Photomultiplier Tube

2" Diameter, 12-Stage, Head-On Type Having a Bialkali Photocathode

General Data

Spectral Response	See **Figure 1**
Wavelength of Maximum Response	385 ± 50 nm
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Minimum projected area	2.54 sq in (16.4 cm^2)
Minjmum diameter	1.80 in (4.57 cm)
Window	Pyrex Corning[a] No.7740, or equivalent
Shape	Spherical Segment
Index of refraction at 589.3 nanometers	1.47
Dynodes:	
Substrate	Copper-Beryllium
Secondary-emitting surface	Beryllium-Oxide
Structure	In-Line Electrostatic Focus Type
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.12	5 pF
Anode to all other electrodes	6 pF
Maximum Overall Length	5.71 in (14.5 cm)
Seated Length	4.98 ± 0.08 in (12.6 ± 0.2 cm)
Maximum Diameter	2.10 in (5.3 cm)
Bulb	T16
Base	RCA 21-Pin (See Base Drawing)
Socket	RCA-AJ2144, AJ2145, or AJ2180[b]
Magnetic Shield	Perfection Mica[c] Part No.22P50, or equivalent
Operating Position	Any
Weight (Approx.)	6 oz

Maximum and Minimum Ratings, Absolute-Maximum Values:

DC Supply Voltage:		
Between anode and cathode	2500 max.	V
Between anode and dynode No.12	300 max.	V
Between consecutive dynodes	300 max.	V
Between dynode No.1 and cathode	600 max.	V
Between focusing electrode and cathode	600 max.	V

Average Anode Current[e]	0.2 max.	mA
Ambient-Temperature Range[f]	−80 to +85	°C

Characteristics Range Values for Equipment Design:

Under conditions with a dc supply voltage (E) across a voltage divider providing electrode voltages shown in Table I, and at a a temperature of 22° C, except as noted.

With E = 1500 volts (Except as noted).

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[g], at 385 nm	–	1.8×10^{5}	–	A/W
Luminous[h] (2870° K)	20	160	750	A/lm
With blue light source[j]	2.6	21	97	A/incident lm
Cathode Sensitivity:				
Radiant[k], at 385 nm	–	0.097	–	A/W
Luminous[m] (2870° K)	7.3×10^{-5}	8.5×10^{-5}	–	A/lm
With blue light source[n]	9.5×10^{-6}	1.1×10^{-5}	–	A/incident lm
Quantum efficiency at 385 nm	–	31	–	%
Current Amplification	–	1.9×10^{6}	–	
Anode Dark Current[p] at 50 A/lm	–	2×10^{-10}	2×10^{-9}	A
Equivalent Anode Dark Current Input at 50 A/lm	–	4×10^{-12}[q]	4×10^{-11}[q]	lm
	–	3.5×10^{-15}[r]	3.5×10^{-14}[r]	W
Equivalent Noise Input[s]	–	4.0×10^{-13}	–	lm
	–	3.5×10^{-16}[t]	–	W
Anode Pulse Rise Time[u] at 2500 V	–	2.4×10^{-9}	–	s
Electron Transit Time[v], at 2500 V	–	3.4×10^{-8}	–	s

a Made by Corning Glass, Corning, NY 14830.

b The AJ2145 is designed specifically for chassis mounting. The AJ2180 is similar to the AJ2145,but is light-tight. The AJ2144 is designed for use in any desired mounting arrangement. It is supplied with an unattached clamp ring which fits to either the top or bottom of its socket body to permit chassis mounting. The ring is not normally required for other mounting arrangements and can be discarded to make such arrangements more compact.

