

# Multiplier Phototube

12-STAGE, HEAD-ON      S-20 RESPONSE      ENCLOSED, IN-LINE  
 SPHERICAL-FACEPLATE TYPE      DYNODE STRUCTURE  
 HIGH CURRENT AMPLIFICATION      EXTREMELY SHORT RISE TIME

For Near-Infrared Ruby-Laser Detector Systems, Flying-Spot Scanning, Photometry, and Scintillation Counters Requiring Low-Dark Current and High Sensitivity over the Visible and Near-Infrared Regions of the Spectrum.

## General:

|                                                |                                                                   |
|------------------------------------------------|-------------------------------------------------------------------|
| Spectral Response. . . . .                     | S-20                                                              |
| Wavelength of Maximum Response . . . . .       | 4200 ± 500 angstroms                                              |
| Cathode, Semitransparent . . . . .             | K-Na-Cs-Sb (Multialkali)                                          |
| Shape. . . . .                                 | Spherical, Circular                                               |
| Minimum area . . . . .                         | 2.2 sq.in.                                                        |
| Minimum diameter . . . . .                     | 1.68 in.                                                          |
| Window . . . . .                               | Borosilicate Glass <sup>a</sup>                                   |
| Index of refraction. . . . .                   | 1.48                                                              |
| Dynode Material. . . . .                       | Copper-Beryllium                                                  |
| Direct Interelectrode Capacitances (Approx.):  |                                                                   |
| Anode to dynode No.12. . . . .                 | 3.8 pf                                                            |
| Anode to all other electrodes. . . . .         | 5.7 pf                                                            |
| Dynode No.12 to all other electrodes . . . . . | 6.8 pf                                                            |
| Maximum Overall Length . . . . .               | 6.31"                                                             |
| Seated Length. . . . .                         | 5.50" ± 0.19"                                                     |
| Maximum Diameter . . . . .                     | 2.06"                                                             |
| Operating Position . . . . .                   | Any                                                               |
| Weight (Approx.) . . . . .                     | 7 oz                                                              |
| Bulb . . . . .                                 | T16                                                               |
| Socket . . . . .                               | Cinch <sup>b</sup> No.20-PM, or equivalent                        |
| Magnetic Shield. . . . .                       | Perfection Mica Co. <sup>c</sup> , or equivalent                  |
| Base . . . . .                                 | Small-Shell Bidecal 20-Pin<br>(JEDEC No.B20-102), Non-hygroscopic |

Basing Designation for BOTTOM VIEW . . . . . 20E

Pin 1 - No Internal 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 - Anode

Pin 9 - Same as Pin 1

Pin 10 - Same as Pin 1

Pin 11 - Same as Pin 1

Pin 12 - Dynode No.12

Pin 13 - Dynode No.10

Pin 14 - Dynode No.8

Pin 15 - Dynode No.6

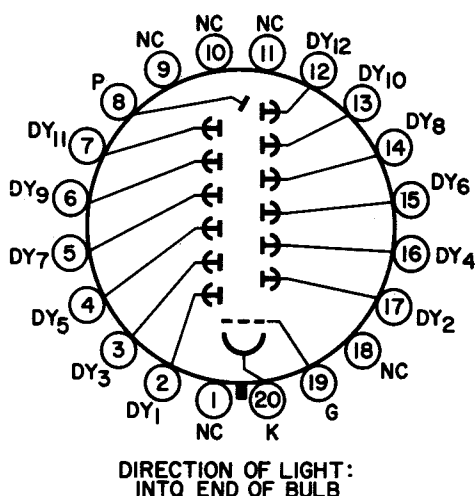
Pin 16 - Dynode No.4

Pin 17 - Dynode No.2

Pin 18 - Same as Pin 1

Pin 19 - (Focusing Electrode)

Pin 20 - Photocathode



## Maximum Ratings, Absolute-Maximum Values:

### DC Supply Voltage:

|                                                    |             |       |
|----------------------------------------------------|-------------|-------|
| Between anode and cathode. . . . .                 | 2800 max.   | volts |
| Between anode and dynode No.12 . . . . .           | 400 max.    | volts |
| Between consecutive dynodes. . . . .               | 400 max.    | volts |
| Between dynode No.1 and cathode. . . . .           | 600 max.    | volts |
| Between focusing electrode<br>and cathode. . . . . | 600 max.    | volts |
| Average Anode Current <sup>d</sup> . . . . .       | 1 max.      | ma    |
| Ambient-Temperature Range. . . . .                 | -200 to +85 | °C    |

## Characteristics Range Values:

Under conditions with dc supply voltage (E) across a voltage divider providing electrode voltages shown in Table I. Focusing electrode is connected to arm of a potentiometer between cathode and dynode No.1 and its voltage is adjusted to that value which provides maximum anode current.

