Photomultiplier Tube

2"-Diameter Type

RCA-8850 is a 12-stage, head-on QUANTACON* Type Having Extremely High-Gain Gallium-Phosphide First Dynode and High Quantum Efficiency Bialkali Photocathode

GENERAL

Spectral Response	See accompanying *Spectral Response Characteristics*
Wavelength of Maximum Response	3850 ± 500 Å
Cathode, Semitransparent	Potassium-Cesium-Antimony (Bialkali)
Minimum projected area	2.54 sq in
Minimum diameter	1.80 in
Window	Pyrex, Corning[a] No.7740, or equivalent
Shape	Plano-Concave
Index of refraction at 5893 angstroms	1.47
Dynode No.1:	
Secondary Emitting Surface	Gallium-Phosphide, GaP
Dynode No.2 through 12:	
Secondary Emitting Surface	Beryllium-Oxide
Dynode 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
Seated Length	4.98 ± 0.08 in
Maximum Diameter	2.10 in
Bulb	T16
Base	See Base Drawing
Socket	RCA AJ2144 or AJ2145[b]
Magnetic Shield	See footnote (c)
Operating Position	Any
Weight (Approx.)	6 oz

MAXIMUM AND MINIMUM RATINGS, *Absolute-Maximum Values*

DC Supply Voltage:		
Between anode and cathode:		
With Voltage Distribution A shown in Table I	3000 max.	V
	1300[e] min.	V
With Voltage Distribution B shown in Table I	3000 max.	V
	1800[e] min.	V

Between anode and dynode No.12	800 max.	V
Between dynode No.12 and dynode No.11.	800 max.	V
Between consecutive dynodes	400 max.	V
Between dynode No.1 and cathode	1000 max. 600[e] min.	V V
Between focusing electrode and cathode.	1000 max.	V
Average Anode Current[f]	0.2 max.	mA
Ambient-Temperature Range[g]	-100 to +85	°C

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN:

Under conditions with dc supply voltage (E) across a voltage divider providing electrode voltages shown in Table I, Column A.
With E = 2000 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[h] at 3850 angstroms	—	7.1×10^{5}	—	A/W
Luminous[i] (2870° K)	46	620	1500	A/lm
Current with blue light source[k] (2870° K + C.S. No.5-58)	6×10^{-7}	8×10^{-6}	—	A
Cathode Sensitivity:				
Radiant[m] at 3850 angstroms	—	0.097	—	A/W
Luminous[n] (2870° K)	7.7×10^{-5}	8.5×10^{-5}	—	A/lm
Current with blue light source[p] (2870° K + C.S. No.5-58)	1×10^{-8}	1.1×10^{-8}	—	A
Quantum Efficiency at 3850 angstroms[q]	28	31	—	%
Current Amplification	—	7.3×10^{6}	—	
Anode Dark Current[r]	—	6×10^{-10}	4×10^{-9}	A
Equivalent-Anode-Dark-Current Input[r]	— —	3×10^{-12} 2.6×10^{-15}[s]	2×10^{-11} 1.8×10^{-14}[s]	lm W
Single Photoelectron Pulse Height Resolution at Full-Width-Half-Maximum Point[t]	—	40	—	%

	Min.	Typical	Max.	
Peak-to-Valley Ratio Between Single and Double Photoelectron Pulse Height[t]	1.4	1.6	—	
Peak-to-Valley Ratio of Pulse Height Spectrum with Fe^{55} Source[u]	—	50	—	
Dark Pulse Summation[v] at 2500 V:				
1 to 128 channels . (See *Typical Dark-Pulse Spectrum*)	—	150	660	cps
Pulse Height Resolution:[w]				
Cs^{137} source, NaI(Tl) scintillator . . .	—	7.5	8.0	%

The following characteristics were measured with an anode-to-cathode voltage distribution of 4, 1, 1.4, 1, 1, 1, 1, 1, 1, 1, 1, 1, and 1. They are included for guidance purposes only.

With E = 1100 volts (Except as noted)

Pulse Height[w,x]				
Cs^{137} source, NaI(Tl) scintillator	—	0.15	—	V
Mean Gain Deviation:[y]	—	1.5×10^{-11}	—	coulombs
With count rate change of 1000 to 10000 cps[z]	—	1	—	%
For a period of 16 hours at a count rate of 1000 cps[aa]	—	1	—	%
Anode-Pulse Rise Time[bb] at 3000 Volts	—	2.1×10^{-9}	—	s
Electron Transit Time[cc] at 3000 Volts	—	3.1×10^{-8}	—	s

The following characteristics were measured with anode-to-cathode voltage distribution of 4, 1, 1.4, 1, 1, 1, 1, 1, 1, 1.5, 2, 4, and 2. They are included for guidance purposes only.

With E = 3000 volts (Except as noted)

Pulse Current:[dd]				
Linear[ee]	—	0.25	—	A
Saturated	—	0.75	—	A

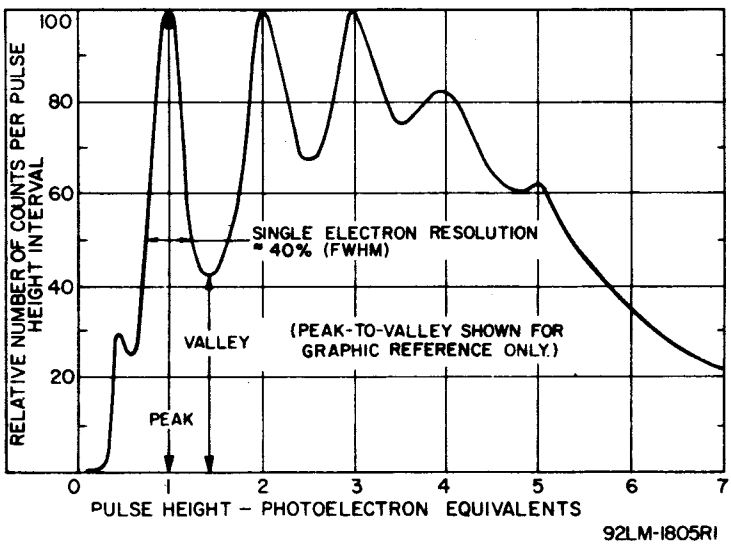
Table I		
Voltage Distribution		
Between the following Electrodes: Cathode (K), Dynode (Dy), and Anode (P)	Column A	Column B*
	8.06% of Dyl-P Voltage (E) Multiplied By:	5.45% of K-P Voltage (E) Multiplied By:
K - Dy1	♦	6
Dy1 - Dy2	1	1
Dy2 - Dy3	1.4	1.4
Dy3 - Dy4	1	1
Dy4 - Dy5	1	1
Dy5 - Dy6	1	1
Dy6 - Dy7	1	1
Dy7 - Dy8	1	1
Dy8 - Dy9	1	1
Dy9 - Dy10	1	1
Dy10 - Dy11	1	1
Dy11 - Dy12	1	1
Dy12 - P	1	1
Dy1 - P	12.4	—
K - P	—	18.4

Focusing Electrode is connected to arm of potentiometer between cathode and dynode No.1. The focusing-electrode voltage is varied to give maximum anode current. Multiplier shield is operated at Dynode-No.5 potential.

