8664

Photomultiplier Tube

Ruggedized, 2"-Diameter, 10-Stage Type

GENERAL

Spectral Response	See *accompanying Spectral Response Characteristics*
Wavelength of Maximum Response	4000 ± 500 Å
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Minimum area	2.54 in^2 (16.4 cm^2)
Minimum diameter	1.8 in (4.6 cm)
Window	UV-Grade Sapphire
Shape	Plano-Plano
Index of refraction	See Table I
Dynodes	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	Venetian-Blind
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10 and guard ring	9.5 pF
Anode to all other electrodes	9.5 pF
Maximum Overall Length	4.00 in (10.2 cm)
Maximum Diameter	2.06 in (5.2 cm)
Magnetic Shield	See footnote a
Operating Position	Any
Weight (Approx.)	7 oz (190 g)

MAXIMUM RATINGS, *Absolute-Maximum Values:*

DC Supply Voltage:		
Between anode and cathode	2000 max.	V
Between anode and dynode No.10	300 max.	V
Between anode and guard ring[c]	300 max.	V
Between consecutive dynodes	250 max.	V
Between dynode No.1 and cathode	600 max.	V
Average Anode Current[d]	2 max.	mA
Ambient-Temperature Range[e]	-100 to + 75 max.	°C

CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a voltage divider providing 3/13 of E between cathode and dynode No.1; 1/13 of E for each succeeding dynode stage; and 1/13 of E between dynode No.10 and anode. The guard ring is operated at or near anode potential.

With E = 1500 Volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[f] at 4000 angstroms	–	1.8×10^{4}	–	A/W
Luminous[g] (2870°K)	7	17	165	A/lm
Current with blue light source[h] (2870°K + C.S. No. 5-58)	9×10^{-6}	2×10^{-5}	2×10^{-4}	A
Cathode Sensitivity:				
Radiant[i] at 4000 angstroms	–	6.9×10^{-2}	–	A/W
Luminous[k] (2870° K)	5.8×10^{-5}	6.7×10^{-5}	–	A/lm
Current with blue light source[m] (2870° K + C.S.. No.5-58)	7×10^{-11}	8×10^{-11}	–	A
Quantum Efficiency[n] at 3750 angstroms	–	22	–	%
Current Amplification	–	2.6×10^{5}	–	
Anode Dark Current[p]	–	1×10^{-9}	9×10^{-9}	A
Equivalent Anode Dark Current Input[p]	–	1.3×10^{-10}	1.2×10^{-9}	lm
	–	1.3×10^{-13}[q]	1.2×10^{-12}[q]	W
Equivalent Noise Input[r]	–	1.4×10^{-12}	–	lm
	–	1.4×10^{-15}[s]	–	W
Peak-to-Valley Ratio of Pulse Height Spectrum with Fe^{55} Source[t]	10	30	–	
Dark Pulse Spectrum		See *accompanying Typical Dark Pulse Spectrum*		
Anode-Pulse Rise Time[u] at 2000 V . .	–	7×10^{-9}	–	s
Electron Transit Time[v] at 2000 V . .	–	4×10^{-8}	–	s

With E = 1100 Volts

Pulse Height Resolution[w]	—	7.7	8	%
Pulse Height[x] . . .	$6x10^{-12}$	—	—	coulombs

Under conditions with dc supply voltage (E) across a voltage divider providing the following cathode-to-anode voltage distribution: 2, 1, 1, 1, 1, 1, 1, 4, 3.5, 4, and 4.8. The guard ring is connected at or near anode potential.

With E = 2000 Volts

	Min.	Typical	Max.	
Pulse Current:				
Space-Charge Limited (Saturated)[y]	—	0.5	—	A
Linear[z]	—	0.033	—	A

[a] Magnetic shielding material in the form of foil or tape as available from the Magnetic Shield Division, Perfection Mica Company, 1322 N. Elston Avenue, Chicago, Ill., 60622, or equivalent.

[c] The guard ring is an electrode located between dynode No. 10 and anode. Its function is to minimize leakage current flowing to the anode.

[d] Averaged over any interval of 30 seconds maximum. When stability of operation is important, the use of an average anode current well below the maximum rated value is recommended.

[e] Tube operation at room temperature or below is recommended.

[f] This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1030 lumens per watt.

[g] These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.12 \times \text{Light Flux of } 1 \times 10^{-5} \text{ (lm)}}$$

The value of 0.12 is the average value of the ratio of the anode current measured under the conditions specified in footnote (h) to the anode current measured under the same conditions but with the blue filter removed.

h 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, New York) 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^{-5} lumen.

i This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1030 lumens per watt.

k These values are calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.12 \times \text{Light Flux of } 1 \times 10^{-5} \text{ (lm)}}$$

The value of 0.12 is the average value of the ratio of the cathode current measured under the conditions specified in footnote (m) to the cathode current measured under the same conditions but with the blue filter removed.

m 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, New York) 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^{-5} lumen and 250 volts are applied between cathode and all other electrodes connected as anode.

n Calculated from the typical cathode radiant sensitivity value.

p At a tube temperature of 22° C. 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 10 microlumens. The supply voltage (E) is adjusted to obtain an anode current of 9 microamperes. Sensitivity of the 8664 under these conditions is approximately equivalent to 7.5 amperes per lumen. Dark current is measured with no light incident on the tube.

[q] At 4000 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 1030 lumens per watt.

