



931-A

931-A

MULTIPLIER PHOTOTUBE

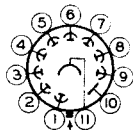
9-STAGE TYPE with S-4 RESPONSE

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 μ f
Anode to All Other Electrodes.	6.5 μ f
Maximum Overall Length	3-11/16"
Maximum Seated Length.	3-1/8"
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



DIRECTION OF LIGHT

Pin 7 - Dynode No.7
Pin 8 - Dynode No.8
Pin 9 - Dynode No.9
Pin 10 - Anode
Pin 11 - Cathode

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	10 max.	ma
AVERAGE ANODE CURRENT [○]	1 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 light.

□ Referred to cathode.

○ Average 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.

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	<u>Min.</u>	<u>Au.</u>	<u>Max.</u>	
Sensitivity:				
At 4000 angstroms.	-	18600	-	$\mu\text{amp}/\mu\text{watt}$
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	-	
Equivalent Noise Input★.	-	7×10^{-12}	-	lumen

→ Characteristics:

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

	<u>Au.</u>	
Sensitivity:		
At 4000 angstroms.	2800	$\mu\text{amp}/\mu\text{watt}$
Luminous:		
Cathode§	20	$\mu\text{amp}/\text{lumen}$
Anode▲, 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.

SPECTRAL-SENSITIVITY CHARACTERISTIC
of Phototube having S-4 Response
is shown at the front of this Section

OPERATING NOTES

The operating stability of the 931-A is dependent on the magnitude of the anode current and its duration. When the 931-A 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 931-A usually recovers a substantial percentage of such loss in sensitivity.

(continued on next page)

→ Indicates a change.

SEPT. 1, 1950

TUBE DEPARTMENT

RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

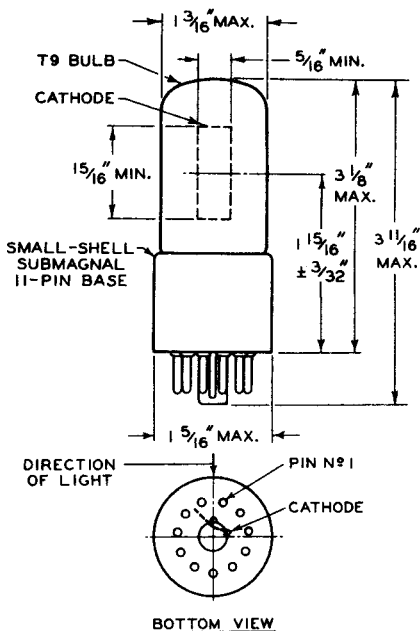
DATA



931-A

931-A MULTIPLIER PHOTOTUBE

The use of an average anode current well below the maximum rated value of 1.0 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 250 microamperes.