♦ Cathode-to-Dynode-No.1 Voltage maintained at 660 volts.

* To take full advantage of the operating capabilities of the 8850 it is required that the cathode-to-dynode No.1 voltage be a minimum of 600 volts.

PHOTOELECTRON PULSE HEIGHT SPECTRUM



*QUANTACON is the RCA designation for photomultiplier tubes employing group III/V compounds as secondary emitters and/or photocathodes. A typical compound is gallium-phosphide.

[a] Made by Corning Glass Works, Corning, NY 14830.

[b] The AJ2145 is ordinarily supplied with the tube and is designed specifically for chassis mounting. The AJ2144 may be supplied as an alternate socket if requested by the user. 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.

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

[e] To take full advantage of the performance capability of the 8850, tube operation at voltage values below these minimum specified values is not recommended.

[f] Averaged over any interval of 30 seconds maximum.

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

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

[i] These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.13 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

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

[k] 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.

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

[n] These values are calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.13 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

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

[p] 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 100 microlumens and 660 volts are applied between cathode and all other electrodes connected as anode.

[q] Calculated from the cathode current measured with blue light source.

[r] 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 0.1 microlumen. The supply voltage E is adjusted to obtain an anode current of 2.6 microamperes. Luminous sensitivity of the tube under these conditions is approximately equivalent to 200 amperes per lumen. Dark current is measured with incident light removed.

[s] At 3850 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 1140 lumens per watt.

[t] Measured under the following conditions: Dark noise is eliminated by use of a coincidence circuit. As a result, most of the low energy pulses below one photoelectron are not counted. The light source is a gallium-phosphide light-emitting diode having peak output at a wavelength of approximately 5600 angstroms. The diode is pulsed at a rate of 30,000 pps; pulse duration is approximately 0.4 μs; anode circuit integrating time is approximately 10 μs. The light intensity from the diode is adjusted to obtain greater or fewer registered counts in a given multielectron peak to obtain an approximately equal number of counts in the first and second photoelectron peaks. A Multichannel Pulse-Height Analyzer having 256 channels is employed.

[u] Measured using a Harshaw Type HG 0.005" beryllium window NaI (T1) scintillator, 0.04" thick and 7/8" in diameter and an isotope of iron having an atomic mass of 55 (Fe^{55}) and an effective activity at the scintillator of one microcurie.

[v] Measured under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a low color temperature to assure the high probability of single photoelectron emission from the photocathode of the tube. The intensity of the light source is adjusted for approximately 10^4 photons per second.

[w] Pulse-height resolution in per cent is defined as 100 times the ratio of the width of the photopeak at half the maximum count rate in the photopeak height to the pulse height at maximum photopeak count rate under the conditions of (x).

[x] Pulse height is defined as the amplitude of the anode pulse voltage (referred to anode) measured across a 100 kilohm resistor and a total capacitance of 100 $\pm$ 3% pF in parallel. 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 photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 2" x 2" thallium-activated sodium-iodide scintillator [NaI (T1)-type 3D8S50, Serial No.AJ651, or equivalent] are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97th Street, Cleveland 6, OH, and is rated by the manufacturer as having a resolving capability of 8.2 per cent to 8.3 per cent. The Cs^{137} source is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the tube by a coupling fluid such as Dow Corning Corp. Type DC200 (Viscosity of 60,000 centistokes)—Manufactured by the Dow Corning Corp., Midland, MI, or equivalent.

[y] Mean gain deviation is defined as the percentage change, regardless of sign, from the average pulse height for a given radiation source and scintillator over a specified time or count rate interval.

[z] Under the following conditions: The scintillator and Cs^{137} radiation source of (x) are employed. The radiation source

is initially centered, on the major axis of the tube and the scintillator, at a point providing a pulse count rate of 1000 cps. The pulse height of the photopeak is measured under this condition. Next, the radiation source is moved rapidly, in approximately 30 seconds, to a new position that is equivalent to a count rate of 10,000 cps. The new position is also centered in the major axis of the tube. The pulse height under this condition is measured. The difference in pulse height between these two measurements is typically 1 per cent.

[aa] Under the same conditions as (z) except the count rate position of 1,000 cps is maintained for 16 hours and the pulse height is sampled at 1 hour intervals.

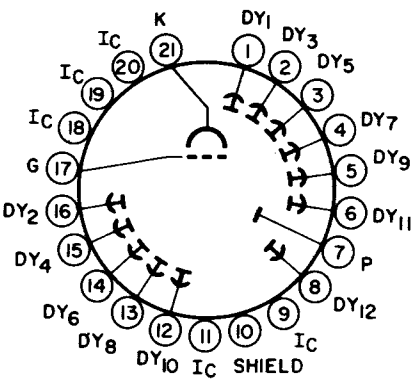
[bb] Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode-pulse rise time is primarily a function of transit time variation and is measured under conditions with the incident light fully illuminating the photocathode.

[cc] 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.

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

[ee] Maximum deviation from linearity is 2 per cent.

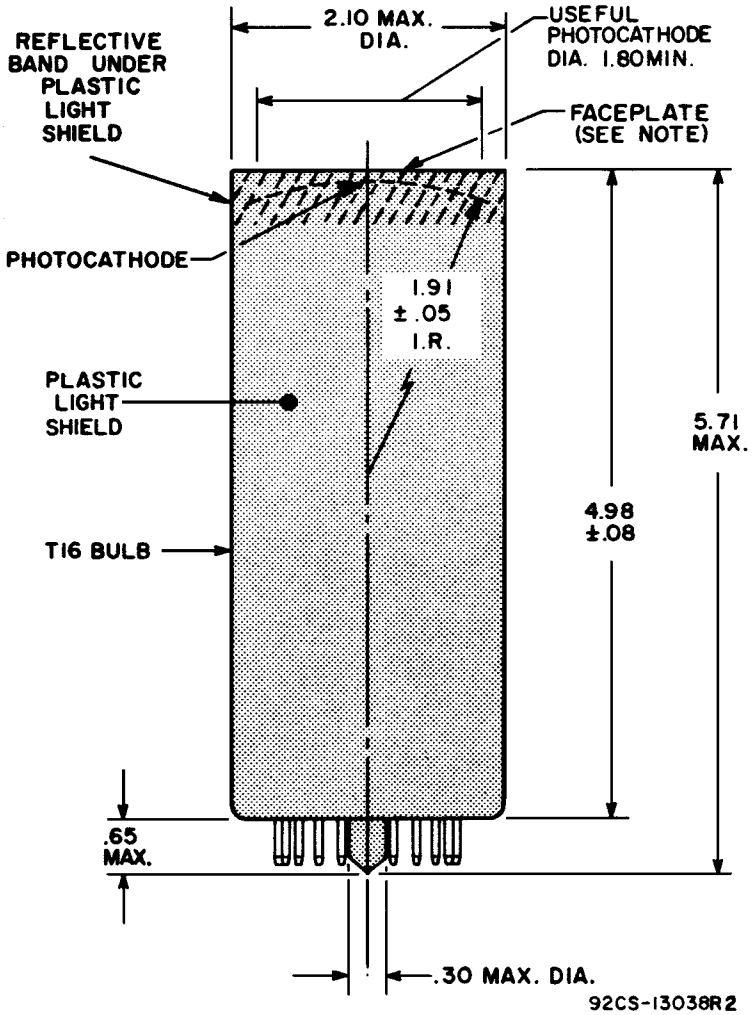
TERMINAL DIAGRAM
(Bottom View)