The 4507 is supplied without a socket. The AJ2144, AJ2145, or the AJ2180 may be ordered from your nearest RCA Field Sales Office.

c Made by Magnetic Shield Division, Perfection Mica Company, 1322 North Elston Avenue, Chicago, IL 60622.

e Averaged over any interval of 30 seconds maximum.

f Tube operation at 22° C or below is recommended.

g This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1140 lumens per watt.

h These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode blue sensitivity (A/incident lm)}}{0.13}$$

The value of 0.13 is the average value of the ratio of the anode current measured under the conditions specified in footnote (j) to the anode current measured under the same conditions but with the blue filter removed.

j Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness—Manufactured by the Corning Glass Works, Corning, NY 14830) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 1×10^{-7} lumen.

k This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1140 lumens per watt.

m These values are calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode blue sensitivity (A/incident lm)}}{0.13}$$

The value of 0.13 is an average value. It is the ratio of the cathode current measured under the conditions specified in footnote

(n) to the cathode current measured under the same conditions but with the blue filter removed.

n Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 1×10^{-4} lumen and 500 volts are applied between cathode and all other electrodes connected as anode.

p Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness). The light flux incident on the filter is 1×10^{-7} lumen. The supply voltage E is adjusted to obtain an anode current of 0.65 microamperes. Luminous sensitivity of the tube under these conditions is approximately equivalent to 50 amperes per lumen. Dark current is measured with incident light removed.

q Equivalent Anode Dark Current Input is the quotient of anode dark current at a given anode luminous sensitivity by the anode luminous sensitivity.

r At 385 nanometers. These values are calculated from the EADCI values in lumens using a conversion factor of 1140 lumens per watt.

s Under the following conditions: An equivalent bandwidth of 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.

t At 385 nanometers. This value is calculated from the ENI value in lumens using a conversion factor of 1140 lumens per watt.

u 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.

v 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.

Operating Considerations

Anode-Dark Current

The 4507 is intended for use in systems requiring very low

dark current. Accordingly, the base of the tube and its socket should never be allowed to become contaminated by handling. Such contamination produces leakage and dark current. It is recommended that if the tube base or its socket is handled that it be washed with a solution of alkaline soap cleaner such as Alconox*, or equivalent, and de-ionized or distilled water having a temperature not exceeding 60° C. Careful scrubbing between pins or socket contacts is useful, but not usually required. The base of socket should then be rinsed in de-ionized or distilled water (60°) for several minutes and then air-blown dry.

A temporary increase in anode dark current by as much as 3 orders of magnitude may occur if the tube is exposed momentarily to high-intensity ultraviolet radiation from sources such as fluorescent room lighting even though voltage is not applied to the tube. The increase in dark current may persist for a period up to 48 hours following such irradiation.

Cathode Current

A peak cathode current of 5×10^{-9} ampere at a tube temperature of 22° C or 1×10^{-11} ampere at −80° C should not be exceeded. Because of the resistivity of the photocathode, the voltage drop caused by higher peak cathode currents may produce radial electric fields on the photocathode which can result in poor photoelectron collection by the first dynode. Photocathode resistivity increases with decreasing temperature.

Leakage Current

The application of high voltage, with respect to cathode, to insulating or other materials supporting or shielding the tube at the photocathode end should not be permitted unless such materials are chosen to limit leakage current to the tube envelope to 1×10^{-12} ampere or less.

In addition to increasing dark current and noise output because of voltage gradients developed across the bulb wall, such high voltage may produce minute leakage current to

the cathode, through the tube envelope and insulating materials, which can permanently damage the tube.

*Distributed by Arthur H. Thomas Company, Vine Street and 3rd, Philadelphia, PA 19105.

Ambient Atmosphere

Operation or storage of this tube in environments where helium is present should be avoided. Helium may permeate through the tube envelope and may lead to eventual tube destruction.

