	1.33	150

The data on lines #1 and #2, shown under "Typical Operation" caption above, each constitute a satisfactory set of simultaneous operating conditions. Fig. 2 shows typical satisfactory pulse shapes for these, observed when using a Line Type Modulator.

COOLING DATA

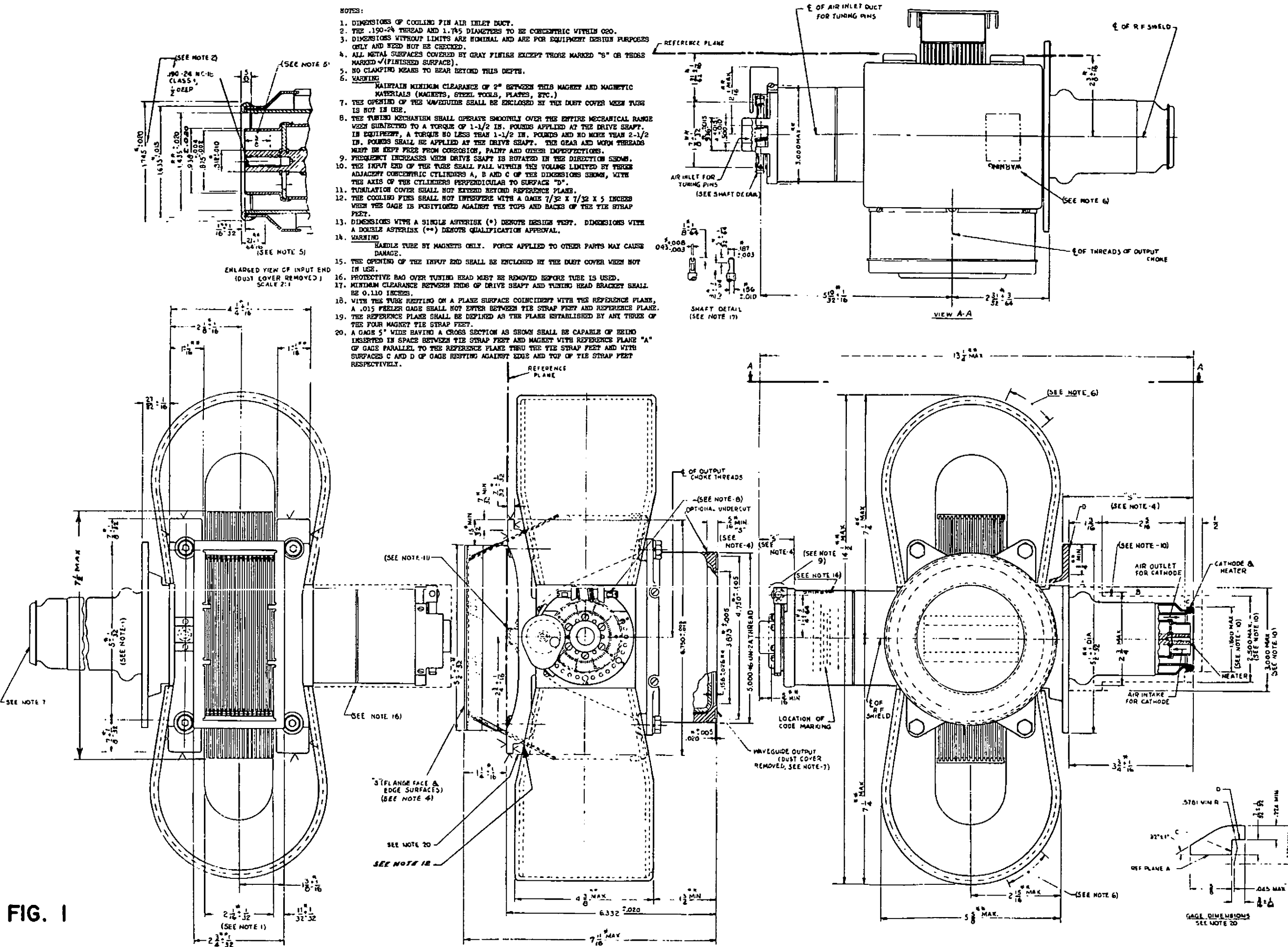
For any ambient temperature to a maximum of 50° C. and any anode dissipation to a maximum of 2250 watts, the tube shall be cooled with forced air as follows:

<u>Locations</u>	<u>Air-flow</u>
Body	300 c.f.m. min. through fins
Cathode	$4\text{-}3/4 \pm 1/2$ c.f.m.
Tuning Head	$6 \pm 1/2$ c.f.m.
Output Window	$1\text{-}1/2$ c.f.m.

OPERATING DATA

These data are embodied in the following set of figures. A family of curves are shown which represents the spread in range of the tube as manufactured. Data involving VSWR have been carried beyond the 1.5 test value for information purposes only.

- Figure 3 This is a plot of required filament current and anode cooling air versus applied average anode power input.
- Figure 4 This is a plot of tuning dial readings versus frequency. It is assumed that thermal equilibrium has been obtained at each of the calibrated points.
- Figure 5 This is a plot of both applied peak anode voltage and overall operating efficiency versus peak anode current. The recommended operating range of voltage, current and efficiency are indicated as a guide within which satisfactory operation is expected. These data were taken at 3300 mc. The spread for lower frequencies will decrease and will increase for higher frequencies.
- Figure 6 This is a plot of percent of power output change, from matched load conditions, one can obtain by varying the phase of a 1.5 and a 2.0 VSWR from sink to anti-sink. The nominal match curve is obtained relative to the frequency tuning band by equating the output at each frequency point against the power output at 3100 mc. Therefore, the change due to load mismatch and phase is that difference between the nominal line and the appropriate sink or anti-sink line at any associated frequency point.
- Figure 7 This is a plot of frequency pulling relative to VSWR and represents the greatest variations wherever encountered in the full frequency tuning band.
- Figure 8 This is a plot of long line relationships versus line length for the specific case of 10 mc pulling which is the maximum specification limit.



NOTES:

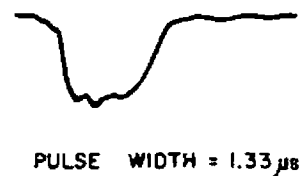
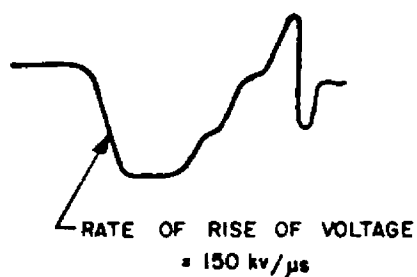
1. DIMENSIONS OF COOLING FIN AIR INLET DUCT.
2. THE .150-24 THREAD AND 1.745 DIAMETERS TO BE CONCENTRIC WITHIN .020.
3. DIMENSIONS WITHOUT LIMITS ARE NOMINAL AND ARE FOR EQUIPMENT DESIGN PURPOSES ONLY AND NEED NOT BE CHECKED.
4. ALL METAL SURFACES COVERED BY GRAY FINISH EXCEPT THOSE MARKED "B" OR THOSE MARKED "C" (FINISHED SURFACE).
5. NO CLAMPING MEANS TO BEAR BEYOND THIS DEPTH.
6. WARNING: MAINTAIN MINIMUM CLEARANCE OF 2" BETWEEN THIS MAGNET AND MAGNETIC MATERIALS (MAGNETS, STEEL TOOLS, PLATES, ETC.)
7. THE OPENING OF THE WAVEGUIDE SHALL BE ENCLOSED BY THE DUST COVER WHEN TUBE IS NOT IN USE.
8. THE TUNING MECHANISM SHALL OPERATE SMOOTHLY OVER THE ENTIRE MECHANICAL RANGE WHEN SUBJECTED TO A TORQUE OF 1-1/2 IN. POUNDS APPLIED AT THE DRIVE SHAFT. IN EQUIPMENT, A TORQUE NO LESS THAN 1-1/2 IN. POUNDS AND NO MORE THAN 2-1/2 IN. POUNDS SHALL BE APPLIED AT THE DRIVE SHAFT. THE GEAR AND WORM THREADS MUST BE KEPT FREE FROM CORROSION, PAINT, AND OTHER IMPURITIES.
9. FREQUENCY INCREASES WHEN DRIVE SHAFT IS ROTATED IN THE DIRECTION SHOWN.
10. THE INPUT END OF THE TUBE SHALL FALL WITHIN THE VOLUME LIMITED BY THREE ADJACENT CONCENTRIC CYLINDERS A, B AND C OF THE DIMENSIONS SHOWN, WITH THE AXIS OF THE CYLINDERS PERPENDICULAR TO SURFACE "D".
11. TUNING COVER SHALL NOT EXTEND BEYOND REFERENCE PLANE.
12. THE COOLING FINS SHALL NOT INTERFERE WITH A GAGE 7/32 X 7/32 X 5 INCHES WHEN THE GAGE IS POSITIONED AGAINST THE TOPS AND BACKS OF THE TIE STRAP FEET.
13. DIMENSIONS WITH A SINGLE ASTERISK (*) DENOTE DESIGN TEST. DIMENSIONS WITH A DOUBLE ASTERISK (**) DENOTE QUALIFICATION APPROVAL.
14. WARNING: HANDLE TUBE BY MAGNETS ONLY. FORCE APPLIED TO OTHER PARTS MAY CAUSE DAMAGE.
15. THE OPENING OF THE INPUT END SHALL BE ENCLOSED BY THE DUST COVER WHEN NOT IN USE.
16. PROTECTIVE BAG OVER TUNING HEAD MUST BE REMOVED BEFORE TUBE IS USED.
17. MINIMUM CLEARANCE BETWEEN ENDS OF DRIVE SHAFT AND TUNING HEAD BRACKET SHALL BE 0.110 INCHES.
18. WITH THE TUBE RESTING ON A PLANE SURFACE COINCIDENT WITH THE REFERENCE PLANE, A .015 FEELER GAUGE SHALL NOT ENTER BETWEEN TIE STRAP FEET AND REFERENCE PLANE.
19. THE REFERENCE PLANE SHALL BE DEFINED AS THE PLANE ESTABLISHED BY ANY THREE OF THE FOUR MAGNET TIE STRAP FEET.
20. A GAGE 5" WIDE HAVING A CROSS SECTION AS SHOWN SHALL BE CAPABLE OF BEING INSERTED IN SPACE BETWEEN TIE STRAP FEET AND MAGNET WITH REFERENCE PLANE "A" OF GAGE PARALLEL TO THE REFERENCE PLANE THRU THE TIE STRAP FEET AND WITH SURFACES C AND D OF GAGE RESTING AGAINST EDGE AND TOP OF TIE STRAP FEET RESPECTIVELY.