DIRECTION OF RADIATION:
INTO END OF BULB

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

DIMENSIONAL OUTLINE



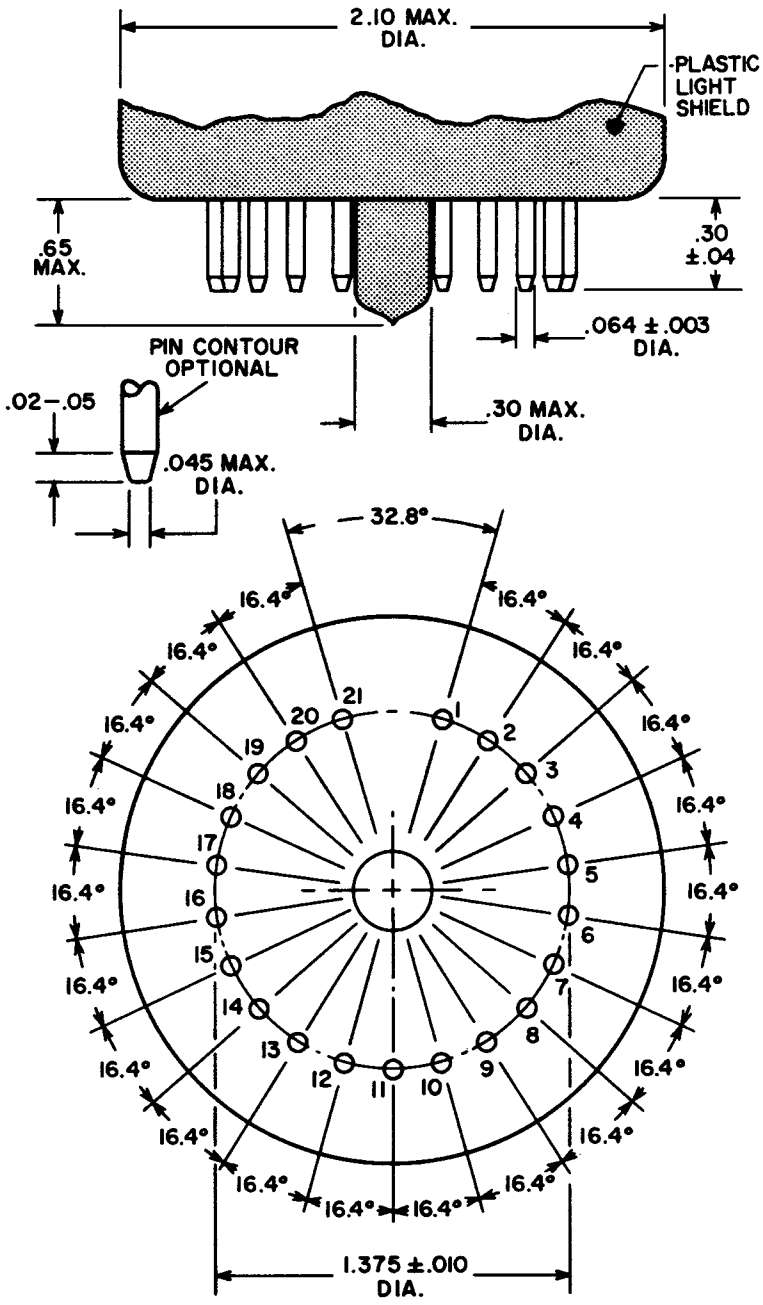
Dimensions in Inches

Note: Deviation from Flatness of External Surface of Faceplate will not exceed 0.010" from Peak to Valley.

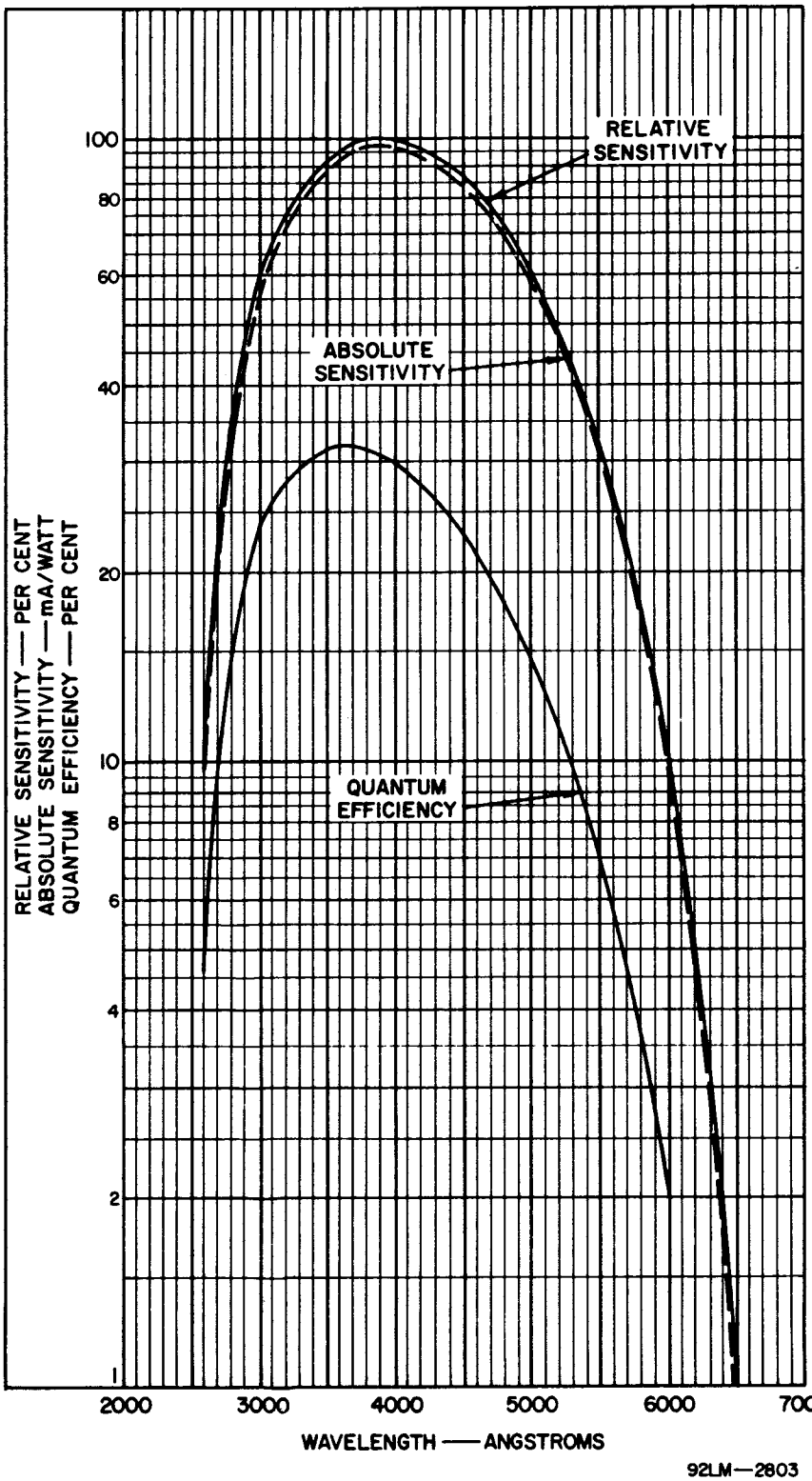
The dimensions in millimeters are derived from the basic inch dimensions (1 inch = 25.4 mm)

