



5727

THYRATRON

"Premium" Gas-Tetrode, Miniature Type

TENTATIVE DATA

The 5727 is a sensitive, four-electrode thyatron of the indirectly heated cathode type designed for use in relay, grid-controlled rectifier, and pulse-modulator applications. Constructed to give dependable performance under conditions of shock and vibration, this "premium" tube, which is similar to the 2D21, is especially suited for use in critical industrial applications and in military equipment. It has a steep control characteristic (high control ratio) which is essentially independent of ambient temperature over a wide range, extremely small pre-conduction or gas-leakage currents right up to the beginning of



conduction, very low grid-No.1-to-anode capacitance, and very low grid-No.1 current. Having very low grid-No.1-to-anode capacitance, the 5727 is not appreciably affected by line-voltage surges; and having very low grid-No.1 current, it can be used with a high value of resistance in the grid-No.1 circuit to give high circuit sensitivity. In a high sensitivity circuit, the 5727 can be operated directly from a high-vacuum phototube.

Featured in the design of the 5727 is a structure in which special attention has been given to features which improve its strength for both shock and vibration. Other design features include: (1) tube parts precisely made and accurately fitted to minimize variations in electrical characteristics due to mechanical movement, (2) ceramic insulator on anode support rod to prevent spurious breakdown, and (3) the use of special micas having slots to minimize leakage resistance between electrodes. In addition, the design of the 5727 incorporates a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent "on-off" switching.

The 5727 is manufactured under rigid controls and undergoes rigorous tests to insure

its "premium" quality as follows: (1) factory tests under typical grid-controlled rectifier and pulse-modulator conditions, and (2) test readings at the end of 1 hour, 100 hours, and 500 hours on sample lots to insure that tubes fall within the established tight characteristics limits and that early failures are held to a low percentage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:

Voltage (AC or DC)	6.3 ± 10%*	volts
Current	0.6	amp

Cathode:

Minimum heating time prior to tube conduction	20	sec
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Direct Interelectrode Capacitances (Approx., without external shield):

Grid No.1 to anode.	0.026	μf
Grid No.1 to cathode, grid No.2, and heater.	2.4	μf
Anode to cathode, grid No.2, and heater.	1.6	μf

Ionization Time (Approx.):

For dc anode volts = 100; grid-No.1 volts (square-wave pulse = 50; peak anode current during conduction = 0.5 ampere	0.5	μsec
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Deionization Time (Approx.):

For dc anode volts = 125; dc anode current = 0.1 ampere; grid-No.1 resistor (ohms) = 1000; and grid-No.1 volts = -100.	35	μsec
For dc anode volts = 125; dc anode current = 0.1 ampere; grid-No.1 resistor (ohms) = 1000; and grid-No.1 volts = -10.	75	μsec

Maximum Critical Grid-No.1 Current:

For anode-supply voltage (rms) = 460 volts, and average anode current = 0.1 ampere.	0.5	μa
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Anode Voltage Drop (Approx.).

8	volts
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Grid-No.1 Control Ratio (Approx.)

with grid-No.1 resistor (megohms) = 0; grid-No.2 volts = 0.	250
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Grid-No.2 Control Ratio (Approx.)

with grid-No.1 resistor (megohms) = 0; grid-No.2 resistor (megohms) = 0; grid-No.1 volts = 0.	1000
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Mechanical:

Operating Position.	Any
Maximum Overall Length.	2-1/8"
Maximum Seated Length.	1-7/8"
Length, Base Seat to Bulb Top (excluding tip)	1-1/2" ± 3/32"
Maximum Diameter.	3/4"
Bulb.	T-5-1/2
Base.	Small-Button Miniature 7-Pin (JETEC No.E7-1)



RELAY and GRID-CONTROLLED RECTIFIER SERVICE

For Anode Supply Frequency of 60 cps

Maximum Ratings, Absolute Values:

PEAK ANODE VOLTAGE:		
Forward	650 max.	volts
Inverse	1300 max.	volts
GRID-No.2 (SHIELD-GRID) VOLTAGE:		
Peak, before anode conduction. . .	-100 max.	volts
Average [■] , during anode conduction. .	-10 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Peak, before anode conduction. . .	-100 max.	volts
Average, during anode conduction. .	-10 max.	volts
CATHODE CURRENT:		
Peak	0.5 max.	amp
Average [□]	0.1 max.	amp
Fault, for duration of 0.1 sec. max..	10 max.	amp
GRID-No.2 CURRENT:		
Average [■]	+0.01 max.	amp
GRID-No.1 CURRENT:		
Average [□]	+0.01 max.	amp
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	25 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	150 max.	°C
AMBIENT TEMPERATURE.	-75 min.	°C

Typical Operating Conditions for Relay Service:

RMS Anode Voltage.	117	400	volts
Grid-No.2 Voltage.	0	0	volts
RMS Grid-No.1 Bias Voltage [□] . . .	5	-	volts
DC Grid-No.1 Bias Voltage. . . .	-	-6	volts
Peak Grid-No.1 Signal Voltage. .	5	6	volts
Grid-No.1-Circuit Resistance . .	1.0	1.0	megohm
Anode-Circuit Resistance [#]	1200	2000	ohms

Maximum Circuit Values:

Grid-No.1-Circuit Resistance . .	10 max.	megohms
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PULSE-MODULATOR SERVICE

For Rectangular-Wave Shapes, Duty Cycle of 0.001 max., Pulse Duration of 5 μ sec. max., and Pulse Repetition Rate of 500 pps max.

Maximum Ratings, Absolute Values:

PEAK ANODE VOLTAGE:		
Forward	500 max.	volts
Inverse	100 max.	volts
GRID-No.2 (SHIELD-GRID) VOLTAGE:		
Peak, before anode conduction. .	-50 max.	volts
Average, during anode conduction	-10 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Peak, before anode conduction. .	-100 max.	volts
Average, during anode conduction	-10 max.	volts
CATHODE CURRENT:		
Peak	10 max.	amp
Average	0.01 max.	amp
Rate of change	100 max.	amp/ μ sec
PEAK GRID-No.2 CURRENT	0.02 max.	amp
PEAK GRID-No.1 CURRENT	0.02 max.	amp
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	0 max.	volts
Heater positive with respect to cathode	0 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	150 max.	°C
AMBIENT TEMPERATURE.	-75 min.	°C

Maximum and Minimum Circuit Values:

Grid-No.1-Circuit Resistance . .	0.5 max.	megohms
Grid-No.2-Circuit Resistance . .	25000 max.	ohms
	2000 min.	ohms

* For pulse-modulator service, tolerance is +10%, -5%.

■ Averaged over any interval of 30 seconds max.

□ Approximately 180° out of phase with the anode voltage.

Sufficient resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are Initial, Unless Otherwise Specified

	Note	Min.	Max.	
Heater Current	1	540	660	ma
Grid-No.1 Supply Voltage for Anode Conduction (1)	1,2	-2.9	-4.5	volts
Grid-No.1 Supply Voltage for Anode Conduction (2)	1,3	-	5.2	volts
Grid-No.1 Supply Voltage for Anode Conduction (3)	4,3	-	-6.4	volts
Anode Supply Voltage for Anode Conduction (1)	1,5	-	38	volts
Anode Supply Voltage for Anode Conduction (1) at 500 hours. . . .	1,5	-	50	volts
Anode Supply Voltage for Anode Conduction (2)	6,5	-	50	volts
Anode Supply Voltage for Anode Conduction (3)	7,8	650	-	volts
RMS Grid-No.2 Supply Voltage for Anode Conduction (this voltage is 180° out of phase with anode supply voltage) . .	1,9	1.9	3.3	volts
Heater-Cathode Leakage Current:				
Heater 25 volts positive with respect to cathode. .	1	-	15	μ a
Heater 100 volts negative with respect to cathode. .	1	-	15	μ a
Heater-Cathode Leakage Current at 500 Hours:				
Heater 25 volts positive with respect to cathode. .	1	-	20	μ a
Heater 100 volts negative with respect to cathode. .	1	-	20	μ a
Leakage Resistance:				
Grid-No.2 to anode	1,10	760	-	megohms
Leakage Resistance:				
Grid-No.2 to anode at 500 Hours.	1,10	380	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With anode supply voltage of 460 volts (rms), grid-No.2 voltage of 0 volts, load resistor of 3000 ohms, and grid-No.1 resistor of 0.1 megohm.

