



IP28

IP28

MULTIPLIER PHOTOTUBE

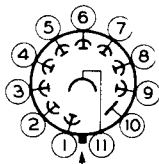
9-STAGE TYPE WITH S-5 RESPONSE

DATA

General:

Spectral Response	S-5
Wavelength of Maximum Response.	3400 $\pm$ 500 angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interelectrode Capacitances:	
Anode to Dynode No.9.	4 μ f
Anode to All Other Electrodes	6.5 μ f
Maximum Overall Length.	3-11/16"
Maximum Seated Length	3-1/8"
Seated Length to Center of Cathode.	1-15/16" $\pm$ 3/32"
Length, Base Seat to Center of	
Useful Cathode Area	1-15/16" $\pm$ 3/32"
Maximum Diameter.	1-5/16"
Bulb.	T-9
Mounting Position	Any
Base.	Small-Shell Submagnal 11-Pin, Non-Hygroscopic
Basing Designation for BOTTOM VIEW	11K

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

DIRECTION OF INCIDENT RADIATION

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
PEAK ANODE CURRENT.	5 max.	ma
AVERAGE ANODE CURRENT [○]	0.5 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics:

*With 100 volts per dynode stage and
100 volts between dynode No.9 and anode*

	<u>Min.</u>	<u>Av.</u>	<u>Max.</u>	
DC Anode Dark Current* [•] . . .	—	—	0.1	μ amp

* On plane perpendicular to indicated direction of incident radiation.

□ Referred to cathode.

○ Averaged over any interval of 30 seconds maximum.

At 25°C. Dark current due to thermionic emission and ion feedback may be reduced by the use of refrigerants.

• For maximum signal-to-noise ratio, operation below 1000 volts is recommended.

← Indicates a change.



IP28 MULTIPLIER PHOTOTUBE

	<u>Min.</u>	<u>Av.</u>	<u>Max.</u>	
Sensitivity:				
At 3400 angstroms.	-	22600	-	$\mu\text{amp}/\mu\text{watt}$
Luminous:				
Cathode§	-	20	-	$\mu\text{amp}/\text{lumen}$
Anode:▲				
At 0 cps	4.5	20	300	amp/lumen
At 100 Mc.	-	19	-	amp/lumen
Current Amplification■	-	1×10^6	-	
Luminous Equivalent				
Noise Input*	-	7×10^{-12}	-	lumen
Ultraviolet Equivalent				
Noise Input†	-	6×10^{-15}	-	watt

→ Characteristics:

*With 75 volts per dynode stage
and 50 volts between dynode No.9 and anode*

Sensitivity:	<u>Av.</u>	
At 3400 angstroms.	3400	$\mu\text{amp}/\mu\text{watt}$
Luminous:		
Cathode§	20	$\mu\text{amp}/\text{lumen}$
Anode▲, at 0 cps	3	amp/lumen
Current Amplification■	150000	

§ For conditions the same as shown under Anode Luminous Sensitivity except that the value of light flux is 0.01 lumen and that 100 volts are applied between cathode and all other electrodes connected together as anode.

▲ Measured under conditions specified on sheet "PHOTOTUBE SENSITIVITY AND SENSITIVITY MEASUREMENTS" at the front of this Section.

■ Ratio of anode sensitivity to cathode sensitivity.

★ Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: 100 volts per stage, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

† Defined the same as Luminous Equivalent Noise Input except that use is made of a monochromatic source having radiation at 2537 angstroms.

SPECTRAL-SENSITIVITY CHARACTERISTIC
of Phototube having S-5 Response
is shown at the front of this Section

OPERATING NOTES

The operating stability of the IP28 is dependent on the magnitude of the anode current and its duration. When the IP28 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.

(continued on next page)

→ Indicates a change.