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	1.91	48.5
.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



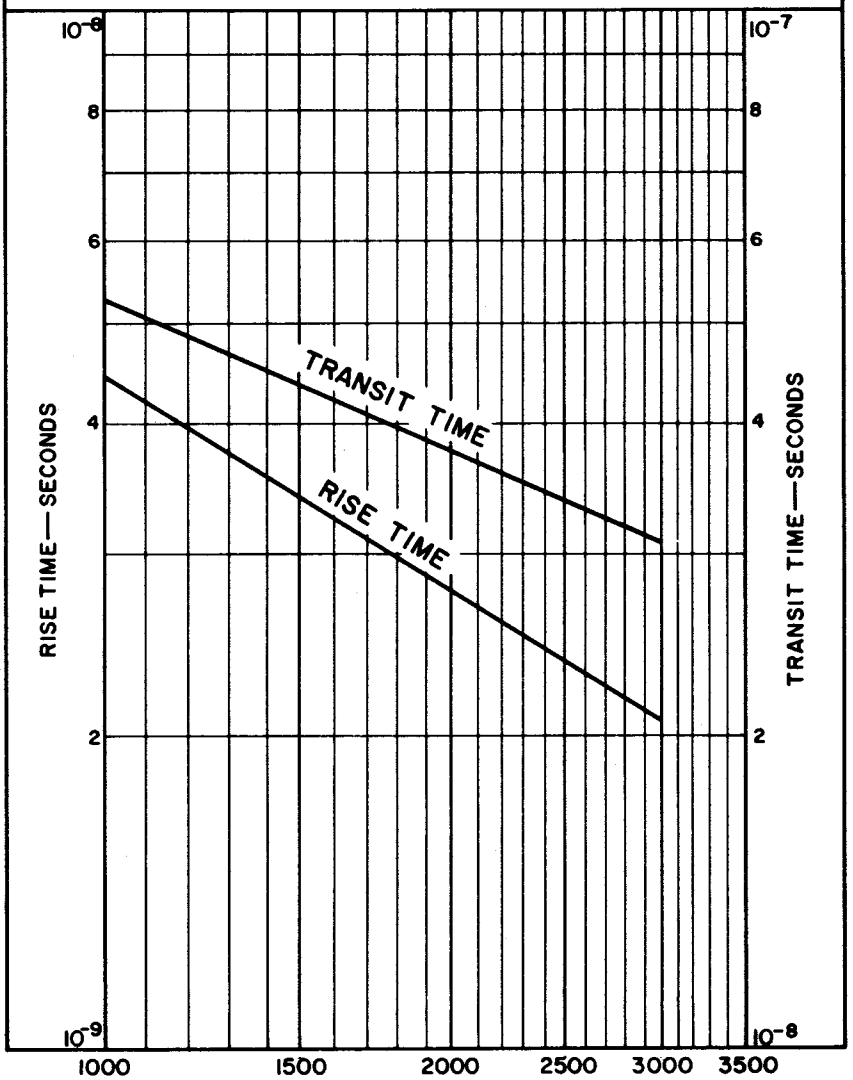
SPECTRAL RESPONSE CHARACTERISTICS



TYPICAL TIME-RESOLUTION CHARACTERISTICS

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGES AS FOLLOWS:	
BETWEEN	6.1% OF E MULTIPLIED BY
CATHODE AND DYNODE No. 1	4.0
DYNODE No. 1 AND DYNODE No. 2	1.0
DYNODE No. 2 AND DYNODE No. 3	1.4
EACH SUCCEEDING DYNODE-STAGE VOLTS	1.0
ANODE AND CATHODE	16.4