[r] Under the following conditions: Supply voltage (E) is as shown, 22° C tube temperature, 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.

[s] At 4000 angstroms. This value is calculated from the ENI value in lumens using a conversion factor of 1030 lumens per watt.

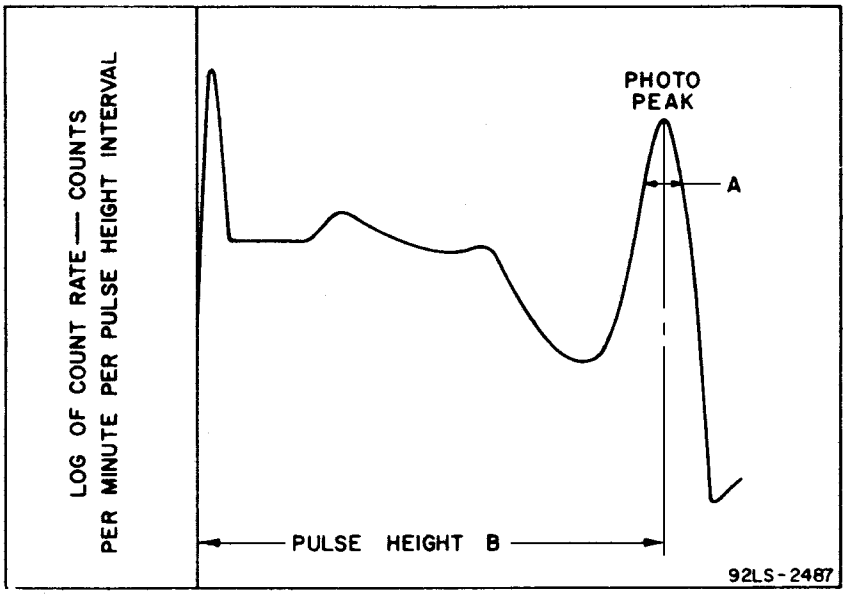
[t] Light incident on the photocathode is obtained from a Harshaw Type HG 0.005" beryllium window NaI(T1) scintillator, 0.04" thick and 7/8" in diameter (or equivalent) and an isotope of iron having an atomic mass of 55 (Fe^{55}) and an effective activity of 1 μcurie.

[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.

[w] With a supply voltage E of 1100 volts. Anode load is a 100-kilohm resistor in parallel with a total capacitance of 100 pF. Under pulse conditions, the interstage voltages of the tube should not deviate more than 2% from the interstage voltage values during no-signal conditions. The 662 keV photons from a one-microcuire Cs^{137} source and a cylindrical 2" x 2" thallium-activated sodium-iodide scintillator NaI(T1)-type Harshaw Type 8D8S50, Serial No. CJ-156, or equivalent, are used. The Cs^{137} source is in direct contact with the metal end of the scintillator container. The faceplate end of the crystal is coupled to the faceplate of the tube using a coupling fluid such as Nujol mineral oil, or equivalent. Pulse-height resolution in per cent is de-

fined at 100 times the ratio of the width of the photopeak at half the maximum count rate in the photopeak height (A) to the pulse height at maximum photopeak count rate (B).



[x] Pulse height is defined as the average charge collected at the anode from a pulse caused by the photoelectric absorption of a 662 keV photon from Cs^{137} in a thallium-activated sodium-iodide scintillator, NaI(T1).

[y] The interstage voltages of the 8664 should not deviate more than 2 per cent from the recommended voltage distribution. Capacitors are connected across the individual resistors making up the voltage-divider arrangement to insure the operating condition.

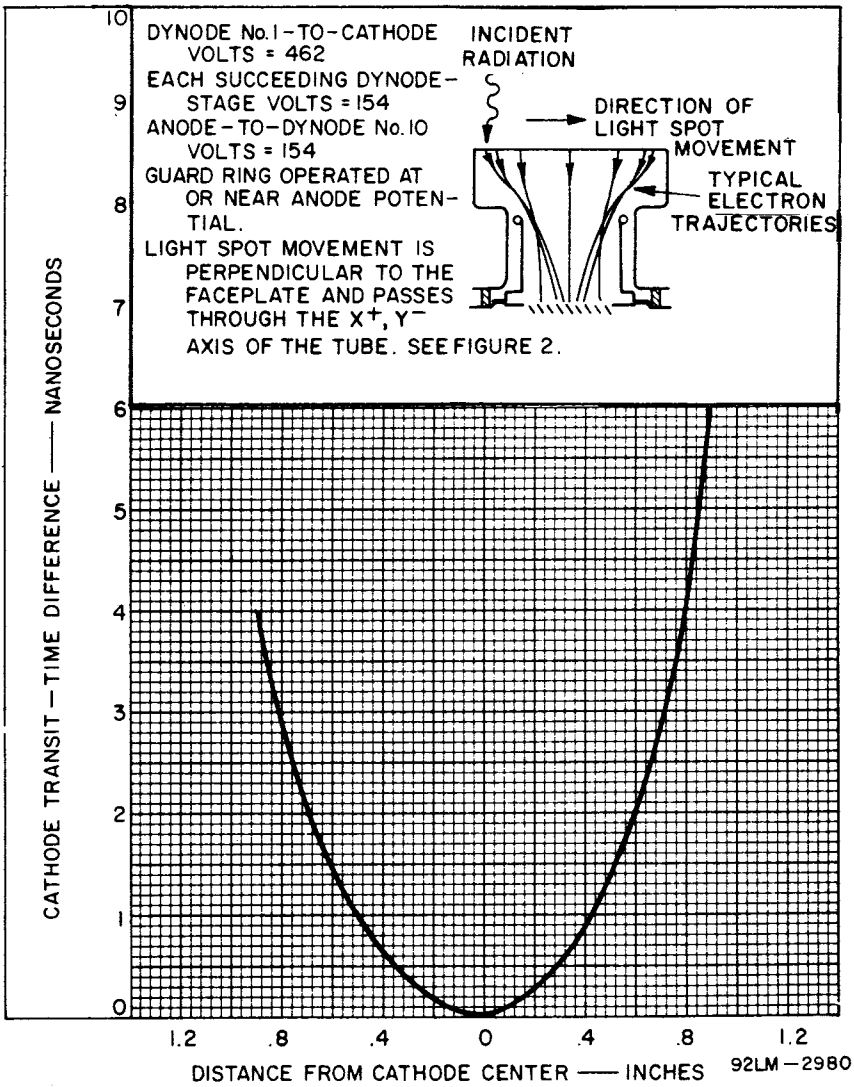
[z] Maximum deviation from linearity is 5 per cent.