With E = 2300 volts (Except as noted)

|                                                                                                                      | Min.                 | Typ.                 | Max.                 |      |
|----------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|------|
| Sensitivity:                                                                                                         |                      |                      |                      |      |
| Radiant, at 4200<br>angstroms . . . . .                                                                              | -                    | $4.3 \times 10^5$    | -                    | a/w  |
| Cathode radiant,<br>at 4200<br>angstroms . . . . .                                                                   | -                    | 0.064                | -                    | a/w  |
| Luminous,<br>at 0 cps <sup>e</sup> . . . . .                                                                         | 250                  | 1000                 | 12000                | a/lm |
| Cathode luminous:                                                                                                    |                      |                      |                      |      |
| With tungsten<br>light source <sup>f</sup> . . . . .                                                                 | $1.1 \times 10^{-4}$ | $1.5 \times 10^{-4}$ | -                    | a/lm |
| With blue light<br>source <sup>g, h</sup> . . . . .                                                                  | $5.5 \times 10^{-8}$ | -                    | -                    | a    |
| With red light<br>source <sup>j, k</sup> . . . . .                                                                   | $3 \times 10^{-7}$   | $5 \times 10^{-7}$   | -                    | a    |
| Current Amplifi-<br>cation. . . . .                                                                                  | -                    | $6.6 \times 10^6$    | -                    |      |
| Equivalent Anode-<br>Dark-Current<br>Input at a<br>luminous sensi-<br>tivity of<br>300 a/lm <sup>m</sup> . . . . .   | -                    | $1 \times 10^{-10}$  | $1.3 \times 10^{-9}$ | lm   |
| Anode-Pulse Rise<br>Time <sup>n</sup> . . . . .                                                                      | -                    | $2 \times 10^{-9}$   | -                    | sec  |
| Greatest Delay<br>Between Anode<br>Pulses:                                                                           |                      |                      |                      |      |
| Due to position<br>from which elec-<br>trons are simul-<br>taneously released<br>within a circle<br>centered on tube |                      |                      |                      |      |

|                                                                                                  | Min.                 | Typ.                          | Max.                  |      |
|--------------------------------------------------------------------------------------------------|----------------------|-------------------------------|-----------------------|------|
| face having a diameter of—                                                                       |                      |                               |                       |      |
| 1.4" . . . . .                                                                                   | —                    | $3 \times 10^{-10} \text{ p}$ | —                     | sec  |
| 1.6" . . . . .                                                                                   | —                    | $5 \times 10^{-10} \text{ p}$ | —                     | sec  |
| <i>With E = 1800 volts (Except as noted)</i>                                                     |                      |                               |                       |      |
|                                                                                                  | Min.                 | Typ.                          | Max.                  |      |
| Sensitivity:                                                                                     |                      |                               |                       |      |
| Radiant, at 4200 angstroms . . . .                                                               | —                    | $4.3 \times 10^4$             | —                     | a/w  |
| Cathode radiant, at 4200 angstroms. .                                                            | —                    | 0.064                         | —                     | a/w  |
| Luminous, at 0 cps <sup>e</sup> .                                                                | —                    | 100                           | —                     | a/lm |
| Cathode luminous:                                                                                |                      |                               |                       |      |
| With tungsten light source <sup>f</sup> .                                                        | $1.1 \times 10^{-4}$ | $1.5 \times 10^{-4}$          | —                     | a/lm |
| With blue light source <sup>g, h</sup> . . .                                                     | $5.5 \times 10^{-8}$ | —                             | —                     | a    |
| With red light source <sup>j, k</sup> . . .                                                      | $3 \times 10^{-7}$   | $5 \times 10^{-7}$            | —                     | a    |
| Current Amplification                                                                            | —                    | $6.6 \times 10^5$             | —                     |      |
| Equivalent Anode-Dark-Current Input at a luminous sensitivity of 300 a/lm <sup>m</sup> . . . . . | —                    | $1 \times 10^{-10}$           | $1.3 \times 10^{-9}$  | lm   |
| Equivalent Noise Input <sup>q</sup> . . . . .                                                    | —                    | $1.1 \times 10^{-12}$         | $2.4 \times 10^{-12}$ | lm   |

<sup>a</sup> Corning No. 7056, made by Corning Glass Works, Corning, New York, or equivalent.