Table I

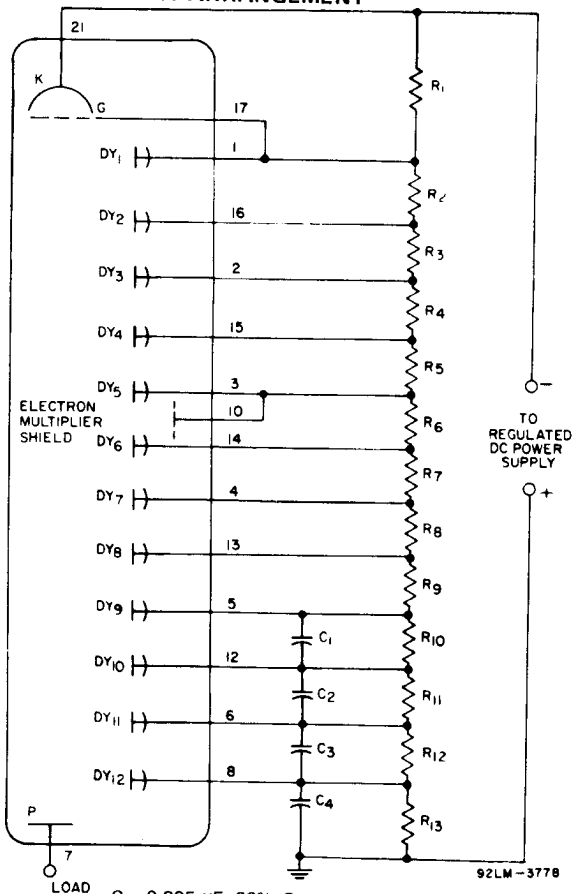
Voltages To Be Provided by Divider

Between the Following Electrodes Cathode (K), Dynode (Dy), and Anode (P)	6.94% of Supply Voltage (E) Multiplied By
K – Dy1	2.0
Dy1 – Dy2	1.0
Dy2 – Dy3	1.4
Dy3 – Dy4	1.0
Dy4 – Dy5	1.0
Dy5 – Dy6	1.0
Dy6 – Dy7	1.0
Dy7 – Dy8	1.0
Dy8 – Dy9	1.0
Dy9 – Dy10	1.0
Dy10 – Dy11	1.0
Dy11 – Dy12	1.0
Dy12 – P	1.0
K – P	14.4

Focusing Electrode (Pin 17) is connected to dynode No.1 potential.

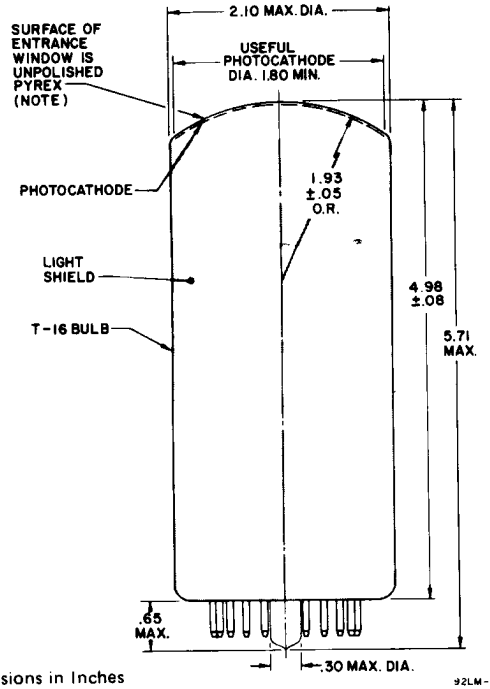
Electron Multiplier Shield (Pin 10) is connected to dynode No.5 potential.

TYPICAL CIRCUIT ARRANGEMENT



C_1: 0.005 μF, 20%, Ceramic Disc, 500 V dc
C_2: 0.01 μF, 20%, Ceramic Disc, 500 V dc
C_3: 0.02 μF, 20%, Ceramic Disc, 500 V dc
C_4: 0.05 μF, 20%, Ceramic Disc, 500 V dc
R_1: 200 kΩ (2-100 kΩ, 5%, 1/2 W in series)
R_2: 100 kΩ, 5%, 1/2 W
R_3: 130 kΩ, 5%, 1 W
R_4 through R_{13}: 100 kΩ, 5%, 1/2 W