Note 3: With plate supply voltage of 460 volts (rms), grid-No.2 voltage of 0 volts, load resistor of 3000 ohms, and grid-No.1 resistor of 10 megohms.

Note 4: With 7.0 volts ac or dc on heater.

Note 5: With grid-No.2 voltage of 0 volts, grid-No.1 voltage of 0 volts, load resistor of 1000 ohms, and grid-No.1 resistor of 0.1 megohm.

Note 6: With 5.7 volts ac or dc on heater.

Note 7: With 0 volts on heater.

Note 8: With grid-No.1 voltage of -100 volts, grid-No.2 voltage of 0 volts, and load resistor of 10000 ohms.

Note 9: With anode supply voltage of 150 volts (rms), grid-No.1 supply voltage of 16 volts (rms and in phase with anode supply voltage).

Note 10: With grid-No.2 voltage of $\pm$ 380 volts with respect to anode and all other electrodes floating.



SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. 750 max. g
This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for heater-cathode leakage current, grid-No.1 supply voltage for anode conduction (1) and anode supply voltage for anode conduction (1).

Fatigue Rating:

Vibrational Acceleration. 2.5 max. g
This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5-g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for heater-cathode leakage current, grid-No.1 supply voltage for anode conduction (1) and anode supply voltage for anode conduction (1).

Heater-Cycling Life Performance:

Cycles of Intermittent Operation. . . 2000 min. cycles
Under the following conditions: Heater voltage of 7.5 volts cycled one minute on and one minute off, heater 100 volts negative with respect to cathode, and all other elements grounded.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that tubes have been properly stabilized. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. Tubes are initially read for Grid-No.1 Supply Voltage for Anode Conduction (1). At the end of 1 hour grid-No.1 supply voltage is read. The variation in the 0-hour and 1-hour readings will not exceed 15 per cent. Tubes must also meet established limits of grid-No.1 supply voltage.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early inoperatives. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit or fails to meet established limits of grid-No.1 supply voltage for anode conduction (1).

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, anode supply voltage of 460 volts (rms), grid-No.2 supply voltage of 0 volts, average anode current of 80 milliamperes, peak anode current of 500 milliamperes, grid-No.1 resistor of 50000 ohms, and minimum bulb temperature of 150°C. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, grid-No.1 supply voltage (1), and 500-hour limits for anode supply voltage (1), heater-cathode leakage current, and leakage resistance shown under Characteristics Range Values.

INSTALLATION AND APPLICATION

The base pins of the 5727 fit the miniature 7-contact socket which may be installed to hold the tube in any position. The socket should be