TYPICAL 5795 PULSES

ANODE VOLTAGE

ANODE CURRENT

TYPICAL OPERATION #1



TYPICAL OPERATION #2

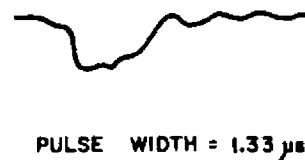
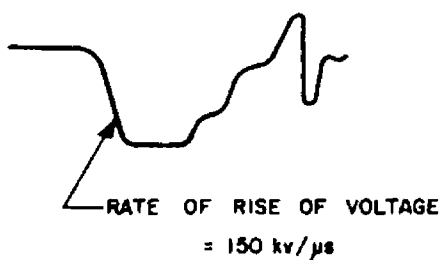


FIG. 2

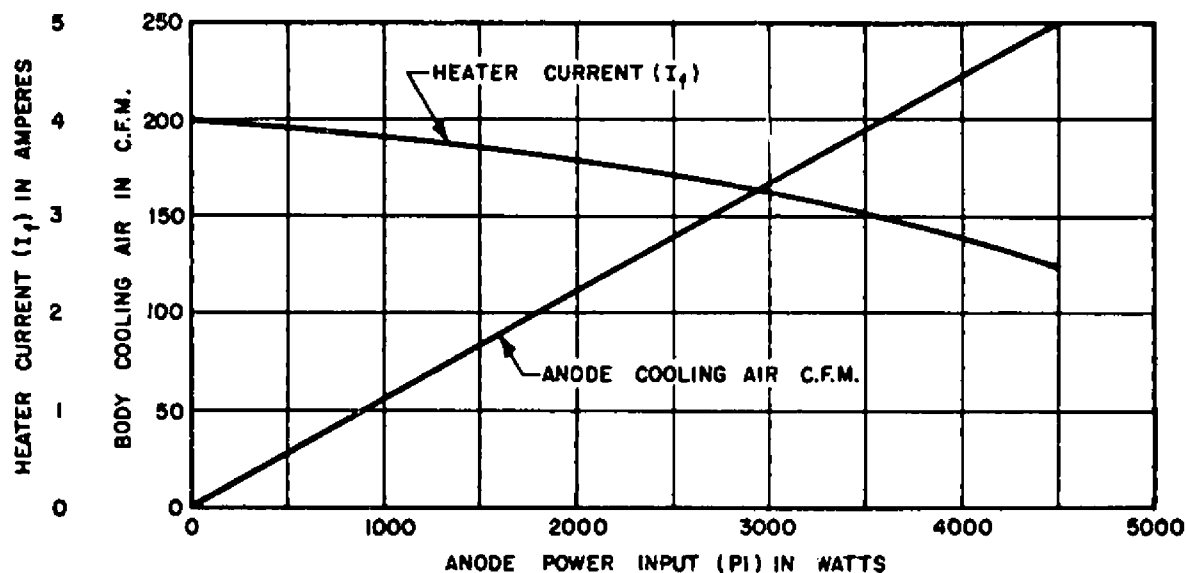


FIG. 3

Note: The air cooling information plotted in Figure 3 above is based on a maximum rise in magnetron body temperature of 60°C above a maximum ambient of 50°C with an anode dissipation of 2250 watts.