TABLE 1

Wavelength - Å	1830	2652	3021	4046	5461	6438	7065
Index of Refraction for Sapphire Window	3.0	1.83	1.81	1.79	1.77	1.77	1.76

For additional information on this type write for Technical Bulletin to RCA Commercial Engineering, Harrison, N. J. 07029

TYPICAL ELECTRON TRANSIT TIME DIFFERENCE AS A FUNCTION OF SPOT POSITION OF INCIDENT RADIATION ON TUBE FACEPLATE



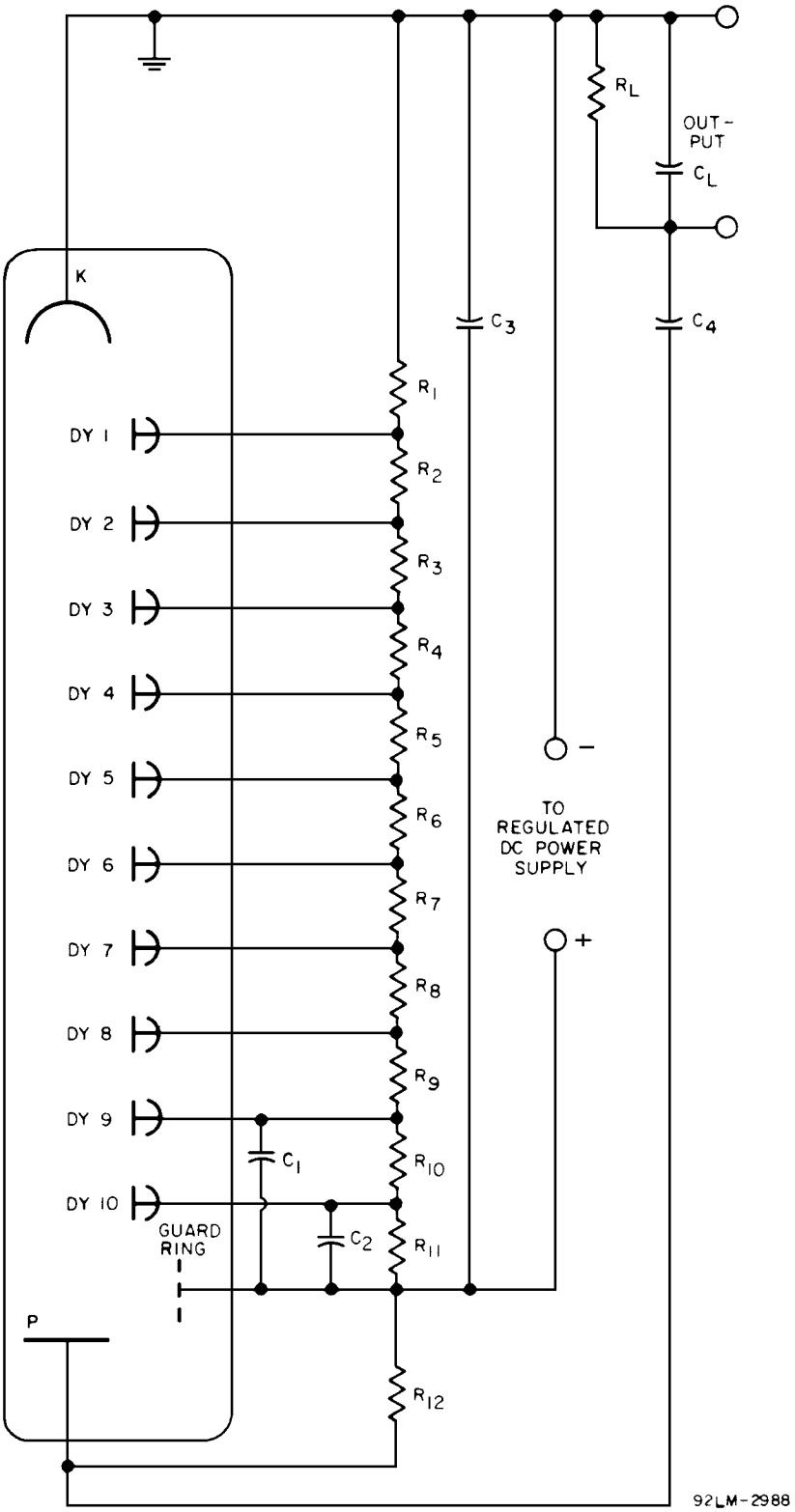
PARTS LIST FOR TYPICAL VOLTAGE-DIVIDER ARRANGEMENT

C_1: 0.005 μF, 20%, 1000 V dc, ceramic disc
C_2: 0.01 μF, 20%, 1000 V dc, ceramic disc
C_3, C_4: 0.01 μF, 20%, 3000 V dc, ceramic disc
R_1: 10 MΩ, 5%, 1/2 Watt
R_2 through R_{11}: 3.3 MΩ, 5%, 1/2 Watt