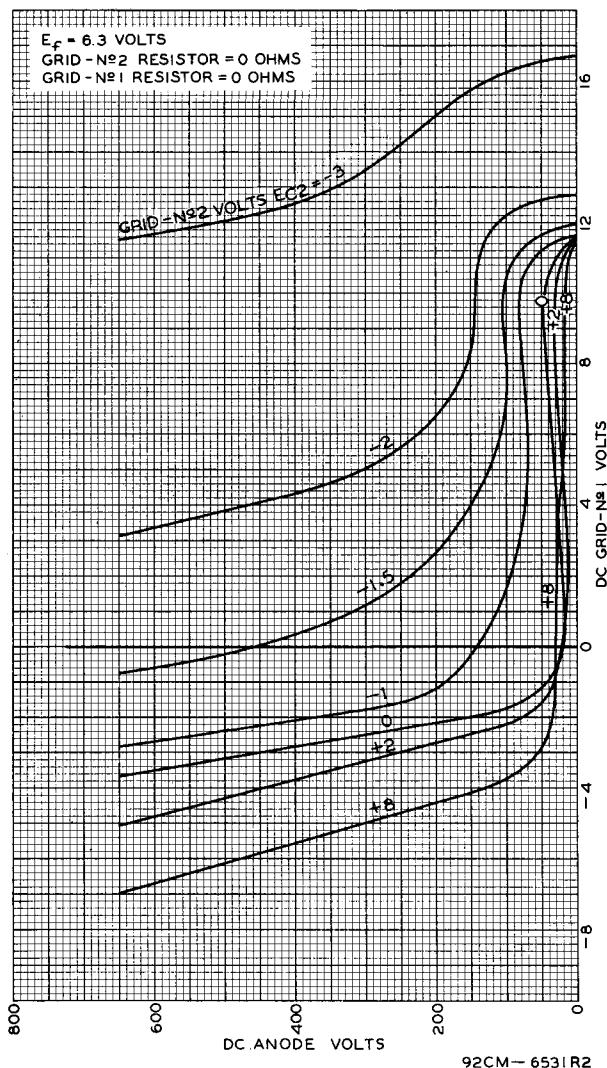


Fig. 1 - Average Control Characteristics of Type 5727.

made of an insulating material having leakage current low in comparison with the pre-conduction grid current of the 5727.

The heater is designed to operate on either ac or dc at 6.3 volts. Regardless of the heater-voltage supply used, the heater voltage must never be allowed to deviate more than 10% from its rated value, except for pulse-modulator service where the tolerance is +10%, -5%. Heater operation outside of this voltage range will impair tube performance and may cause tube failure. Low heater voltage causes low cathode temperature



with resultant cathode sputtering and consequent destruction of the cathode; high heater voltage causes high cathode temperature with resultant heating of the grid and consequent grid emission which produces unpredictable shifts in the critical grid-No.1 voltage for conduction.

The *cathode* should be allowed to reach normal operating temperature before anode current is drawn. *The delay period should not be less than 20 seconds after application of heater voltage.* Unless this recommendation is followed, the cathode will be damaged.

The *shield grid* (grid No.2) is normally connected to the cathode. It may, however, be used as a control electrode because the control characteristic of grid No.1 may be shifted by varying the potential of grid No.2. As grid No.2 is made negative, the grid-No.1 characteristic is shifted in the positive direction. With -2 volts on grid No.2, the grid-No.1 characteristic lies completely in the positive region. The use of grid No.2 as the control electrode (with grid No.1 tied to cathode) has the advantage of increased sensitivity but consideration must be given to the higher pre-conduction current, higher capacitance to anode, and less stability of operation.

A *grid-No.1 resistor* having a value as high as 10 megohms to give circuit sensitivity can be used with the 5727 because its control-grid current is very low. However, when a high value of grid resistor is used, care should be taken to keep the tube base and socket clean and dry in order to make the effect of leakage currents between the control-grid base pin and anode base pin very small.

When the 5727 is operated with a high value of grid-No.1 resistor and ac voltage on the anode, the circuit capacitance between grid No.1 and anode should be kept low by placing the grid resistor directly at the socket grid terminal, by connecting both grid-No.2 terminals (pins 5 and 7) to the cathode (pin 2) at the socket, and by using a close-fitting shield connected to the cathode terminal.

Sufficient anode-circuit resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings of the tube.

OPERATING CONSIDERATIONS

The 5727 operates by virtue of the fact that, for any specific grid-No.2 potential and positive anode potential, there is a critical value of grid-No.1 voltage. If grid No.1 is maintained more negative than this critical value, the tube does not conduct and the anode current remains zero. If grid No.1 is made less negative than the critical value, the tube will conduct and the anode current assumes a value determined

by the applied anode potential and the impedance in the anode circuit. In the conducting condition, the 5727 has a voltage drop which is quite low and substantially independent of both anode current and grid-No.1 bias. Conduction may be stopped and grid No.1 allowed to regain control by reducing the anode voltage to zero or making it negative. A family of curves showing the relations between grid-No.1 voltage, grid-No.2 voltage, and anode voltage is given in Fig.1.

