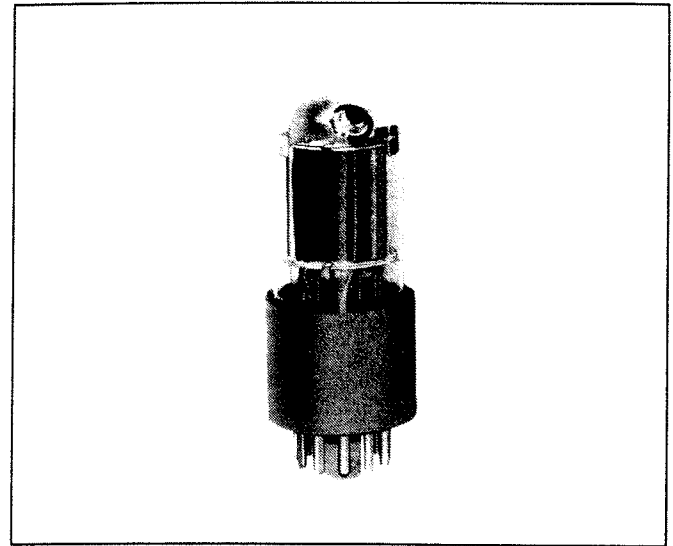


# 931A, 931B

## Photomultiplier

28-mm (1-1/8 inch) Diameter 9-Stage, Side Window PMTs

- Anti-Hysteresis Design
- Narrow Range of Anode Sensitivities  
 931A: 30 A/lm - 600 A/lm  
 931B: 100 A/lm - 1000 A/lm
- Low Dark Current



BURLE 931A is a 9-stage, side-window type of photomultiplier tube intended for general purpose applications in low-light level detection and measurement systems. It features a circular-cage with electrostatically focussed dynodes and fast time resolution characteristics.

BURLE 931B is a 9-stage, side-window type of photomultiplier tube intended for general purpose applications in low light level detection and measurement systems. It features a circular-cage with electrostatically focussed dynodes, and fast time resolution characteristics. Typically, the 931B offers higher photocathode quantum efficiency, higher anode sensitivity, and lower dark current than the 931A. The 931B also features an anode current drift rating which limits variations in anode current to a maximum of  $\pm 2\%$ .

### GENERAL DATA

Photocathode Spectral Response.....	See Figure 1
Wavelength of maximum response.....	380 nm
Window Material <sup>1</sup> .....	Corning No. 0080, or Equivalent
Index of refraction @ 436 nanometers.....	1.523
Projected Cathode Minimum Dimensions: <sup>2</sup>	
Length.....	23.9 mm (0.94 in)
Width.....	7.9 mm (0.31 in)
Dynodes:	
Secondary-Emitting Surface.....	Cs-Sb
Structure.....	Circular-Cage, Electrostatic-Focus
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode no. 9.....	4.4 pF
Anode to all other electrodes.....	6.0 pF
Anode Pulse Rise Time, 1000 V <sup>3</sup> .....	1.8 ns
Electron Transit Time, 1000 V <sup>4</sup> .....	18.0 ns
Base.....	JEDEC B11-88, Non-Hygroscopic
Socket.....	BURLE AJ2256
Magnetic Shield.....	BURLE AJ2240
Operating Position.....	Any
Weight (Approx.).....	45 g (1.6 oz.)

### ABSOLUTE MAXIMUM RATINGS

DC Supply Voltage:	
Between anode and cathode.....	1250 V
Between anode and dynode no. 9.....	250 V
Between adjacent dynodes.....	250 V
Between dynode no. 1 and cathode.....	250 V
Average Anode Current <sup>5</sup> .....	1.0 mA
Temperature: <sup>6</sup>	
Operating and storage.....	-80 to +70 °C

### PERFORMANCE DATA

Under conditions with dc supply voltage (E) across a voltage divider providing 1/10 of E between cathode and dynode no. 1; 1/10 of E for each succeeding dynode stage; and 1/10 of E between dynode no. 9 and anode. Ambient temperature is 22 °C.