R_{12}: 1 MΩ, 5%, 1/2 Watt

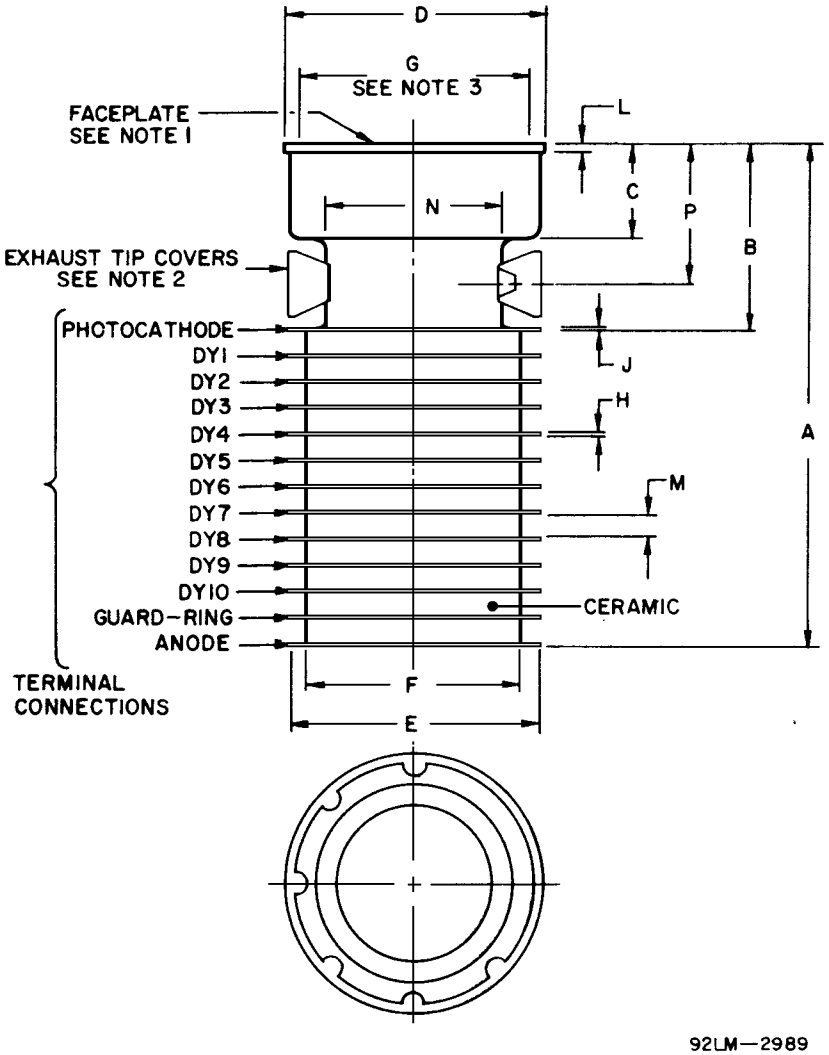
Note: The value of the load elements, R_L and C_L, depend on the application:

$R_L C_L$ = 10 microseconds for most applications

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



DIMENSIONAL OUTLINE



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

Note 1: Deviation from flatness of external surface of faceplate will not exceed 0.005" from peak to valley.

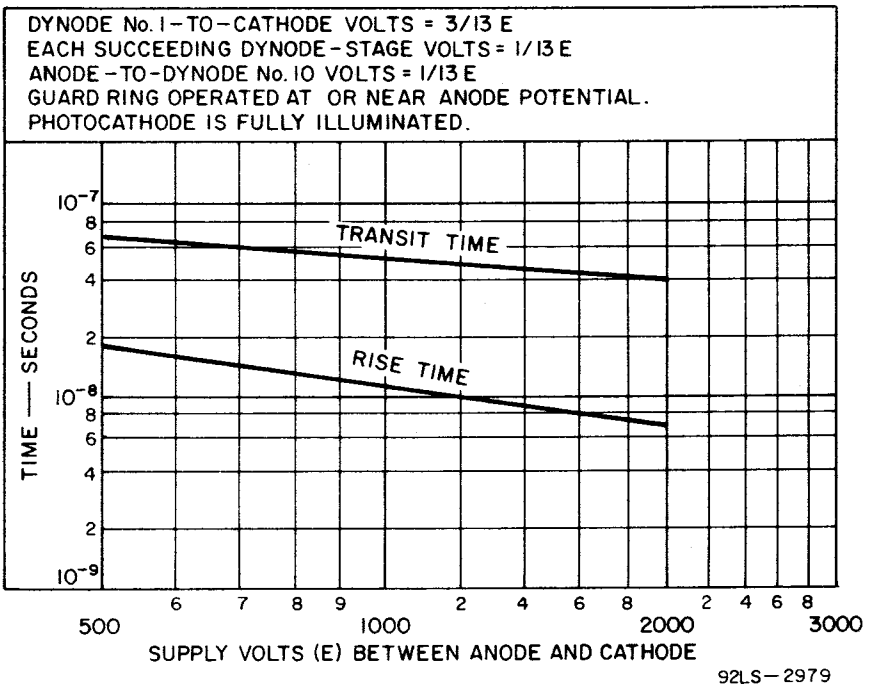
Note 2: The maximum dimension of both exhaust tip covers will not extend beyond the maximum diameter of the tube. Care should be exercised not to subject these covers to any stress or strain.