In the design of equipment to utilize the 5727, consideration should be given to its maximum ratings which are on an *absolute maximum* basis. In order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that

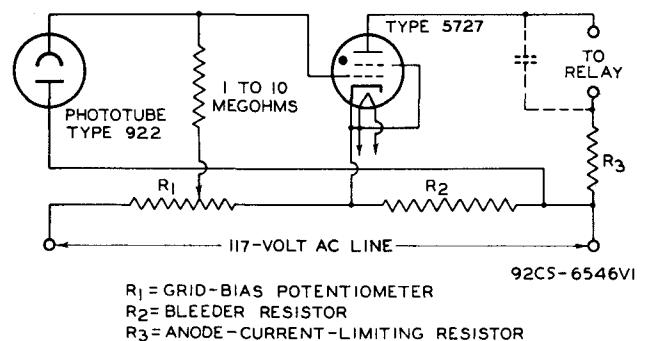


Fig.2 - Typical Light-Operated Relay Circuit Utilizing Type 5727.

the absolute values will never be exceeded under any usual conditions of supply-voltage variation, or manufacturing variation in the equipment itself.

The 5727 can be operated with an anode voltage obtained from either an ac or a dc source. When a dc supply is used, the circuit has a lock-in feature because grid No.1 loses control when conduction starts. In order for grid No.1 to regain control and to restore the tube to the non-conducting condition, the anode voltage must be removed momentarily. When an ac supply is used, the circuit has no lock-in feature because the anode becomes negative during the negative half of the ac cycle and allows grid No.1 to resume control. In ac operation, control of the average anode current may be accomplished by relative phasing of the grid-No.1, grid-No.2, and anode potentials. A typical light-operated relay circuit is shown in Fig.2.

The electrode structure of the 5727 provides very low grid-No.1-to-anode capacitance with the result that the tube is insensitive to line-voltage surges. This characteristic also insures that only very low values of capacitive current will flow through the grid-No.1 resistor. Such a characteristic is very desirable because the



grid-No.1 bias required to prevent conduction is increased by an amount equal to the peak IR drop across the grid resistor.

The effective grid-No.1 bias obtained when a high value of grid-circuit resistor is used is influenced by the grid-No.1 currents flowing before and during conduction. The magnitude of these currents before conduction is shown in microamperes in Fig.3 and during conduction in milliamperes in Fig.4.

The critical grid-No.1 voltage for any given anode voltage is that value of grid-No.1 voltage which will permit conduction to start. The value of critical grid-No.1 voltage is affected by several factors including: the operating anode voltage, grid-No.2 voltage, variation of

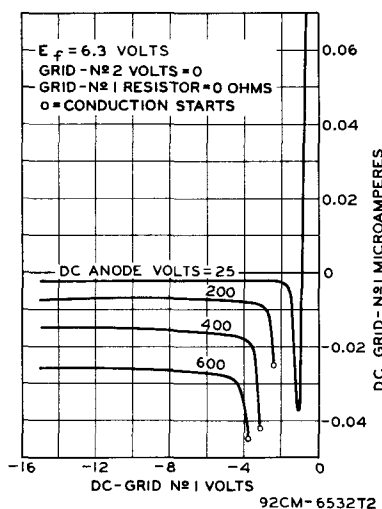


Fig. 3 - Average Grid-No.1 Characteristics Before Anode Conduction.

heater-supply voltage, value of grid-No.1 resistor, and individual tube variations both initially and during life. In Fig.5 is shown the range of critical grid-No.1 voltage based on the combined effect of individual tube variation, and variation throughout tube life for a grid resistor value of 0.1 megohm and also for a value of 10 megohms. About 10% of the total variation range for any particular operating condition is attributable to a heater-voltage variation of $\pm 10\%$ from the rated value.