With E = 1000 volts (except as noted). See Table 1.

#### 931A PHOTOMULTIPLIER

	Min.	Typ.	Max.	
Anode Responsivity:				
Radiant @ 380 nm.....	--	2.1x10 <sup>5</sup>	--	A/W
Luminous <sup>7</sup> .....	30	300	600	A/lm
Cathode Responsivity:				
Radiant @ 380 nm.....	--	38	--	mA/W
Luminous <sup>8</sup> .....	25	55	--	$\mu$ A/lm
Current Amplification (Gain) ..	--	5.5x10 <sup>6</sup>	--	
Anode Dark Current <sup>9</sup> .....	--	6	150	nA

#### 931B PHOTOMULTIPLIER

	Min.	Typ.	Max.	
Anode Responsivity:				
Radiant @ 380 nm.....	--	3.4x10 <sup>5</sup>	--	A/W
Luminous <sup>7</sup> .....	100	360	1000	A/lm
Cathode Responsivity:				
Radiant @ 380 nm.....	--	56	--	mA/W
Luminous <sup>8</sup> .....	40	60	--	$\mu$ A/lm
Current Amplification (Gain) ..	--	6x10 <sup>6</sup>	--	
Anode Dark Current <sup>9</sup> .....	--	2	40	nA
Anode Current Drift <sup>10</sup> .....	--	1	2	%

## NOTES

- Made by Corning Glass Works, Corning, NY 14830.
- On plane perpendicular to the indicated direction of incident light and passing through the major axis of the tube.
- Measured between 10 percent and 90 percent 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.
- 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.
- Averaged over any 30 seconds interval.
- Tube operation at room temperature or below is recommended.
- Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2856 degrees K and a light flux of  $1 \times 10^{-6}$  lumen is used.
- Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2856 degrees K and a light flux of  $1 \times 10^{-2}$  lumen is used. 100 volts are applied between cathode and all other electrodes connected as anode.
- At a tube temperature of 22 degrees C. The supply voltage is adjusted to 1000 volts. Dark current is measured with the light source removed.
- Anode current drift is measured under the following conditions: The tube is operated at a supply voltage of 1000 volts for 30 minutes with the incident light level adjusted initially to provide an anode current ( $lb$ ) of 3.0 microamperes. The change in anode current for the next 12 minutes is continuously recorder and must not vary by more than the value specified. Anode current drift is defined as follows:

$$\text{Anode Current Drift} = \frac{lb_1 \text{ (30 to 42 minutes)}}{lb \text{ (at 30 minutes)}}$$

where  $lb_1$  = the incremental change in anode current.

TABLE 1

Voltage Distribution	
Between the Following Electrodes: K = Cathode P = Anode Dy = Dynode	10.0% of K-P Voltage Multiplied By:
K - Dy 1	1
Dy 1 - Dy 2	1
Dy 2 - Dy 3	1
Dy 3 - Dy 4	1
Dy 4 - Dy 5	1
Dy 5 - Dy 6	1
Dy 6 - Dy 7	1
Dy 7 - Dy 8	1
Dy 8 - Dy 9	1
Dy 9 - P	1
K - P	10

## OPERATING CONSIDERATIONS

Unless otherwise stated the operating conditions discussed in the following paragraphs apply to both the 931A and the 931B.

## OPERATING STABILITY

The operating stability of the photomultipliers is dependent on the magnitude of the anode current. The use of an average anode current well below the maximum rated value of 1.0 milliampere is recommended when stability of operation is important. When maximum stability is required, operation at an average current of 1.0 microampere or less is suggested.

## AMBIENT ATMOSPHERE

Operation or storage of these tubes in environments where helium is present should be avoided. Helium may permeate the tube envelope and may lead to eventual tube destruction.

## TUBE ORIENTATION

The responsivity of the photocathode surface varies with respect to the position of the light spot on the surface. **Figure 4** shows the variation in responsivity of the surface as the position of a 1-mm diameter light spot is moved from one end of the photocathode to the other. Similarly, the curve in **Figure 5** shows how the responsivity of the photocathode surface varies across its projected width in the plane of the grill. From these curves the equipment designer can readily determine the optimum position of any light spot on the photocathode surface to give the highest responsivity.

