4518

Photomultiplier Tube

2-Inch Diameter, 10-Stage, Head-On Type
Bialkali Photocathode of High Quantum Efficiency
Circular-Cage Electrostatically-Focused Dynode Structure
For use in pulse counting and other low light level detection and measurement systems

GENERAL

Spectral Response	See accompanying *Spectral Response Characteristics*
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Shape	Spherical Section
Minimum projected area	2.2 in^2
Minimum diameter	1.68 in.
Window	Corning[a] No.0080, or equivalent
Shape	Plano-Concave
Index of refraction at 4360 angstroms	1.523
Dynodes:	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	Circular-Cage Electrostatic-Focus Type
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	4.4 pF
Anode to all other electrodes	7 pF
Maximum Overall Length	5.81 in.
Seated Length	4.87 in. ± 0.19 in.
Maximum Diameter	2.31 in.
Bulb	T-16
Socket	Cinch-Jones[b] No.3M14, or equivalent
Magnetic Shield	Millen[c] No.80802B, or equivalent
Operating Position	Any
Weight (Approx.)	5.2 oz
Base	Medium-Shell Diheptal 14-Pin (JEDEC No.B14-38), Non-hygroscopic

ABSOLUTE-MAXIMUM RATINGS

DC Voltage:		
Between anode and cathode	2000 max.	V
Between anode and dynode No.10	250 max.	V
Between consecutive dynodes	400 max.	V
Between dynode No.1 and cathode	300 max.	V
Between focusing electrode and cathode	400 max.	V
Average Anode Current[e]	0.5 max.	mA
Ambient-Temperature Range[f]	-100 to +85	°C

CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a voltage divider providing voltages as shown in Table I, except as noted.

With E = 1500 volts except as noted

	Min.	Typ.	Max.	
Sensitivity				
Radiant[g] at 4000 angstroms	-	3.9×10^{4}	-	A/W
Cathode Radiant[h] at 4000 angstroms	-	0.079	-	A/W
Luminous:				
With tungsten light source[i]	13	33	200	A/lm
With blue light source[k]	2×10^{-5}	5×10^{-5}	3×10^{-4}	A
Cathode Luminous:				
With tungsten light source[m]	-	6.7×10^{-5}	-	A/lm
With blue light source[n]	8×10^{-10}	1×10^{-9}	-	A
Quantum Efficiency at 4000 angstroms	-	24	-	%
Current Amplification	-	5×10^{5}	-	
Anode Dark Current[p]	-	2.4×10^{-10}	5×10^{-10}	A
Equivalent Anode-Dark-Current Input	-	3×10^{-11}[q]	-	lm
	-	2.5×10^{-14}[r]	-	W
Dark-Pulse Spectrum[s]	-	(x)	-	
Pulse-Height Resolution[t]	-	9	-	%
Anode-Pulse Rise Time[u,v]	-	2.3×10^{-9}	-	s
Electron Transit Time[u,w]	-	2.7×10^{-8}	-	s

[a]Made by Corning Glass Works, Corning, New York 14830.

[b]Made by Cinch Manufacturing Co., 1026 S. Homan Ave., Chicago, Ill. 60624

[c]Made by James Millen Manufacturing Co., 150 Exchange St., Malden, Mass. 02148

[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 1190 lumens per watt.

[h]This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1190 lumens per watt.

[i] These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-5} \text{ (lm)}}$$

The value of 0.15 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, 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 10 microlumens.

[m]This value is calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

The value of 0.15 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.

[n]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 100 microlumens and 200 volts are applied between cathode and all other electrodes connected as anode.

[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 10 microamperes. Sensitivity of the 4518 under these conditions is approximately equivalent to 7 amperes per lumen. Dark current is measured with no light incident on the tube.

[q]With supply voltage (E) adjusted to give an equivalent luminous sensitivity of 7 amperes per lumen.

[r]At 4000 angstroms. This value is calculated from the EADCI value in lumens using a conversion factor of 1190 lumens per watt.

[s]Measured under the following conditions: A Nuclear Data Model No.ND-180 Multichannel Pulse-Height Analyzer is used. The single-photoelectron pulse height is established by fully illuminating the photocathode with a weak light source, such as a tungsten-filament lamp operated at a low color temperature, to assure the high probability of single photoelectron emission from the photocathode of the 4518. The intensity of the light source is adjusted for approximately 50 per cent counting loss. The dark-pulse spectrum is then obtained, using the same gain setting of the Multichannel Pulse-Height Analyzer, with the light source removed.