Note 3: Minimum useful photocathode diameter.

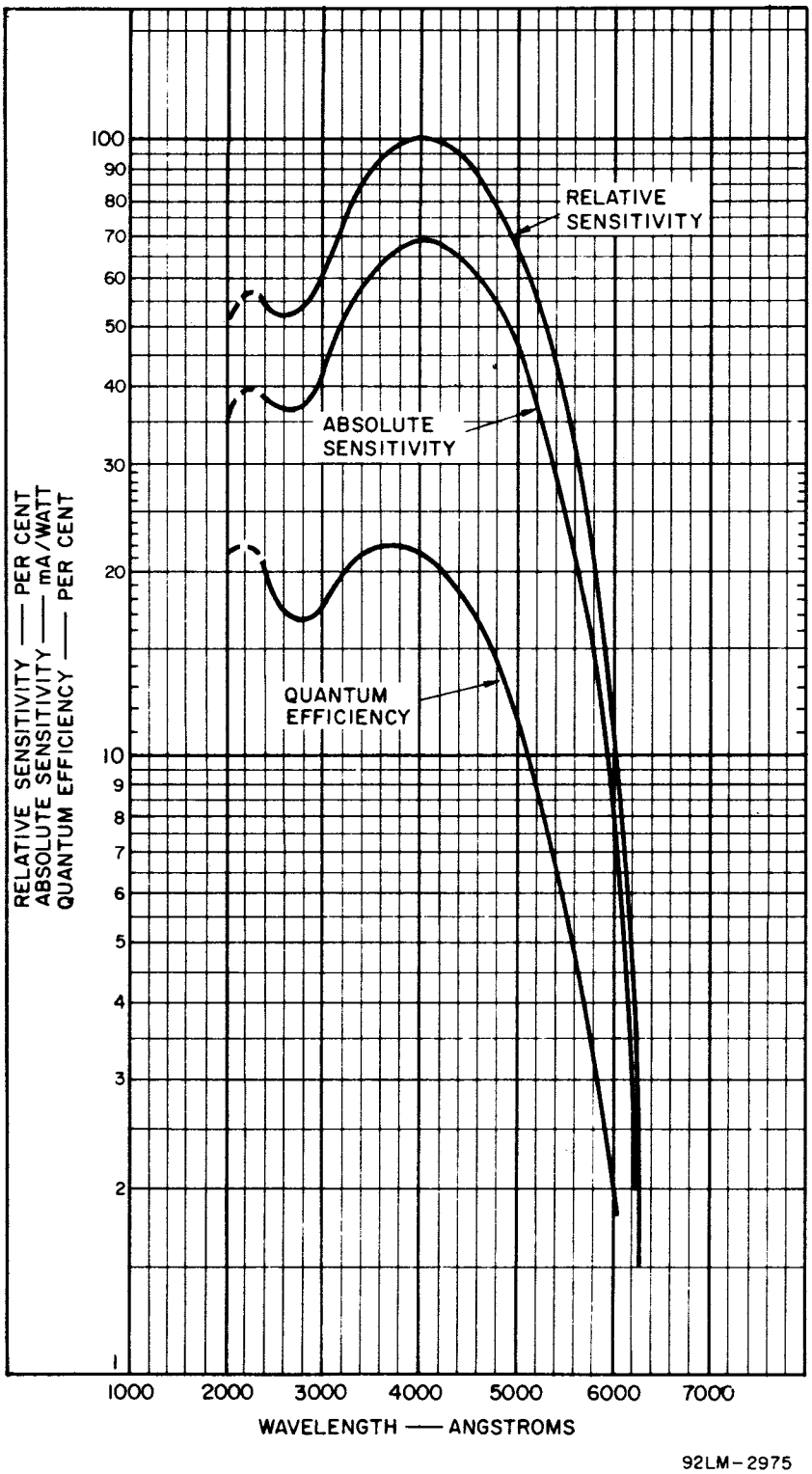
OUTLINE DIMENSIONS

Dimensions	Inches	mm
A	4.00 Max.	101.6 Max.
B	1.45	36.8
C	.73	18.5
D	2.06 Max. Dia.	52.3 Max. Dia.
E	2.00 Dia.	50.8 Dia.
F	1.80 Max. Dia.	45.7 Max. Dia.
G	1.80 Max. Dia.	45.7 Max. Dia.
H	.02	.5
J	.03	.8
L	.06	1.5
M	.18	4.6
N	1.37 Dia.	34.8 Dia.
P	1.075	27.3