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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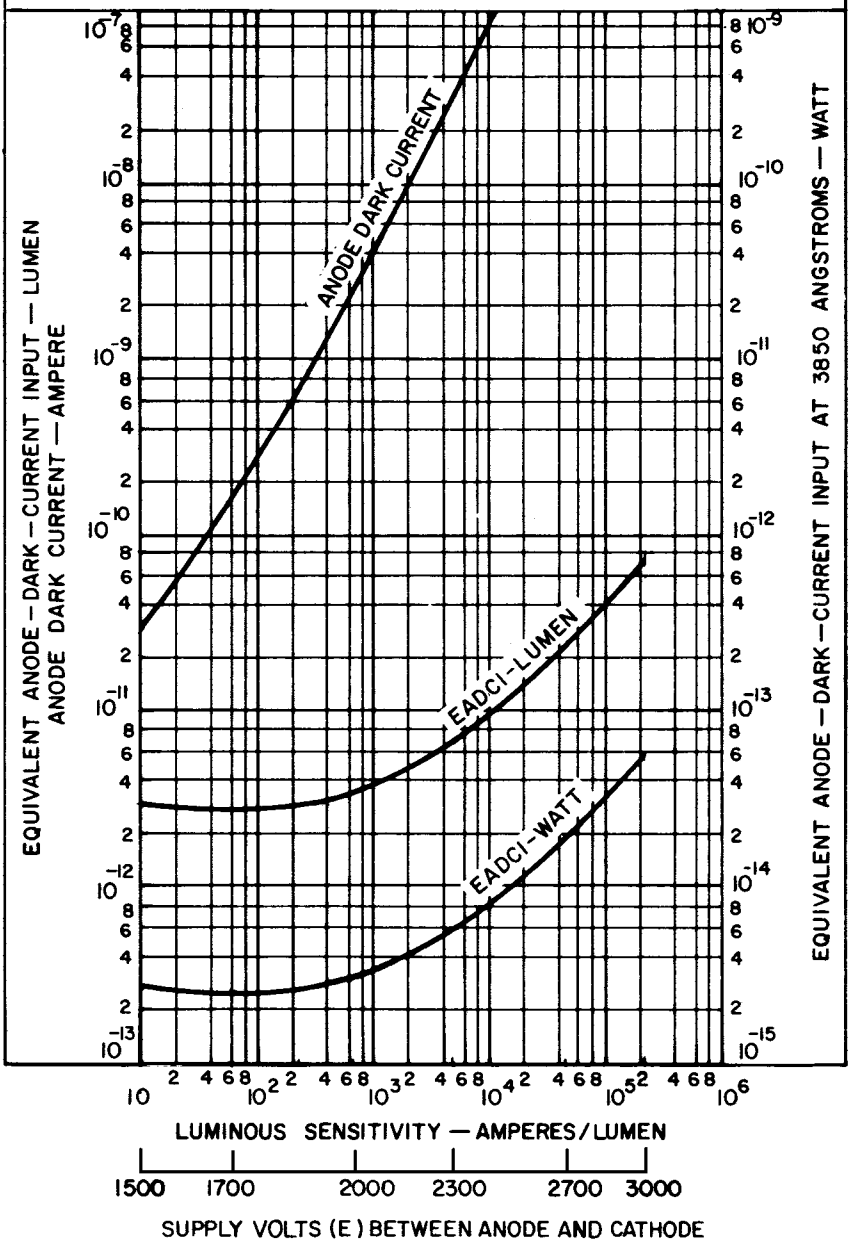
TYPICAL ANODE DARK CURRENT AND EADCI CHARACTERISTICS

SENSITIVITY IS VARIED BY ADJUSTMENT OF THE SUPPLY VOLTAGE (E) ACROSS A VOLTAGE DIVIDER WHICH PROVIDES VOLTAGE DISTRIBUTION OF COLUMN A, TABLE I.

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



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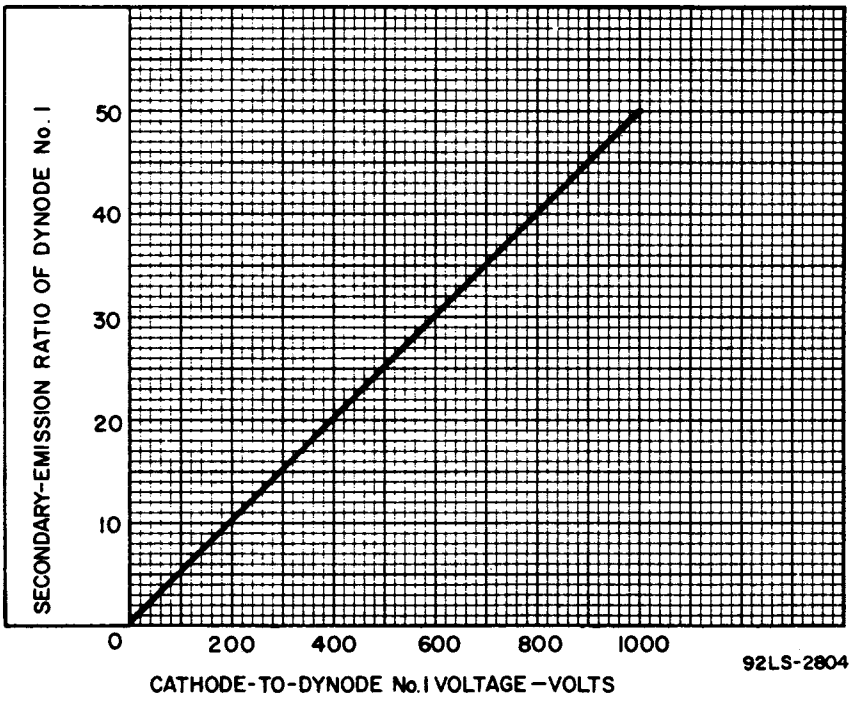
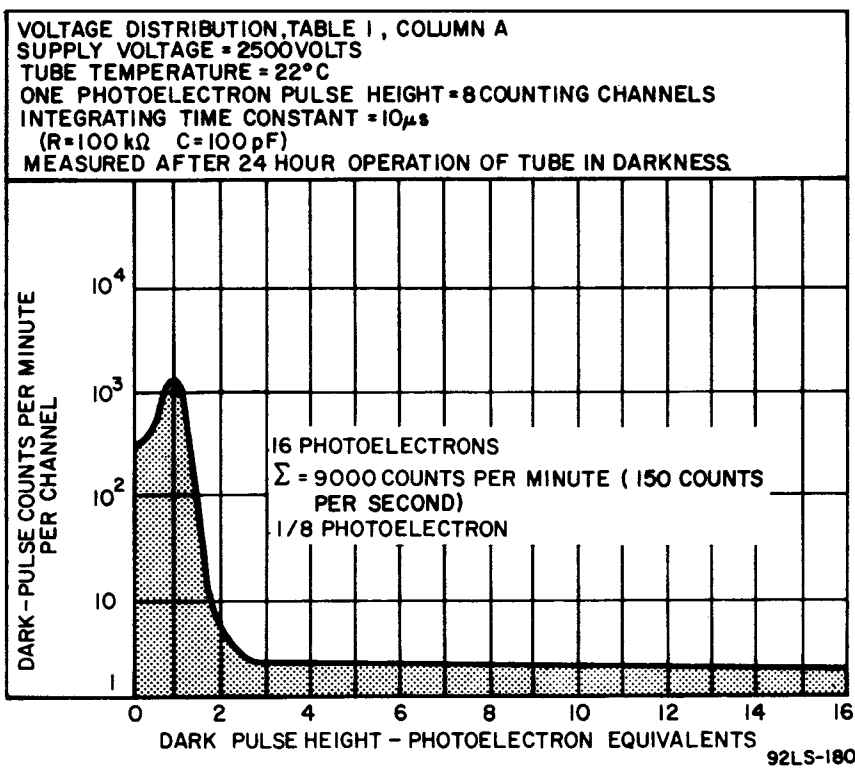
TYPICAL SECONDARY-EMISSION RATIO OF FIRST DYNODE AS A FUNCTION OF CATHODE-TO-DYNODE NO. 1 VOLTAGE

