

Photomultiplier Tube

2"- Diameter, 14-Stage, Head-On Type

Havina S-11 Spectral Response

GENERAL

Spectral Response	S-11
Wavelength of Maximum Response	$4400 \pm 500 \text{ \AA}$
Cathode, Semitransparent	Cesium-Antimony
Minimum projected area	$2.2 \text{ in}^2 (14.2 \text{ cm}^2)$
Minimum diameter	1.68 in (4.2 cm)
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	In-Line, Electrostatic-Focus Type

Direct Interelectrode Capacitances (Approx.):

Anode to dynode No.14	2.8 pF
Anode to all other electrodes	6 pF
Dynode No.14 to all other electrodes	7.5 pF

Maximum Overall Length	7.5 in (19 cm)
Seated Length	6.69 in (17 cm) ± 0.19 in
Maximum Diameter	2.38 in (6 cm)
Bulb	T16
Base	Small-Shell Bidecal 20-Pin, JEDEC No.B20-102
Socket	Alden ^b Part 220FTC, or equivalent
Magnetic Shield	Millen ^c No.80802E, or equivalent
Operating Position	Any
Weight (Approx.)	8 oz (226 g)

MAXIMUM RATINGS, Absolute-Maximum Values:

DC Supply Voltage:

Between anode and cathode	2400 max.	V
Between anode and dynode No.14	400 max.	V
Between consecutive dynodes	500 max.	V
Between accelerating electrode and grid No.13	± 500 max.	V

Between dynode No.1 and cathode	400 max.	V
Between focusing electrode and cathode	400 max.	V
Average Anode Current ^e	2 max.	mA
Ambient Temperature ^f	75 max.	°C

→ CHARACTERISTICS RANGE VALUES

Voltage Distribution A, Table 1

With E = 2000 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant ^g at 4400 angstroms	—	3×10^6	—	A/W
Luminous ^h (2870° K).	4.8×10^2	3.8×10^3	2×10^4	A/lm.
Cathode Sensitivity:				
Radiant ⁱ at 4400 angstroms	—	0.056	—	A/W
Luminous ^k (2870° K).	5×10^{-5}	7×10^{-5}	—	A/lm
Current with blue light source ^m (2870° K + C.S. No.5-58)	5×10^{-8}	7×10^{-8}	—	A
Quantum Effici- ency at 4200 angstroms	—	16	—	%
Current Amplifi- cation.	—	5.4×10^7	—	
Anode Dark Current ⁿ	—	1×10^{-6}	3×10^{-6}	/
Equivalent Anode Dark Current Input ⁿ	{	5×10^{-10}	1.5×10^{-9}	lm
		6.2×10^{-13p}	1.8×10^{-12p}	W
Equivalent Noise Input ^q	{	3.3×10^{-12}	—	lm
		4.1×10^{-15r}	—	V
Anode-Pulse Rise Time ^s at 2400 V.	—	3.1×10^{-9}	—	s
Electron Transit Time ^t at 2400 V.	—	4.4×10^{-8}	—	s

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

^b Made by Alden Products Co., 262 N. Main Street, Brockton, MA 02403.

→ Indicates a change or addition.

- ^c Made by James Millen Manufacturing Company, 150 Exchange Street, Malden, MA 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 anode luminous sensitivity rating using a conversion factor of 803 lumens per watt.
- ^h 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 0.1 microlumen is used.
- ⁱ This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 803 lumens per watt.
- ^k 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 200 volts are applied between cathode and all other electrodes connected as anode.
- ^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, NY) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 0.01 lumen and 200 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 2000 amperes per lumen. Dark current caused by thermionic emission may be reduced by use of a refrigerant. Dark current is measured with incident light removed.
- ^p At 4400 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 803 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.

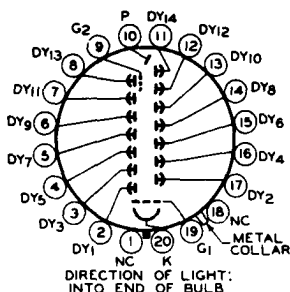
^r At 4400 angstroms. This value is calculated from the ENI value in lumens using a conversion factor of 803 lumens per watt.

^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.

^t 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.