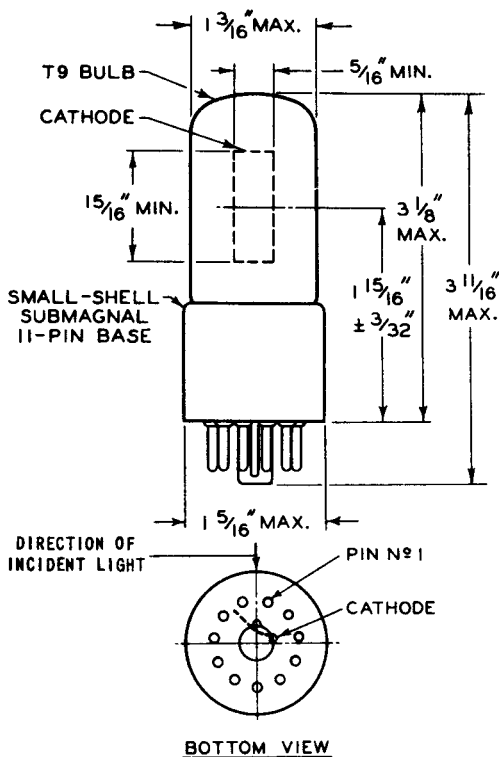
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MULTIPLIER PHOTOTUBE

After a period of idleness, the IP28 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.5 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 10 microamperes.



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

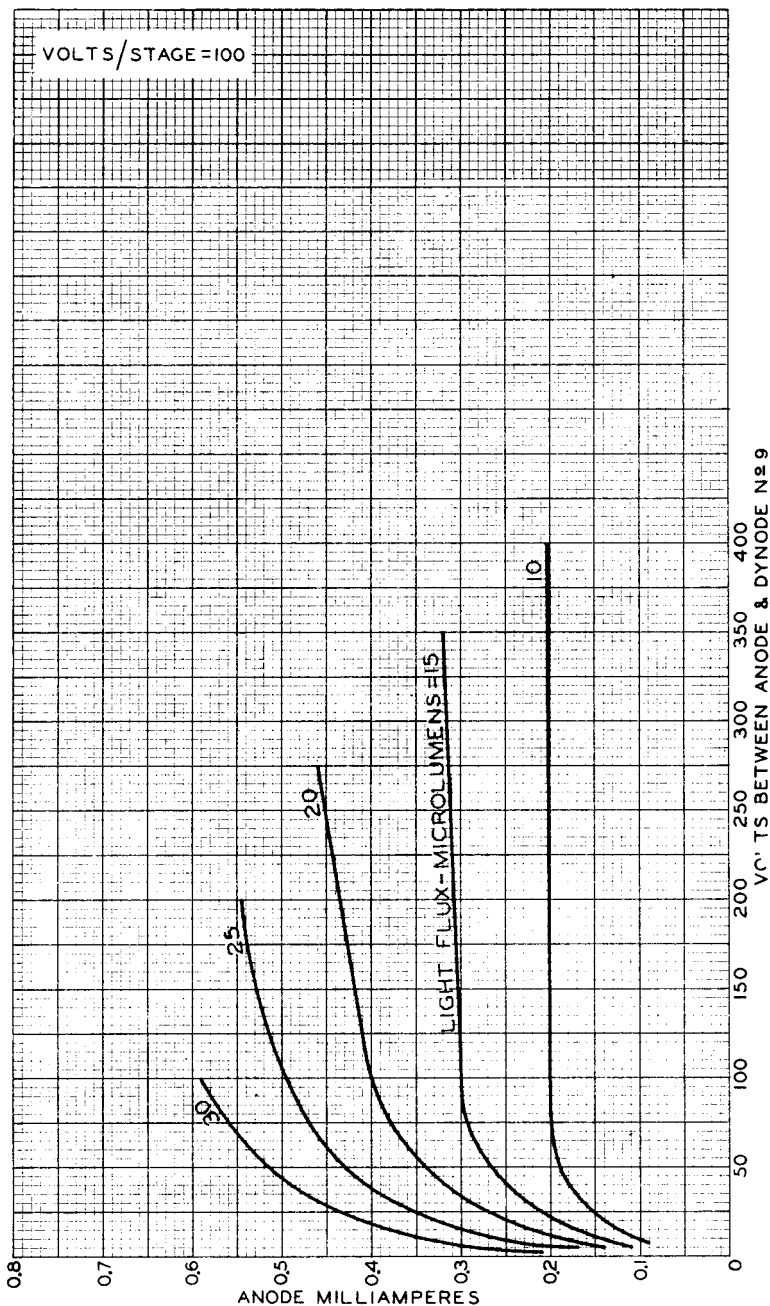
92CM-6264R2

IP28



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AVERAGE ANODE CHARACTERISTICS