<sup>b</sup> Made by Cinch Manufacturing Company, 1026 South Homan Avenue, Chicago 24, Illinois.

<sup>c</sup> Magnetic shielding material in the form of foil or tape as available from the Magnetic Shield Division, Perfection Mica Company, 1829 Civic Opera Bldg., 20 North Wacker Drive, Chicago 6, Illinois, or equivalent.

<sup>d</sup> Averaged over any interval of 30 seconds maximum.

<sup>e</sup> 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.

<sup>f</sup> 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.

<sup>g</sup> 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 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected as anode.

<sup>h</sup> See *Spectral Characteristic of 2870° K Light Source and Spectral Characteristic of Light from 2870° K Source after passing through Indicated Blue Filter* at front of this Section.

<sup>j</sup> Under the following conditions: Light incident on the cathode is transmitted through a red filter (Corning C.S. No. 2-62—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 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected as anode.



- k See *Spectral Characteristic of 2870° K Light Source and Spectral Characteristic of Light from 2870° K Source after passing through Indicated Red Filter* at front of this Section.
- m At a tube temperature of 25° C. Dark current may be reduced by use of a refrigerant.
- n 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.
- p These values also represent the difference in time of transit between the photocathode and dynode No.1 for electrons simultaneously released from the center and from the periphery of the specified areas.
- q Under the following conditions: Supply voltage (E) is as shown, 25° C tube temperature, external shield connected to cathode, bandwidth 1 cycle per second, 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.

TABLE I

| VOLTAGE TO BE PROVIDED BY DIVIDER |                                           |
|-----------------------------------|-------------------------------------------|
| Between                           | 6.95% of Supply Voltage (E) multiplied by |
| Cathode and Dynode No.1           | 2                                         |
| Dynode No.1 and Dynode No.2       | 1.4                                       |
| Dynode No.2 and Dynode No.3       | 1                                         |
| Dynode No.3 and Dynode No.4       | 1                                         |
| Dynode No.4 and Dynode No.5       | 1                                         |
| Dynode No.5 and Dynode No.6       | 1                                         |
| Dynode No.6 and Dynode No.7       | 1                                         |
| Dynode No.7 and Dynode No.8       | 1                                         |
| Dynode No.8 and Dynode No.9       | 1                                         |
| Dynode No.9 and Dynode No.10      | 1                                         |
| Dynode No.10 and Dynode No.11     | 1                                         |
| Dynode No.11 and Dynode No.12     | 1                                         |
| Dynode No.12 and Anode            | 1                                         |
| Anode and Cathode                 | 14.4                                      |

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.

OPERATING CONSIDERATIONS

The *operating stability* of the 4459 is dependent on the magnitude of the anode current and its duration. When the 4459 is operated at high average values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends of the severity of the operating conditions. After a period of idleness, the 4459 usually recovers a substantial percentage of such loss in sensitivity.

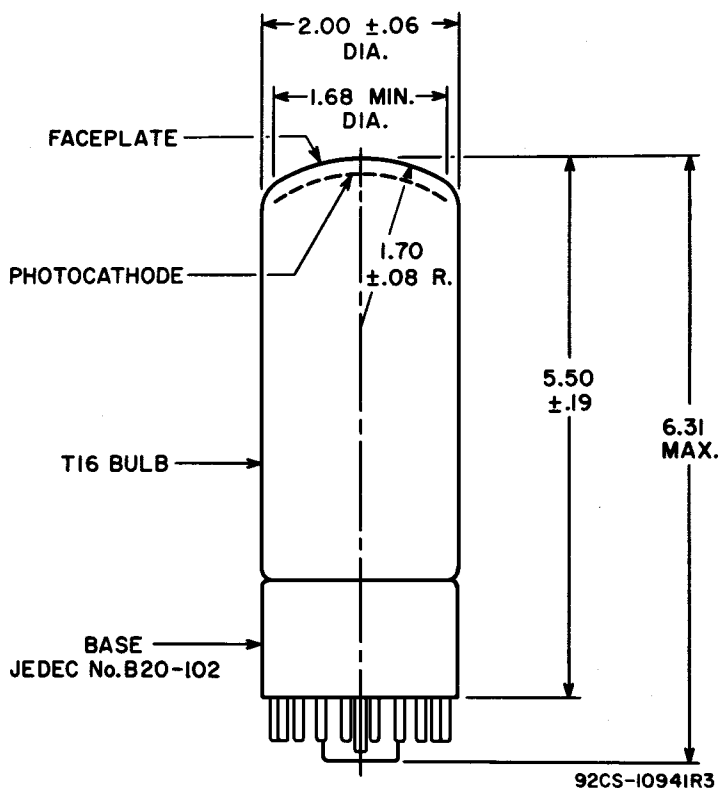
It is recommended that the average anode current be well below the maximum-rated value of 1 milliampere when stability of operation is important. When maximum stability is required, the average anode current should not exceed 10 microamperes.