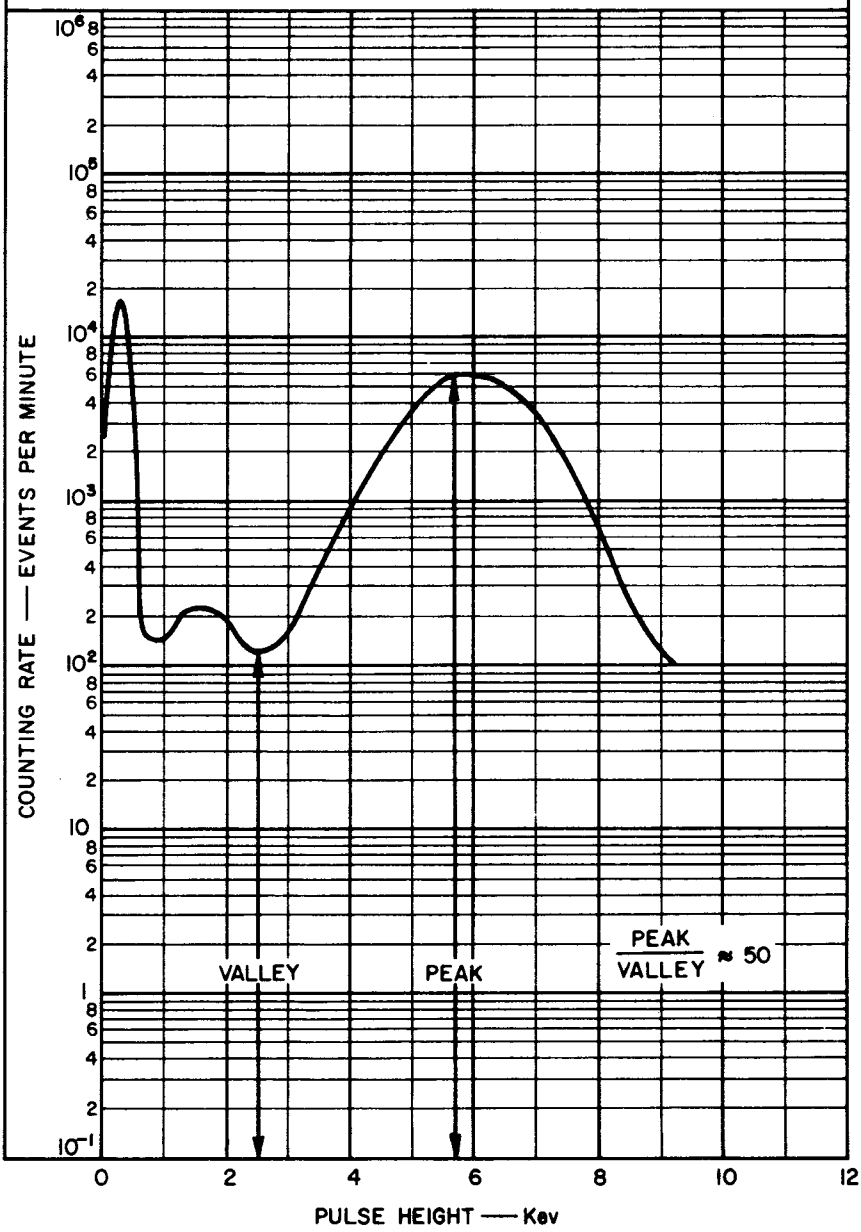


TYPICAL DARK-PULSE SPECTRUM



DIFFERENTIAL Fe^{55} SPECTRUM

Fe^{55} SOURCE, ACTIVITY 1 μ CURIE
SCINTILLATOR: HARSHAW, TYPE HG 0.005" BERYLLIUM WINDOW, NaI(Tl), 7/8" DIAMETER, 0.040" THICK
CATHODE – TO – DYNODE No. 1 VOLTS = 660
DYNODE No. 1 – TO – DYNODE No. 2 VOLTS = 108
DYNODE No. 2 – TO – DYNODE No. 3 VOLTS = 151
EACH SUCCEEDING DYNODE – STAGE VOLTS = 108
ANODE – TO – CATHODE VOLTS = 2000
FOCUSING ELECTRODE IS CONNECTED TO DYNODE No. 1 POTENTIAL
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE No. 5 POTENTIAL



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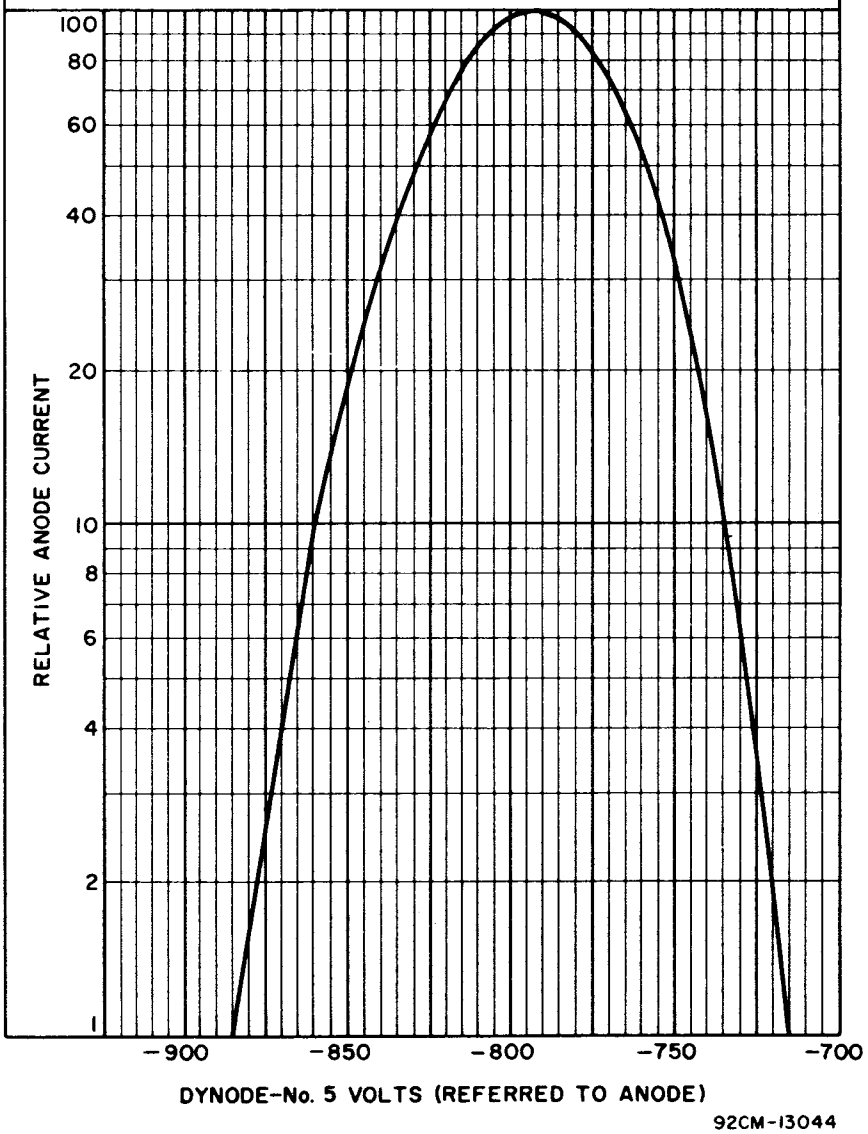
TYPICAL DYNODE MODULATION CHARACTERISTIC

