



6328

MULTIPLIER PHOTOTUBE

9-Stage Type with S-4 Response
for Headlight-Control Service

TENTATIVE DATA

RCA-6328 is a short, rugged multiplier phototube of the 9-stage type intended especially for automobile headlight-dimming service.



Having instantaneous response to meet the critical timing requirements of headlight-control service, the 6328 is capable of providing stable performance over long periods. Its high luminous sensitivity allows use of an amplifier with relatively low-impedance input and fewer stages than required by a less-sensitive tube. Furthermore, the 6328 has low electrode dark current which makes feasible the use of high-resistance voltage-divider networks to minimize power requirements and to improve not only operating stability but also life.

DATA

General:

Spectral Response. S-4
Wavelength of Maximum Response. . . . 4000 $\pm$ 500 angstroms
Cathode:
Minimum Projected Length* 15/16"
Minimum Projected Width* 5/16"
Direct Interelectrode Capacitances:
Anode to Dynode No.9 4.2 $\mu\mu\text{f}$
Anode to All Other Electrodes. 5.5 $\mu\mu\text{f}$
Maximum Overall Length 3-1/8"
Maximum Seated Length. 2-11/16"
Length from Base Seat to Center
of Useful Cathode Area 1-9/16" $\pm$ 3/32"
Maximum Diameter 1-5/16"
Bulb T-9
Base . . Small-Shell Neosubmagnal 11-Pin, Non-hygroscopic
(JETEC No. B11-104)
Mounting Position. Any

Maximum Ratings, Absolute Values:

ANODE-SUPPLY VOLTAGE (DC or Peak AC) . . 1250 max. volts
SUPPLY VOLTAGE BETWEEN DYNODE NO.9
AND ANODE (DC or Peak AC). 250 max. volts
AVERAGE ANODE CURRENT^o 0.1 max. ma
AMBIENT TEMPERATURE. 75 max. $^{\circ}\text{C}$

* On plane perpendicular to the indicated direction of light (see *Dimensional Outline*).

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/10 of E between cathode and dynode No.1; 1/10 of E for each succeeding dynode stage; and 1/10 of E between dynode No.9 and anode

With E = 1000 volts

	Min.	Average	Max.	
Sensitivity:				
Radiant, at 4000 angstroms	-	32500	-	$\mu\text{amp}/\mu\text{watt}$
Luminous: [▲]				
At 0 cps	5	35	250	amp/lumen
At 100 Mc.	-	33	-	amp/lumen
Electrode Dark Current (At 25 $^{\circ}\text{C}$):				
Anode.	-	-	0.1	μamp
Any other electrode.	-	-	0.75	μamp

^o Averaged over any interval of 30 seconds maximum.

[▲] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870 $^{\circ}\text{K}$. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant energy of a given wavelength, at constant electrode voltages.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Electrode Dark Current. The electrode current which flows when there is no radiant flux incident on the photocathode.

GENERAL CONSIDERATIONS

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 6328 multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.9) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.9 is so shaped as to enclose partially the anode and to serve as a shield for

it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grating which allows the electrons

photocathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration.

The grill through which the incident radiation reaches the photocathode, is connected to the photocathode and serves as an electrostatic shield for the open side of the electrode structure.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6328 may be impaired from the