*Electrostatic and/or magnetic shielding* of the 4459 may be necessary.

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 4459.

The *high voltages at which the 4459 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.

**SPECTRAL-SENSITIVITY CHARACTERISTIC  
OF PHOTSENSITIVE DEVICE HAVING S-20 RESPONSE**  
is shown at the front of this Section



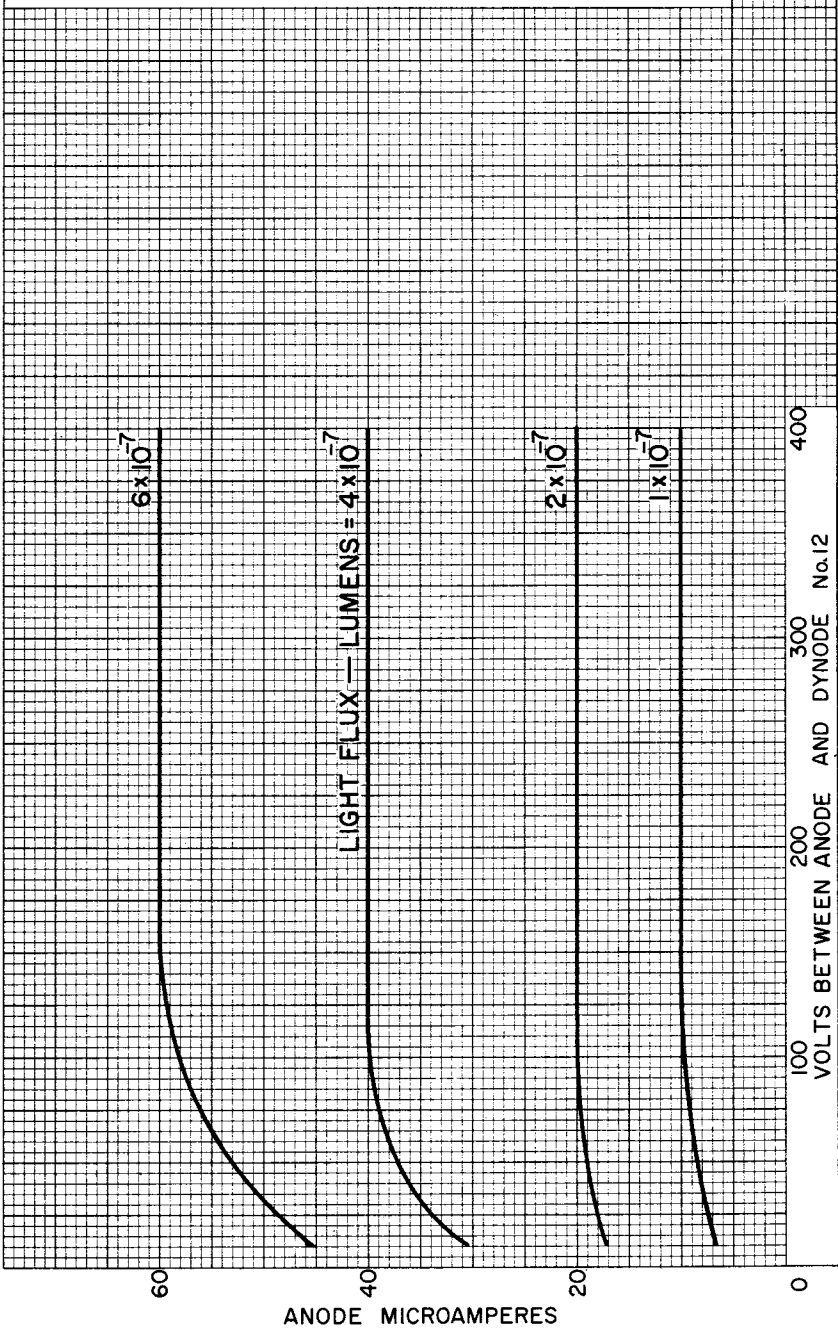
**DIMENSIONS IN INCHES**

Center line of bulb will not deviate more than  $2^{\circ}$  in any direction from the perpendicular erected at the center of bottom of the base.



## TYPICAL ANODE CHARACTERISTICS

DYNODE — No.1 — TO — CATHODE VOLTS = 250  
 DYNODE — No.1 — TO — DYNODE — No.2 VOLTS = 175  
 EACH SUCCEEDING — DYNODE — STAGE VOLTS = 125  
 FOCUSING — ELECTRODE VOLTAGE ADJUSTED TO THAT  
 VALUE BETWEEN CATHODE AND DYNODE No.1 THAT  
 PROVIDES MAXIMUM ANODE CURRENT.  
 LIGHT SOURCE IS A TUNGSTEN — FILAMENT LAMP OPERATED  
 AT A COLOR TEMPERATURE OF 2870° K.