[t]Pulse-height resolution is defined as the quotient of the full width of the photopeak at half height by the pulse height at maximum count rate under the following 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 8D8] are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97 Street, Cleveland 6, Ohio, and is rated by the manufacturer as having a resolution capability of 7.5%. 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 4518 by a coupling fluid such as Dow Corning Corp., Type DC200 (viscosity of 60,000 centistokes) – Manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

[u]Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of (E) between cathode and dynode No.1; 1/12 of (E) for each succeeding dynode stage; and 1/12 of (E) between dynode No.10 and anode. Focusing electrode potential is adjusted as shown in Table I.

[v]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.

[w]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.

[x]See accompanying *Typical Dark-Pulse Spectrum.*

TABLE I

TYPICAL POTENTIAL DISTRIBUTION

Between:	7.75% of Supply Voltage (E) Multiplied by:
Cathode and Dynode No.1	1.8
Dynode No.1 and Dynode No.2	1.4
Dynode No.2 and Dynode No.3	1.5
Dynode No.3 and Dynode No.4	1.2
Dynode No.4 and Dynode No.5	1.0
Dynode No.5 and Dynode No.6	1.0
Dynode No.6 and Dynode No.7	1.0
Dynode No.7 and Dynode No.8	1.0
Dynode No.8 and Dynode No.9	1.0
Dynode No.9 and Dynode No.10	1.0
Dynode No.10 and Anode	1.0
Anode and Cathode	12.9

Focusing Electrode is connected to arm of potentiometer between cathode and dynode No.1. The focusing-electrode voltage is varied between 10% and 60% of dynode No.1 potential (referred to cathode) to give maximum anode current.

OPERATING CONSIDERATIONS

The *base pins* of the 4518 fit a diheptal 14-contact socket, such as Cinch-Jones No.3M14 or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that incident light falls on the face end of the tube.

The *operating stability* of the 4518 is dependent on the magnitude of the anode current. 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 stability is of prime importance, the use of an average anode current of 1 microampere or less is recommended.

Electrostatic and magnetic shielding of the 4518 is ordinarily required. When a shield is used, it must be at cathode potential.

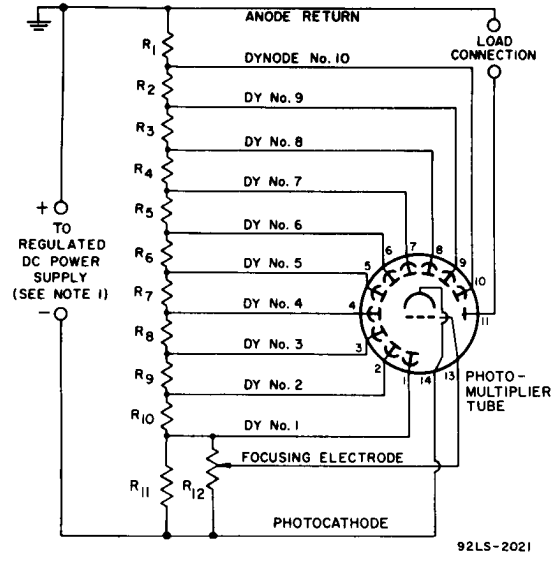
The *high voltages* at which the 4518 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

Accompanying typical voltage-divider arrangements are recommended for use with the 4518. The resistance values for the voltage dividers range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for any voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required power rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is mounted near the photocathode.