When an application involves use of light flux which covers essentially the entire cathode area, consideration should be given to the effect on luminous responsivity caused by angular position of the photocathode with respect to the direction of incident light. This effect is shown in **Figure 6**. As the tube is rotated from the position of maximum responsivity (approximately +13 degrees as shown in **Figure 6**) the internal structure prevents portions of a large beam of light from striking the cathode. With a light spot covering only a small portion of the cathode area, relatively minor cutoff of light occurs making the directional effect on luminous responsivity very small.

## SHIELDING

Electrostatic and/or magnetic shielding of the photomultipliers may be necessary. An external electrostatic shield, in contact with the sides of the glass envelope and connected to a negative dc potential essentially the same as that of the photocathode, should be employed in those applications where it is desired to reduce the equivalent noise input of the tube to a minimum.

It is noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the high negative potential source. If the shield is not so connected, extreme care should be observed in providing adequate safeguards to prevent personnel from coming into contact with the high potential of the shield.

Magnetic shielding of the photomultiplier is necessary if it is operated in the presence of strong magnetic fields. With increase in supply voltage between anode and cathode, the effect of a given magnetic field will cause less decrease in anode current.

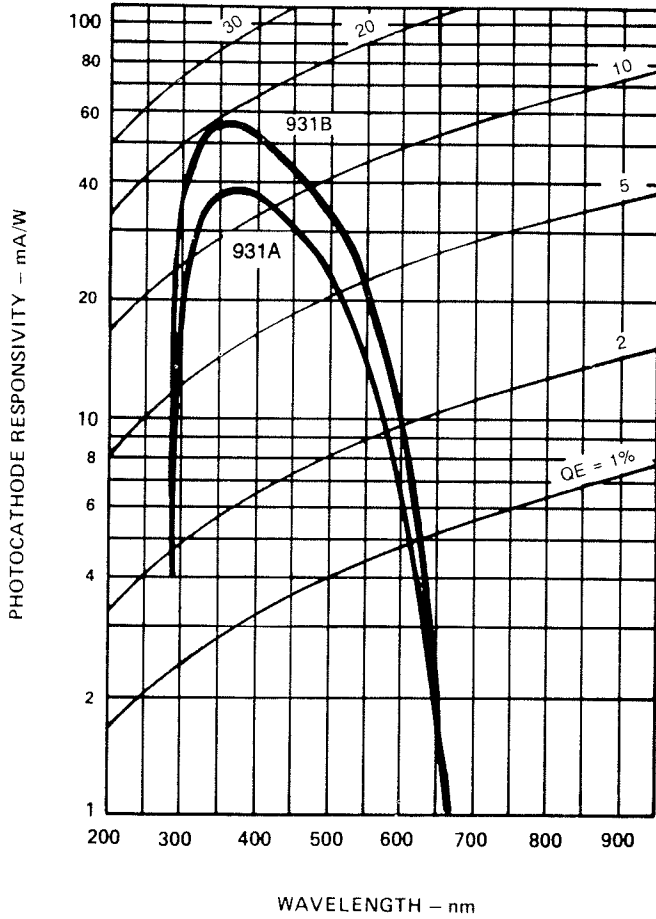
Adequate light shielding should be provided to prevent extraneous light from reaching any part of the tube.