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

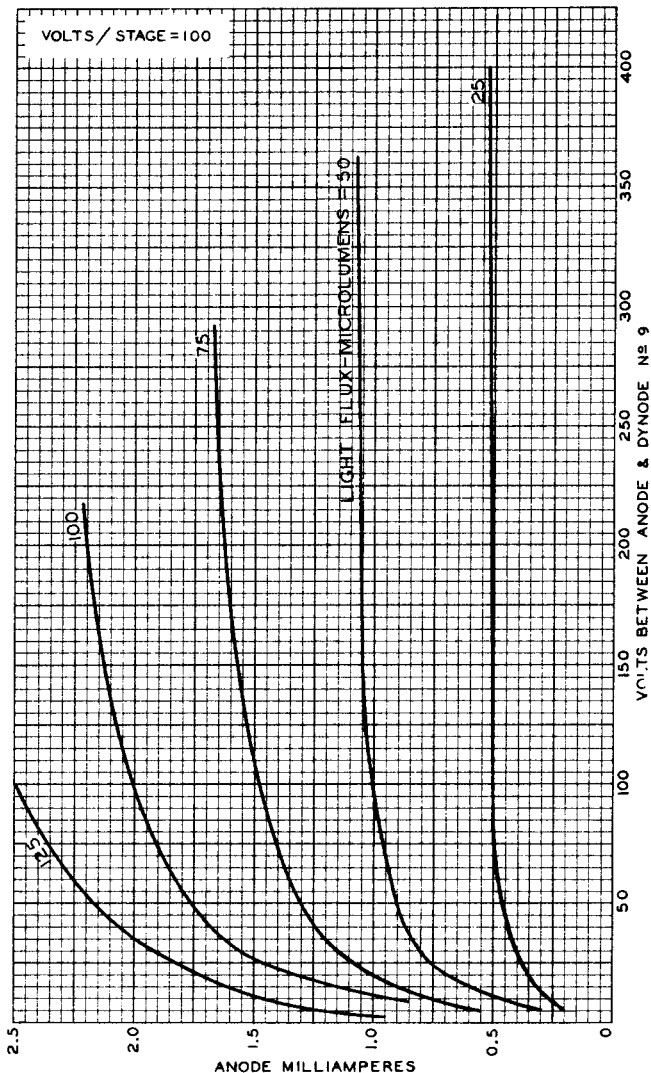
92CM-6264R2

931-A



931-A

AVERAGE ANODE CHARACTERISTICS



JUNE 30, 1950

TUBE DEPARTMENT

92CM-6268R4

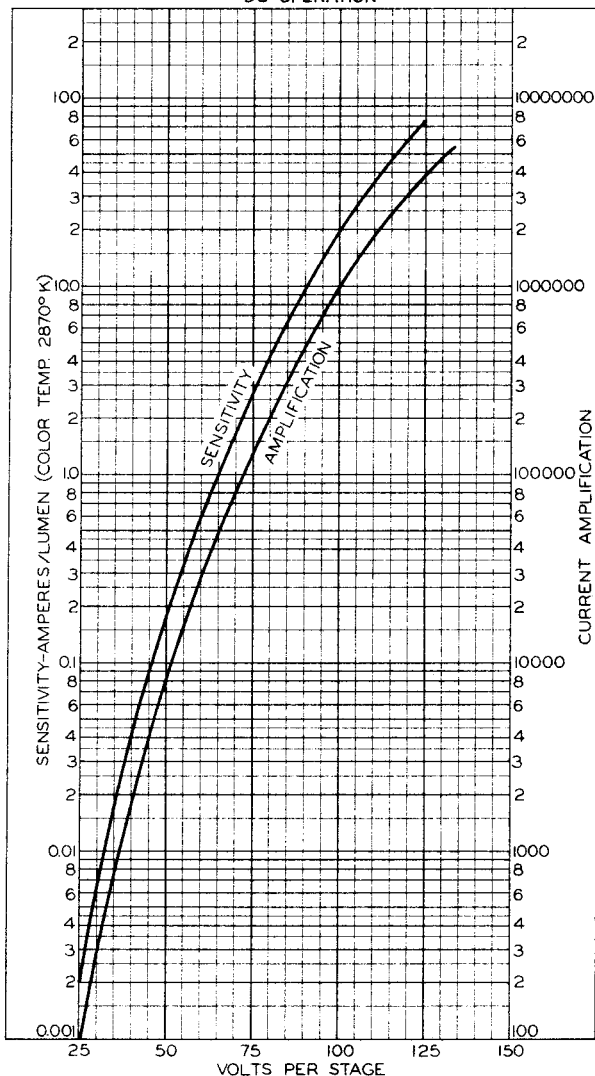
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AVERAGE CHARACTERISTICS
DC OPERATION



JULY 21, 1950

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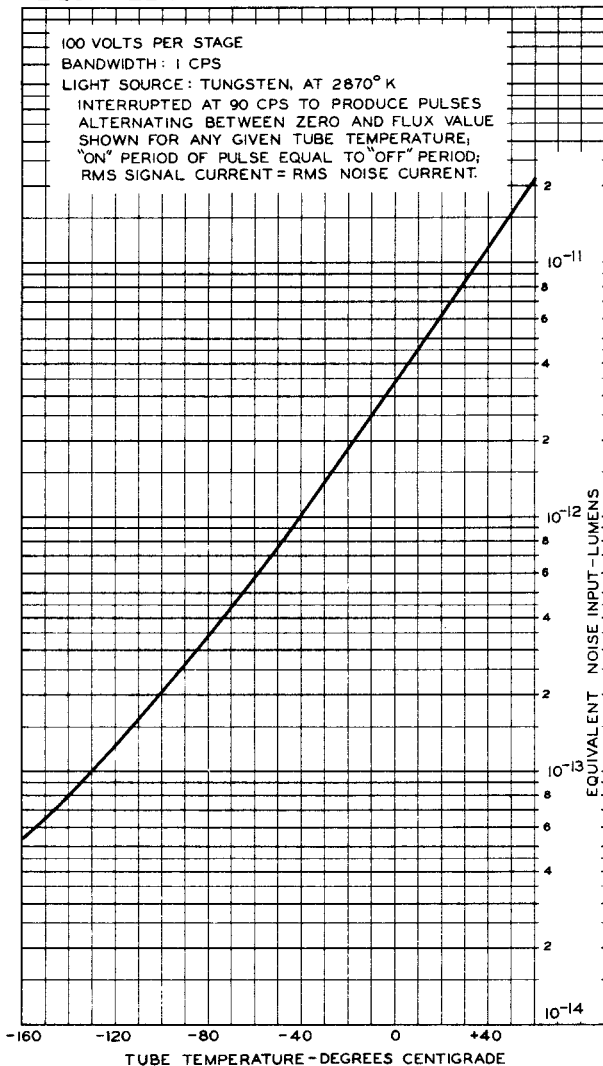
92CL-6459R2