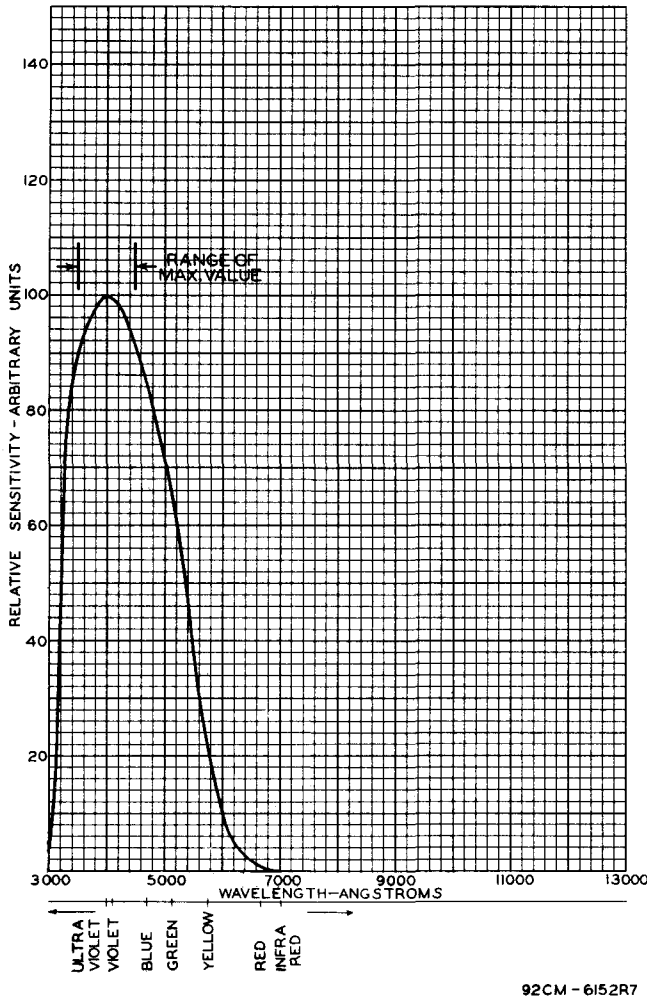


Fig. 1 - Spectral Sensitivity Characteristic of Type 6328 which has S-4 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

from dynode No.8 to pass through it to dynode No.9. Spacing between dynode No.9 and anode creates a collecting field such that all the electrons emitted by dynode No.9 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 6328 can be coupled to any practical load impedance.

The shield which extends between the photocathode and the anode shields the photocathode from the anode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the

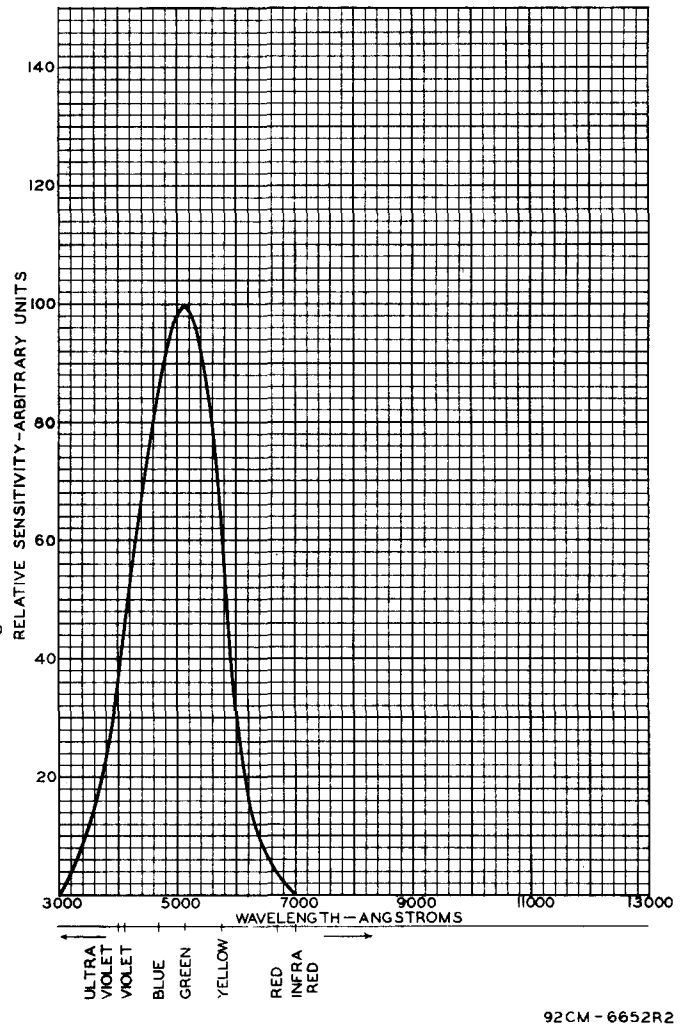


Fig. 2 - Sensitivity Characteristic of Type 6328 Obtained by Multiplying Its Spectral Sensitivity Characteristic in Fig.1 by the Relative Energy Distribution Characteristic of a Tungsten Lamp at 2870°K.

viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value



for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

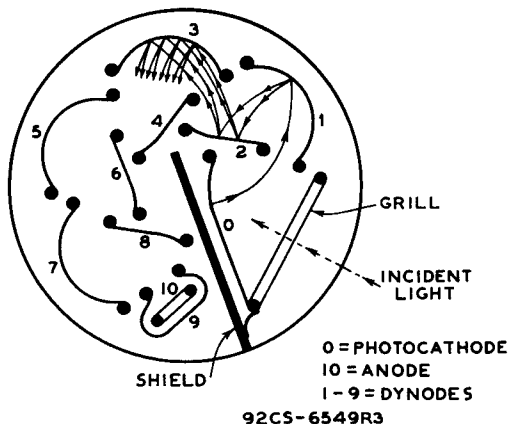


Fig. 3 - Schematic Arrangement of Type 6328 Structure.