TERMINAL DIAGRAM (Bottom View)

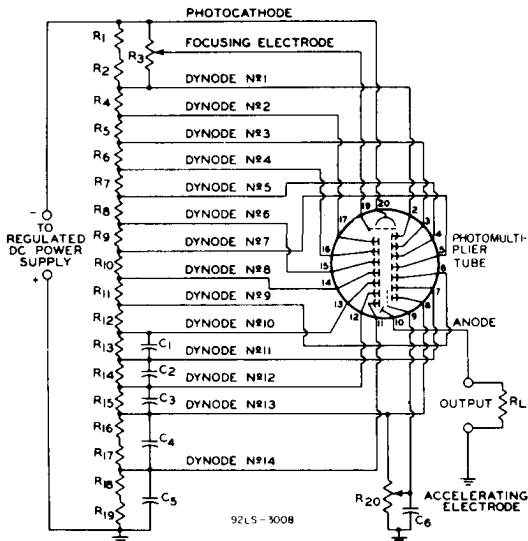
- Pin 1: No Connection
- Pin 2: Dynode No.1
- Pin 3: Dynode No.3
- Pin 4: Dynode No.5
- Pin 5: Dynode No.7
- Pin 6: Dynode No.9
- Pin 7: Dynode No.11
- Pin 8: Dynode No.13
- Pin 9: Grid No.2
(Accelerating Electrode)
- Pin 10: Anode
- Pin 11: Dynode No.14
- Pin 12: Dynode No.12
- Pin 13: Dynode No.10
- Pin 14: Dynode No.8
- Pin 15: Dynode No.6
- Pin 16: Dynode No.4
- Pin 17: Dynode No.2
- Pin 18: No Connection
- Pin 19: Grid No.1 (Focusing Electrode)
- Pin 20: Photocathode
- Metal Collar: No Connection



20 D

Note — If used, connect only to photocathode.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



C₁: 25 pF, 20%, 600 volts (dc working), ceramic disc

C₂: 50 pF, 20%, 600 volts (dc working), ceramic disc

C₃: 100 pF, 20%, 600 volts (dc working), ceramic disc

C₄: 250 pF, 20%, 600 volts (dc working), ceramic disc

C₅: 500 pF, 20%, 600 volts (dc working), ceramic disc

C₆: 100 pF, 20%, 1000 volts (dc working), ceramic disc

R₁: 24000 ohms, 5%, 1 watt

R₂: 22000 ohms, 5%, 1 watt

R₃: 1 megohm, 20%, 2 watts, adjustable

R₄ through R₁₃: 22000 ohms, 5%, 1 watt

R₁₄: 27000 ohms, 5%, 2 watts | R₁₇: 18000 ohms, 5%, 2 watts

R₁₅: 33000 ohms, 5%, 2 watts | R₁₈: 22000 ohms, 5%, 2 watts

R₁₆: 22000 ohms, 5%, 2 watts | R₁₉: 22000 ohms, 5%, 2 watts

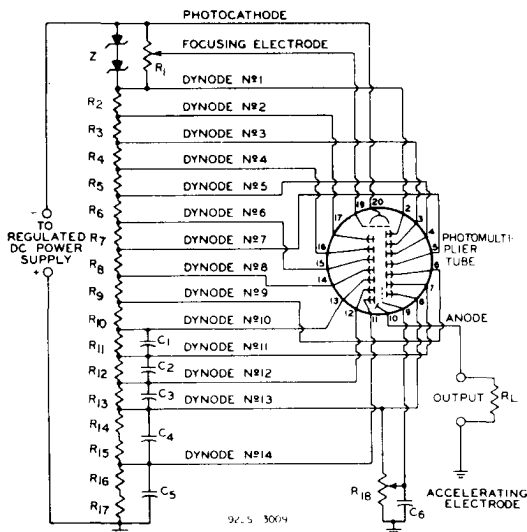
R₂₀: 10 megohms, 2 watts, adjustable

R_L: Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 300 ohms.

Note 1: Adjustable between approximately 800 and 2400 volts dc.