JUNE 26, 1950

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

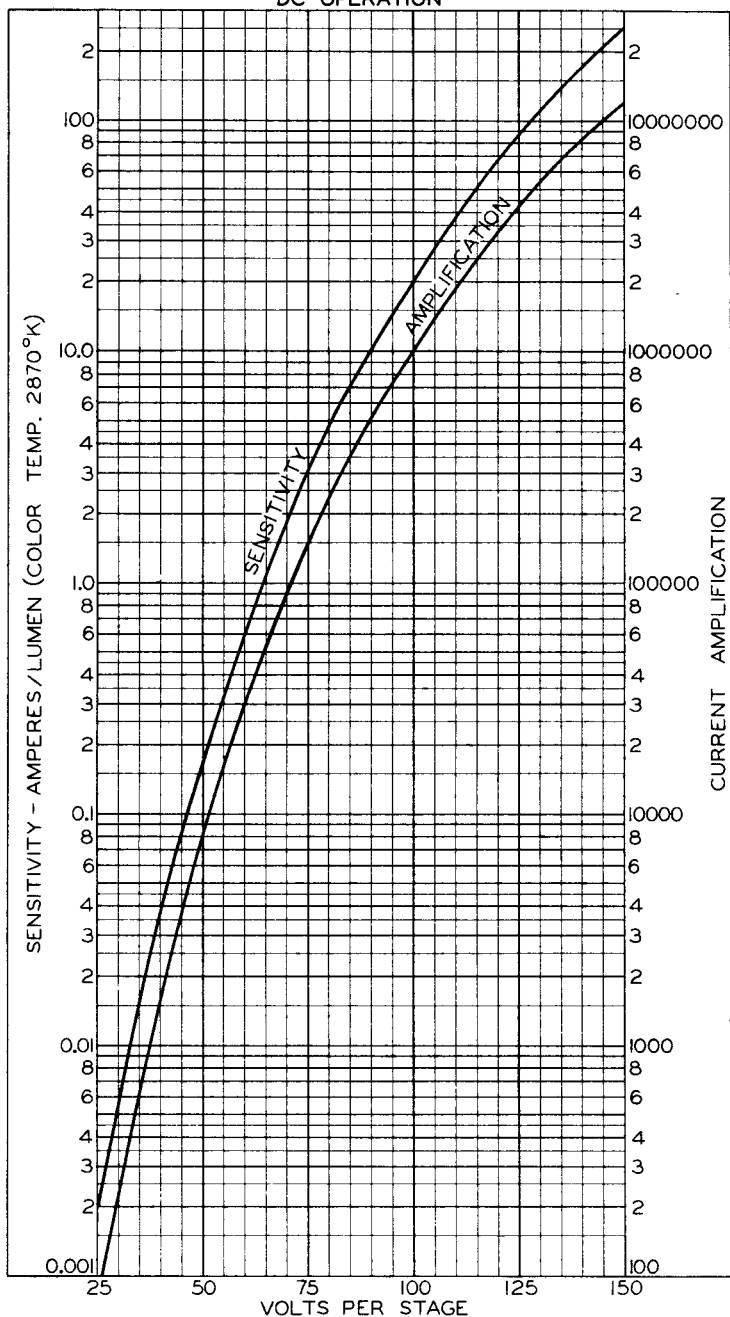
92CM-6632R2



IP28

AVERAGE CHARACTERISTICS
DC OPERATION

IP28



JUNE 23, 1950

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

92CL - 6547R2



EQUIVALENT-NOISE-INPUT CHARACTERISTIC

100 VOLTS PER STAGE

BANDWIDTH: 1 CPS

LIGHT SOURCE: TUNGSTEN, AT 2870°K;