92CM-12212

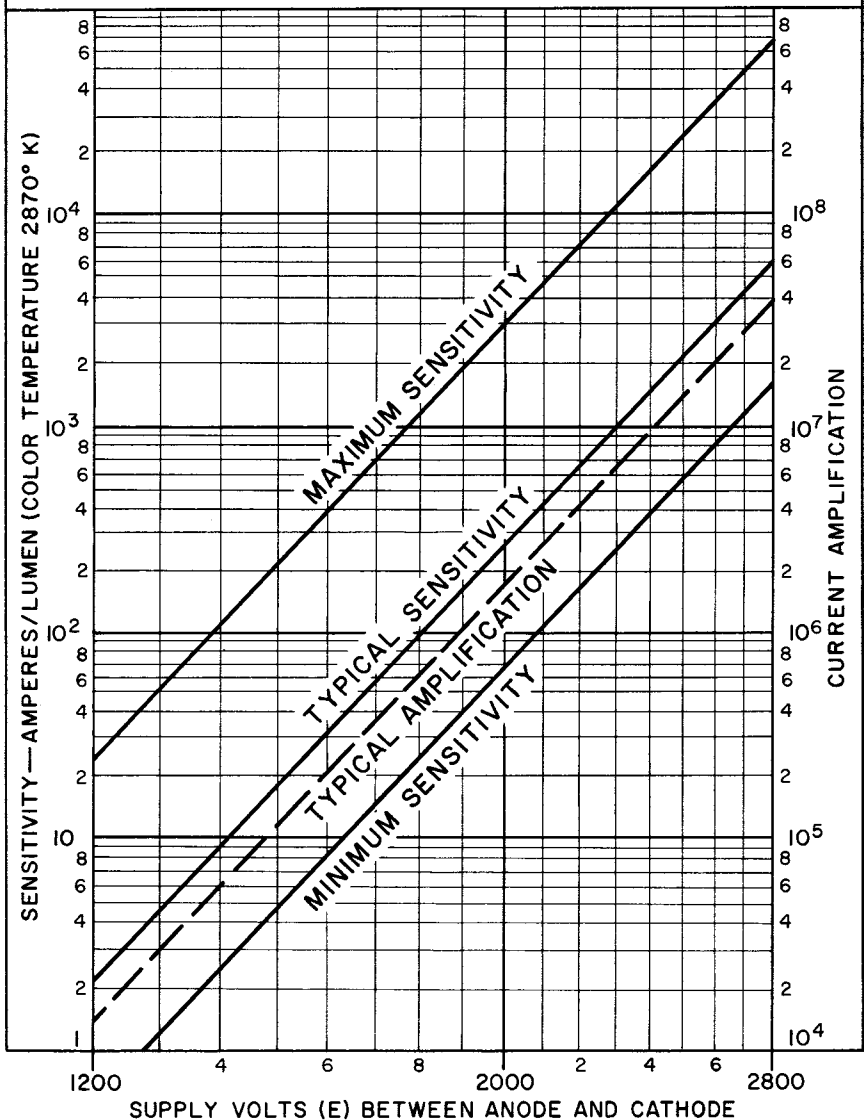


## SENSITIVITY AND AMPLIFICATION CHARACTERISTICS

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

| BETWEEN                             | 6.95 % OF E<br>MULTIPLIED BY |
|-------------------------------------|------------------------------|
| CATHODE & DY <sub>1</sub>           | 2.0                          |
| DY <sub>1</sub> & DY <sub>2</sub>   | 1.4                          |
| DY <sub>2</sub> & DY <sub>3</sub>   | 1.0                          |
| THROUGH<br>DY <sub>12</sub> & ANODE |                              |
| ANODE & CATHODE                     | 14.4                         |

FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO  
THAT VALUE BETWEEN CATHODE AND DYNODE  