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EQUIVALENT-NOISE-INPUT CHARACTERISTIC



JUNE 28, 1950

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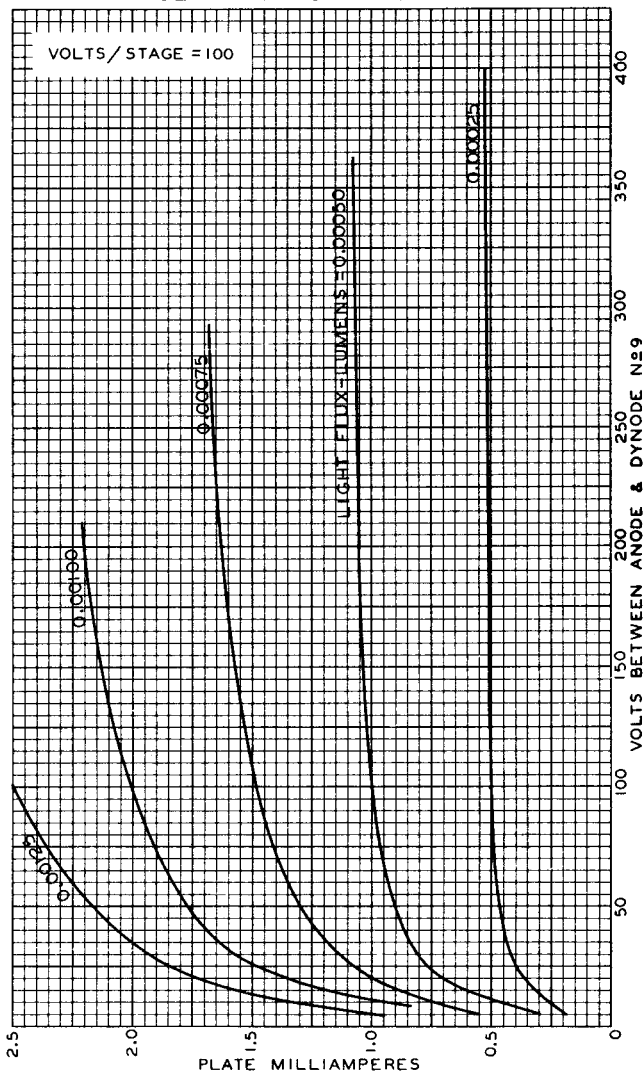
92CM-7505



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AVERAGE ANODE CHARACTERISTICS



DEC. 1, 1943

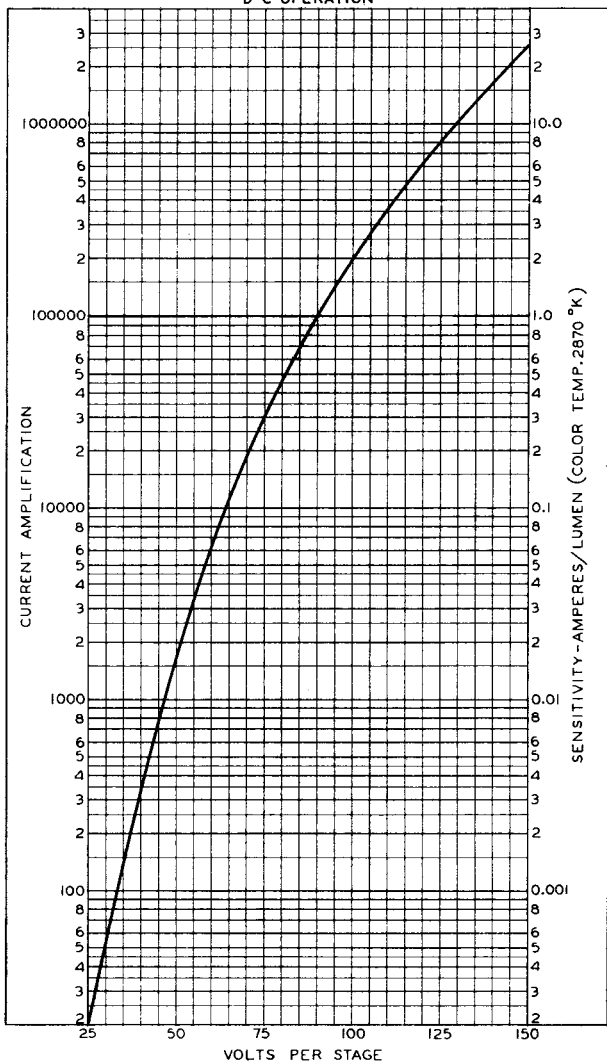
RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