The use of high resistance values per stage may cause deviation from linearity if the voltage-divider current is not maintained at a value of at least 10 times that of the maximum value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No.7 and No.8, dynodes No.8 and No.9, dynodes No.9 and No.10, and

between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 10 megohms per stage make the 4518 more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT WHICH PERMITS DIRECT COUPLING TO THE ANODE

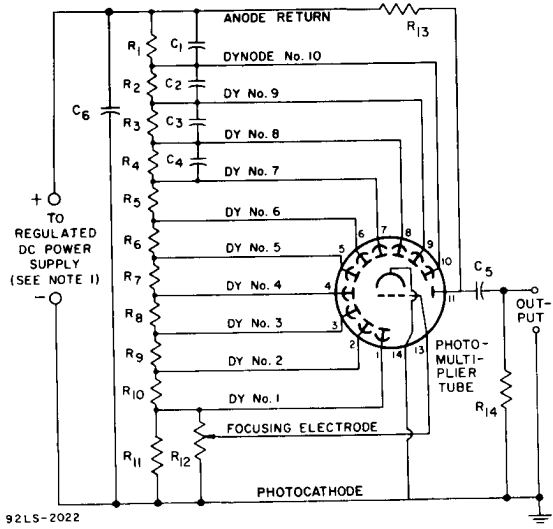


R_1 through R_7: 390,000 ohms, 1/2 watt
R_8: 470,000 ohms, 1/2 watt
R_9: 620,000 ohms, 1/2 watt
R_{10}: 560,000 ohms, 1/2 watt
R_{11}: 720,000 ohms, 1/2 watt
R_{12}: 5 megohms, 1/2 watt, adjustable

Note 1: Adjustable between approximately 500 and 2000 volts dc.

Note 2: Component values are dependent upon nature of application and output signal desired.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR USE IN SCINTILLATION-COUNTING APPLICATIONS



C_1: 0.05 μF, 500 volts (dc working)
C_2: 0.02 μF, 500 volts (dc working)
C_3: 0.01 μF, 500 volts (dc working)
C_4: 0.005 μF, 500 volts (dc working)
C_5 and C_6: 0.005 μF, 3000 volts (dc working)
R_1 through R_7: 390,000 ohms, 1/2 watt
R_8: 470,000 ohms, 1/2 watt
R_9: 620,000 ohms, 1/2 watt
R_{10}: 560,000 ohms, 1/2 watt
R_{11}: 720,000 ohms, 1/2 watt
R_{12}: 5 megohms, 1/2 watt, adjustable
R_{13}: 1 megohm, 1/2 watt
R_{14}: 100,000 ohms, 1/2 watt

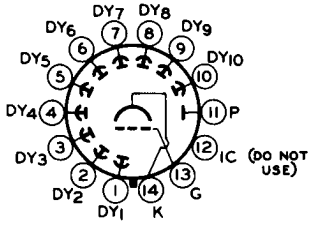
Note 1: Adjustable between approximately 500 and 2000 volts dc.

Note 2: Capacitors C_1 through C_6 should be connected at tube socket for optimum high-frequency performance.

Note 3: Component values are dependent upon nature of application and output signal desired.

TERMINAL DIAGRAM (Bottom View)

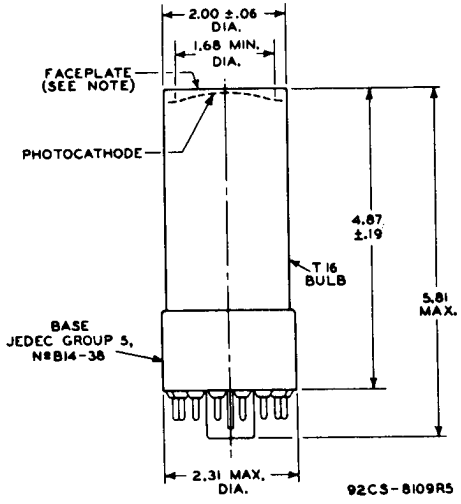
Pin 1: Dynode No.1
Pin 2: Dynode No.2
Pin 3: Dynode No.3
Pin 4: Dynode No.4
Pin 5: Dynode No.5
Pin 6: Dynode No.6
Pin 7: Dynode No.7
Pin 8: Dynode No.8
Pin 9: Dynode No.9
Pin 10: Dynode No.10
Pin 11: Anode
Pin 12: Internal Connection — Do Not Use
Pin 13: Focusing Electrode
Pin 14: Photocathode