**DARK CURRENT**

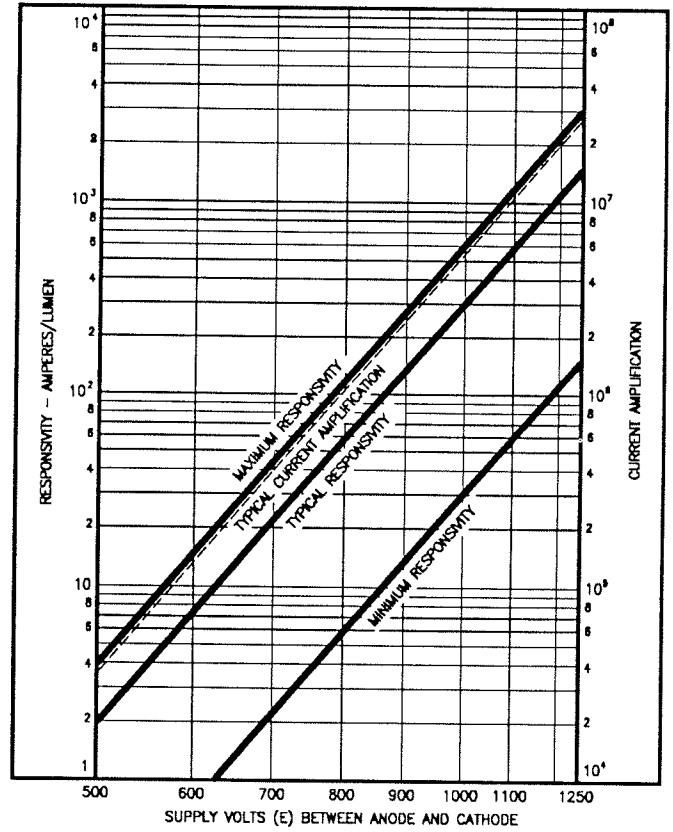
The use of a refrigerant, such as dry ice, to cool the tube is recommended in those applications where

maximum current amplification with minimum dark current is required.

Typical anode dark current and EADCI as a function of luminous responsivity at a temperature of +22 degrees C are shown in **Figures 7 and 8**.



**Figure 1 - Typical Photocathode Spectral Response Characteristics**



**Figure 2 - Typical Current Amplification and Responsivity Characteristics - Type 931A**

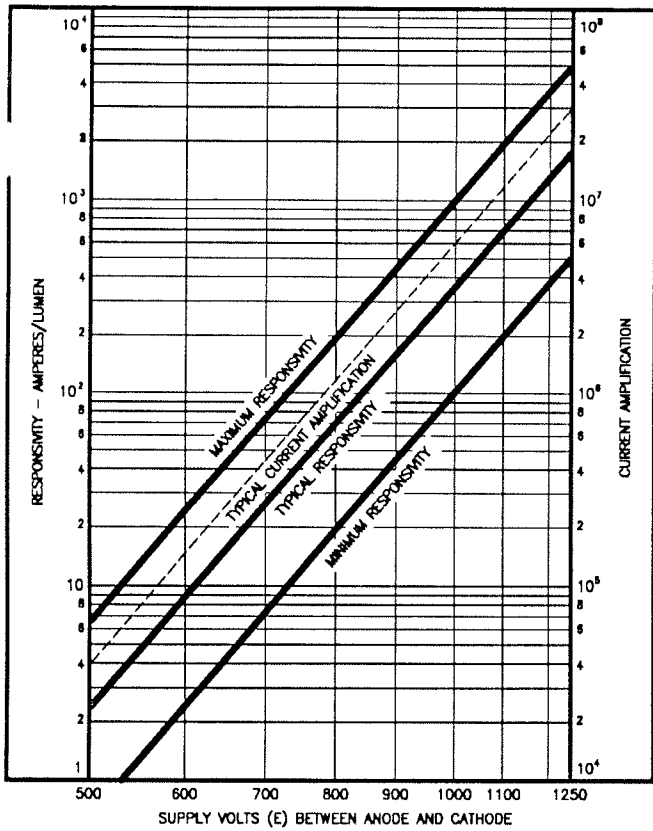


Figure 3 - Typical Current Amplification and Responsivity Characteristics - Type 931B