TYPICAL TIME-RESOLUTION CHARACTERISTICS

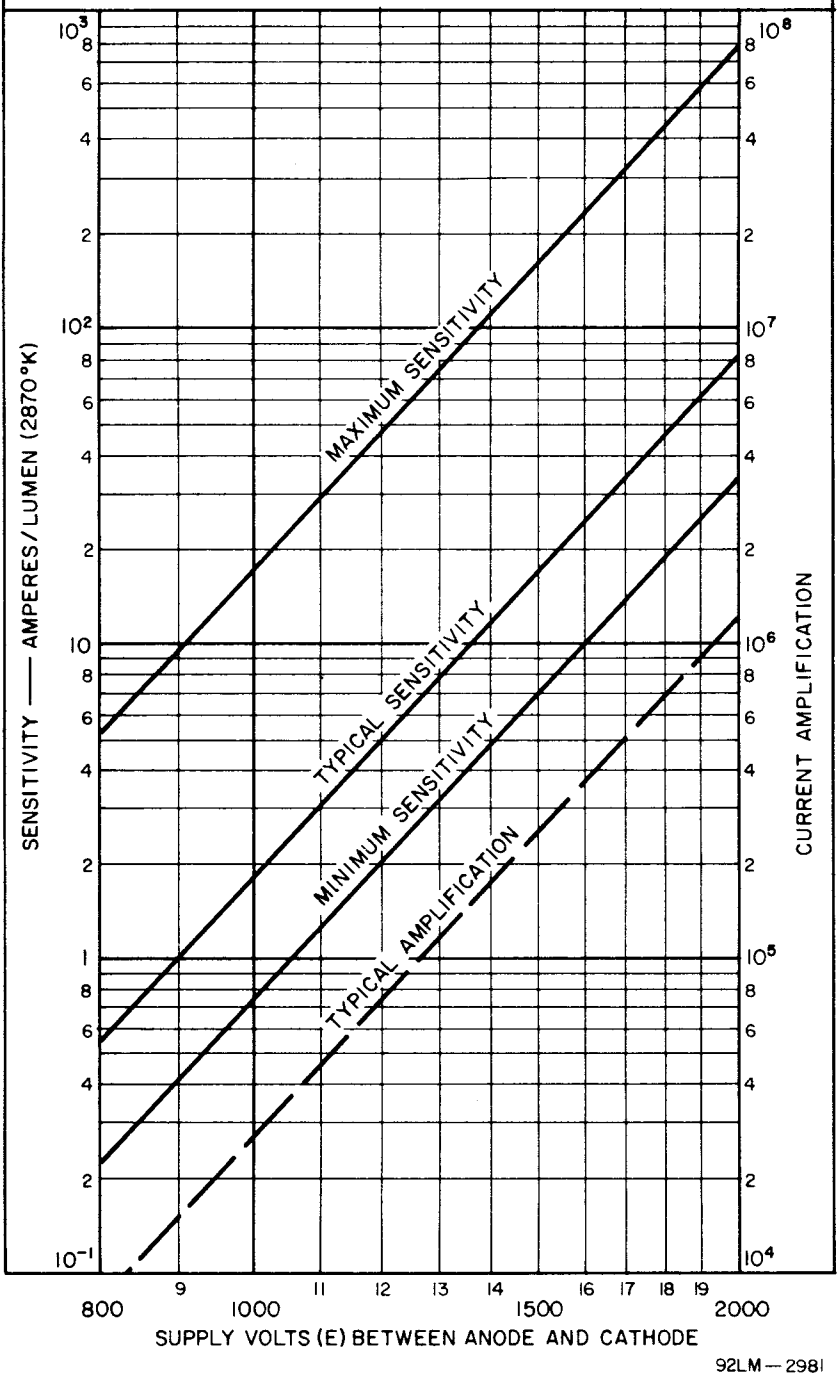


SPECTRAL RESPONSE CHARACTERISTICS



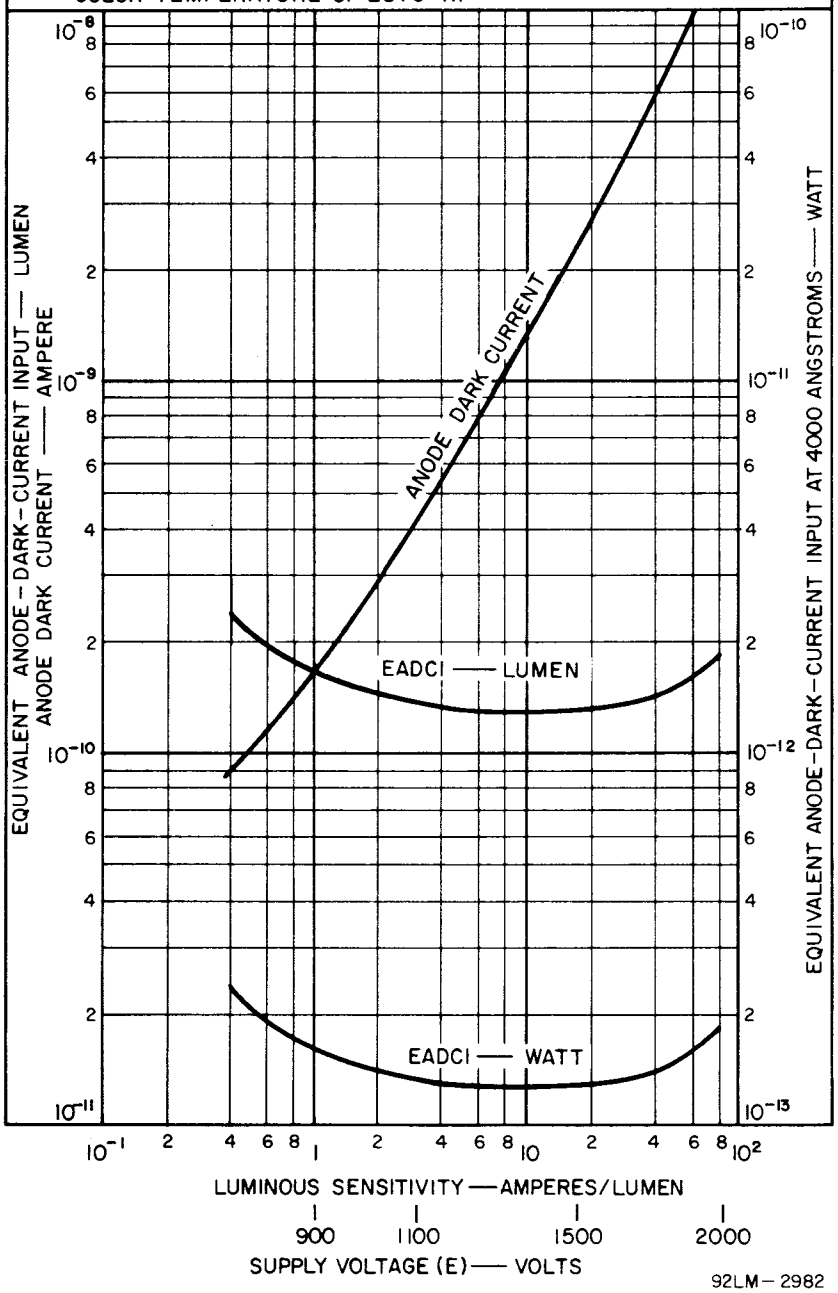
TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

UNDER CONDITIONS WITH DC SUPPLY VOLTAGE (E) ACROSS A VOLTAGE DIVIDER PROVIDING 3/13 OF E BETWEEN CATHODE AND DYNODE No.1; 1/13 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/13 OF E BETWEEN DYNODE No.10 AND ANODE. THE GUARD RING IS OPERATED AT OR NEAR ANODE POTENTIAL.