DIRECTION OF RADIATION: INTO END OF BULB

14AA

DIMENSIONAL OUTLINE



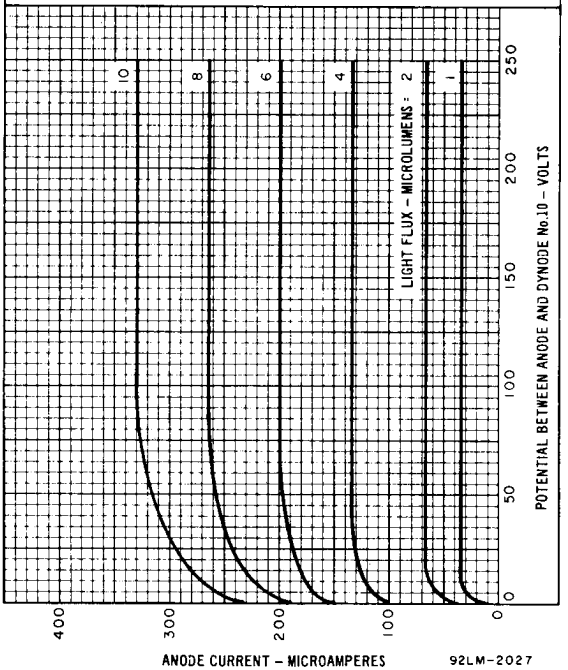
DIMENSIONS IN INCHES

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

Note: Within 1.68" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

TYPICAL ANODE CHARACTERISTICS

CATHODE-TO-DYNODE-No.1 VOLTS = 280
DYNODE-No.1-TO-DYNODE-No.2 VOLTS = 220
DYNODE-No.2-TO-DYNODE-No.3 VOLTS = 230
DYNODE-No.3-TO-DYNODE-No.4 VOLTS = 185
EACH SUCCEEDING DYNODE-STAGE VOLTS = 155
FOCUSING ELECTRODE IS CONNECTED TO THE ARM OF A POTENTIOMETER BETWEEN CATHODE AND DYNODE-No.1. FOCUSING ELECTRODE VOLTAGE IS ADJUSTED BETWEEN 10% AND 60% OF DYNODE-No.1 POTENTIAL TO GIVE MAXIMUM ANODE CURRENT.
LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870° K

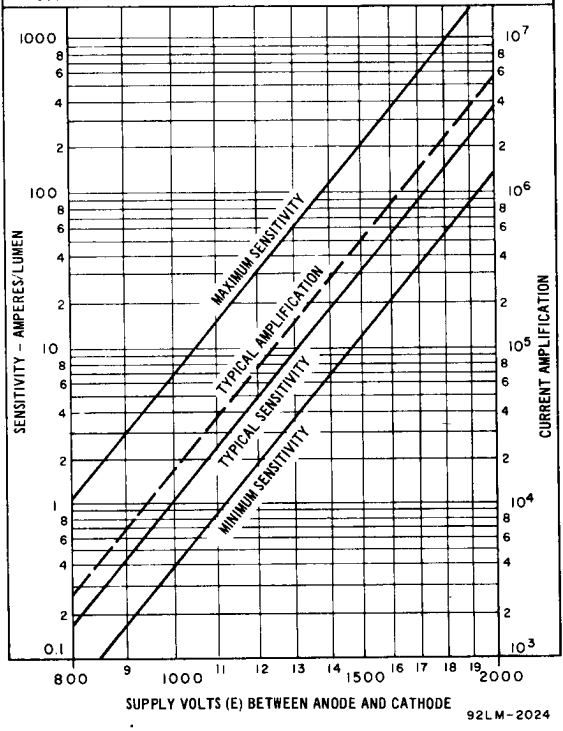


SENSITIVITY AND CURRENT-AMPLIFICATION CHARACTERISTICS

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE-DIVIDER WHICH DISTRIBUTES THE VOLTAGE AS FOLLOWS:

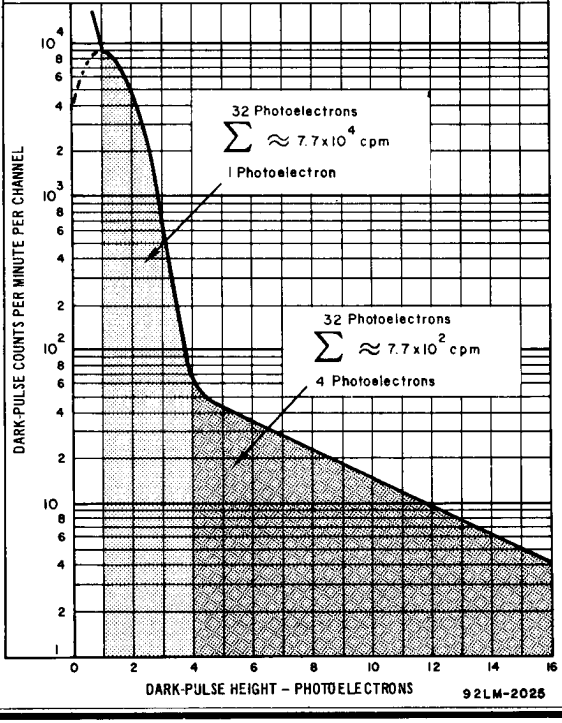
BETWEEN:	7.75% OF E MULTIPLIED BY:
CATHODE AND DYNODE No.1	1.8
DYNODE No.1 AND DYNODE No.2	1.4
DYNODE No.2 AND DYNODE No.3	1.5
DYNODE No.3 AND DYNODE No.4	1.2
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	12.9

FOCUSING ELECTRODE VOLTAGE IS ADJUSTED FOR MAXIMUM ANODE CURRENT



TYPICAL DARK-PULSE SPECTRUM

CATHODE-TO-DYNODE No.1 VOLTAGE = 280
DYNODE No.1-TO-DYNODE No.2 VOLTAGE = 220
DYNODE No.2-TO-DYNODE No.3 VOLTAGE = 230
DYNODE No.3-TO-DYNODE No.4 VOLTAGE = 185
EACH SUCCEEDING DYNODE-STAGE VOLTAGE = 155
ANODE-TO-CATHODE VOLTAGE = 2000
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO GIVE MAXIMUM ANODE CURRENT
DASHED PORTION INDICATES LOCATION OF SINGLE PHOTOELECTRON PEAK. THIS PORTION OF CURVE IS NORMALIZED TO COINCIDE WITH SINGLE PHOTOELECTRON PEAK OF DARK PULSE SPECTRUM AND IS OBTAINED WITH PHOTOCATHODE FULLY ILLUMINATED BY A TUNGSTEN-FILAMENT LAMP OPERATED AT A LOW COLOR TEMPERATURE. DARK PULSES ARE SUBTRACTED.
SOLID-LINE PORTION INDICATES DARK-PULSE SPECTRUM.
TUBE TEMPERATURE = 22° C.
ONE PHOTOELECTRON PULSE HEIGHT = 4 COUNTING CHANNELS.
INTEGRATING TIME CONSTANT = 30 μ SEC. (R_L = 300 k, C = 100 pF).

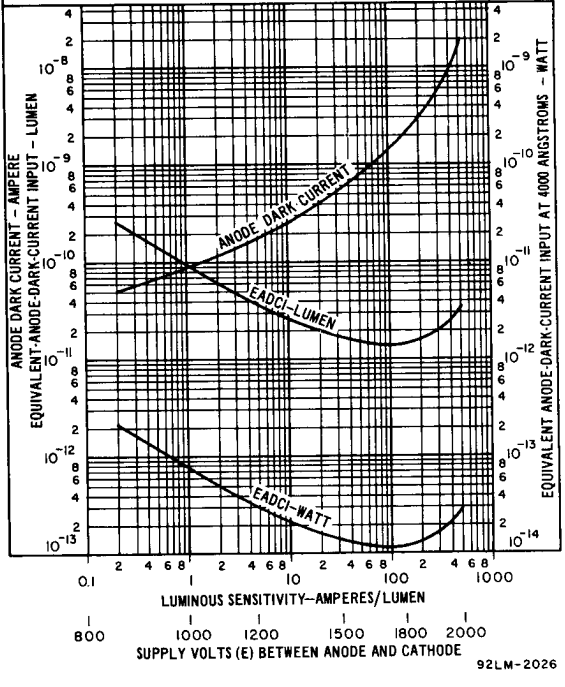


TYPICAL DARK CURRENT AND EADCI CHARACTERISTICS

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

BETWEEN:	7.75% OF E MULTIPLIED BY:
CATHODE AND DYNODE No.1	1.8
DYNODE No.1 AND DYNODE No.2	1.4
DYNODE No.2 AND DYNODE No.3	1.5
DYNODE No.3 AND DYNODE No.4	1.2
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	12.9