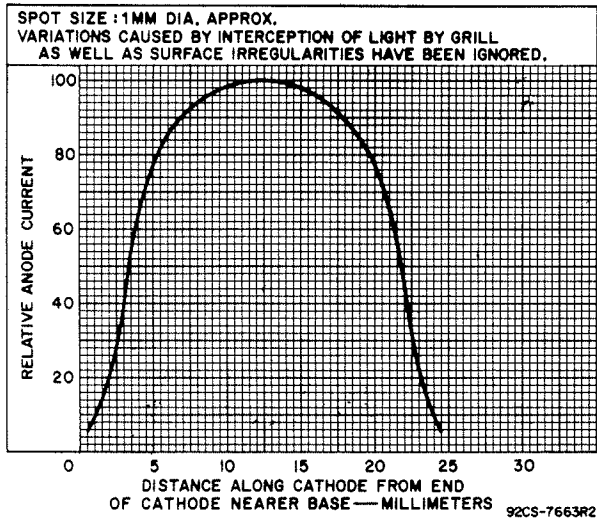


Figure 4 - Typical Variation of Photocathode Sensitivity Along Tube Length

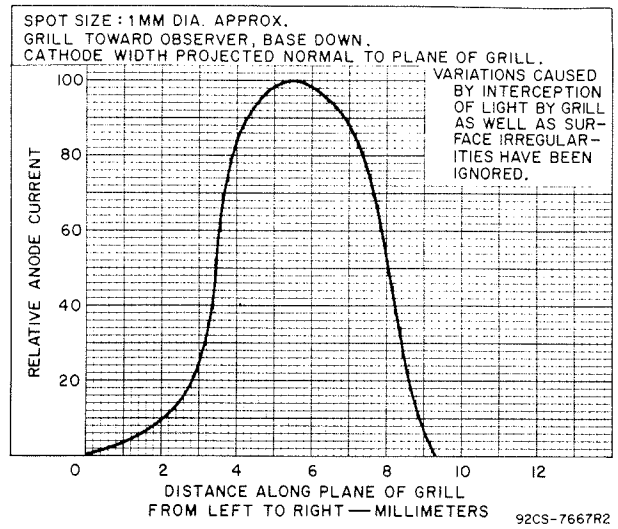


Figure 5 - Typical Variation of Photocathode Sensitivity Across Projected Width in Plane of Grill

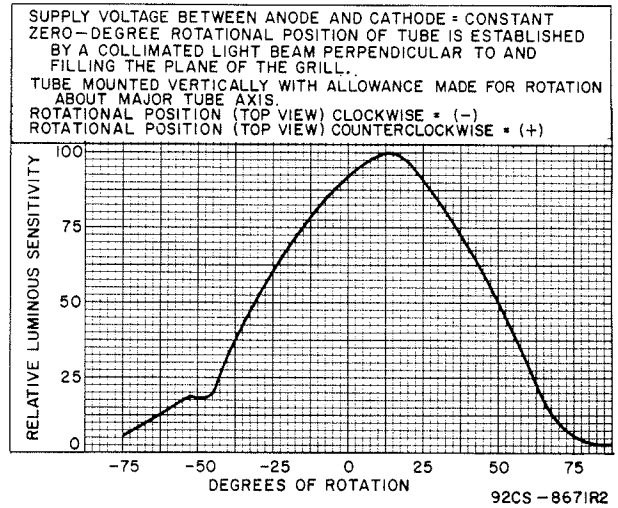


Figure 6 - Typical Variation of Responsivity as Tube is Rotated with Respect to Fixed Light Beam