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

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR CONSTANT VOLTAGE BETWEEN CATHODE AND DYNODE NO. 1



C₁: 25 pF, 20%, 600 volts (dc working), ceramic disc

C₂: 50 pF, 20%, 600 volts (dc working), ceramic disc

C₃: 100 pF, 20%, 600 volts (dc working), ceramic disc

C₄: 250 pF, 20%, 600 volts (dc working), ceramic disc

C₅: 500 pF, 20%, 600 volts (dc working), ceramic disc

C₆: 100 pF, 20%, 1000 volts (dc working), ceramic disc

R₁: 5 megohms, 20%, 1/2 watt, adjustable

R₂ through R₁₁: 22000 ohms, 5%, 1 watt

R₁₂: 27000 ohms, 5%, 2 watts | R₁₅: 18000 ohms, 5%, 2 watts

R₁₃: 33000 ohms, 5%, 2 watts | R₁₆: 22000 ohms, 5%, 2 watts

R₁₄: 22000 ohms, 5%, 2 watts | R₁₇: 22000 ohms, 5%, 2 watts

R₁₈: 10 megohms, 2 watts, adjustable

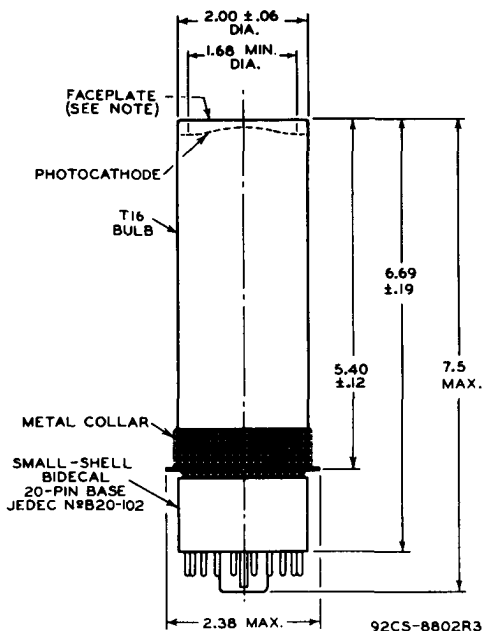
R_L: Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 300 ohms.

Z: (2) - 180 V, 2 W zener diodes, or equivalent

Note 1: Adjustable between approximately 800 and 2400 volts dc.

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

DIMENSIONAL OUTLINE



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

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

Dimensions are in inches unless otherwise stated.

INCH DIMENSION EQUIVALENTS IN MILLIMETERS

Inch	mm	Inch	mm	Inch	mm
0.06	1.5	1.68	42.6	5.40	137.1
0.12	3.0	2.00	50.8	6.69	169.9
0.19	4.8	2.38	60.4	7.5	190.5

Table 1

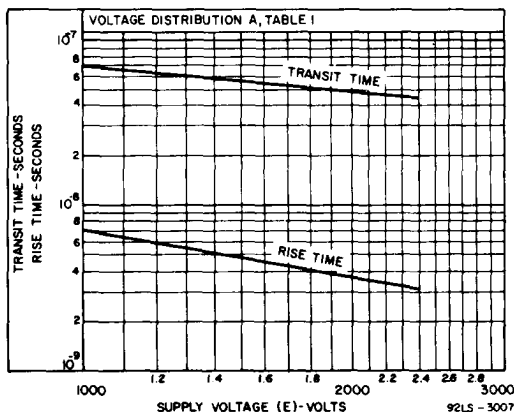
Voltage Distribution

Between the following Electrodes: Cathode (K), Dynode (Dy), and Anode (P)	A	B
	5.4% of Supply Voltage (E) multiplied by	6.06% of Supply Voltage (E) multiplied by
K - Dy1	2	2
Dy1 - Dy2	1	1
Dy2 - Dy3	1	1
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	1.25	1.25
Dy12 - Dy13	1.5	1.5
Dy13 - Dy14	1.75	1.75
Dy14 - P	2	2
Dy1 - P	—	16.5
K - P	18.5	—

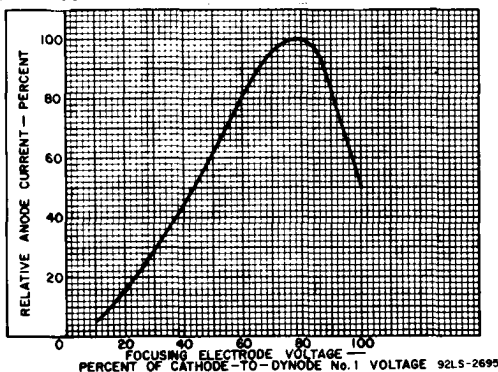
Focusing electrode is connected to arm of potentiometer between cathode and dynode No.1; the focusing electrode voltage is varied to give maximum anode current.

• Cathode-to-dynode No.1 voltage is maintained at 360 volts.