FOCUSING ELECTRODE VOLTAGE IS ADJUSTED FOR MAXIMUM ANODE CURRENT
TUBE TEMPERATURE = 22° C

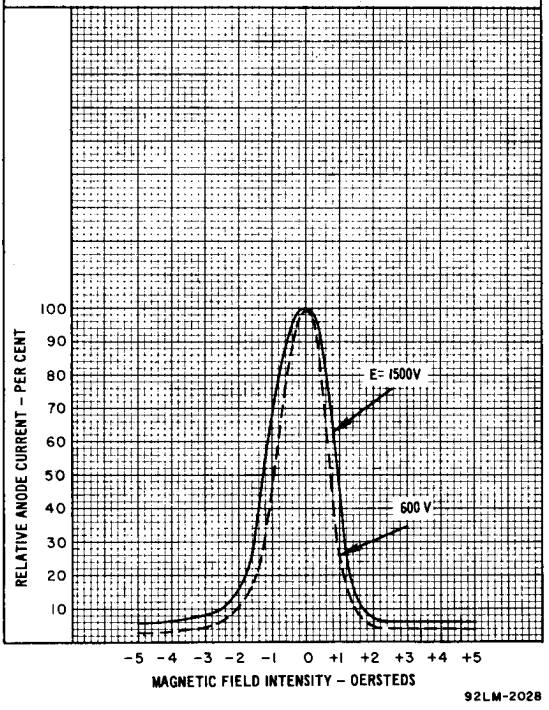


TYPICAL EFFECT OF INDICATED MAGNETIC FIELD ON ANODE CURRENT

SUPPLY VOLTAGE (E) ACROSS VOLTAGE DIVIDER PROVIDING 1/6 OF E BETWEEN CATHODE AND DYNODE No.1; 1/12 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/12 OF E BETWEEN DYNODE No.10 AND ANODE.
FOCUSING-ELECTRODE VOLTAGE ADJUSTED TO GIVE MAXIMUM ANODE CURRENT.

THE PHOTOCATHODE IS FULLY ILLUMINATED.

POSITIVE VALUES OF MAGNETIC FIELD INTENSITY (H) ARE FOR LINES OF FLUX OUT OF PAPER



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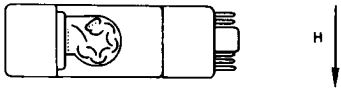
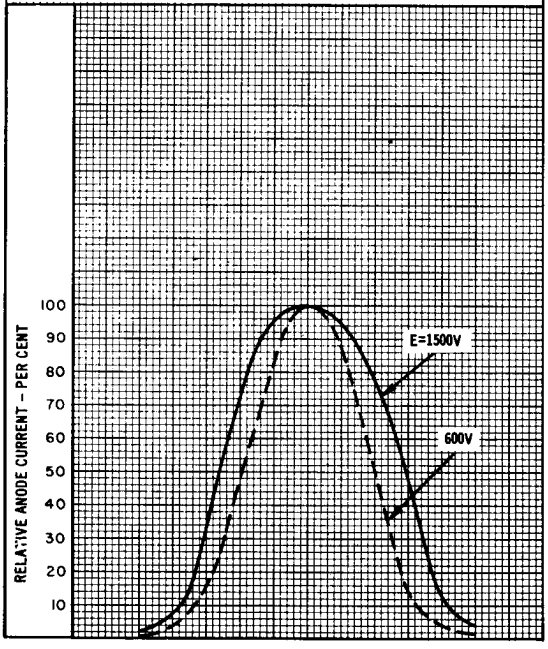
TYPICAL EFFECT OF INDICATED MAGNETIC FIELD ON ANODE CURRENT

SUPPLY VOLTAGE (E) ACROSS VOLTAGE DIVIDER PROVIDING 1/6 OF E BETWEEN CATHODE AND DYNODE No.1; 1/12 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/12 OF E BETWEEN DYNODE No.10 AND ANODE.
FOCUSING-ELECTRODE VOLTAGE ADJUSTED TO GIVE MAXIMUM ANODE CURRENT.

THE PHOTOCATHODE IS FULLY ILLUMINATED.