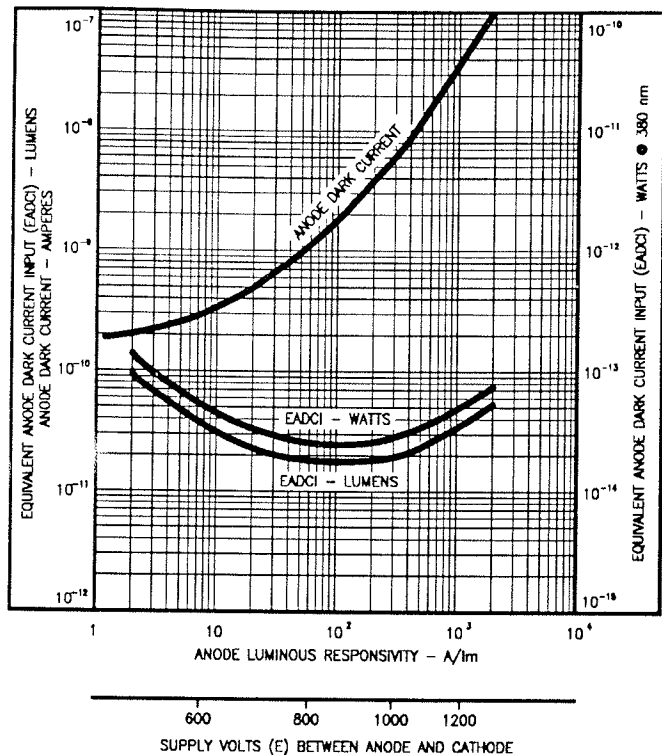


Figure 7 - Typical EADCI and Dark Current Characteristics - Type 931A

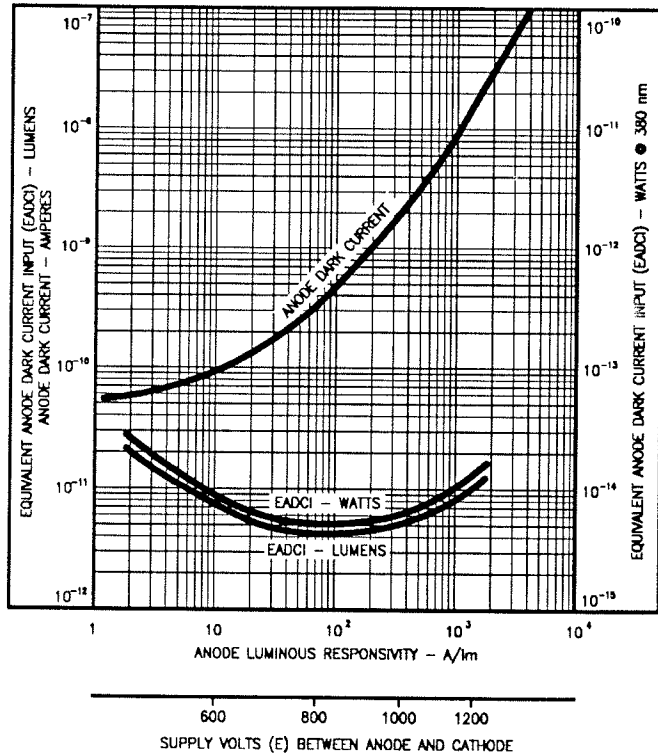
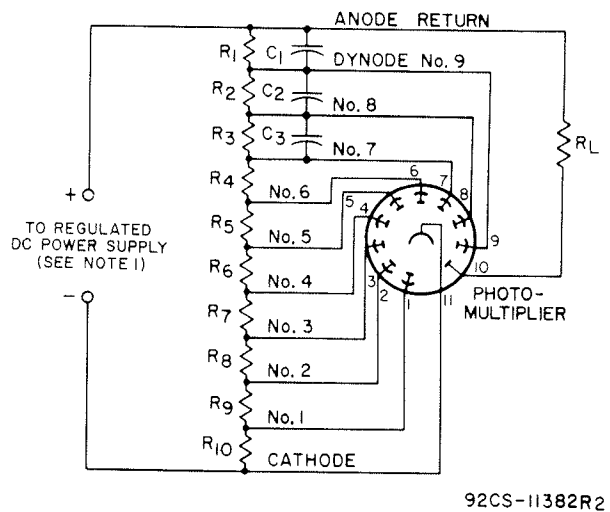


Figure 8 - Typical EADCI and Dark Current Characteristics - Type 931B



R<sub>1</sub> through R<sub>10</sub> = 20,000 to 1,000,000 ohms.

Note 1: Adjustable between approximately 500 and 1250 volts.

Note 2: Capacitors C<sub>1</sub> through C<sub>3</sub> should be connected at tube socket for optimum high-frequency performance. The capacitors are not required for dc applications.