DIMENSIONAL OUTLINE



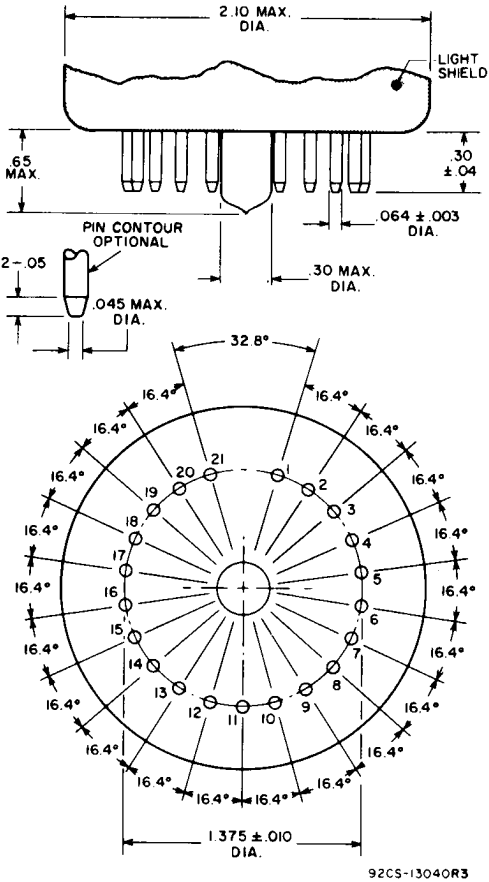
Dimensions in Inches

Note: Caution must be employed when handling this tube because of the thinness (approx. 0.02 inch thick) of the entrance window.

The dimensions in millimeters are derived from the basic inch dimensions (1 inch = 25.4 mm).

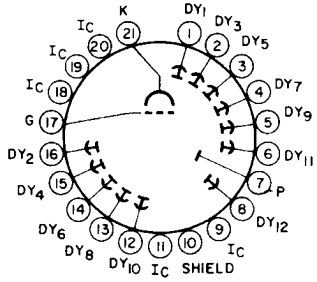
Inch	mm	Inch	mm	Inch	mm
.003	.08	.05	1.3	1.375	34.93
.010	.25	.064	1.63	1.80	45.7
.02	.5	.08	2.0	1.93	49.0
.04	1.0	.30	7.6	2.10	53.3
.045	1.14	.65	16.5	4.98	126.5
				5.71	145.0

DETAIL OF BASE ARRANGEMENT



Dimensions in Inches

TERMINAL DIAGRAM (Bottom View)



DIRECTION OF RADIATION:
INTO END OF BULB

92LS-2812

Pin 1: Dynode No.1
Pin 2: Dynode No.3
Pin 3: Dynode No.5
Pin 4: Dynode No.7
Pin 5: Dynode No.9
Pin 6: Dynode No.11
Pin 7: Anode
Pin 8: Dynode No.12
Pin 9: Internal Connection, Do not use
Pin 10: Electron Multiplier Shield
Pin 11: Internal Connection, Do not use
Pin 12: Dynode No.10
Pin 13: Dynode No.8
Pin 14: Dynode No.6
Pin 15: Dynode No.4
Pin 16: Dynode No.2
Pin 17: Focusing Electrode
Pin 18: Internal Connection, Do not use
Pin 19: Internal Connection, Do not use
Pin 20: Internal Connection, Do not use
Pin 21: Photocathode