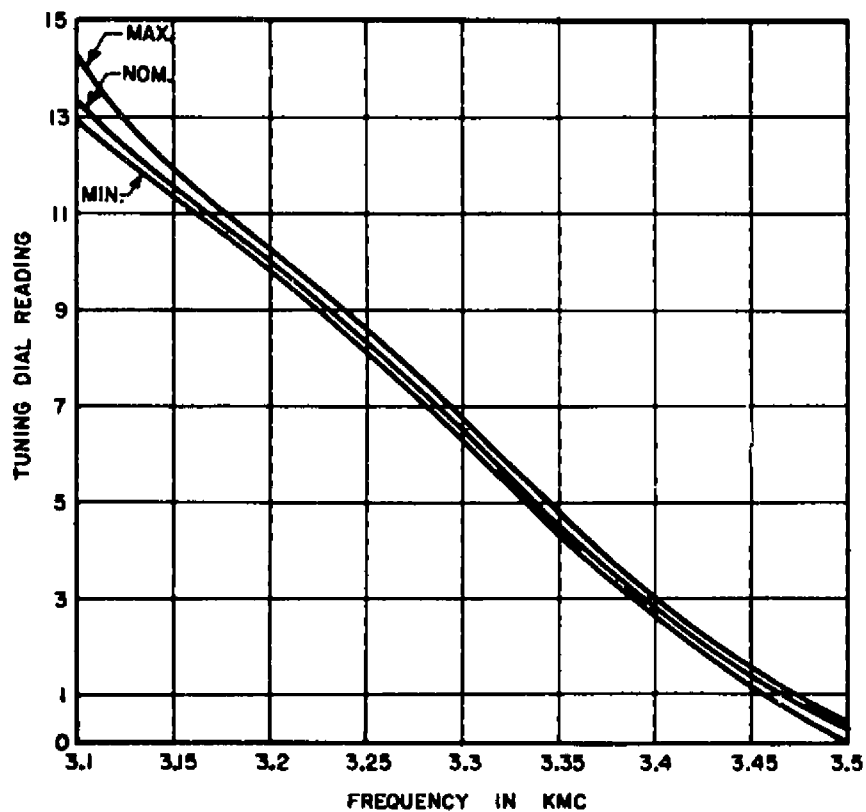


FIG. 4

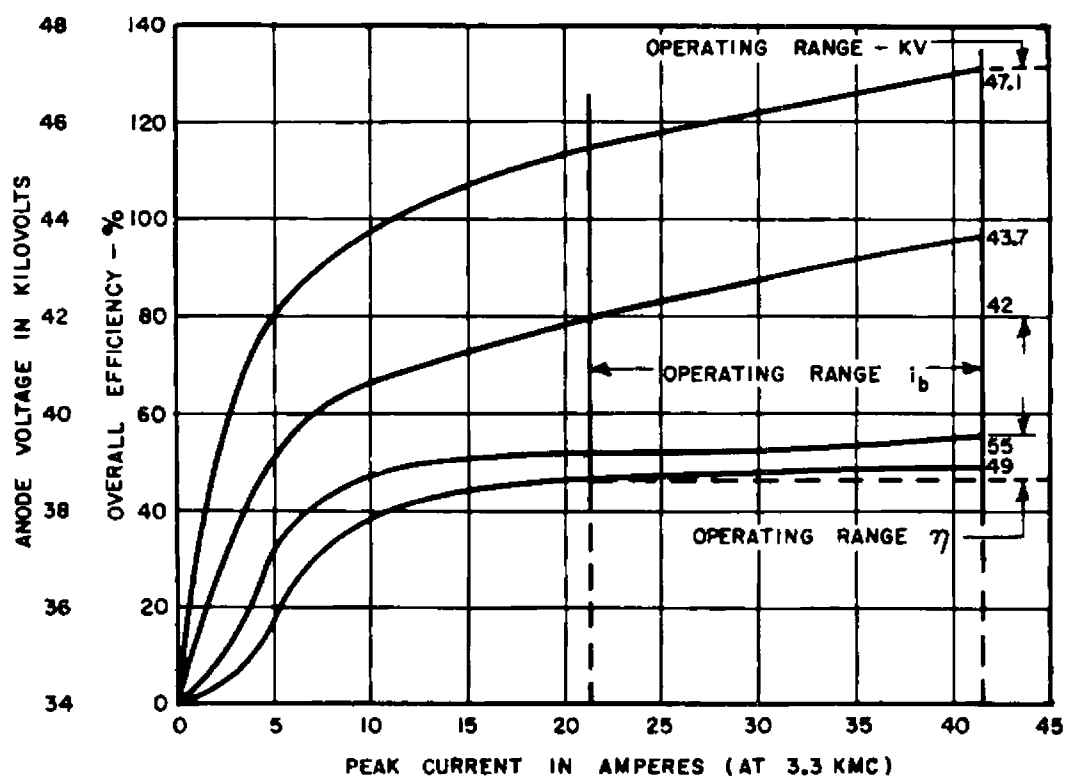


FIG. 5

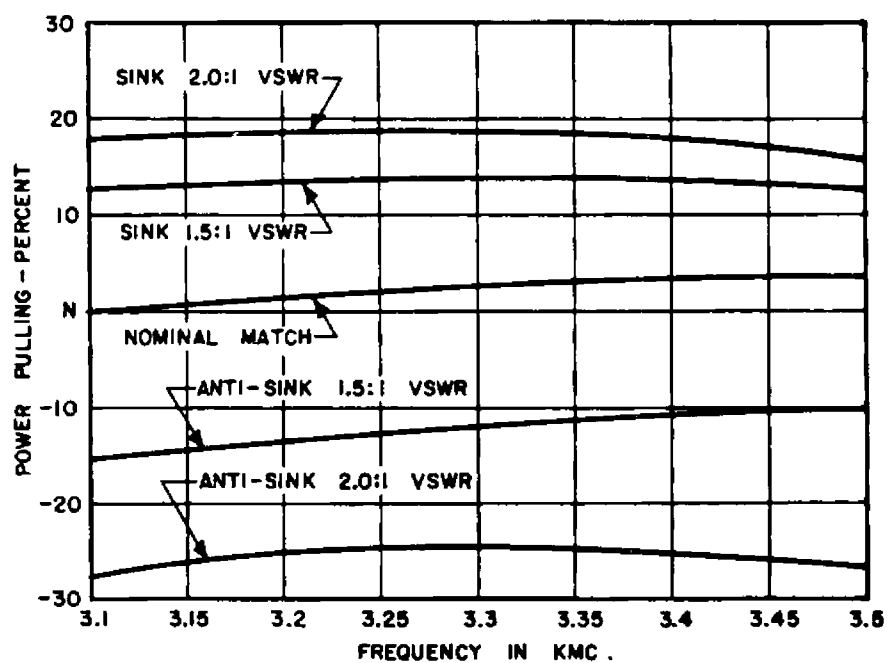


FIG. 6

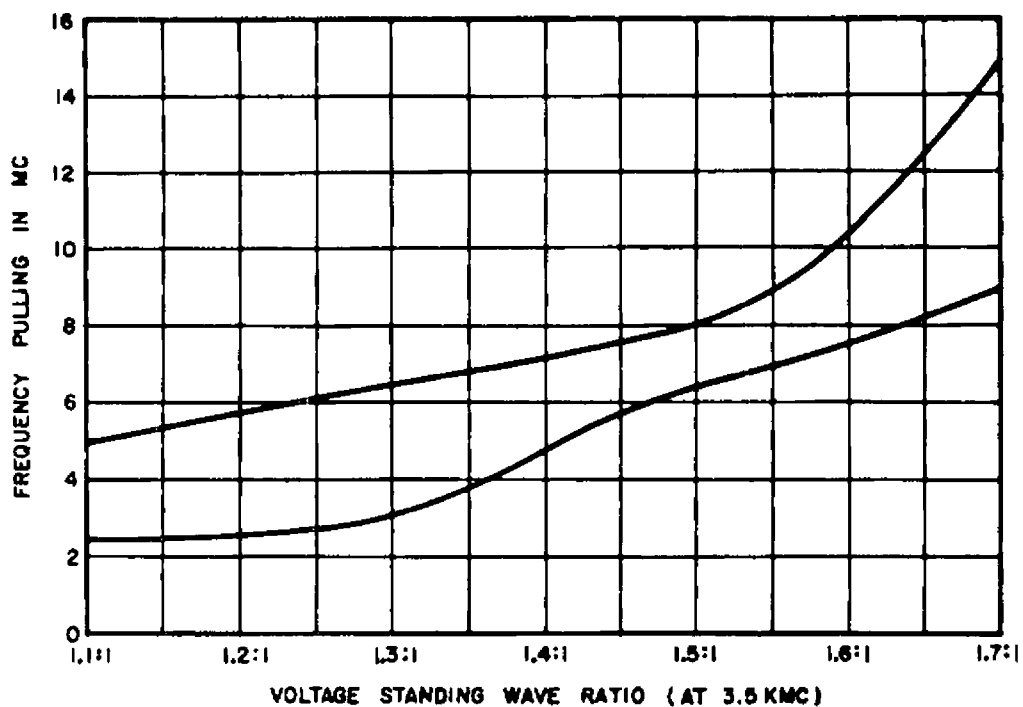


FIG. 7

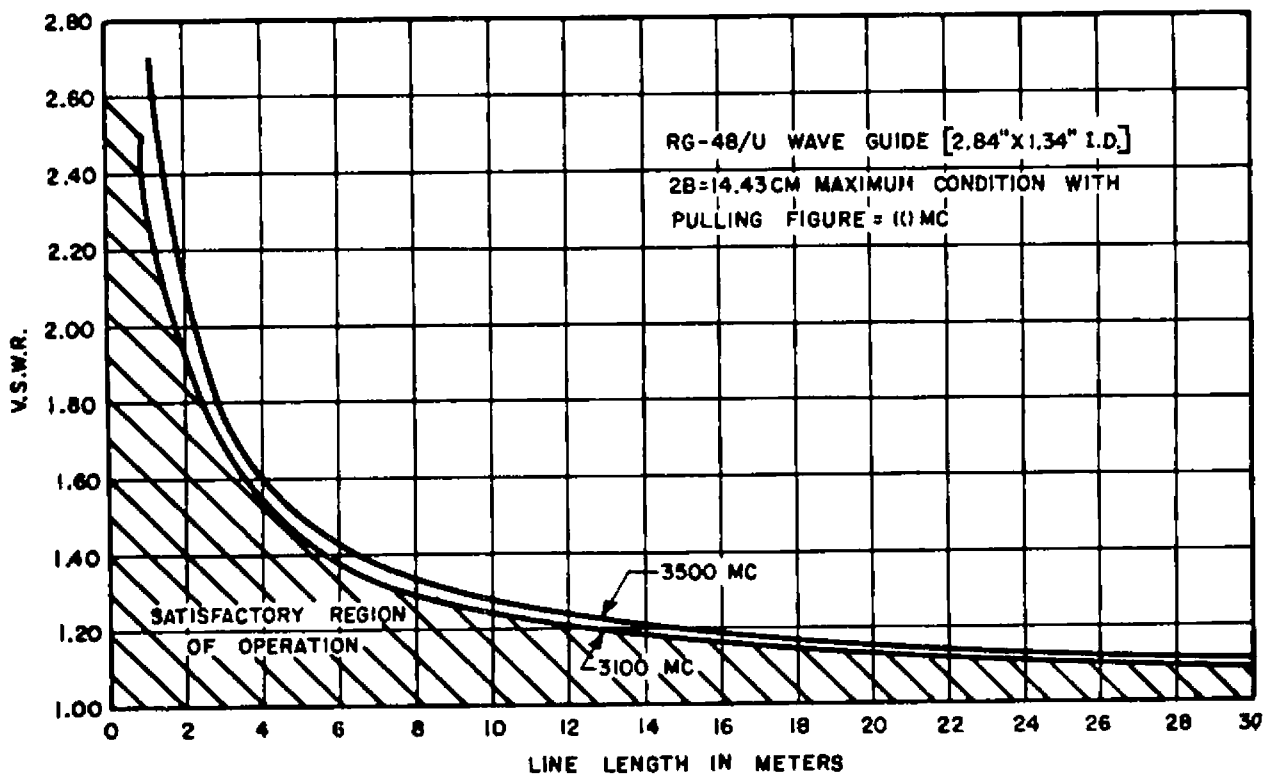
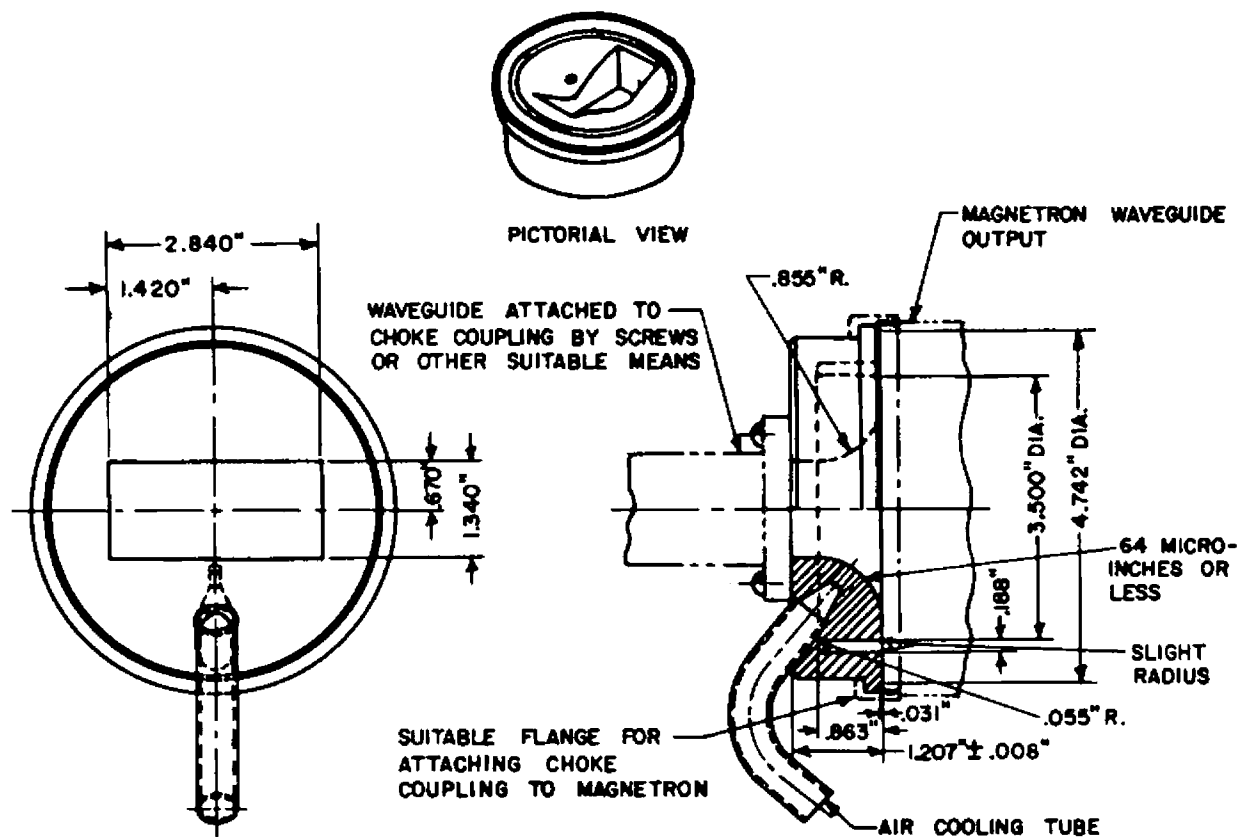


FIG. 8



CHOKE COUPLING

FIG. 9

TYPE 5650/5981

RAYTHEON

TYPE 5650/5981

TECHNICAL INFORMATION VELOCITY VARIATION OSCILLATOR

The type 5650 5981 is a velocity variation oscillator of the single cavity (integral) reflex type, designed for operation in the frequency range of 1,245 to 1,460 megacycles with an average power output of 100 milliwatts. The mechanical tuning mechanism provides a simple method of making wide frequency adjustments. In addition, the 5650/5981 can be electrically tuned to give a 4 megacycle vernier adjustment. The 5650 5981 is designed for operation at any frequency within the specified range, and is particularly suited for local oscillator service in microwave receivers. It is useful, also, as a local oscillator in microwave spectrum analyzers, as a pulse generator for testing circuit response, and as a microwave source for test purposes.



GENERAL CHARACTERISTICS

Heater, for oxide coated unipotential cathode:

Voltage. (AC or DC)	6.3 $\pm$.5 Volts
Current	0.455 Amperes
Frequency Range	1,245 to 1,460 Mc.

MAXIMUM RATINGS, Absolute Values

DC Resonator Voltage	250 Volts
DC Resonator Current	50 Ma.
DC Reflector Voltage	
Min. Negative Value	-30 Volts
Max. Negative Value	-220 Volts
Heater-Cathode Voltage	

Heater negative with respect to cathode
-50 Max. Volts

Heater positive with respect to cathode
-50 Max. Volts

Ambient temperature of air around shell	110 Max. °C
Temperature of coaxial output line	75 Max. °C

TYPICAL OPERATING CONDITIONS: C.W Oscillator: Frequency 1390 Mc.

DC Resonator Voltage	225 Volts
DC Resonator Current	35 Ma.
DC Reflector Voltage range*	-85 to -150 Volts
DC Reflector Current	Less than 7 Ma.
Electronic Tuning (Half Power)**	
Frequency change	5 Mc.
Power Output	134 MW
Thermal Compensation	$\pm$.05 Mc./°C

* Adjusted for maximum output at 1390 Mc.

** Change in frequency between the two $\frac{1}{2}$ power points when the reflector voltage is varied above and below the point of maximum power output corresponding to the given frequency.

MECHANICAL

Mounting	Any Position
Overall dimensions	See outline drawing
Resonator Cavity	Integral part of tube
Envelope	Metal

TECHNICAL INFORMATION

VELOCITY VARIATION OSCILLATOR

Cap	Miniature
Base	To fit standard octal with No. 4 pin enlarged and tapped to admit transducer.

INSTALLATION

The 5650, 5981 requires a standard octal socket modified with No. 4 pin enlarged and tapped to admit the coaxial transducer. The tube may be mounted in any position but should be rigidly clamped to insure proper contact of tube with the transducer, and to guard against excessive strains on the coaxial output line. The tube must be clamped on or below the shoulder of the header skirt.

The coaxial output line is coupled into a type "N" connector through a wide band transducer unit. (See outline drawing for transducer) All the tabulated data contained in this data sheet has been taken using this transducer operating into a matched load.

It is important that this transducer or its electrical equivalent be used to insure tube interchange ability and satisfactory tuning range characteristics. The standing wave ratio at the transducer should not exceed a VSWR of 1.1.

SHIELDING

Where the 5650/5981 is to be operated in the presence of strong magnetic fields, shielding of the resonator and reflector voltage leads is usually required in order to avoid undesirable modulation of the tube output. In extremely troublesome conditions, it may be advisable to place the 5650/5981 in a metal chamber with polyiron chokes provided to bring the voltages into the chamber. Adequate ventilation must be provided.

CATHODE

In most applications, the metal envelope (resonator) of the 5650/5981 is operated at ground potential. The cathode circuit is therefore negative with respect to ground by the amount of the resonator potential and must not be grounded. The cathode may be connected to one side of the heater or to the center tap of the heater transformer secondary. When cathode and heater are connected together, connections to the cathode should be made directly to the cathode contacts on the tube socket and never to the heater lead. When cathode and heater are not connected together, the heater-cathode voltage should not exceed ± 50 volts.

In all cases where the resonator is operated at ground potential, the heater transformer must be insulated to withstand the maximum resonator voltage.

In applications where the metal envelope (resonator) of the 5650/5981 is not at ground potential, it is essential that the tube be surrounded by a grounding shield, and be mechanically tuned with an insulated tool. Adequate ventilation must be provided through this shield to keep the ambient temperature of the chamber below the maximum specified value.