No. 1 THAT PROVIDES MAXIMUM ANODE CURRENT.



92CM-12213

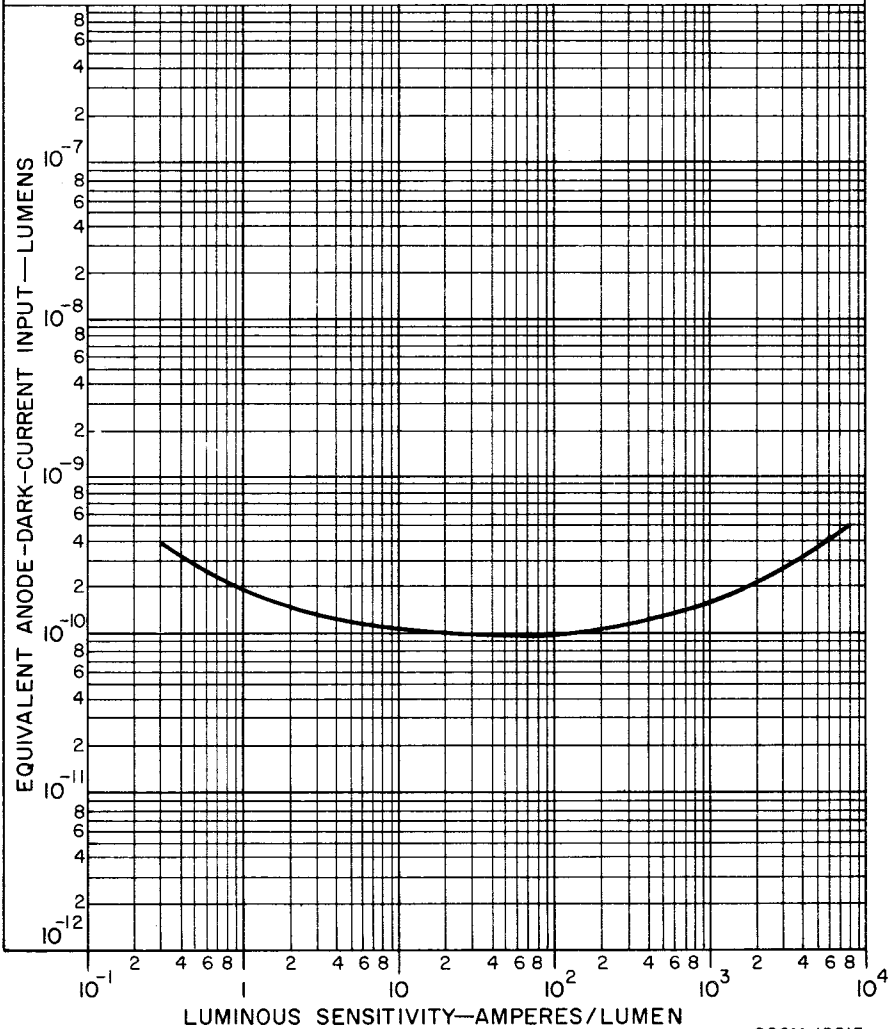


TYPICAL ANODE-DARK-CURRENT CHARACTERISTIC

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

| BETWEEN                             | 6.95% OF E<br>MULTIPLIED BY |
|-------------------------------------|-----------------------------|
| CATHODE & DY <sub>1</sub>           | 2.0                         |
| DY <sub>1</sub> & DY <sub>2</sub>   | 1.4                         |
| DY <sub>2</sub> & DY <sub>3</sub>   | 1.0                         |
| THROUGH<br>DY <sub>12</sub> & ANODE |                             |
| ANODE & CATHODE                     |                             |
|                                     | 14.4                        |

FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN CATHODE AND DYNODE No.1 THAT PROVIDES MAXIMUM ANODE CURRENT. LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870° K. TUBE TEMPERATURE=25° C

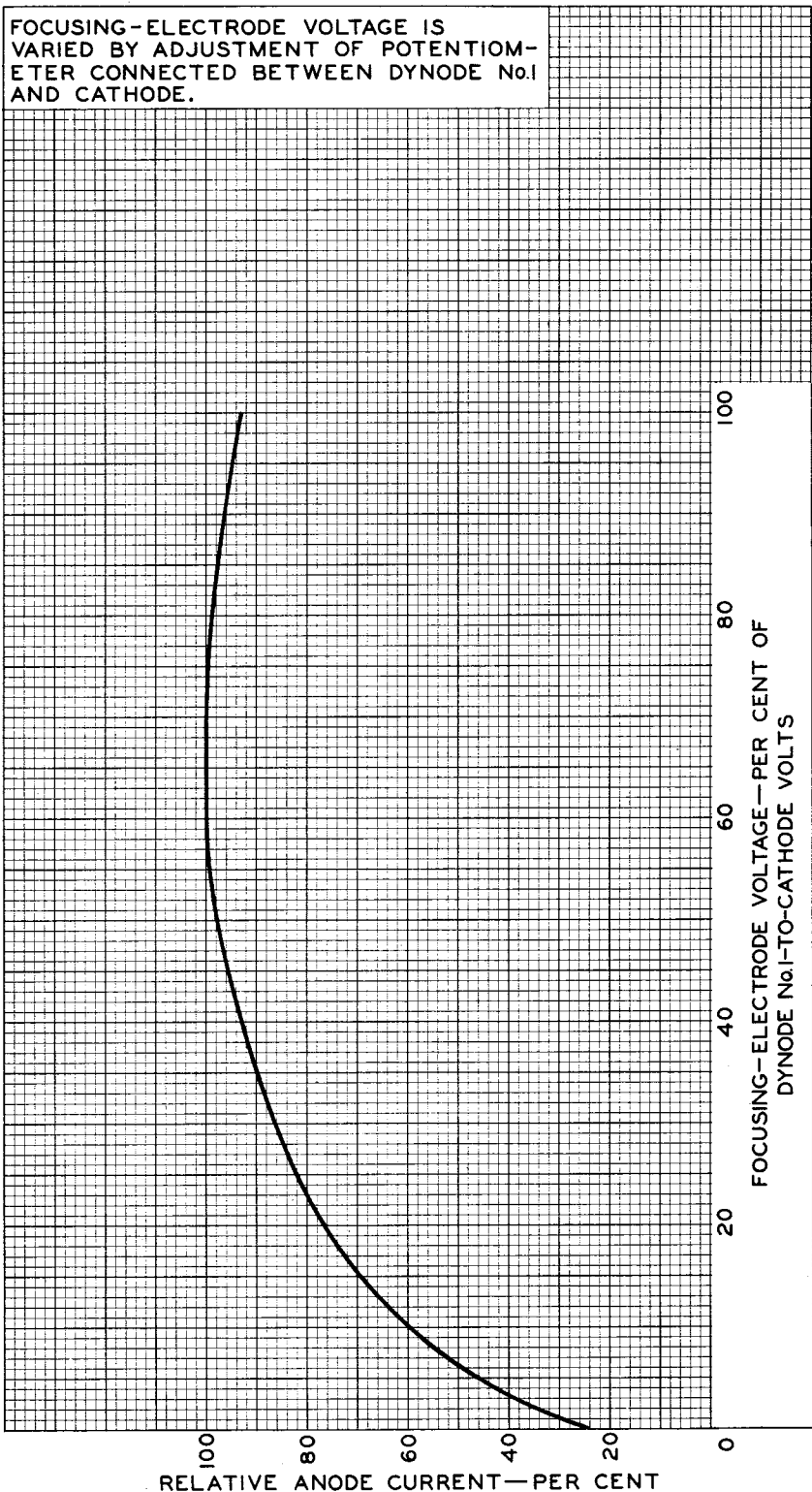


92CM-12215