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

BETWEEN	6.1% OF E MULTIPLIED BY
CATHODE AND DYNODE No. 1	4.0
DYNODE No. 1 AND DYNODE No. 2	1.0
DYNODE No. 2 AND DYNODE No. 3	1.4
EACH SUCCEEDING DYNODE-STAGE VOLTS	1.0
ANODE AND CATHODE	16.4

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



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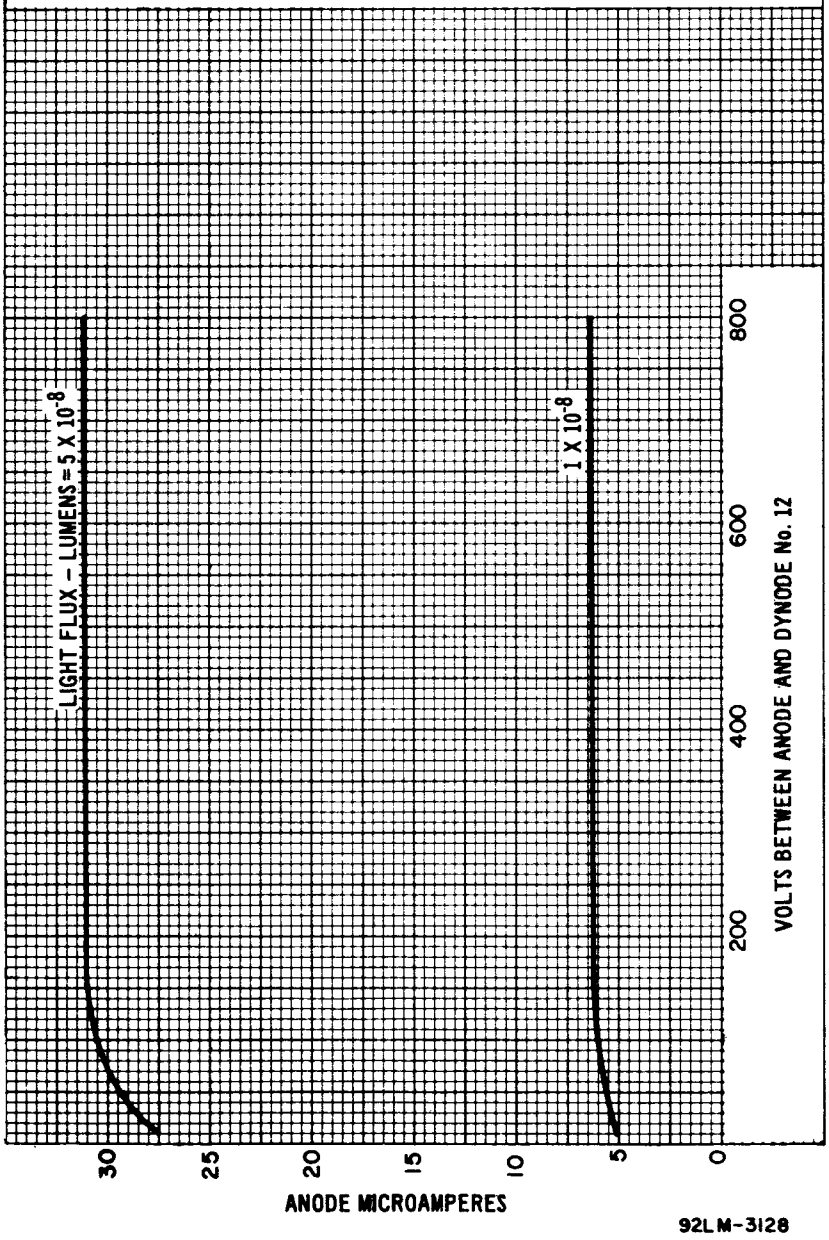
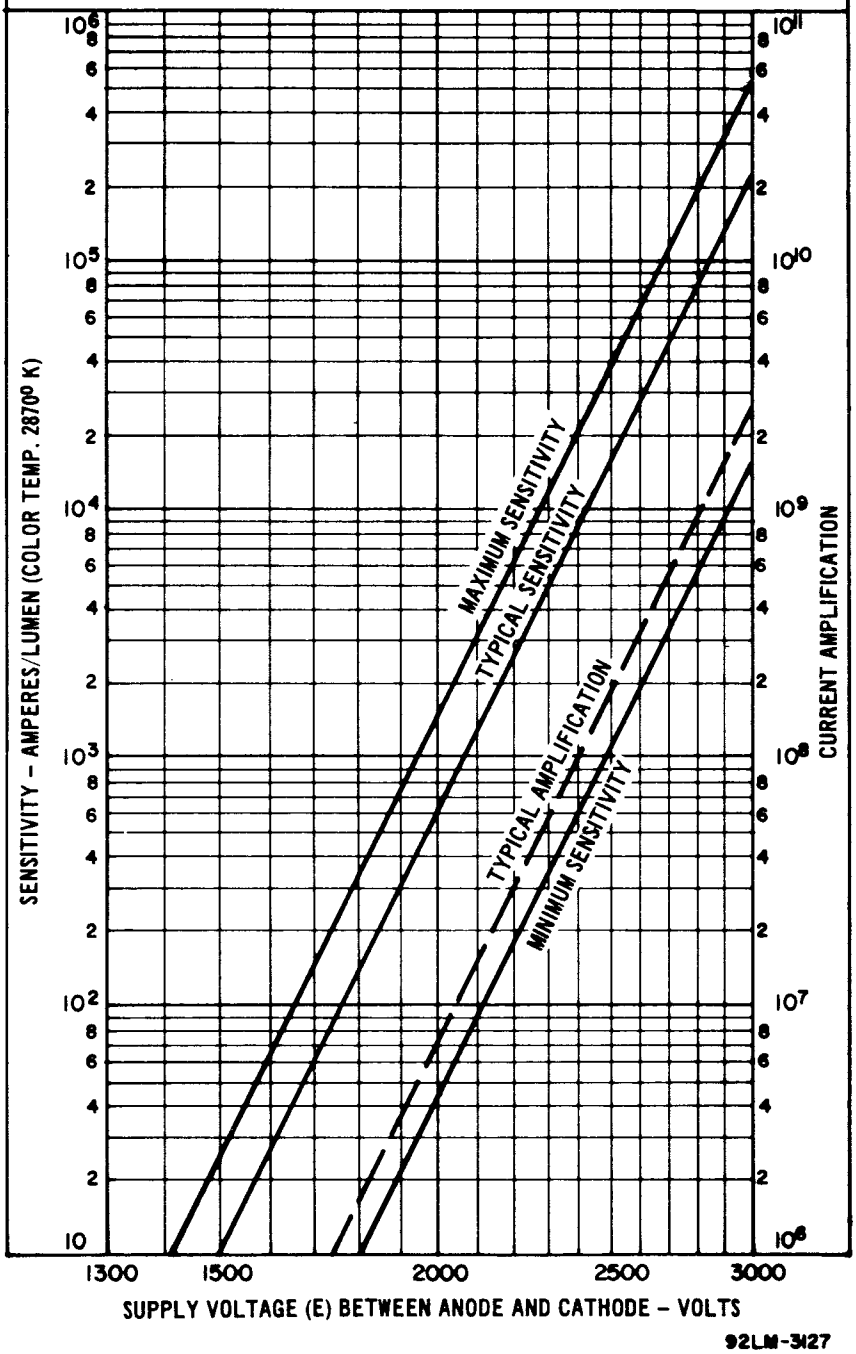
TYPICAL ANODE CHARACTERISTICS