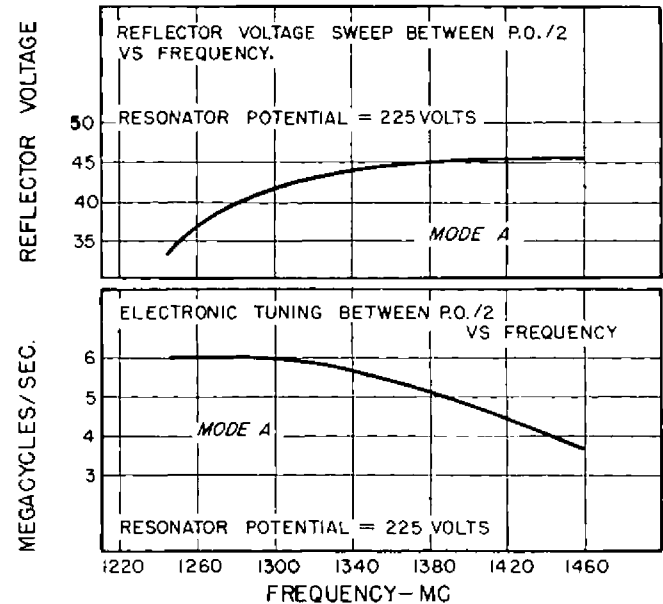
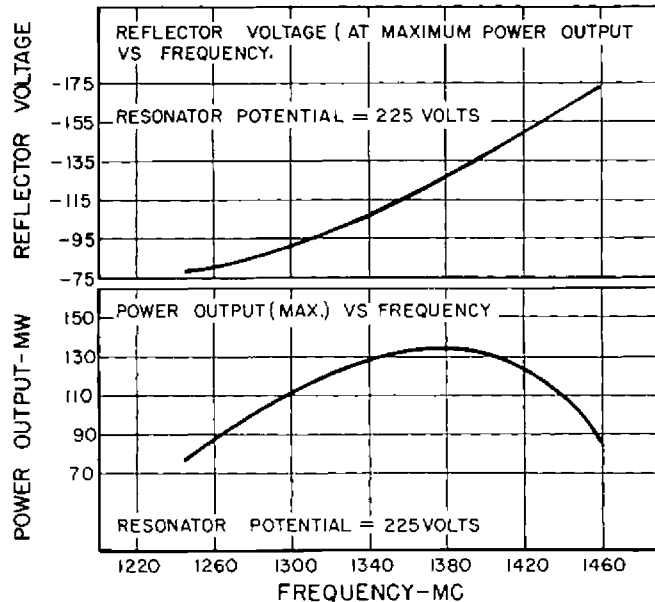
REFLECTOR

The reflector electrode is connected to pin No. 5, on the base of the tube. The power supply furnishing the reflector potential must be insulated to withstand the total resonator and reflector voltage. The reflector must never be allowed to become positive with respect to the cathode. If this precaution is not observed, damage to the reflector may result. In cases where modulating potentials bring the reflector voltage close to zero volts, or where extremely high reflector circuit impedances are required, a diode should be connected between cathode and reflector to prevent the reflector from going positive.

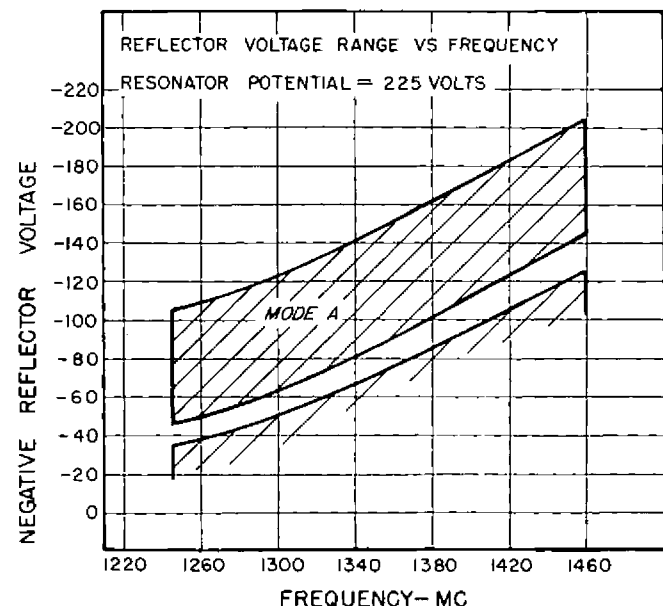
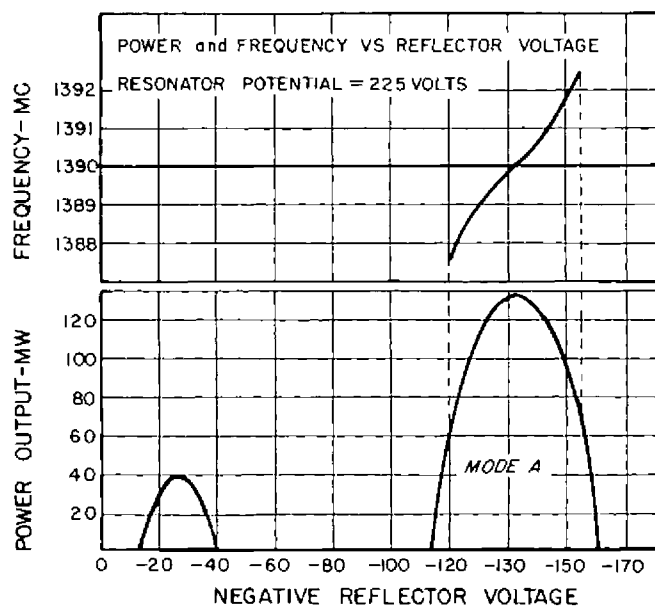
TECHNICAL INFORMATION VELOCITY VARIATION OSCILLATOR

THE FOLLOWING DATA IS REPRESENTATIVE OF AVERAGE TUBES

TUBES DESIGNED FOR USE IN MODE A



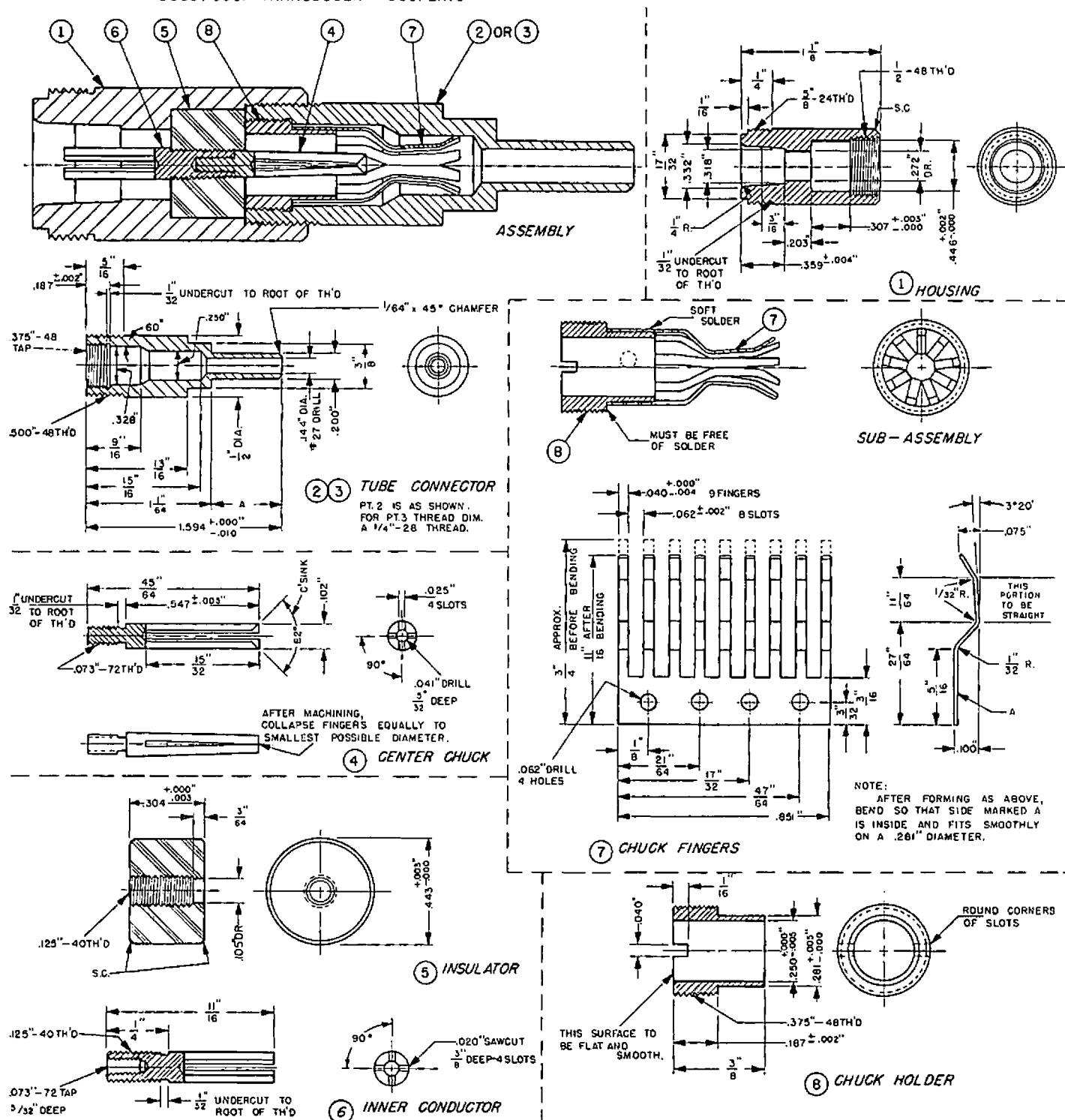
THE EXACT VALUE OF REFLECTOR VOLTAGE, PRODUCING MAXIMUM OUTPUT AT A CERTAIN FREQUENCY, VARIES FROM TUBE TO TUBE. THE VOLTAGE FOR ALL TUBES, AT EACH MODE, WILL FALL WITHIN THE SHADED AREA INDICATED BELOW.



TECHNICAL INFORMATION

VELOCITY VARIATION OSCILLATOR

5650 / 5981 TRANSDUCER COUPLING



TECHNICAL INFORMATION VELOCITY VARIATION OSCILLATOR

MECHANICAL TUNING MECHANISM

The mechanical tuning mechanism of the 5650 5981 is designed to permit occasional frequency adjustments. Rotating the tuning screw in a clockwise direction increases the frequency. Approximately three revolutions of the tuning nut are required to cover the recommended frequency range of the tube.

When the tube is first put into service, it should be mechanically tuned to the desired frequency. The tuning nut should then be flexed several times to relax the strains in the tuning mechanism. In this process the tuning nut should be adjusted to overshoot the desired frequency several times, each time decreasing the amount of tuning nut movement.