The maximum ambient temperature as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The base pins of the 6328 fit the neosubmagnal 11-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

In general, the operating voltages for the 6328 are as follows. The successive stages are operated at voltages increasing in equal steps from the photocathode to the 9th dynode. The steps are generally chosen as 50 to 100 volts per stage. The voltage between dynode No. 9 and the anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig. 4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltage between dynode No. 9 and anode reduces the dark current. As a result, the operating stability of the 6328 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No. 9 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

The operating stability of the 6328 is dependent on the magnitude of the anode current and

its duration. When the 6328 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6328 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.1 milliampere is recommended when stability of operation is important. When maximum stability is required, the

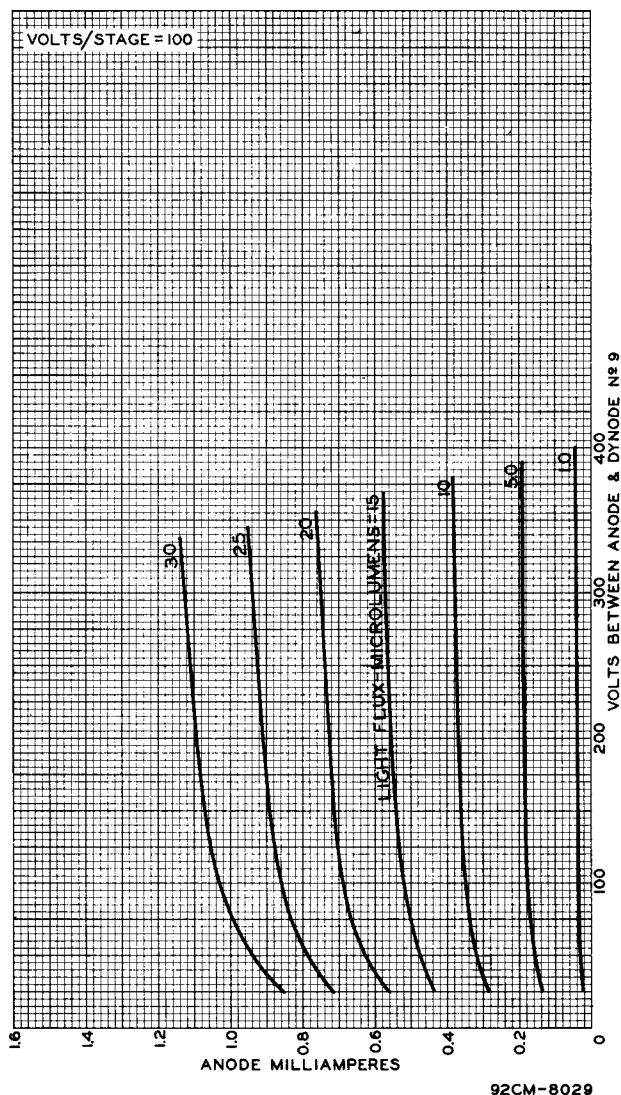


Fig. 4 - Average Anode Characteristics of Type 6328.

The sensitivity of the photocathode surface varies with respect to the position of the light spot on the surface. Fig. 5a shows the variation in sensitivity of the surface as the position of

a 1-mm light spot is moved from one end of the photocathode to the other. Similarly, the curve in Fig.5b shows how the sensitivity of the photocathode surface varies across its projected width in the plane of the grill. From these curves, the equipment designer can readily determine the optimum position of any light spot on the photocathode surface to give the highest sensitivity.

where n is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for the equipment designer to provide adequate adjustment of the supply voltage