TYPICAL TIME-RESOLUTION CHARACTERISTICS

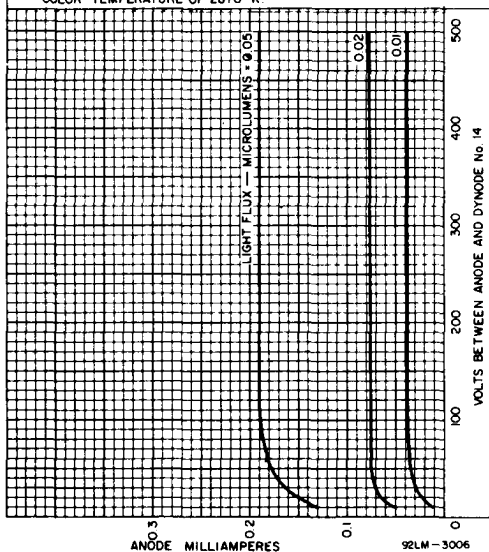


TYPICAL FOCUSING ELECTRODE CHARACTERISTIC



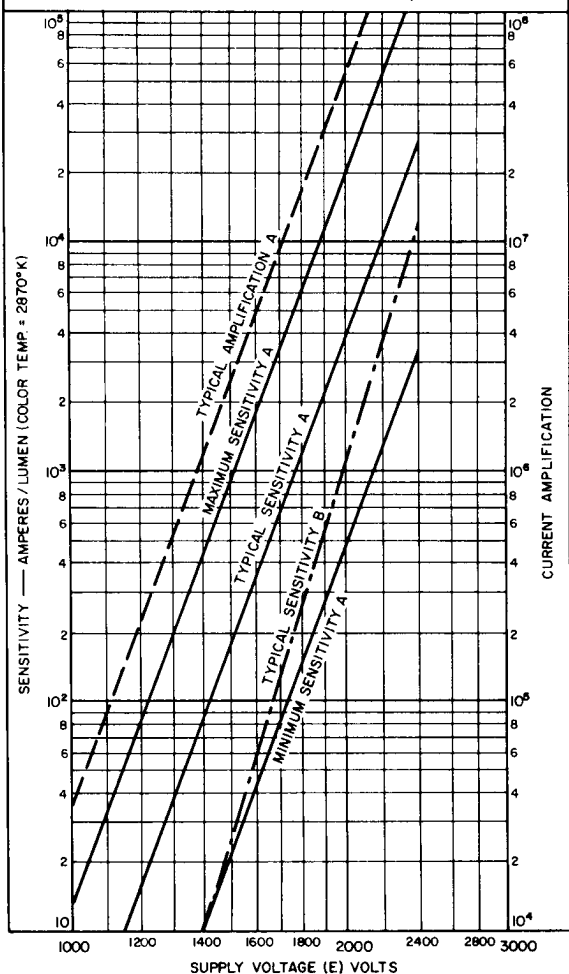
TYPICAL ANODE CHARACTERISTICS

CATHODE-TO-FOCUSING ELECTRODE VOLTS = 173
 CATHODE-TO-DYNODE No. 1 (DY1) VOLTS = 216
 DY1-TO-DY2 }
 DY2-TO-DY3 } VOLTS = 108
 ETC. TO }
 DY10-TO-DY11 }
 DY11-TO-DY12 VOLTS = 135
 DY12-TO-DY13 VOLTS = 160
 DY13-TO-DY14 VOLTS = 189
 GRID No. 2 VOLTS ADJUSTED TO
 GIVE MAX. ANODE CURRENT.
 LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A
 COLOR TEMPERATURE OF 2870° K.



SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

VOLTAGE DISTRIBUTION A OR B AS SHOWN ON CURVE, TABLE 1.



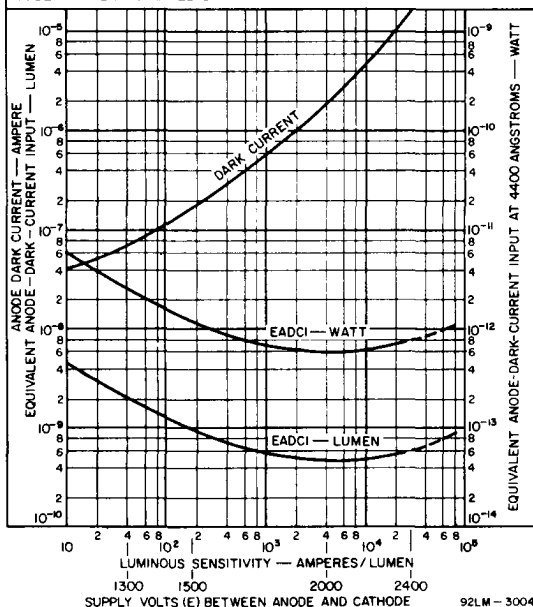
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TYPICAL EADCI AND ANODE DARK CURRENT CHARACTERISTICS

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

BETWEEN	54% OF E MULTIPLIED BY
CATHODE AND FOCUSING ELECTRODE	1.6
CATHODE AND DYNODE No.1 (DY1)	2
DY1 & DY2	1
DY2 & DY3	1
DY3 & DY4	1
DY4 & DY5	1
DY5 & DY6	1
DY6 & DY7	1
DY7 & DY8	1
DY8 & DY9	1
DY9 & DY10	1
DY10 & DY11	1
DY11 & DY12	1.25
DY12 & DY13	1.5
DY13 & DY14	1.75
DY14 & ANODE	2
ANODE & CATHODE	18.5

GRID - No. 2 VOLTS ADJUSTED TO GIVE MAXIMUM ANODE CURRENT.
 LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR
 TEMPERATURE OF 2870°K.
 TUBE TEMPERATURE = 22°C



TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