The equipment designer should give careful consideration to the range values shown in Fig.5. From them he can determine for specified operating conditions not only the proper value of grid-No.1 bias to prevent conduction until it is desired but also the magnitude of the signal (triggering) voltage to cause conduction. Ample triggering voltage should always be provided to insure anode conduction even under the worst operating conditions to which the equipment will usually be subjected.

In addition to the factors contributing to the range values shown in Fig.5, the effect of high ambient temperature may become important. When the 5727 is used with a low value of grid-No.1 resistor, the effect on critical grid-No.1

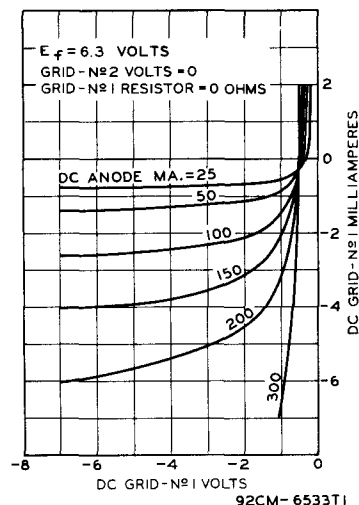


Fig. 4 - Average Grid-No.1 Characteristics During Anode Conduction.

voltage of temperature changes between the minimum ambient temperature rating and the maximum bulb temperature rating is negligible. However, when the grid-No.1 resistor has a high value, tempera-

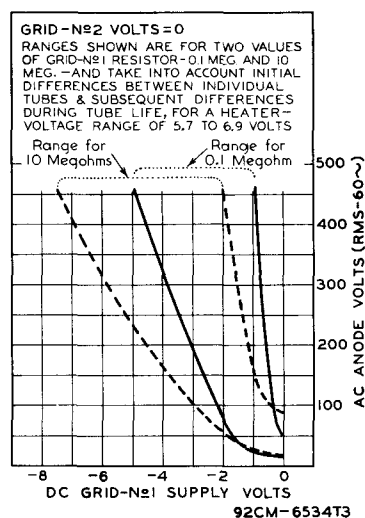


Fig. 5 - Operational Range of Critical Grid-No.1 Voltage.

ture changes within the minimum ambient temperature and maximum bulb temperature range may cause a change of 20% in the critical grid-No.1 voltage. Most of this change occurs at the higher temperatures and is caused by leakage outside the tube.



Therefore, under operating conditions involving a high value of grid-No.1 resistor and high bulb temperature, it is essential that precautions be taken to minimize leakage.

The *maximum average cathode current, shown under relay and grid-controlled rectifier service*, is the highest current which can be drawn continuously through the tube and is based on the allowable heating of the tube. The average current should be determined on the basis of 30-

second operation of the tube. If the cycle of operation during the 30-second period is rapid, the average current can be read on a dc meter. If the cycle is long, it is necessary to calculate the average current from readings taken during the 30-second period.

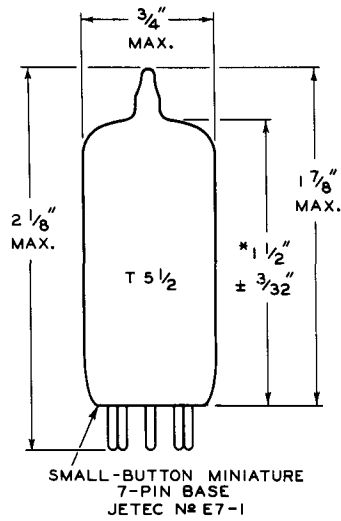
REFERENCE

"Pulse-Firing Time and Recovery Time of the 2D21 Thyatron", by J. A. Olmstead and M. Roth, RCA REVIEW, June, 1957.

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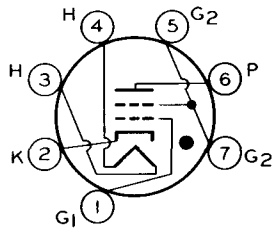
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



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- PIN 1 - GRID No.1
- PIN 2 - CATHODE
- PIN 3 - HEATER
- PIN 4 - HEATER
- PIN 5 - GRID No.2
- PIN 6 - ANODE
- PIN 7 - GRID No.2