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS

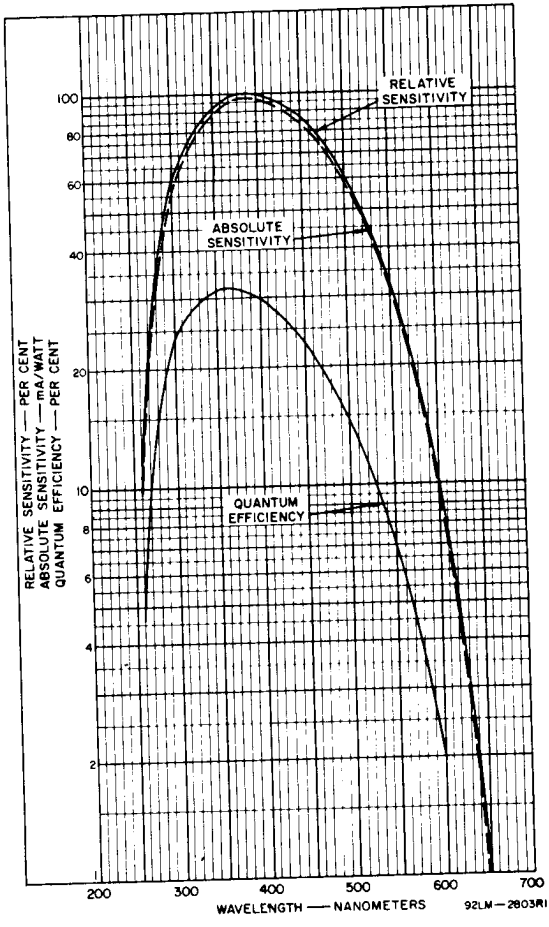


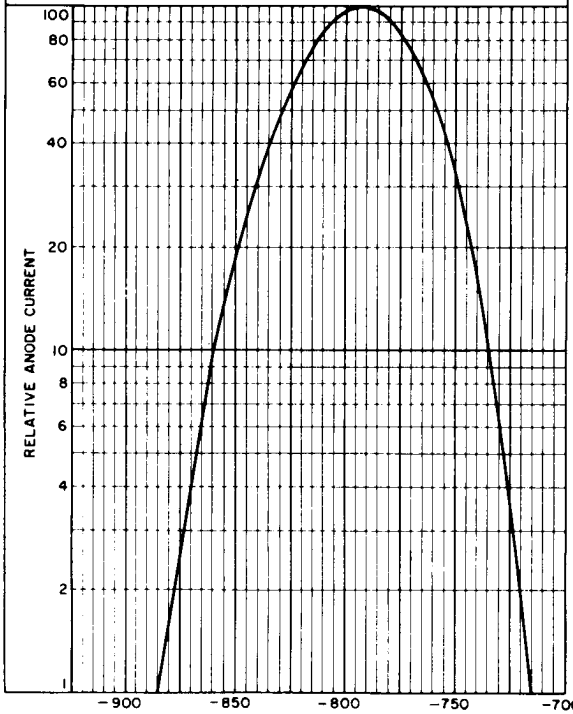
Figure 1

TYPICAL DYNODE MODULATION CHARACTERISTIC

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

BETWEEN	6.94% OF E MULTIPLIED BY
CATHODE AND DYNODE No. 1	2.0
DYNODE No. 1 AND DYNODE No. 2	1.0
DYNODE No. 2 AND DYNODE No. 3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No. 1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No. 5 POTENTIAL.
CATHODE IS AT GROUND POTENTIAL.