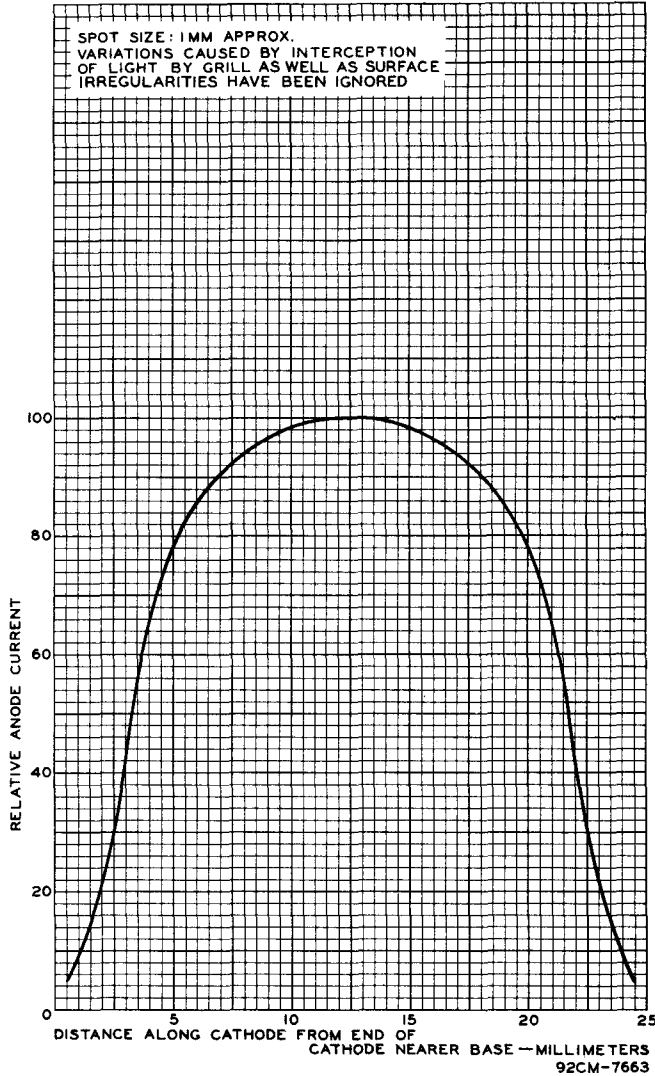


Fig.5a - Variation in Sensitivity of Photocathode Along Its Length.

Fig.6 shows the range of luminous sensitivity versus the dc voltage per stage for the 6328.

The range of sensitivity values is dependent on the respective amplification of each dynode stage. Hence, large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the n th power,

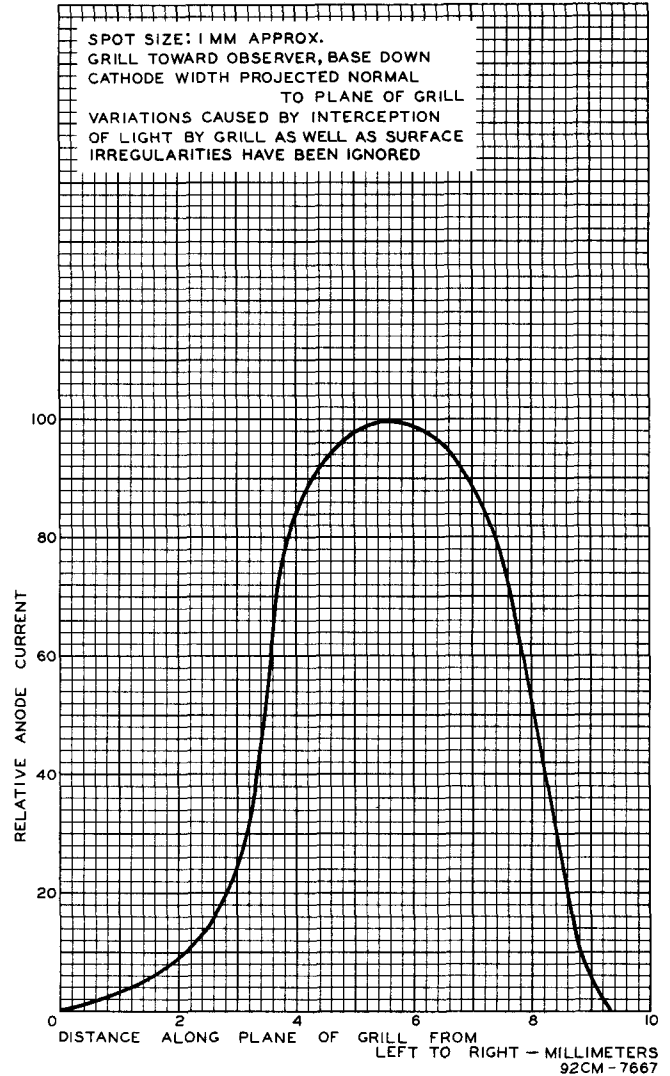


Fig.5b - Variation in Sensitivity of Photocathode Across Its Projected Width in Plane of Grill.

so that the amplification of individual tubes can be adjusted to the desired design value. It is suggested that an overall voltage-adjustment range of 2 to 1 be provided.