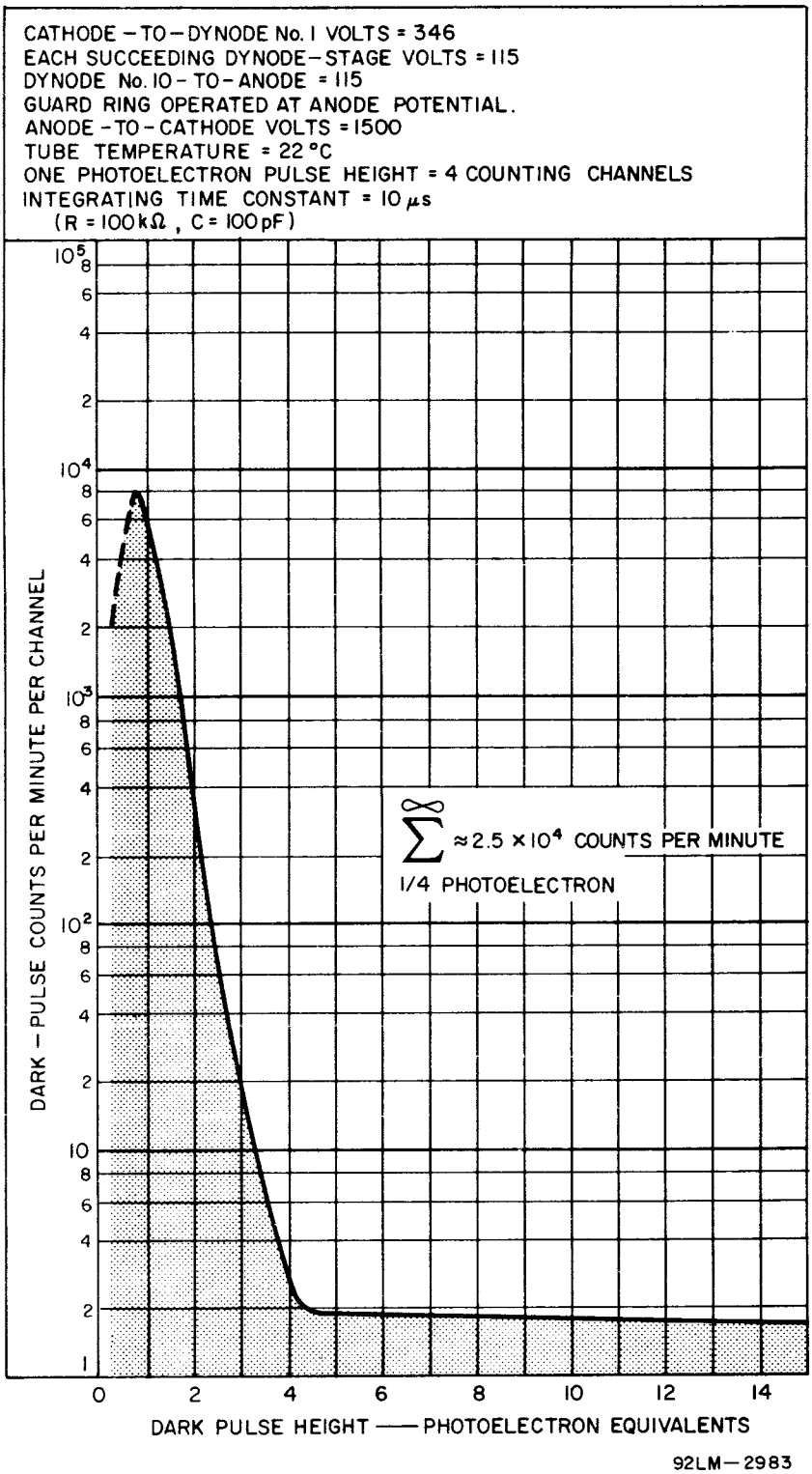


TYPICAL ANODE DARK CURRENT AND EADCI CHARACTERISTICS

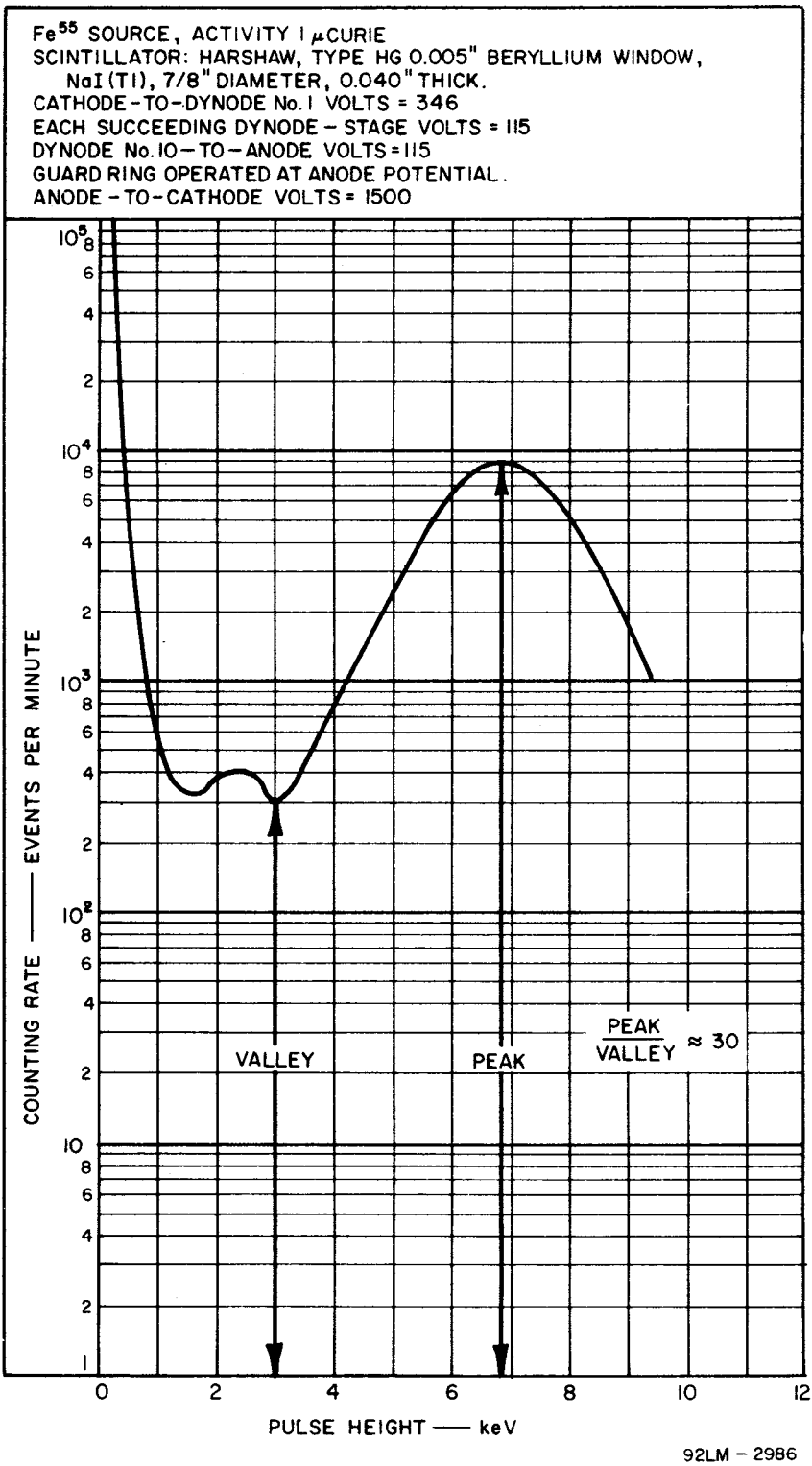
LUMINOUS SENSITIVITY IS VARIED BY ADJUSTING THE SUPPLY VOLTAGE (E) ACROSS A VOLTAGE DIVIDER WHICH PROVIDES 3/13 OF E BETWEEN CATHODE AND DYNODE No. 1; 1/13 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/13 OF E BETWEEN DYNODE No. 10 AND ANODE. THE GUARD RING IS OPERATED AT OR NEAR ANODE POTENTIAL.
TUBE TEMPERATURE = 22 °C
LIGHT SOURCE IS A TUNGSTEN–FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870 °K.



TYPICAL DARK PULSE SPECTRUM



DIFFERENTIAL Fe^{55} SPECTRUM



TYPICAL ANODE CHARACTERISTICS