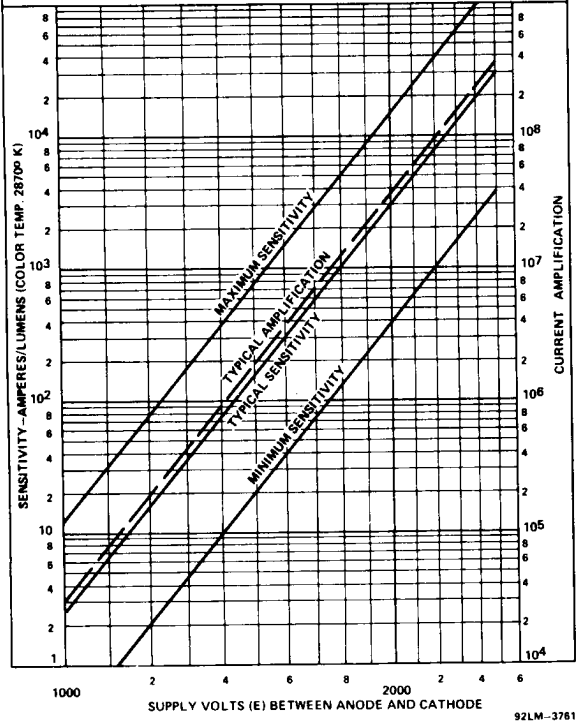


TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

BETWEEN	6.94% OF E MULTIPLIED BY
CATHODE AND DYNODE No.1	2.0
DYNODE No.1 AND DYNODE No.2	1.0
DYNODE No.2 AND DYNODE No.3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No.1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No.5 POTENTIAL.
PHOTOCATHODE IS FULLY ILLUMINATED.

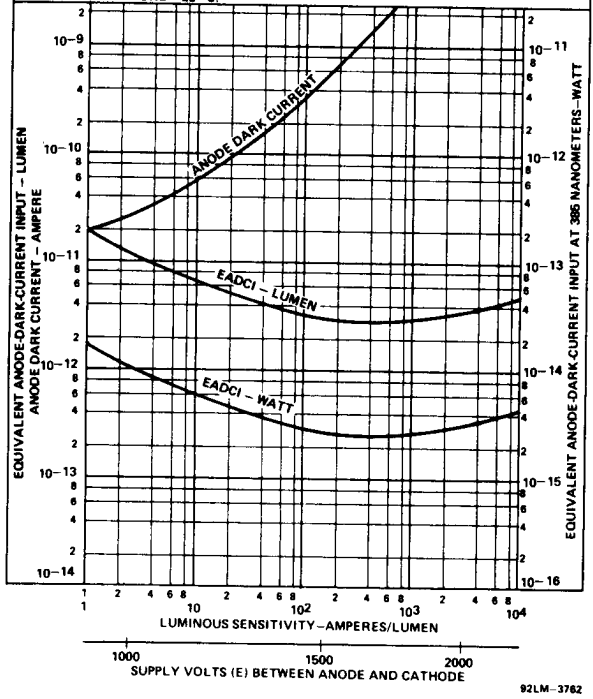


TYPICAL ANODE DARK CURRENT AND EACDI CHARACTERISTICS

LUMINOUS SENSITIVITY IS VARIED BY ADJUSTMENT OF THE SUPPLY VOLTAGE (E) ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

BETWEEN	6.94% OF E MULTIPLIED BY
CATHODE AND DYNODE No.1	2.0
DYNODE No.1 AND DYNODE No.2	1.0
DYNODE No.2 AND DYNODE No.3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE No.5 POTENTIAL.
FOCUSING ELECTRODE IS CONNECTED TO DYNODE No.1 POTENTIAL.
LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870° K.
TUBE TEMPERATURE = 22° C.



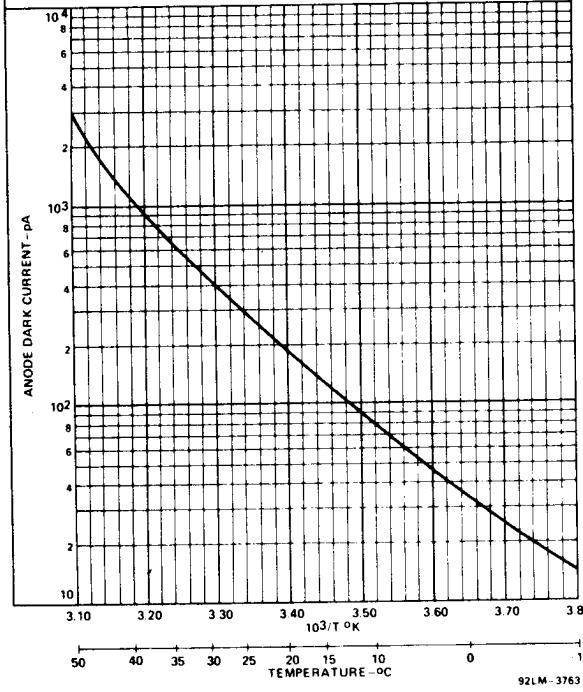
TYPICAL ANODE DARK CURRENT AS A FUNCTION OF TEMPERATURE

WITH SUPPLY VOLTAGE ADJUSTED TO PROVIDE AN ANODE LUMINOUS SENSITIVITY OF 50 AMPERES PER LUMEN.