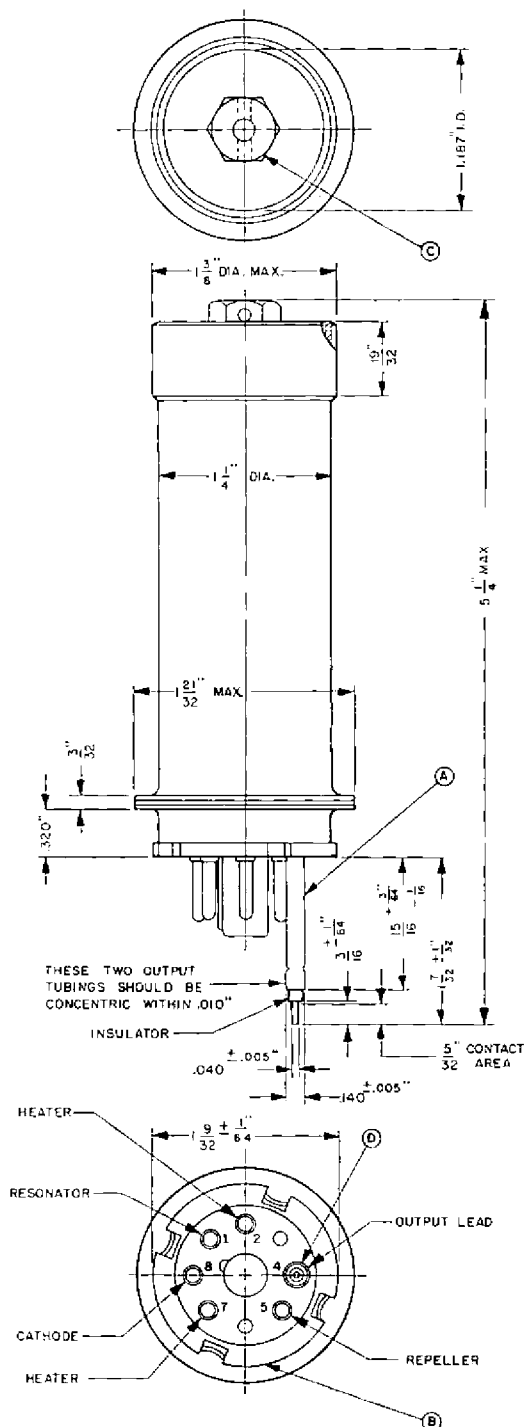
ELECTRONIC TUNING

With the mechanical tuning mechanism set near the desired frequency, vernier adjustment of the frequency may be accomplished by varying the reflector voltage. Maximum power output for a fixed mechanical tuner position, however, will be obtained at only one reflector value. If the mechanical tuning mechanism and the reflector voltage are mutually adjusted for a maximum power output at a given frequency, and if the reflector voltage is then varied above and below the value for maximum power output such that the power output is reduced to one half, the frequency change between the half-power values is defined as electronic tuning range. The amount of electronic tuning and the linearity of its variation with reflector voltage is dependent upon the type of load used, and the coupling to the load. When maximum electronic tuning range is required, it is recommended that the transducer be operated into a resistive load. A highly reactive load will shorten the electronic tuning range, and cause non-linear variation of frequency with reflector voltage.

FREQUENCY STABILITY

To obtain the most stable operation from the 5650 5981 the reflector and resonator voltage supplies should be very well regulated. It is also essential that the 5650/5981 be operated at a near constant ambient temperature. Under no circumstances should the temperature exceed the maximum specified values.

The materials used in the mechanical tuning mechanism of the 5650 5981 have been selected in such a way that their thermal expansion coefficient will produce a



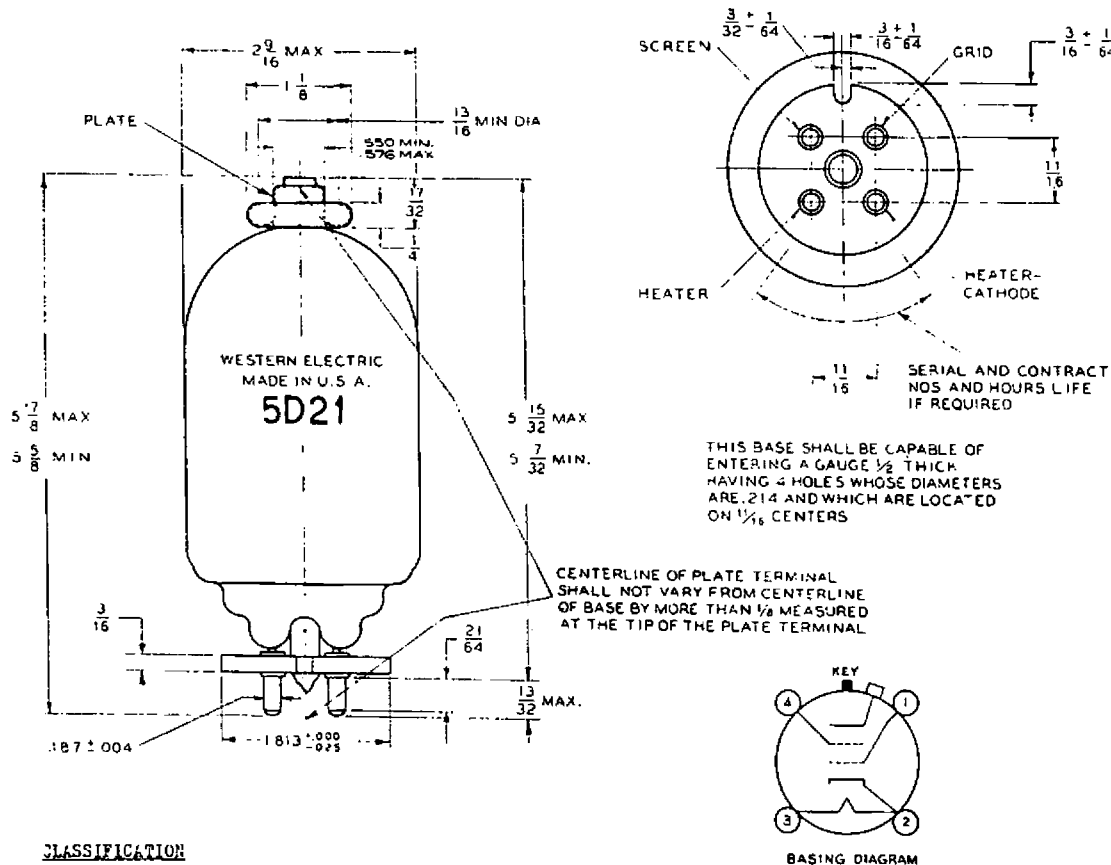
TECHNICAL INFORMATION VELOCITY VARIATION OSCILLATOR

desirable ambient temperature vs. frequency coefficient. In order that this desirable temperature coefficient will not be interfered with, a tube should not be clamped above the header skirt.

MODES OF OPERATION

Oscillation may be obtained in a given tube with several combinations of resonator and reflector voltages at a particular frequency. The regions where oscillation occurs within the reflector voltage range are referred to as voltage modes. The curves show characteristics of the average 5650/5981 in the recommended mode. This mode has been chosen because it represents the best compromise between optimum power output and wide electronic tuning range.

TECHNICAL INFORMATION
WESTERN ELECTRIC 5D21 VACUUM TUBE



CLASSIFICATION

Special purpose tetrode with indirectly heated cathodes.

SOCKET AND MOUNTING

This tube employs a Western Electric 152A or similar type socket. The plate terminal is located at the top of the bulb. There should be a free circulation of air around the bulb or some other method used to insure proper cooling.

The dimensions and arrangement of terminal connections are shown in the above drawing.

HEATER RATING

*Heater voltage	26.0 $\pm$ 10% volts a-c or d-c
Nominal heater current	2.10 amperes
*Required heating time	3 minutes

OPERATION - MAXIMUM RATINGS

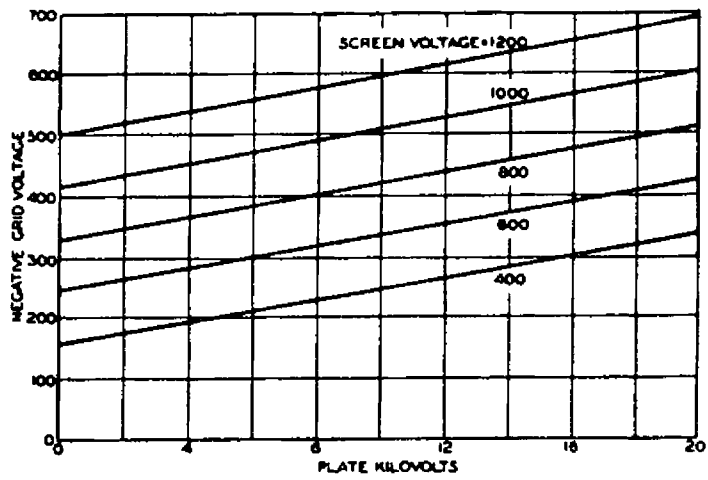
***Direct plate voltage	20,000 volts
Direct screen voltage	1,250 volts
Average plate current	30 milliamperes
****Peak plate current	15 amperes
Plate dissipation	60 watts
Screen dissipation	8 watts
Positive peak control-grid	300 volts
Direct control-grid bias	-1000 volts

INTER-ELECTRODE CAPACITANCES

Nominal Values	
Control-grid to plate	1.2 puf
Input - Control-grid to cathode and screen	35.0 puf
Output- Plate to cathode and screen	7.0 puf

- * The heater is designed for operation from a 24 volt battery supply. The standard heater rating for such use is 25 volts. It must be recognized that under battery charging conditions the voltage may be as high as 28 volts. Longest life is to be obtained with the lowest heater voltage which will furnish the required cathode emission. Where a well regulated heater supply is available, the heater should be operated at 25 volts.
- ** In applications where the peak current drawn is less than the maximum rating the heating time may be reduced in proportion. In no case, however, can it be less than 1/2 minute.
- *** Due to the high plate voltage, this tube may spark internally a few times when the voltage is first applied. This is not an indication that the tube is defective.
- **** The product of the pulse duration in seconds and the pulse recurrence frequency in cycles per second shall not exceed 0.001. At higher duty cycles, the peak current must be reduced. In case the peak current drawn from the tube exceeds 5 amperes the tube shall not be operated longer than 5 μ sec in any 100 μ sec interval. For peak currents less than 5 amperes the plate rating of 60 watts shall determine the pulse interval.