92CM-6268R2

931-A



931-A

AVERAGE CHARACTERISTIC
D-C OPERATION

DEC. 1, 1943

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

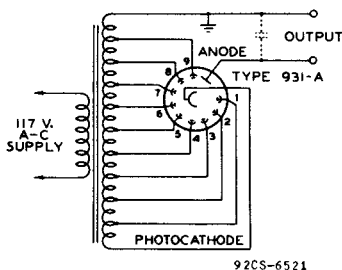
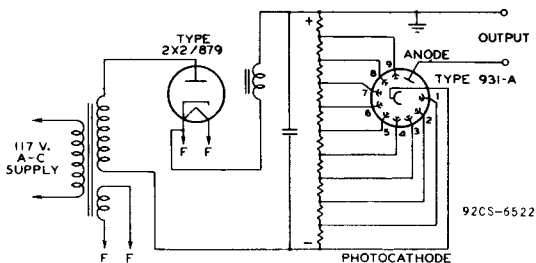
92CL-6459



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TYPICAL CIRCUITS

A-C POWER-SUPPLY CIRCUIT
with uniformly tapped transformerHALF-WAVE POWER-SUPPLY CIRCUIT
with bleeder for supplying d-c voltages

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

DEC. 1, 1943

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

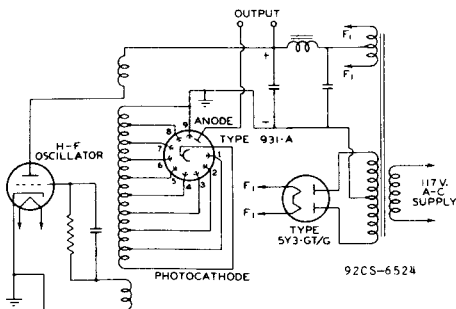
CIRCUITS



TYPICAL CIRCUITS

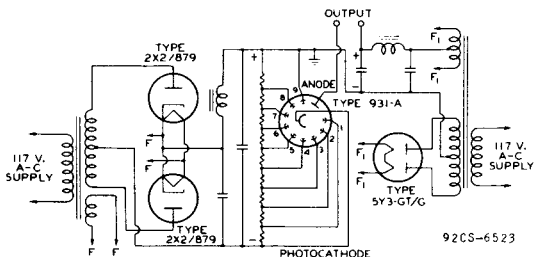
CIRCUIT USING H-F OSCILLATOR

for supplying a-c voltages to dynodes No.1 to No.9
and separate d-c voltage supply for the anode stage



FULL-WAVE POWER-SUPPLY CIRCUIT

with bleeder for supplying d-c voltages to dynodes No.1 to
No.9 and separate d-c voltage supply for the anode stage



Photomultiplier Tube

9-Stage, Side-On Type Having S-4 Spectral Response

For general purpose applications in low-light level detection and measurement systems.

GENERAL

Spectral Response	S-4
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode, Opaque	Cesium-Antimony
Minimum projected length ^a	0.94 in (2.4 cm)
Minimum projected width ^a	0.31 in (0.8 cm)
Window	Lime Glass (Corning ^b No. 0080), or equivalent
Index of refraction at 4360 angstroms	1.523

Dynodes:

Substrate	Nickel
Secondary-Emitting Surface	Cesium-Antimony
Structure	Circular-Cage, Electrostatic-Focus Type

Direct Interelectrode Capacitances (Approx.):

Anode to dynode No.9	4.4 pF
Anode to all other electrodes	6.0 pF
Maximum Overall Length	3.68 in (9.3 cm)
Seated Length	3.12 in (7.9 cm)
Maximum Diameter	1.31 in (3.3 cm)
Gulb	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 No. 80801B, or equivalent
Operating Position	Any
Weight (Approx.)	1.6 oz