CATHODE-TO-DYNODE-No. 1 VOLTS = 660
DYNODE-No. 1-TO-DYNODE-No. 2 VOLTS = 108
DYNODE-No. 2-TO-DYNODE-No. 3 VOLTS = 151
EACH SUCCEEDING DYNODE-STAGE VOLTS = 108
ANODE-TO-CATHODE VOLTS = 2000
FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No. 1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No. 5 POTENTIAL.
LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870° K.



TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

VOLTAGE DISTRIBUTION, TABLE I, COLUMN A
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED FOR MAXIMUM ANODE CURRENT.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No. 5 POTENTIAL.

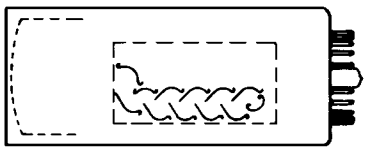


TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

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

BETWEEN:	6.1 % OF E MULTIPLIED BY
CATHODE AND DYNODE No.1	4.0
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	16.4

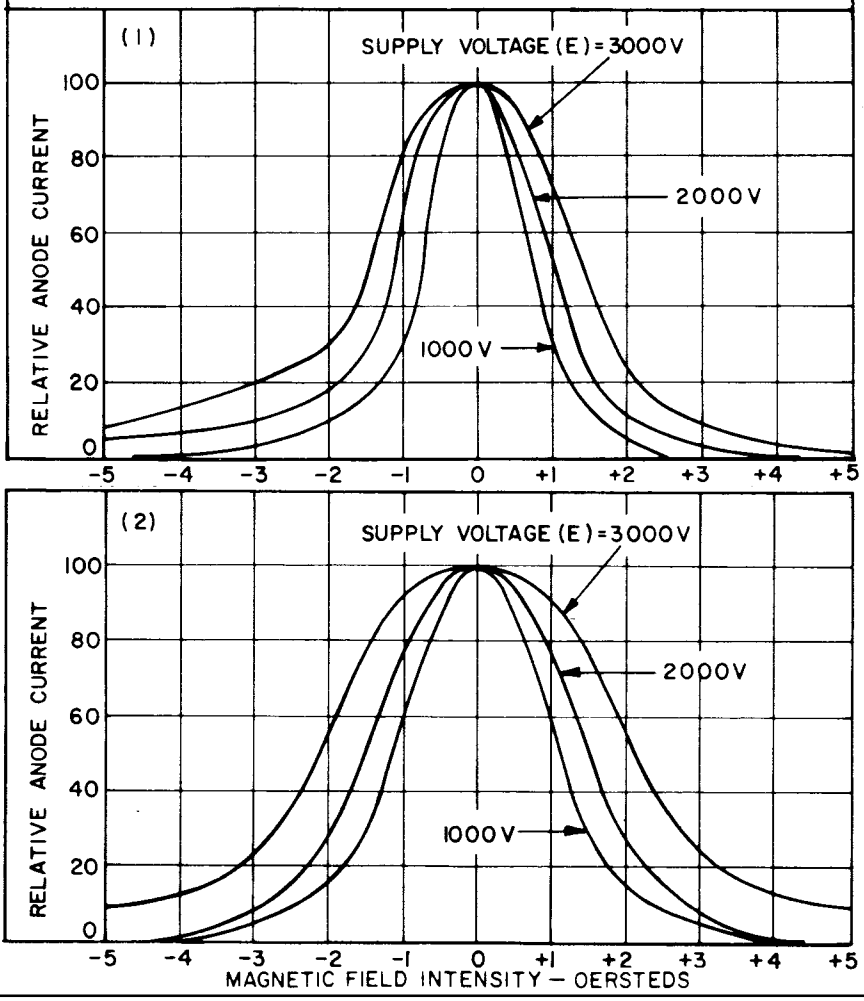
FOCUSING ELECTRODE IS CONNECTED TO DYNODE-No.1 POTENTIAL.
ELECTRON MULTIPLIER SHIELD IS CONNECTED TO DYNODE-No.5 POTENTIAL.
PHOTOCATHODE IS FULLY ILLUMINATED.



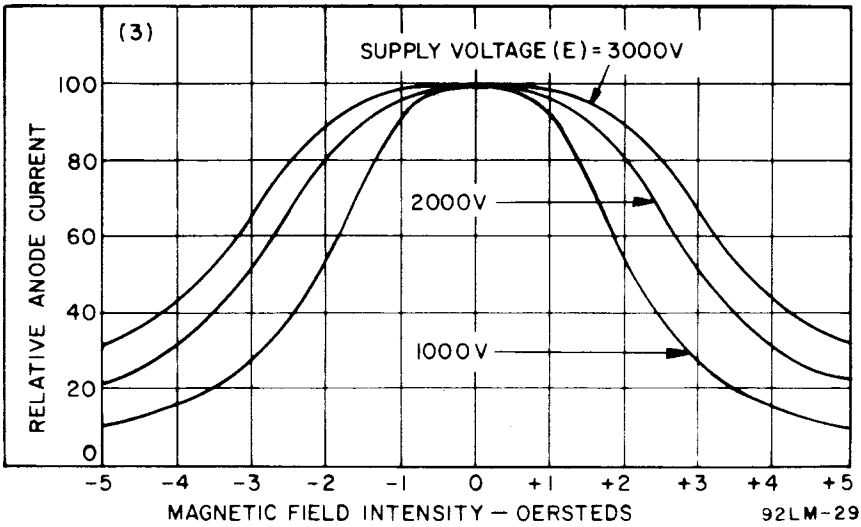
POSITIVE VALUE OF H IN DIRECTION SHOWN:

(1)*, (2) ↑ OR (3) →

*DIRECTION (1) IS OUT OF PAPER



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



TYPICAL FOCUSING-ELECTRODE CHARACTERISTIC