# AVERAGE FOCUSING-ELECTRODE-VOLTAGE CHARACTERISTIC

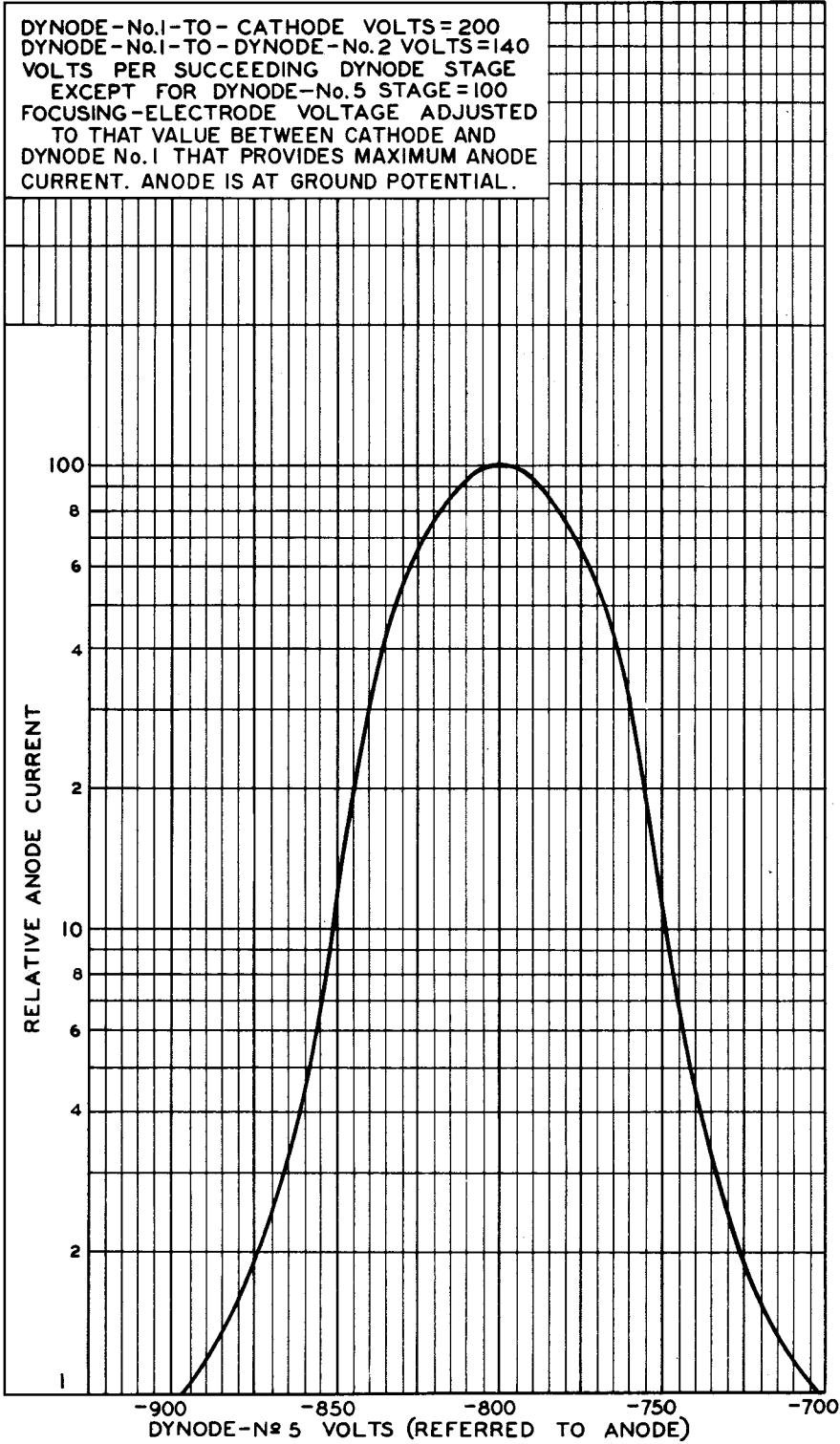
FOCUSING-ELECTRODE VOLTAGE IS VARIED BY ADJUSTMENT OF POTENTIOMETER CONNECTED BETWEEN DYNODE No.1 AND CATHODE.



92CM-10590



TYPICAL ANODE-CURRENT CHARACTERISTIC



92CM-10959R1