MAXIMUM RATINGS, Absolute-Maximum Values

DC or Peak AC Supply Voltage:

Between anode and cathode	1250 max.	V
Between anode and dynode No.9	250 max.	V
Between consecutive dynodes	250 max.	V
Between dynode No.1, and cathode	250 max.	V

Average Anode Current ^f	1.0 max. mA
Ambient Temperature ^g	+75 max. °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 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant ^h at 4000 angstroms . . .	—	8.3×10^4	—	A/W
Luminous ⁱ (2870° K).	10	80	600	A/lm
Cathode Sensitivity:				
Radiant ^k at 4000 angstroms . . .	—	0.04	—	A/W
Luminous ^m (2870° K).	—	4×10^{-5}	—	A/lm
Quantum Efficiency at 3800 angstroms . . .	—	13	—	%
Current Amplification	—	2×10^6	—	
Anode Dark Current ⁿ	—	5×10^{-9}	5×10^{-8}	A
Equivalent Anode Dark Current Input ⁿ	{	2.5×10^{-10}	2.5×10^{-9}	lm
		2.4×10^{-13p}	2.4×10^{-12p}	W
Equivalent Noise Input ^q	{	3×10^{-12}	—	lm
		2×10^{-15r}	—	W
Anode-Pulse Rise Time ^s at 1250 V . .	—	1.6×10^{-9}	—	s
Electron Transit Time ^t at 1250 V.	—	1.6×10^{-8}	—	s

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

^b Made by Corning Glass Works, Corning, NY 14830.

^c Made by Amphenol Electronics Corporation, 1830 South 54th Avenue, Chicago 50, IL 60650.

^d Made by James Millen Manufacturing Company, 150 Exchange Street, Malden, MA 02148.

^f Averaged over any interval of 30 seconds maximum.

→ Indicates a change or addition.

- 9** Tube operation at room temperature or below is recommended.

This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1036 lumens per watt.

- i** 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** This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1036 lumens per watt.

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.

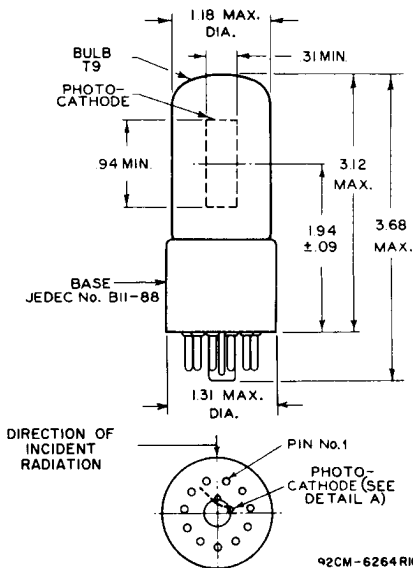
- n** At a tube temperature of 22° C. With supply voltage adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission may be reduced by use of a refrigerant.
- p** At 4000 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 1036 lumens per watt.
- q** Under the following conditions: Tube temperature 22° C, external shield connected to cathode, bandwidth 1 Hz, 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.

At 4000 angstroms. This value is calculated from the ENI value in lumens using a conversion factor of 1036 lumens per watt.

- s** 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.

† 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.

DIMENSIONAL OUTLINE

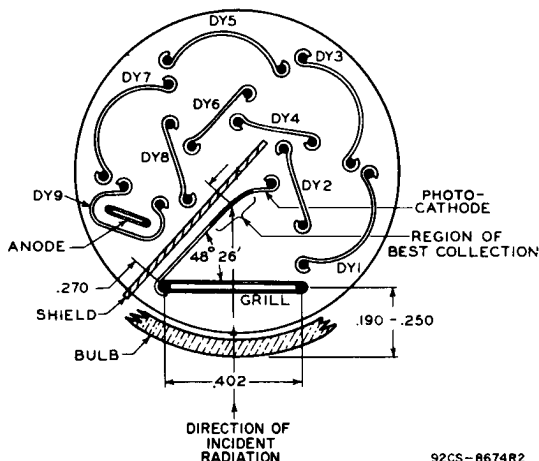


℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at center of bottom of base. Dimensions are in inches unless otherwise stated.