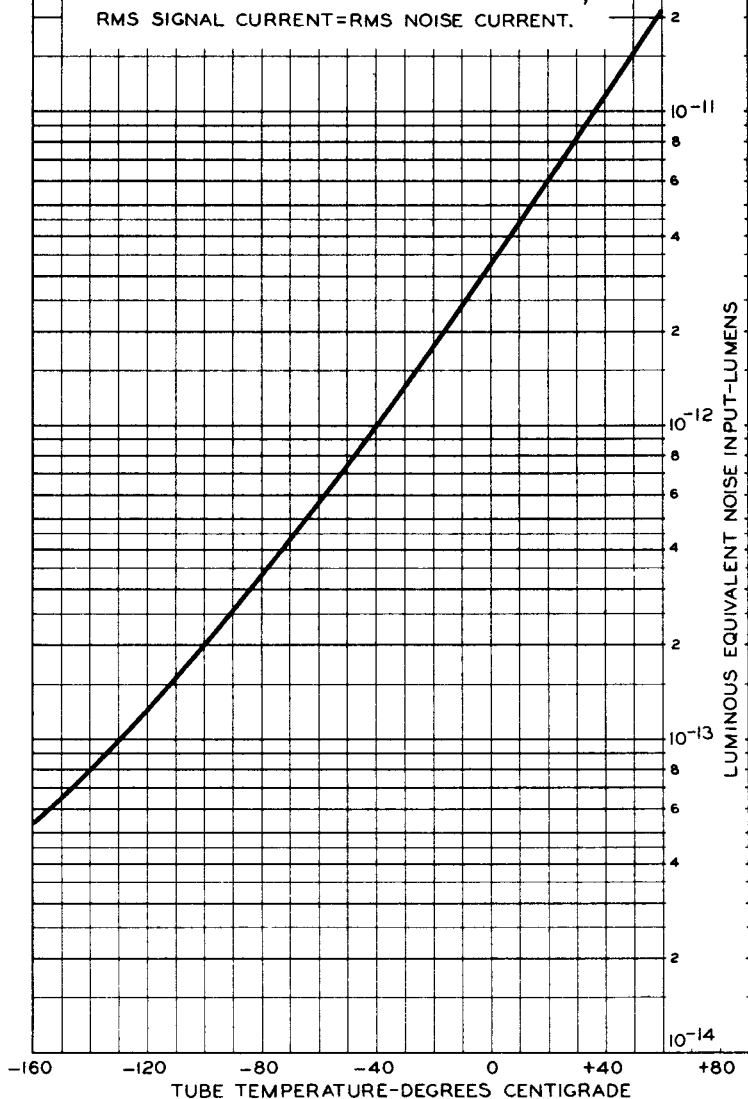
INTERRUPTED AT 90 CPS TO PRODUCE PULSES

ALTERNATING BETWEEN ZERO AND FLUX VALUE

SHOWN FOR ANY GIVEN TUBE TEMPERATURE;

"ON" PERIOD OF PULSE EQUAL TO "OFF" PERIOD;

RMS SIGNAL CURRENT = RMS NOISE CURRENT.



Photomultiplier Tube

9-STAGE, SIDE-ON TYPE

S-5 RESPONSE

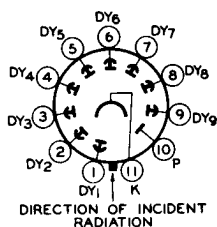
*For Detection and Measurement of
Ultraviolet and Visible Radiation*

GENERAL

Spectral Response	S-5
Wavelength of Maximum Response	3400 $\pm$ 500 angstroms
Cathode, Opaque	Cs-Sb
Minimum projected length ^a	15/16 inch
Minimum projected width ^a	5/16 inch
Window	Ultraviolet-Transmitting Glass ^b
Index of refraction at 5893 angstroms	1.47 $\leftarrow$
Dynodes	
Substrate	Ni $\leftarrow$
Secondary-emitting surface	Cs-Sb
Structure	Circular Cage
Direct Interelectrode Capacitances (Approx.)	
Anode to dynode No.9	4.4 pF
Anode to all other electrodes	6.0 pF
Maximum Overall Length	3-11/16 inch
Maximum Seated Length	3-1/8 inch
Length from Base Seat to Center of	
Useful Cathode Area	1-15/16 $\pm$ 3/32 inch
Maximum Diameter	1-5/16 inch
Operating Position	Any
Weight (Approx.)	1.6 oz
Envelope	JEDEC T9
Base	Small-Shell Submagnal 11-Pin, (JEDEC Group 2, No.B11-88), Non-hygroscopic
Socket	Amphenol ^c No.78S11T, or equivalent
Magnetic Shield	Millen ^d Part No.80801B, or equivalent $\leftarrow$

TERMINAL DIAGRAM (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 - Photocathode



$\leftarrow$ Indicates a change.