MAXIMUM CUT-OFF CHARACTERISTICS



GRID CHARACTERISTICS

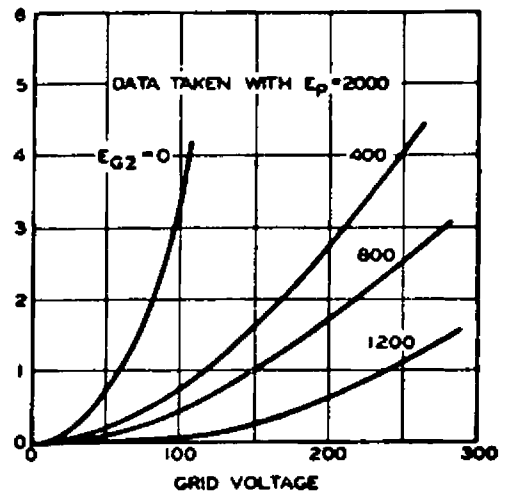
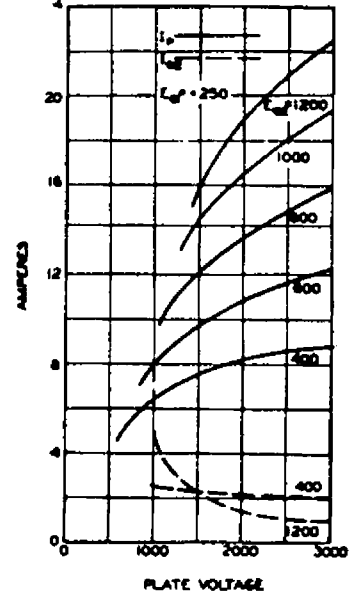
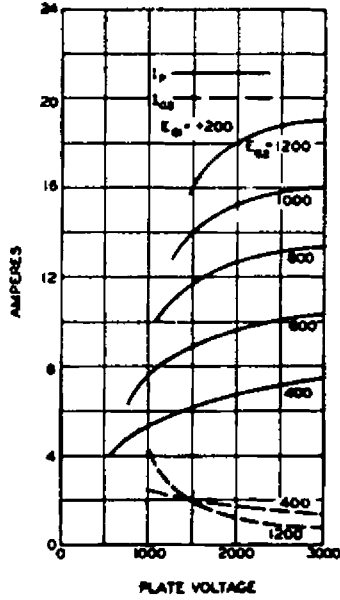
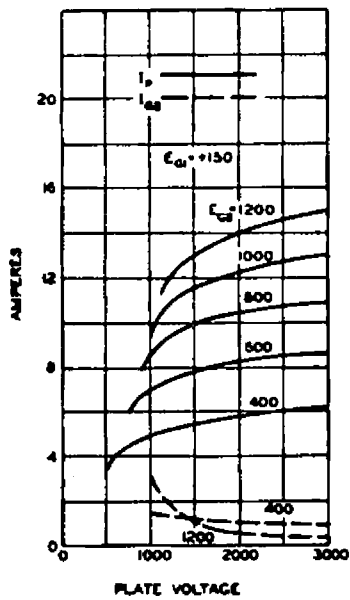
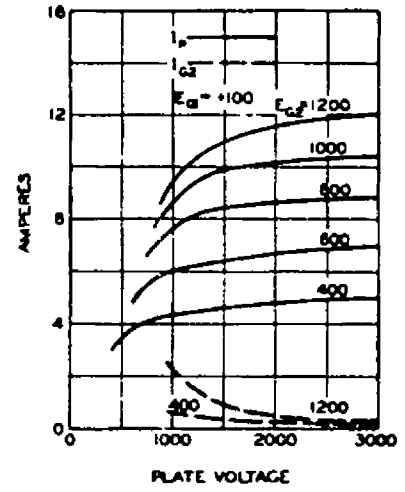
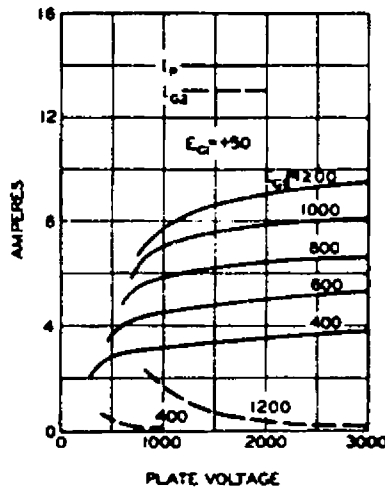
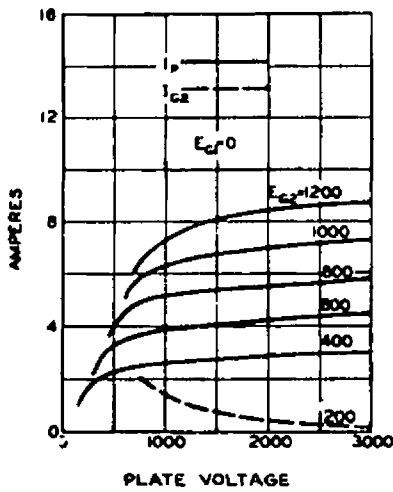


PLATE CHARACTERISTICS



WESTERN ELECTRIC 6028 *ELECTRON TUBE

TYPE DESIGNATION REGISTRATION

DESCRIPTION

The 6028* is miniature type pentode having an indirectly heated cathode. It is designed for use in amplifier circuits at high and ultra high frequencies.

MECHANICAL DATA

Cathode	Coated Unipotential
Outline	5-1
Bulb	T 5-1/2
Base	E7-1 miniature button 7-pin
Mounting positions	Any
Maximum bulb diameter	3/4 inch
Maximum overall length	1-3/4 inch
Maximum seated height	1-1/2 inch
Pin connections	Basing No. 7BD
Pin #1 Grid #1	Pin #5 Plate
Pin #2 Cathode, grid #3 & internal shield	Pin #6 Grid #2
Pins #3 & #4 Heater	Pin #7 Cathode, Grid #3 & internal shield

ELECTRICAL DATA

Heater voltage	20 volts	
Heater current	50 milliamperes	
Direct interelectrode capacitances	without external shield	with external shield #316(a)
Grid to plate (g1 to p) maximum	.03	.02 uuf
Input: g1 to (h+k+g2+g3+i.s.)	4.0	4.0 uuf
Output: p to (h+k+g2+g3+i.s.)	2.1	2.8 uuf

(a) External shield #316 connected to pins #2 and #7

MAXIMUM RATINGS, DESIGN CENTER VALUES

Plate voltage	180 volts
Grid #2 voltage	See J5-C4
Grid #2 supply voltage	180 volts
Positive d-c grid #1 voltage	0 volts
Heater cathode voltage	75 volts
Cathode current	18 milliamperes
Plate dissipation	1.7 watts
Grid #2 dissipation	0.5 watt

WESTERN ELECTRIC 6028 *ELECTRON TUBE

TYPE DESIGNATION REGISTRATION

Page 2

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS, CLASS A1 AMPLIFIER

Plate voltage	120 volts
Grid #2 voltage	120 volts
Grid bias resistor	180 ohms
Plate resistance (approx.)	0.30 megohm
Transconductance	5000 umhos
Plate current	7.5 milliamperes
Grid #2 current	2.5 milliamperes
Grid #1 voltage for $I_b = 10 \text{ ua}$	-8.5 volts

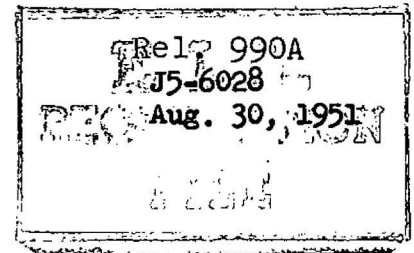
*6028/408A

May 21, 1951

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6028

PENTODE



MECHANICAL DATA

Coated unipotential cathode		
Outline drawing	5-1	Bulb T-5-1/2
Base		E7-1 miniature button 7-pin
Maximum diameter		3/4"
Maximum overall length		1-3/4"
Maximum seated height		1-1/2"
Pin connections		Basing 7BD
Pin 1 - Grid #1		Pin 5 - Plate
Pin 2 - Cathode, grid #3, internal shield		Pin 6 - Grid #2
Pin 3 - Heater		Pin 7 - Cathode, grid #3, internal shield
Pin 4 - Heater		
Mounting position		any

ELECTRICAL DATA

<u>Direct Interelectrode Capacitances</u>	<u>Without Shield</u>	<u>With Shield*</u>	
Grid to plate: (g1 to p) max.	0.03	0.02	μf
Input: g1 to (h+k+g2+g3+i.s.)	4.0	4.0	μf
Output: p to (h+k+g2+g3+i.s.)	2.1	2.8	μf

*External shield #316 connected to pins 2 and 7.

Ratings

Heater voltage	20	volts
Maximum heater-cathode voltage	75	volts
Maximum plate voltage	180	volts
Maximum grid #2 voltage	See J5-C4	
Maximum grid #2 supply voltage	180	volts
Maximum plate dissipation	1.7	watts
Maximum positive dc grid #1 voltage	0	volts
Maximum cathode current	18	ma
Maximum Grid #2 dissipation	0.5	watts

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	20	volts
Heater current	50	ma
Plate voltage	120	volts
Grid #2 voltage	120	volts
Cathode resistor	180	ohms
Plate resistance (approx.)	0.3	megohm
Transconductance	5000	μmhos
Plate current	7.5	ma
Grid #2 current	2.5	ma
Grid #1 voltage (approx.) for Ib = 10 μa	-8.5	volts

Refer to "Interpretation of Receiving Tube Ratings"

WESTERN ELECTRIC 6140* ELECTRON TUBE

TYPE DESIGNATION REGISTRATION

DESCRIPTION

The 6140* is a two-electrode inert-gas-filled cold cathode tube designed for use as a voltage reference tube.

RATINGS, Absolute Values

Cathode Current

Maximum Forward - - - - - 8 milliamperes
Minimum Forward - - - - - 4 milliamperes
Maximum Inverse Anode Current - - - - - 0.0 milliampere
Ambient Temperature Limits- - - - - -55 to +60 centigrade

ELECTRICAL DATA

	<u>Min.</u>	<u>Bogey</u>	<u>Max.</u>	
Anode Breakdown Voltage	--	---	160	volts
Anode Voltage Drop at 6 Milliamperes (D-C) ¹	99	100	103	volts
Regulation (4 to 6 Milliamperes D-C)	--	---	0.75	volt
Temperature Sensitivity, Anode Voltage Drop.				
at Anode Current of 4 Milliamperes (D-C)	--	-0.01	---	volt/c
at Anode Current of 8 Milliamperes (D-C)	--	-0.02	---	volt/c
Fluctuation ²	--	---	0.1	volt
Stability ³	--	0.05	0.3	volt

MECHANICAL DATA

Mounting Position - - - - - Any
Net Weight, Approximate - - - - - 0.3 ounce
Outline - - - - - 6-1
Bulb - - - - - T6-1/2
Base - - - - - E9-1 Small Button 9-Pin
Maximum Bulb Diameter - - - - - 7/8 inch
Maximum Overall Length - - - - - 1-3/4 inch
Maximum Seated Height - - - - - 1-7/32 inch
Pin Connections⁴ - - - - -
 Pin #1 Internal Connection
 Pins #2 and #3 Cathode
 Pins #4, #5 and #6 Internal Connection
 Pins #7 and #8 Anode
 Pin #9 Internal Connection

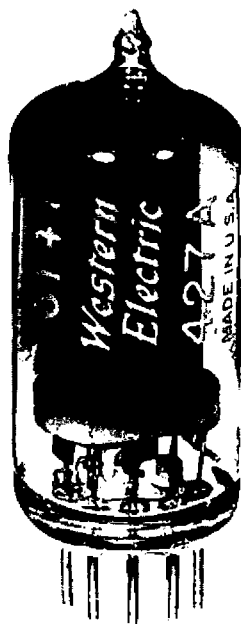
- Note 1 These values are for new tubes. The stability characteristic should be considered during tube life. Anode voltage drop will stabilize within 5 minutes after starting.
- Note 2 The anode voltage drop variation during a short period of time (one to ten minutes), with the tube operating at one value of current and temperature within its ratings, will not exceed the above stated maximum value.
- Note 3 The drift of anode voltage drop over a period of 1000 hours, with the tube operating at one value of current and temperature within its ratings, will not exceed the above stated maximum value.
- Note 4 Pins marked "Internal Connection" should not be connected to any portion of an external circuit. Failure to observe this precaution may result in improper operation of the tube.

*6140/423A

September 14, 1951

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 6141* ELECTRON TUBE



DESCRIPTION

The 6141/427A* is a three-electrode inert-gas-filled cold cathode tube designed for use as a voltage regulator and has characteristics which are exceptionally stable with life and with variation in ambient temperature. The third electrode is primarily a starting element.