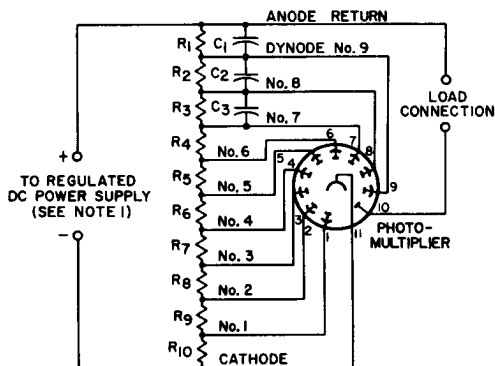
Inch Dimension Equivalents in Millimeters

Inch	mm	Inch	mm	Inch	mm
.09	2.3	.31	7.9	1.31	33.2
.190	4.8	.402	10.2	1.94	49.2
.250	6.3	.94	23.8	3.12	79.2
.270	6.8	1.18	29.9	3.68	93.4

DETAIL A (Top View)



TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



R_1 through $R_{10} = 20,000$ to $1,000,000$ ohms

Note 1: Adjustable between approximately 500 and 1250 volts.

Note 2: Capacitors C_1 through C_3 should be connected at tube socket for optimum high-frequency performance.

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

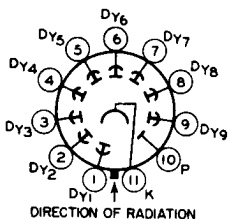
Pin 7: Dynode No.7

Pin 8: Dynode No.8

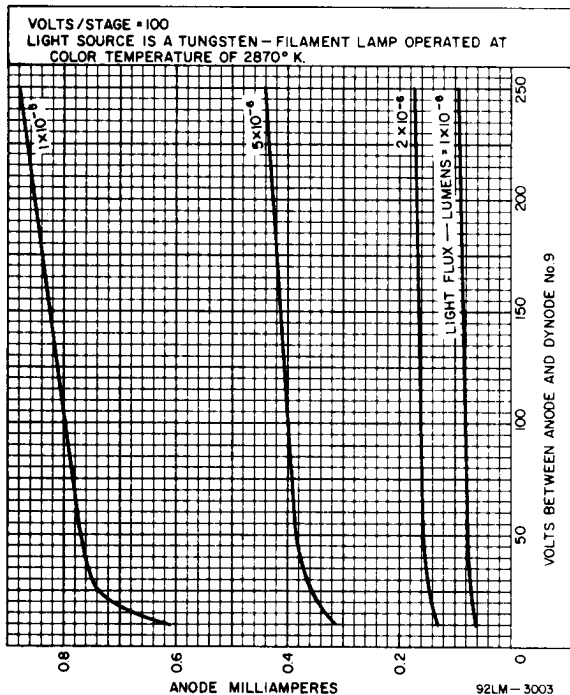
Pin 9: Dynode No.9

Pin 10: Anode

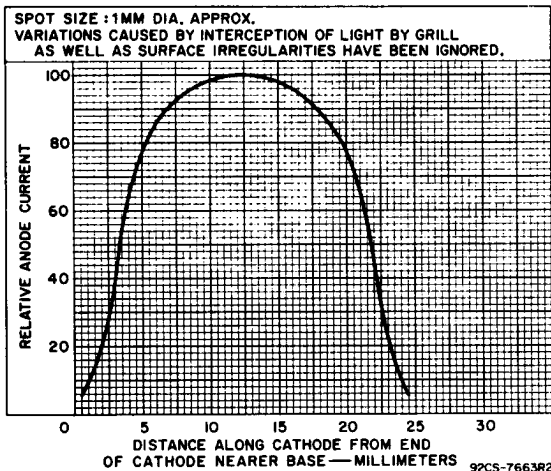
Pin 11: Photocathode



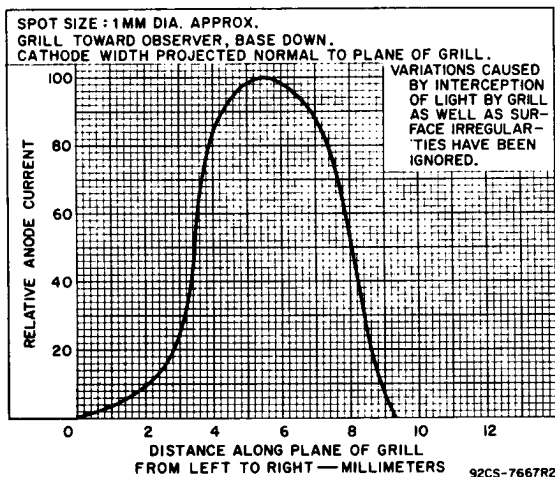
TYPICAL ANODE CHARACTERISTICS



TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ALONG TUBE LENGTH

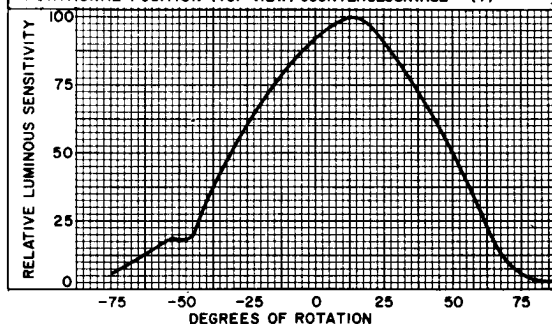


TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ACROSS PROJECTED WIDTH IN PLANE OF GRILL



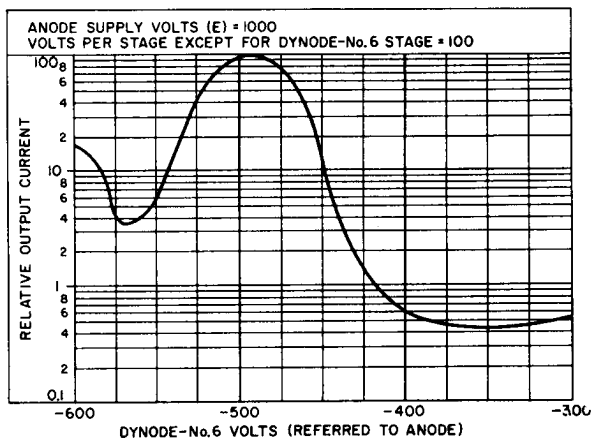
TYPICAL VARIATION OF SENSITIVITY AS TUBE IS ROTATED WITH RESPECT TO FIXED LIGHT BEAM

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE = CONSTANT
 ZERO-DEGREE ROTATIONAL POSITION OF TUBE IS ESTABLISHED BY A COLLIMATED LIGHT BEAM PERPENDICULAR TO AND FILLING THE PLANE OF THE GRILL.
 TUBE MOUNTED VERTICALLY WITH ALLOWANCE MADE FOR ROTATION ABOUT MAJOR TUBE AXIS.
 ROTATIONAL POSITION (TOP VIEW) CLOCKWISE = (-)
 ROTATIONAL POSITION (TOP VIEW) COUNTERCLOCKWISE = (+)



92CS-8671R2

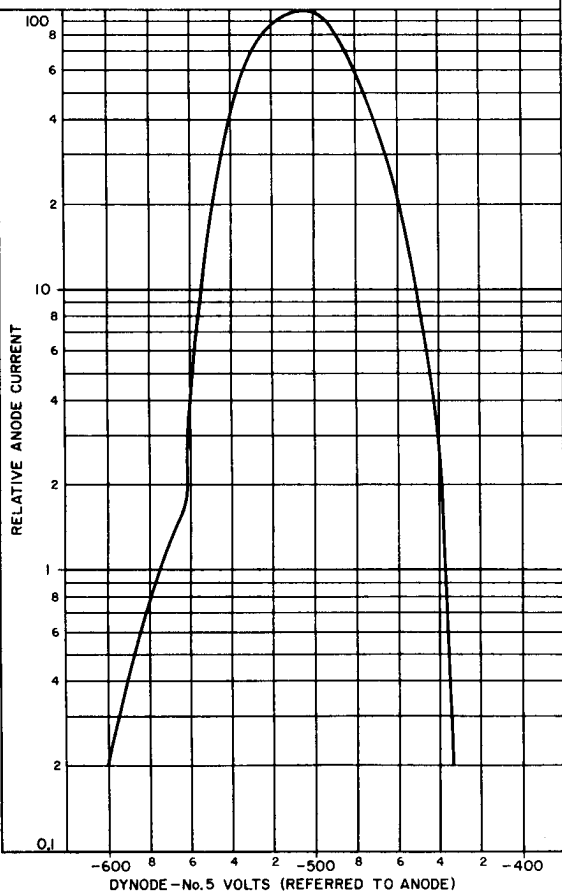
TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF DYNODE-NO.6 VOLTS