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DATA 1
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ABSOLUTE-MAXIMUM VALUES

DC or Peak AC Supply Voltage

Between anode and cathode	1250	V
Between dynode No.9 and anode	250	V
Between consecutive dynodes	250	V
Between dynode No.1 and cathode	250	V
Average anode current ^e	0.5	mA
Ambient temperature ^f	75	°C

CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a 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 V (Except as noted)

	Min	Typ	Max	
Sensitivity				
Radiant, ^g at 3400 angstroms	-	1.2×10^5	-	A/W
Cathode radiant, ^h at 3400 angstroms	-	0.05	-	A/W
Luminous ^j	17.5	100	500	A/lm
Cathode luminous ^k	1×10^{-5}	4×10^{-5}	-	A/lm
Quantum efficiency at 3200 angstroms	-	19	-	%
Current Amplification	-	2.5×10^6	-	
Equivalent Anode-Dark-Current Input ⁿ	{ -	2.5×10^{-10m} 2×10^{-13p}	1.25×10^{-9m} 1×10^{-12p}	lm W
Anode Dark Current at 20 A/lm ^m , ⁿ	-	5×10^{-9}	2.5×10^{-8}	A
Equivalent Noise Input ^q	{ -	7.5×10^{-13} 6×10^{-16p}	-	lm W
Anode-Pulse Rise Time ^r	-	1.9×10^{-9}	-	s
Electron Transit Time ^s	-	1.7×10^{-8}	-	s

^a On plane perpendicular to the indicated direction of incident light and passing through the major axis of the tube.

^b Corning No.9741, Corning Glass Works, Corning, New York, or equivalent.

^c Made by Amphenol Electronics Corporation, 1830 South 54th Avenue, Chicago 50, Illinois.

^d Made by James Millen Manufacturing Company, 150 Exchange Street, Malden 48, Mass.

^e Averaged over any interval of 30 seconds maximum.

^f Tube operation at room temperature or below is recommended.

^g This value is calculated from the typical luminous sensitivity rating using a conversion factor of 1252 lumens per watt.

^h This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1252 lumens per watt.

^j Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870°K and a light input of 10 microlumens is used.

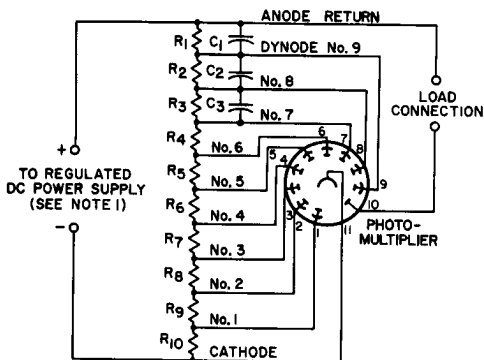
^k Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870°K. The value of light flux is 0.01 lumen and 100 volts are applied between cathode and all other electrodes connected as anode.

→ Indicates a change.



- m At a tube temperature of 22°C and with supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current may be reduced by use of a refrigerant.
- n For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.
- p At 3400 angstroms. This value is calculated from the rating in lumen using a conversion factor of 1252 lumens/watt.
- q Under the following conditions: Supply voltage (E) is as shown, 22°C tube temperature, external shield connected to cathode, bandwidth 1 cycle per second, tungsten-light source at a color temperature of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period.
- r Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode-pulse rise time is primarily a function of transit time variation and is measured under conditions with the incident light fully illuminating the photocathode.
- s The electron transit time is the time interval between the arrival of a delta function light pulse at the entrance window of the tube and the time at which the output pulse at the anode terminal reaches peak amplitude. The transit time is measured under conditions with the incident light fully illuminating the photocathode.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



92CS-11382R1

R1 through R10 = 20,000 to 1,000,000 ohms

Note 1: Adjustable between approximately 500 and 1250 volts.

Note 2: Capacitors C1 through C3 should be connected at tube socket for optimum high-frequency performance.