When the 6328 is operated with an ac supply, its effective sensitivity is reduced because appreciable anode current flows only near the peak of the positive cycle. The amount of the reduction is dependent on the ac waveshape. For

an ideal square wave, the sensitivity is reduced by a factor of 2.

The *electrode voltages* may be obtained from an adequately regulated ac or dc power supply. An *ac supply* may be conveniently obtained from a high-voltage transformer operated from a suitable vibrator. A *dc supply* may be obtained by employing a high-voltage, vacuum tube rectifier operated from a high-voltage transformer fed by a vibrator. The voltage for each dynode and for the anode can be supplied by fixed taps on a voltage divider across the power supply.

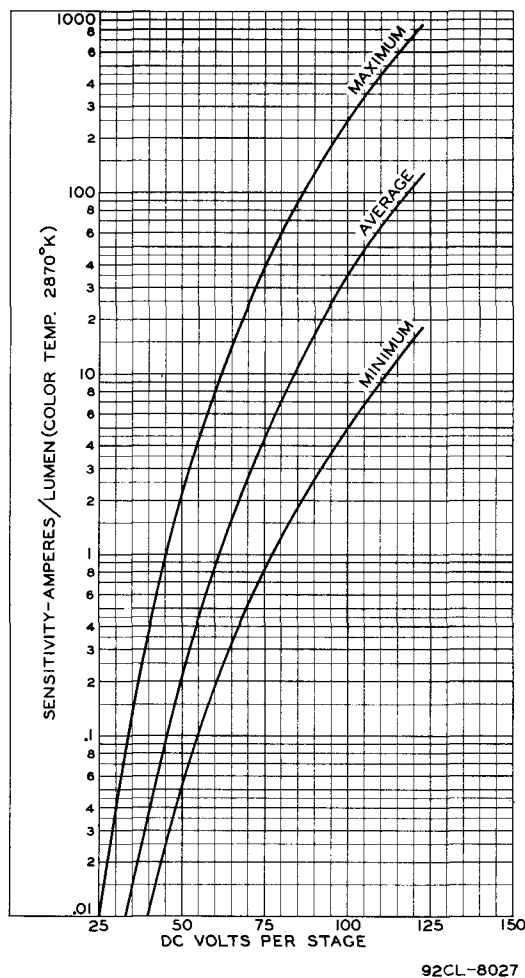


Fig. 6 - Range of Luminous Sensitivity of Type 6328.

A recommended design of voltage-divider network for use with the 6328 to provide stable operation and long tube life is shown in Fig. 7. This design provides linear operation within the range normally required for dimming. At higher

light levels, the network design limits the tube output to a safe value. The indicated design values provide dimming operation for an anode current in the range between 5 and 10 microamperes.