92CS-8672R1

TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF SIMULTANEOUS MODULATION OF DYNODES NO.5 AND NO.6

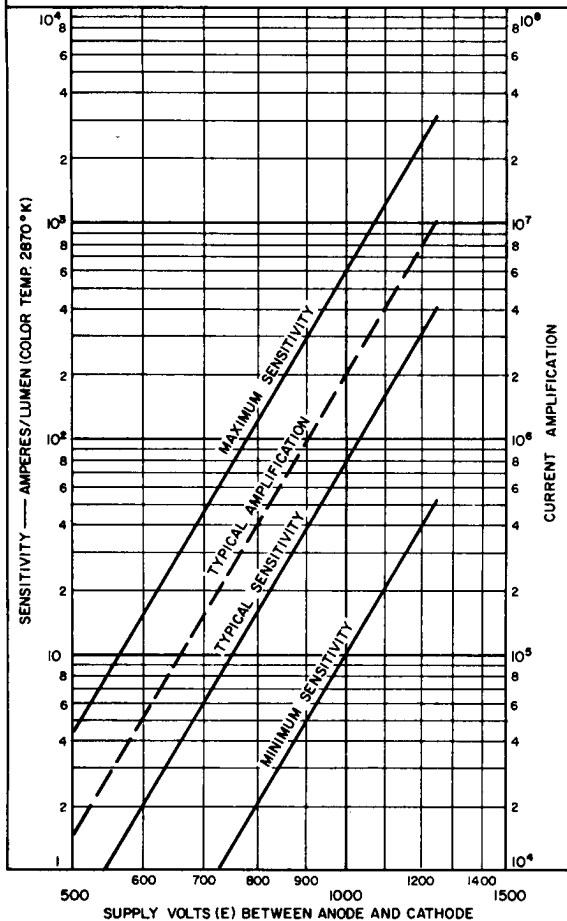
ANODE - TO - DYNODE No. 9 VOLTS = 200
VOLTS PER SUCCEEDING DYNODE STAGE EXCEPT FOR DYNODES
No. 5 AND No. 6 = 100
A CONSTANT VOLTAGE DIFFERENCE OF 100 VOLTS IS MAINTAINED
BETWEEN DYNODES No. 5 AND No. 6 DURING MODULATION.
ANODE IS AT GROUND POTENTIAL.



92CM-11375

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

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.



92LM-2999

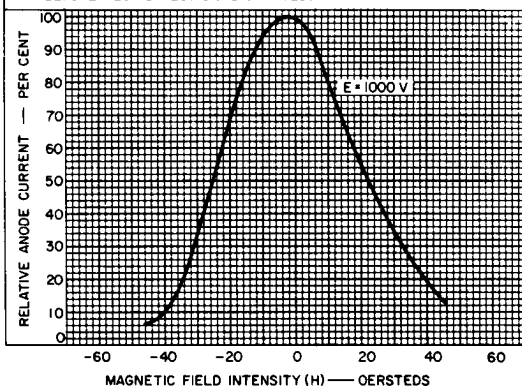
TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

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.

PHOTOCATHODE IS FULLY ILLUMINATED.

UNIFORM MAGNETIC FIELD PARALLEL TO MAJOR AXIS OF TUBE. POSITIVE VALUES OF MAGNETIC FLUX ARE FOR LINES OF FORCE TOWARD TUBE BASE.

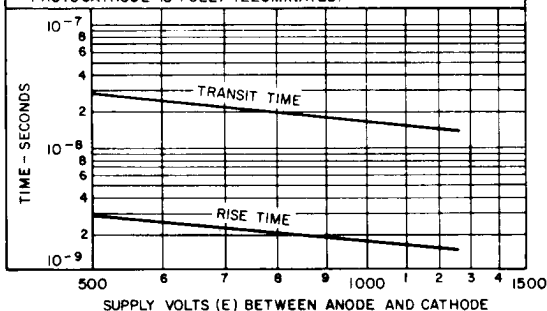
TUBE IS DEGAUSSED PRIOR TO TEST AND IS AGAIN DEGAUSSED BEFORE FLUX DIRECTION IS CHANGED.



92LS-3001

TYPICAL TIME-RESOLUTION CHARACTERISTICS

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. PHOTOCATHODE IS FULLY ILLUMINATED.



92LS-3010

TYPICAL EADCI AND DARK CURRENT CHARACTERISTICS

LUMINOUS SENSITIVITY IS VARIED BY ADJUSTING THE SUPPLY VOLTAGE (E) ACROSS VOLTAGE DIVIDER WHICH PROVIDES 1/10 OF E PER STAGE.
 LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870°K.
 TUBE TEMPERATURE = 22°C