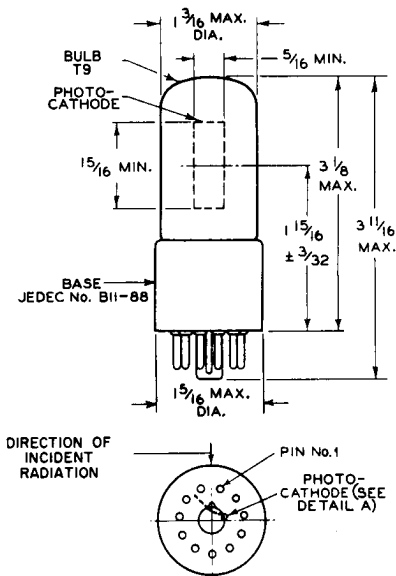
SPECTRAL-SENSITIVITY CHARACTERISTIC
OF PHOTSENSITIVE DEVICE HAVING S-5 RESPONSE
is shown at the front of this section



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DATA 2
4-66

DIMENSIONAL OUTLINE

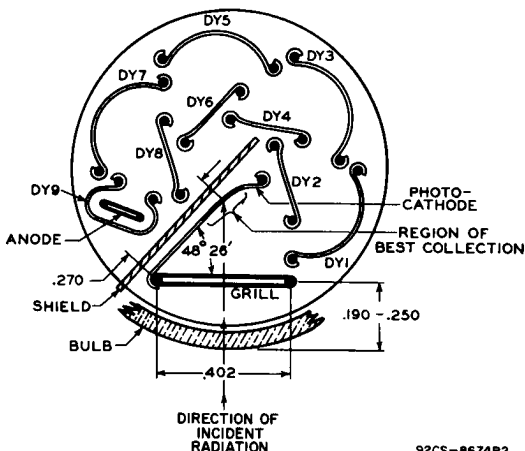


92CM-6264R9

DIMENSIONS IN INCHES

Center line of bulb will not deviate more than 2° in any direction from the perpendicular erected at center of bottom of base.

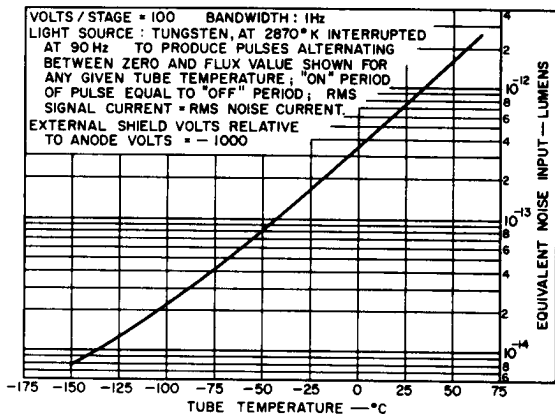
DETAIL A



92CS-8674R2

DIMENSIONS IN INCHES

Equivalent-Noise-Input Characteristic



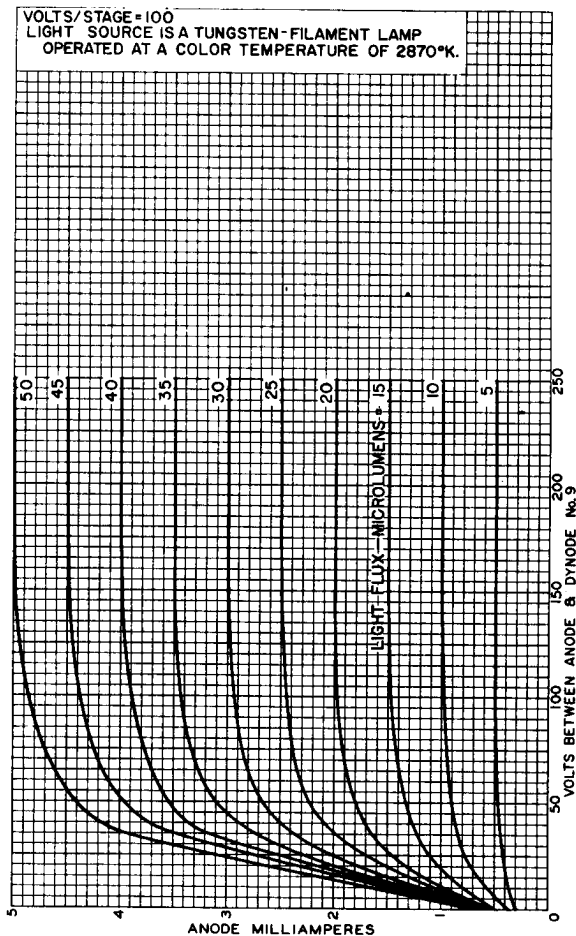
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DATA 3
 4-66