CHARACTERISTICS

Cathode Current	5 to 40 milliamperes
Anode Voltage Drop	100 volts
Regulation (Max.) at 5 to 40 milliamperes d-c	1.5 volts

RATINGS, Absolute Values

Cathode Current, Forward

Maximum 40 milliamperes

Minimum 5 milliamperes

Starter Current, Forward

Maximum 5 milliamperes

Minimum¹. 0.5 milliampere

Maximum Inverse Starter or Anode Current 0.0 milliampere

Ambient Temperature Limits -55 to + 85 centigrade

ELECTRICAL DATA

	<u>Min.</u>	<u>Bogey</u>	<u>Max.</u>	
Anode Breakdown Voltage	---	165	---	volts
Anode Voltage Drop at 40 Milliamperes, D-C ² .	99	100	103	volts
Regulation (5 to 40 Milliamperes, D-C) ³ . . .	---	0.3	1.5	volts
Starter Breakdown Voltage	115	125	135	volts
Starter Voltage Drop at 5 Milliamperes, D-C .	100	110	120	volts
Required Transfer Current	See Curve			
Stability ⁴	---	0.1	1.0	volt
Temperature Sensitivity, Anode Voltage Drop				
Anode Current, 5 milliamperes D-C	---	-0.007	---	volt/c
Anode Current, 40 milliamperes D-C	---	-0.004	---	volt/c

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	0.4 ounce
Base	Small Button 9-pin
Bulb	T6-1/2

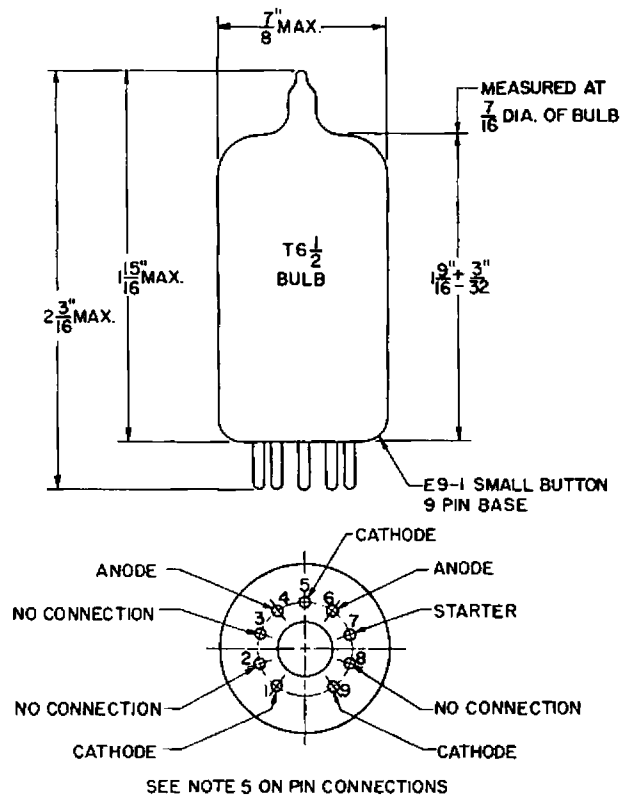
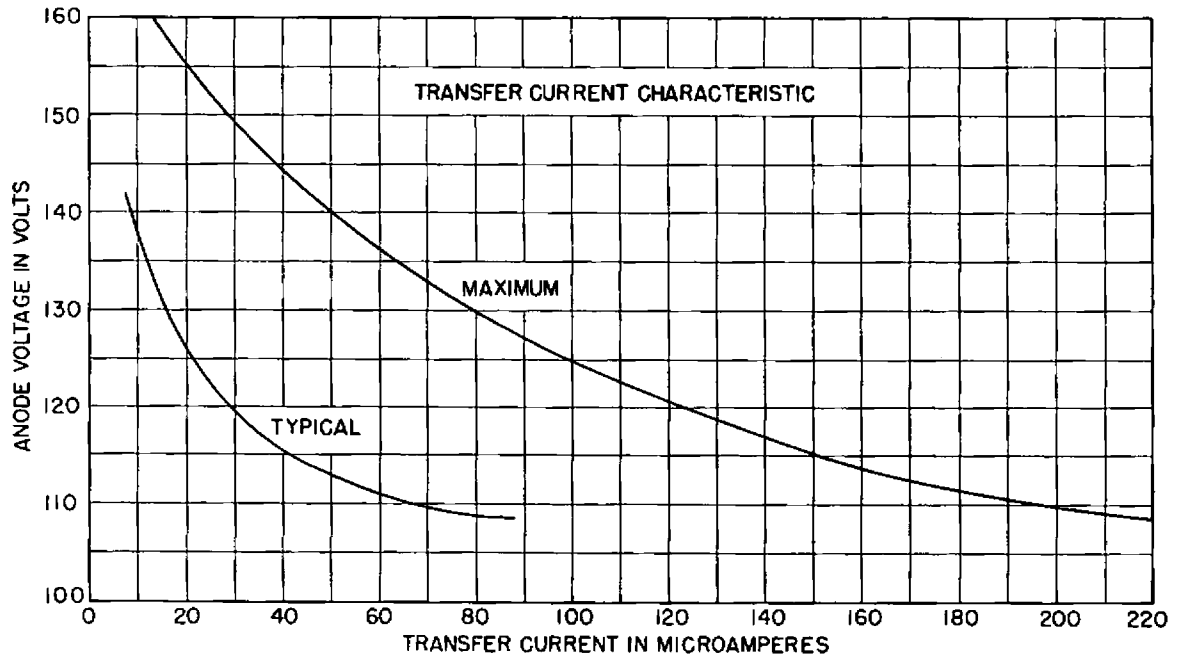
Note 1: The minimum starter current requirement applies only when the tube is operated for extended periods (hundreds of hours) between starting operations to assure maintaining starter breakdown and transfer current characteristics.

Note 2: These values are for new tubes. Anode voltage drop will stabilize within 3 minutes after starting. The stability characteristic should be considered during life.

Note 3: Continuous operation at a current value in the low portion of the operating range for an extended period (hundreds of hours) may result temporarily in regulation exceeding the above stated values.

Note 4: The drift of anode voltage drop over a period of 1000 hours, with the tube operating at one value of current and temperature within its ratings, will not exceed the above stated maximum value. Stability improves with operating life. After 1000-2000 hours operation the drift of anode voltage drop per 1000 hours will not exceed 0.3 volt.

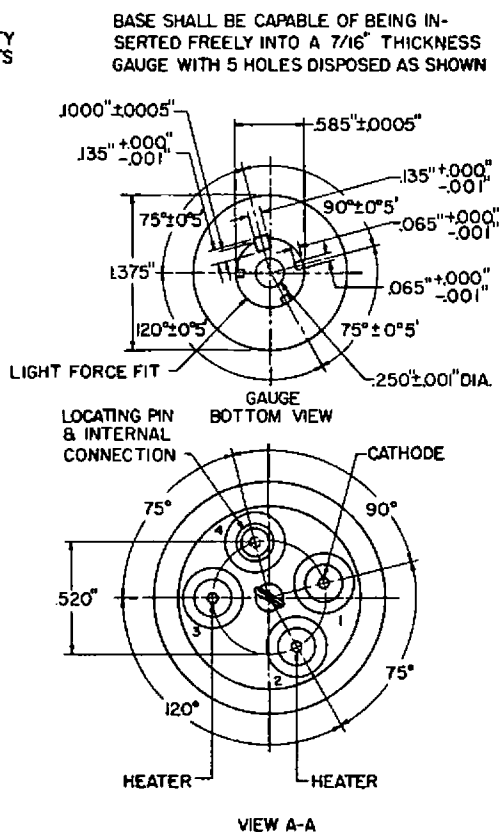
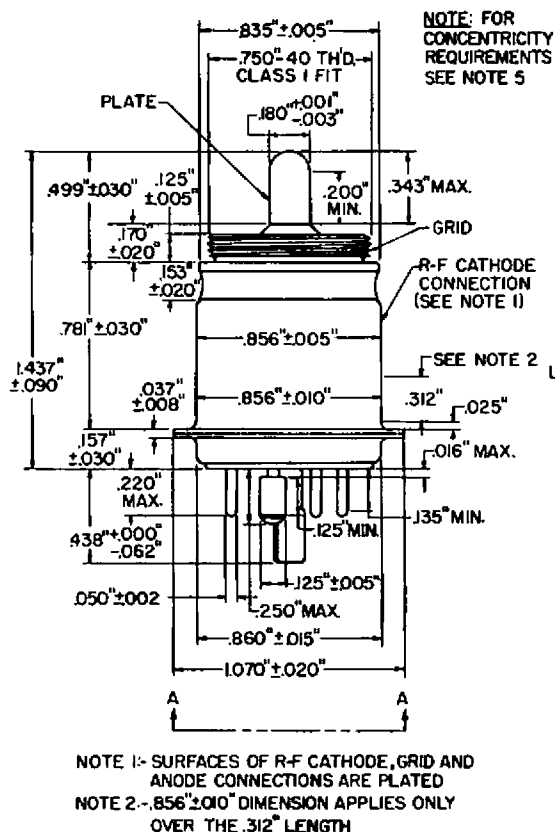
Note 5: Pins marked "NO CONNECTION" should not be connected to any portion of an external circuit. Failure to observe this precaution may result in improper operation of the tube.



Western Electric

ADVANCE ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 6280* ELECTRON TUBE



DESCRIPTION

The 6280/416B* is a planar type triode designed for use as an amplifier or frequency multiplier at frequencies in the order of 4000 megacycles.

CHARACTERISTICS

Heater Voltage	6.3 volts
Plate Voltage	200 volts
Frequency	4000 megacycles
Gain (50 milliwatts output)	9 decibels
Bandwidth (3 db down)	100 megacycles

GENERAL CHARACTERISTICSELECTRICAL DATA

	<u>Min.</u>	<u>Bogey</u>	<u>Max.</u>	
Heater Voltage(3)	---	6.3	---	volts
Heater Current	---	1.18	---	amperes
Amplification Factor	---	200	---	
Transconductance ($I_b = 30$ ma)	---	50000	---	micromhos
Direct Interelectrode Capacitances				
Grid to Plate	1.25	1.45	1.60	uuf
Grid to Shell(4)	8.5	11.2	17.0	uuf
Grid to Shell(4) Hot ($E_f = 6.1$ v; $E_b = 0$ v)	7.6	8.7	10.3	uuf
Plate to Shell(4)	---	.019	.050	uuf
Cathode to Shell	30	42.5	57	uuf

MECHANICAL DATA

Cathode	Unipotential
Mounting Position	Any
Weight, Approximate	1 ounce
Socket	(Equivalent to or). KS14134

MAXIMUM RATINGS, ABSOLUTE VALUES

Plate Voltage	270 volts
Grid Voltage	{ +1.5 volts -15.0 volts
Plate Current	33 milliamperes
Grid Current	15 milliamperes
Plate Dissipation	7.5 watts
Plate Seal Temperature	150° Centigrade
Grid Seal Temperature	100° Centigrade
Heater-Cathode Voltage	45 volts

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

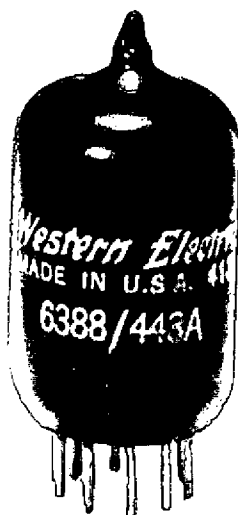
Plate Voltage	200 volts
Plate Current	30 milliamperes
Bias Circuit	
Cathode Bias Resistor	260 ohms
Grid Supply Voltage	8 volts
Frequency	4000 megacycles
Gain (50 Milliwatts Output)	9 decibels
Gain (500 Milliwatts Output)	5 decibels
Band Width (3 db Down)	100 megacycles

Note (3): For optimum life, heater may be supplied from a source of 10.8 ± 0.2 volts through a circuit resistance of 4.16 ohms.