POSITIVE VALUES OF MAGNETIC FIELD INTENSITY (H) ARE FOR LINES OF FLUX IN INDICATED DIRECTION



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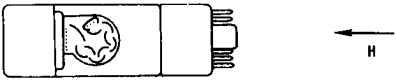
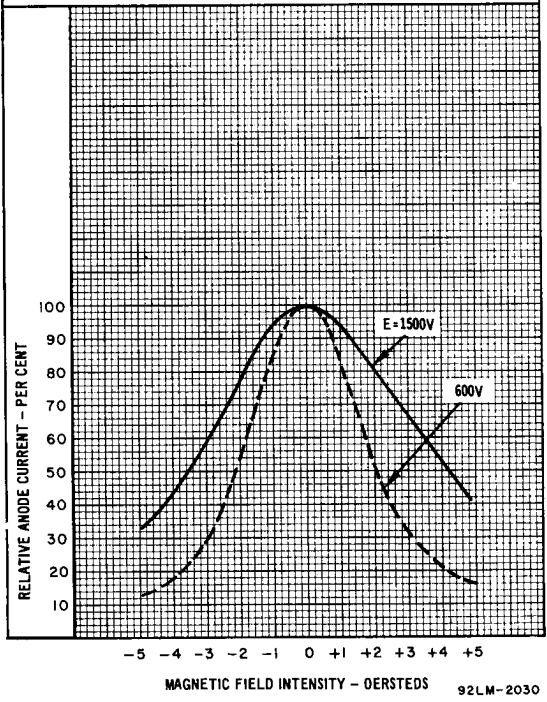
TYPICAL EFFECT OF INDICATED MAGNETIC FIELD ON ANODE CURRENT

SUPPLY VOLTAGE (E) ACROSS VOLTAGE DIVIDER PROVIDING 1/6 OF E BETWEEN CATHODE AND DYNODE No.1; 1/12 OF E FOR EACH SUCCEEDING DYNODE STAGE: AND 1/12 OF E BETWEEN DYNODE No.10 AND ANODE.
FOCUSING-ELECTRODE VOLTAGE ADJUSTED TO GIVE MAXIMUM ANODE CURRENT.

THE PHOTOCATHODE IS FULLY ILLUMINATED.



POSITIVE VALUES OF MAGNETIC FIELD INTENSITY (H) ARE FOR LINES OF FLUX IN INDICATED DIRECTION



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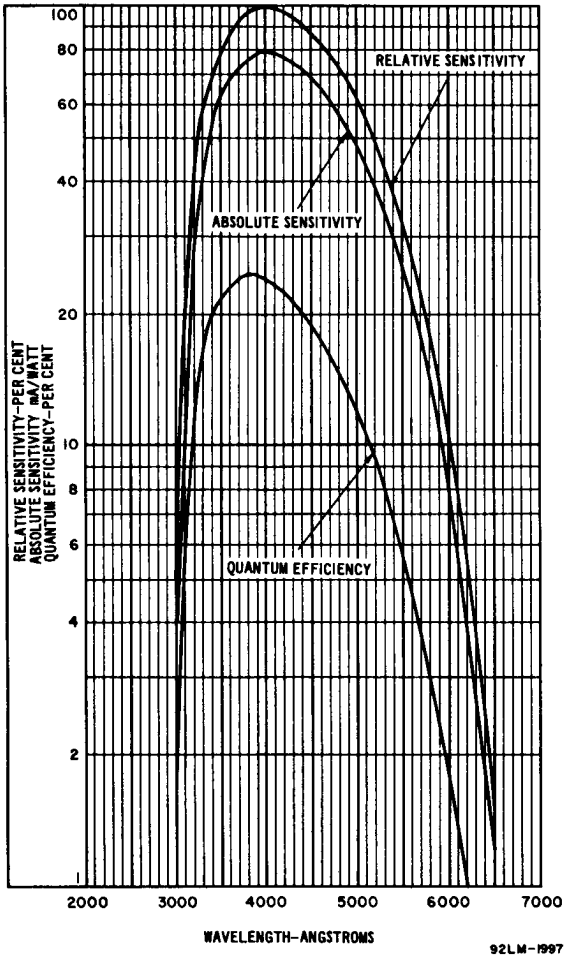
SPECTRAL RESPONSE CHARACTERISTICS



TYPICAL TIME-RESOLUTION CHARACTERISTICS