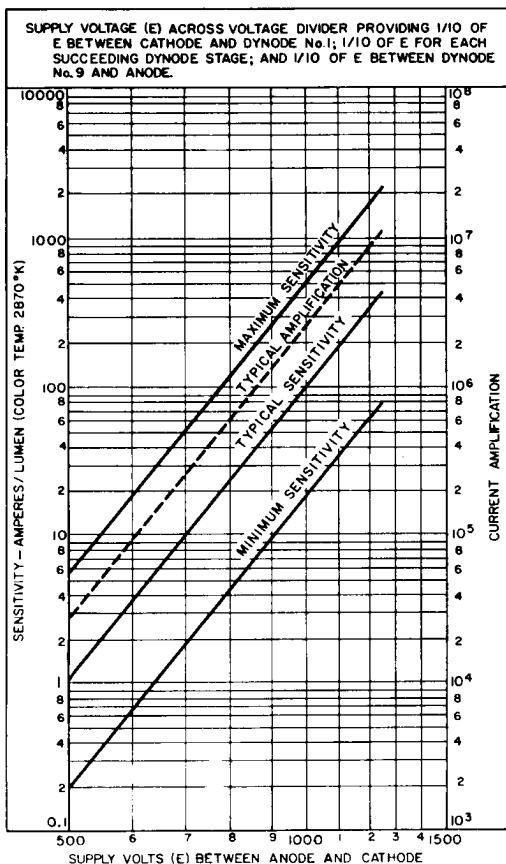
Typical Anode Characteristics



92CM-6632 R4



Typical Sensitivity and Current Amplification Characteristics



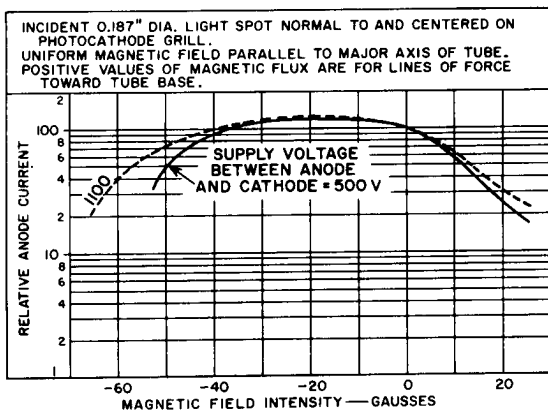
92 LM-1216



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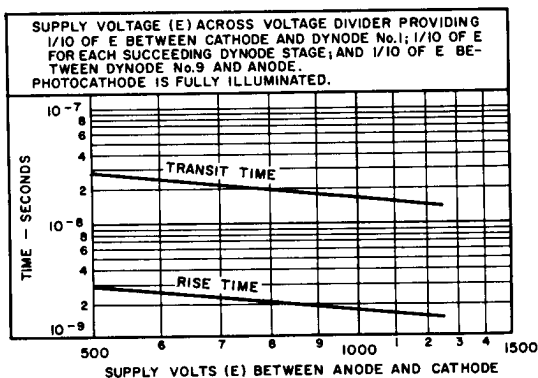
DATA 4
4-66