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

BETWEEN	6.94% OF E MULTIPLIED BY
CATHODE AND DYNODE No.1	2.0
DYNODE No.1 AND DYNODE No.2	1.0
DYNODE No.2 AND DYNODE No.3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

FOCUSING ELECTRODE IS CONNECTED TO DYNODE No.1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE No.5 POTENTIAL.
PHOTOCATHODE IS FULLY ILLUMINATED.

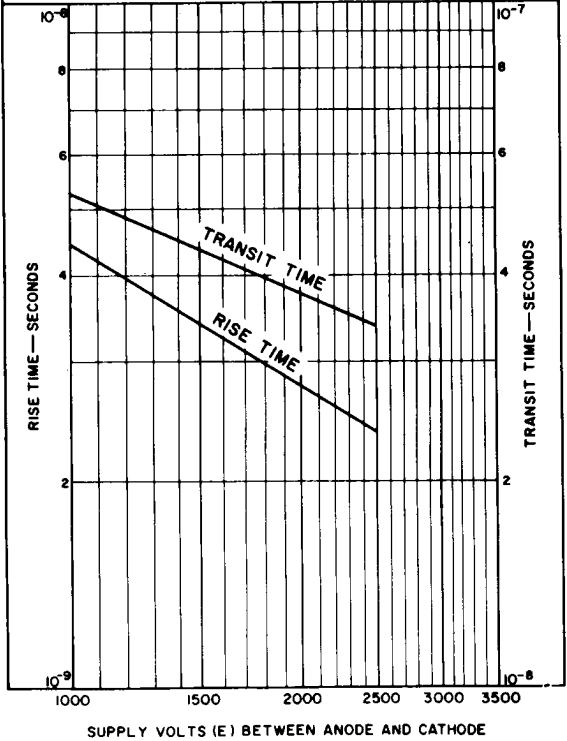


TYPICAL TIME-RESOLUTION CHARACTERISTICS

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

BETWEEN	6.94% OF E MULTIPLIED BY
CATHODE AND DYNODE No. 1	2.0
DYNODE No. 1 AND DYNODE No. 2	1.0
DYNODE No. 2 AND DYNODE No. 3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No. 1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No. 5 POTENTIAL.
PHOTOCATHODE IS FULLY ILLUMINATED.



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TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:

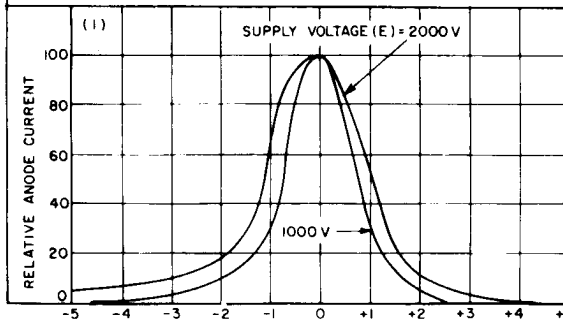
BETWEEN	6.94 % OF E MULTIPLIED BY
CATHODE AND DYNODE No. 1	2.0
DYNODE No. 1 AND DYNODE No. 2	1.0
DYNODE No. 2 AND DYNODE No. 3	1.4
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	14.4

FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No. 1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No. 5 POTENTIAL.
PHOTOCATHODE IS FULLY ILLUMINATED.

POSITIVE VALUE OF H IN DIRECTION SHOWN

(1)*, (2) ↑ OR (3) →

*DIRECTION (1) IS OUT OF PAPER



MAGNETIC FIELD INTENSITY — OERSTEDS

TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT (Cont'd)