Note (4): Cathode connected to shell through cathode to shell capacitance.

Note (5): With the .750"-40 thread screwed into a guage having a thread with a .750"-40 class 1 fit, the .856", 1.070" and .180" diameters must fit in cylinders concentric with the .750"-40 thread and having diameters of .895" x .720" long; 1.135" x .157" long; and .210" x .375" long. Allowances for these tolerances must be made in any circuit design.

ELECTRON TUBE DATA SHEET
WESTERN ELECTRIC 6388* ELECTRON TUBE



DESCRIPTION

The 6388/443A* is a three-electrode inert-gas filled miniature cold cathode tube for use in relay, voltage regulator or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting or switching apparatus.

MAXIMUM RATINGS

Peak Anode Voltage		180 volts
Average Cathode Current	7.5	60 milliamperes
Average Life, Approximate	10000	10 hours

MAXIMUM RATINGS, Absolute Values

Forward Peak Anode Voltage	180 volts
Forward Cathode Current ¹	
Peak	60 milliamperes
Average	30 milliamperes
Averaging Time	2 seconds
Peak Inverse Current ¹	
Anode	5 milliamperes
Starter	1 milliampere
Ambient Temperature Limits	-55 to +85 centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage	65	72	85	volts
Starter Voltage Drop at 3 Milliamperes ² . .	53	63	72	volts
Anode Voltage Drop at 10 Milliamperes ^{3,4} . .	63	69	75	volts
Transfer Current	See curve			
Ionization Time, Starter Gap ⁵	--	10	--	milliseconds
Deionization Time, Main Gap	--	6	--	milliseconds
Inverse Current at -120 Volts Anode Potential ⁶	--	--	3	milliamperes

MECHANICAL DATA

Mounting	Any Position
Net Weight	0.7 ounce
Dimensions and Pin Connections shown in outline drawing on Page 4	

- Note 1: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed the maximum rated values.
- Note 2: Starter voltage oscillations of approximately 1 to 10 kilocycles and 12 volts peak-to-peak will be present at starter current values below 0.05 milliampere.
- Note 3: Approximately 95% of tubes will be within limits of ± 2.8 volts from the bogey value.
- Note 4: Anode voltage oscillations of approximately 5 to 20 kilocycles and 3 volts peak-to-peak will be present at anode currents within the ratings.
- Note 5: With 15 volts starter overvoltage (15 volts above Starter Breakdown Voltage).
- Note 6: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100,000 ohms.

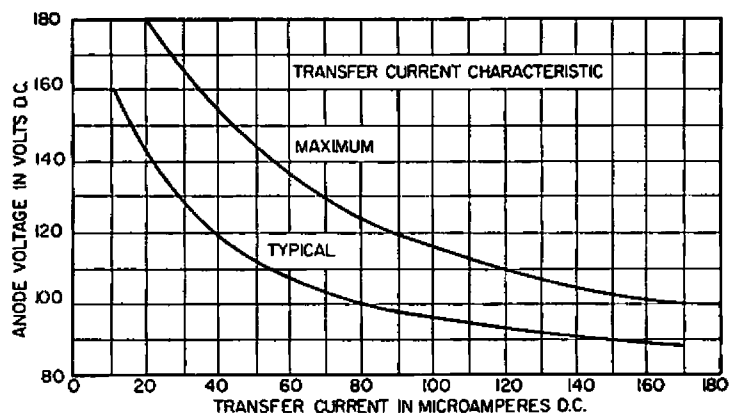
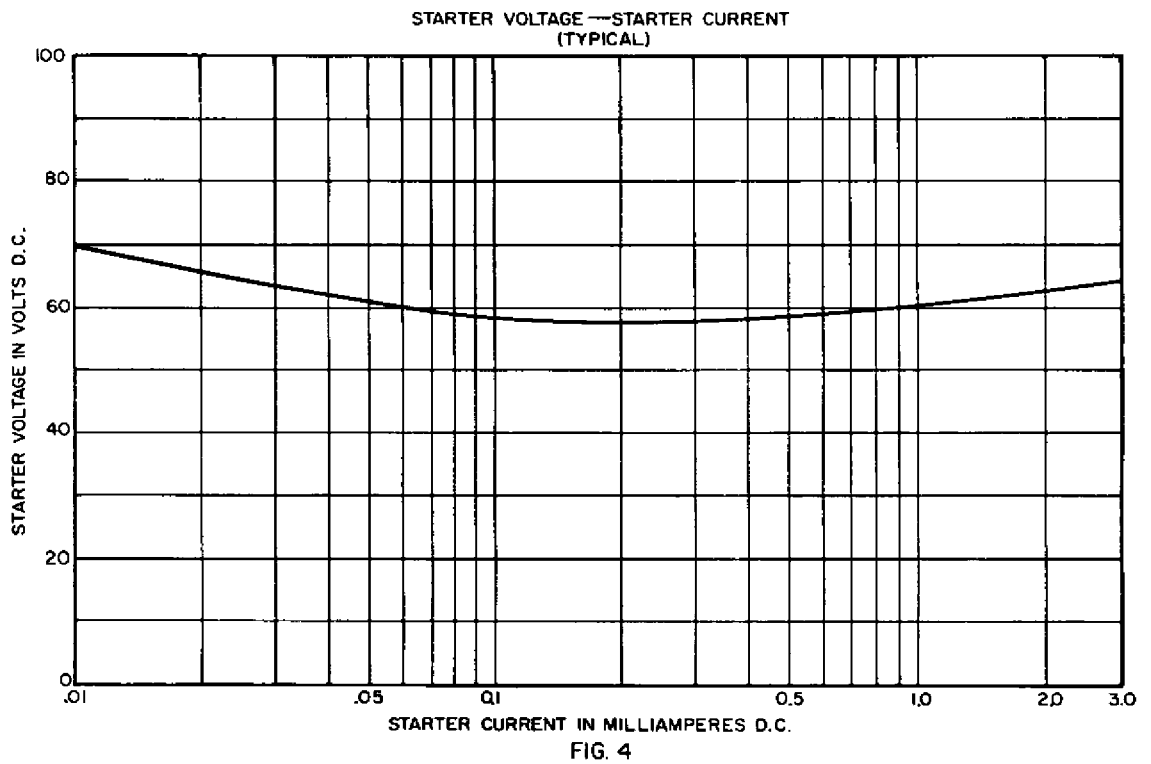
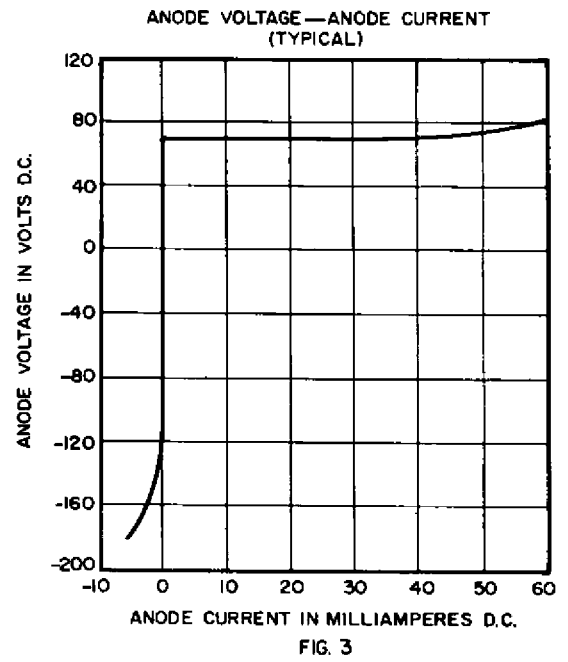
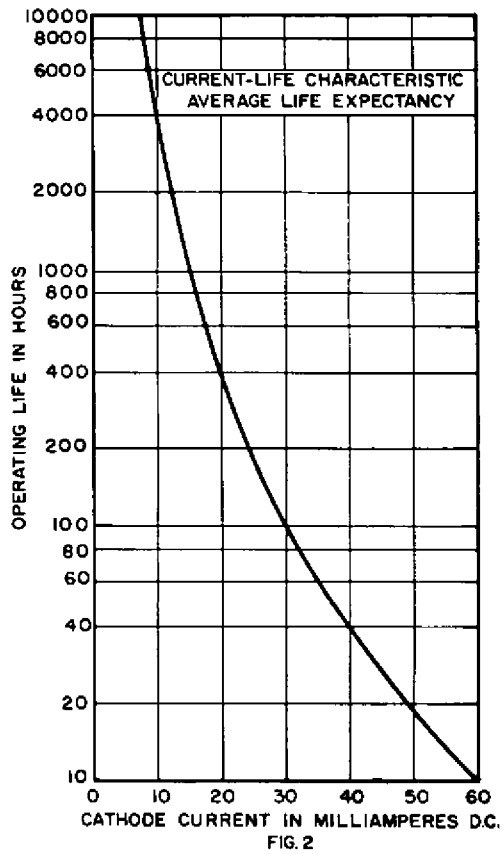
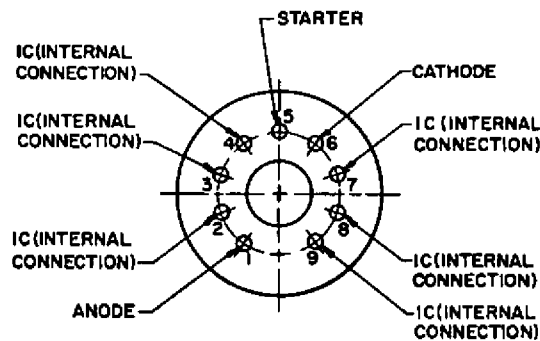
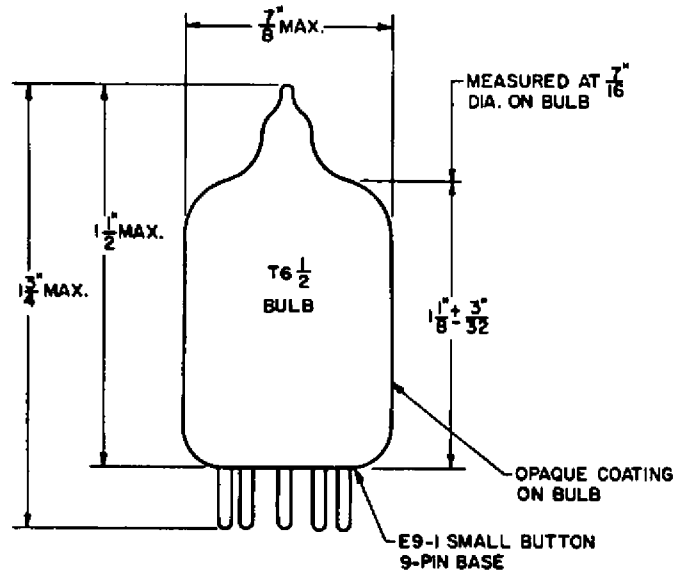


FIG. 1





Note - Pins marked IC (internal connection) should not be connected to any portion of an external circuit. Failure to observe this precaution may result in improper operation of the tube.