Typical Effect of Magnetic Field on Anode Current



92CS-7664R2

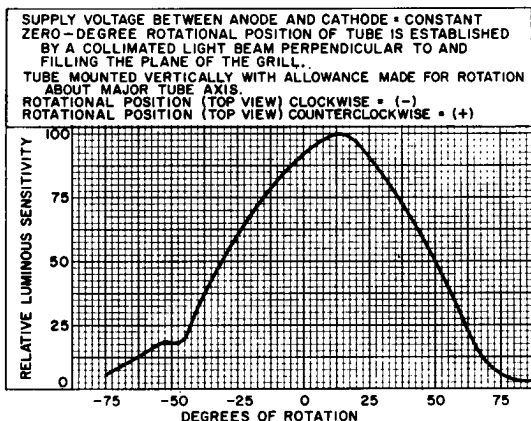
Typical Time-Resolution Characteristics



92LS-1215

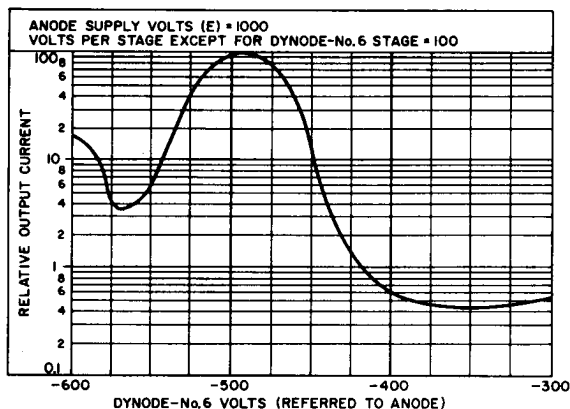


Typical Variation of Sensitivity as Tube is Rotated with Respect to Fixed Light Beam



92CS-8671R2

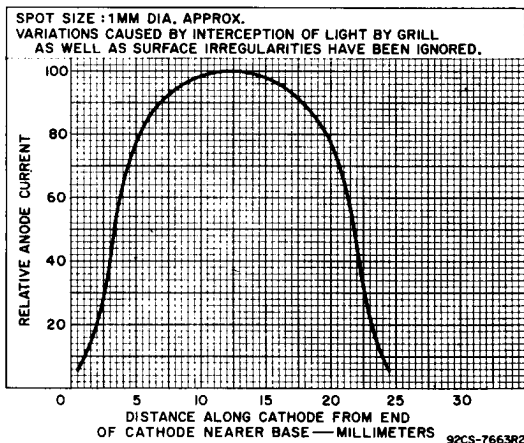
Dynode Modulation Characteristics



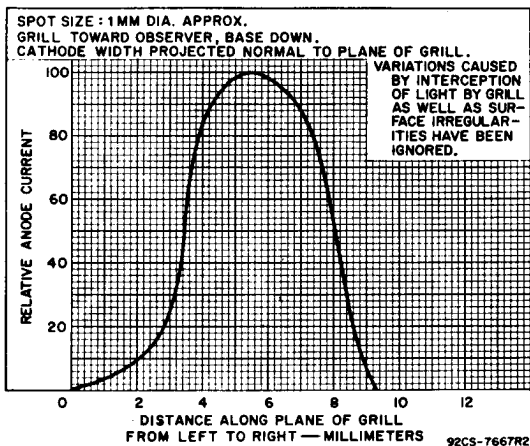
92CS-8672R1



Typical Variation of Photocathode Sensitivity Along Tube Length



Typical Variation of Photocathode Sensitivity Across Projected Width in Plane of Grill



Photomultiplier Tube

9-STAGE, SIDE-ON TYPE

S-5 RESPONSE

For Detection and Measurement of Ultraviolet and Visible Radiation

The 1P28A is the same as the 1P28 except for the following items:

CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a 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	Typ	Max	
Sensitivity,				
Luminous J.	35	200	500	A/1m
"Red-to-White" Ratio	7	-	-	%

^j Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870 °K and a light input of 10 microlumens is used.

RED-TO-WHITE RATIO

The sensitivity of the 1P28A above the wavelength of 5800 angstroms is controlled. This control is important in applications where a high-level of sensitivity in the red region of the spectral-response characteristic is required. The degree of this controlled sensitivity in the red region is specified by a "red-to-white" ratio of anode currents. Anode current is measured first using a tungsten-lamp source, and then measured with a red filter interposed between the light source and phototube.

The anode current comprising the "white" portion of this ratio is measured with a light input of 10 microlumens. The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870 °K.

The anode current comprising the "red" portion of the ratio is measured under conditions identical with the "white" measurement except that the light input of 10 microlumens is transmitted through a red filter (Corning C.S. No.2-112-manufactured by the Corning Glass Works, Corning, N.Y., or equivalent) which has the following characteristics: the transmittance of all wavelengths from 3000 to 5790 angstroms is less than 0.5%; the 37% transmittance point lies between 6030 and 6070 angstroms; the transmittance from 6400 to 7000 angstroms is greater than 80%; and the difference between the wavelengths where transmittance is 15% and 60% is not greater than 150 angstroms.