It is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

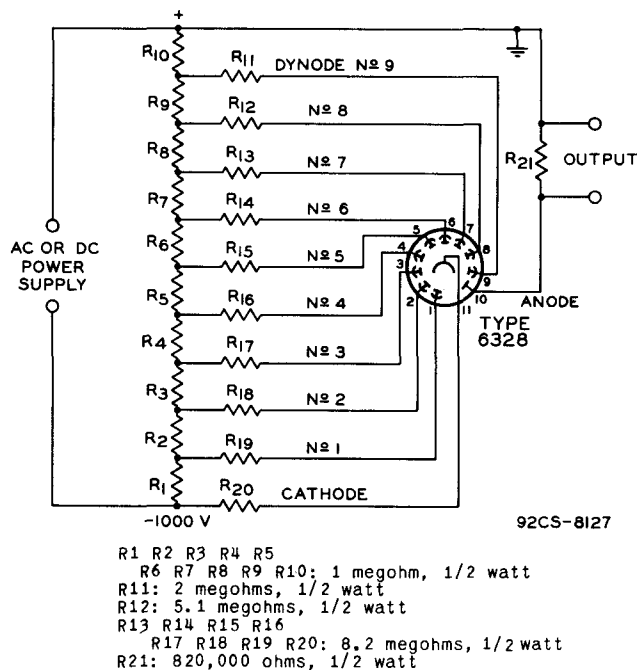


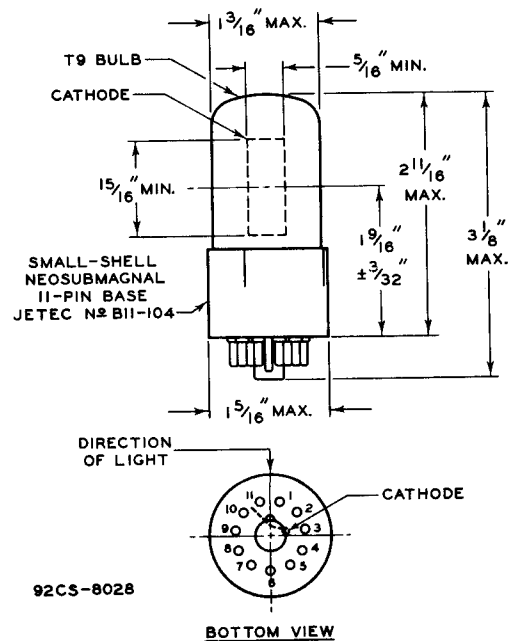
Fig. 7 - Recommended Voltage-Divider Network for Use with Type 6328 in Headlight Dimming Service.

The high voltages at which the 6328 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 6328, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power supply should be disconnected and both terminals of any capacitors grounded.



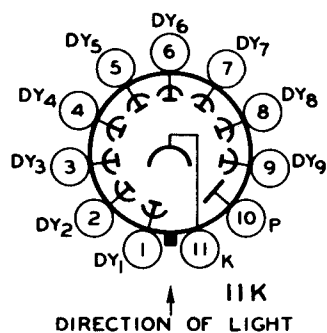
DIMENSIONAL OUTLINE



CL OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: THE MAXIMUM ANGULAR VARIATION BETWEEN THE PLANE THROUGH PINS NO. 1 AND NO. 11 AND THE PLANE OF THE GRILL WILL NOT EXCEED 6° .

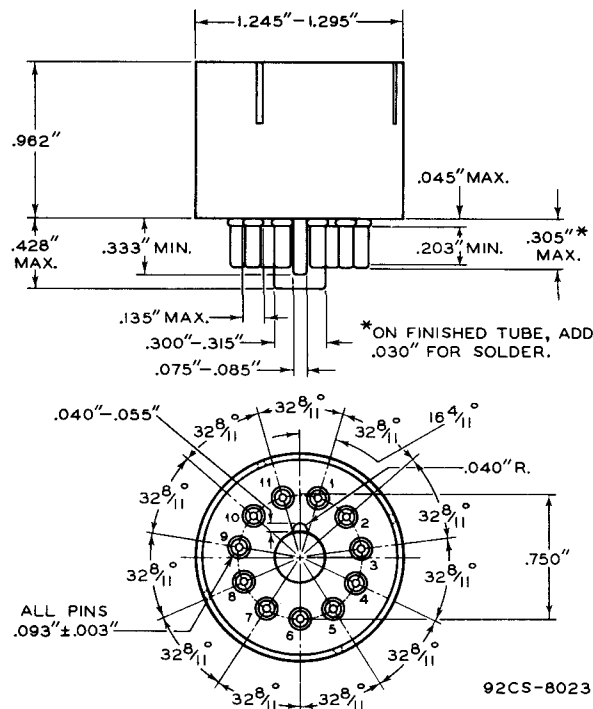
SOCKET CONNECTIONS Bottom View



- PIN 1: DYNODE No.1
- PIN 2: DYNODE No.2
- PIN 3: DYNODE No.3
- PIN 4: DYNODE No.4
- PIN 5: DYNODE No.5
- PIN 6: DYNODE No.6
- PIN 7: DYNODE No.7
- PIN 8: DYNODE No.8
- PIN 9: DYNODE No.9
- PIN 10: ANODE
- PIN 11: CATHODE



SMALL-SHELL NEOSUBMAGNAL
11-PIN BASE
JETEC No. B11-104



Base-pin positions are held to tolerances such that pins will fit flat-plate gauge having thickness of 1/4 inch and eleven 0.1030"-0.1035" holes so located on a 0.7500" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2125" ± 0.0005". Pin fit in gauge shall be such that entire length of pins will enter gauge, and on withdrawal, they will become disengaged without lifting gauge and supplementary weight totaling 3 pounds.

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