Figure 9 - Typical Voltage-Divider Arrangement

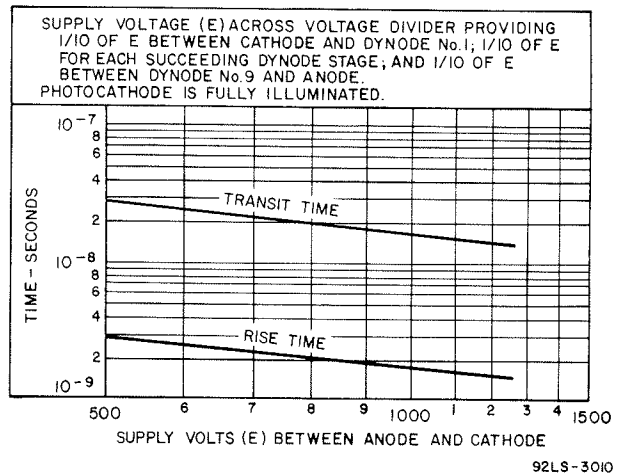
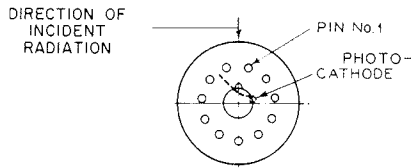
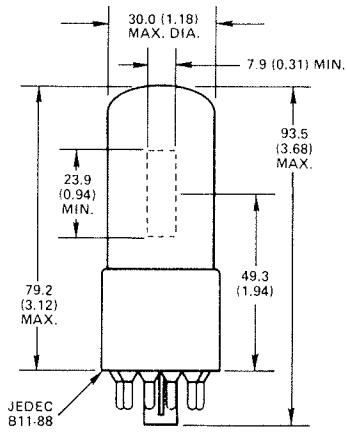


Figure 10 - Typical Time Characteristics



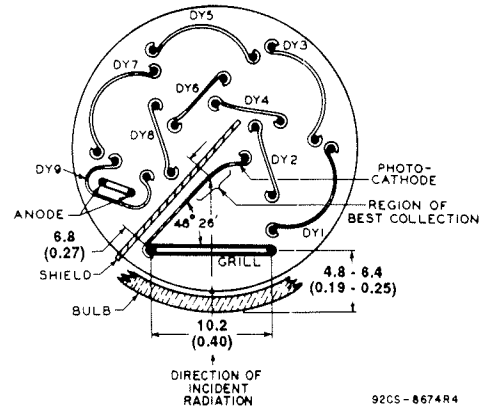
Dimensions in millimeters. Dimensions in parentheses are in inches.

**Note 1:** Envelope material is Corning No.0080, or equivalent. Its index of refraction at 436 nanometers is 1.52.

**Note 2:** Magnetic shielding of the tube is ordinarily required. Typical magnetic shield: BURLE AJ2240.

**Note 3:** Typical socket: BURLE AJ2256, or equivalent.

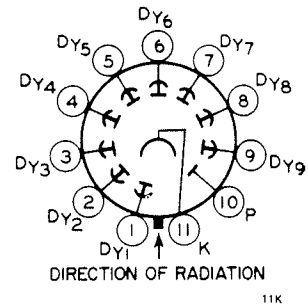
**Figure 11 - Dimensional Outline**



Dimensions in millimeters. Dimensions in parentheses are in inches.

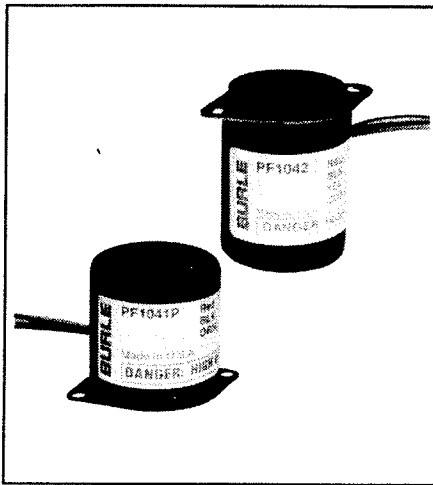
**Figure 12 - Construction Detail - Top View**

- 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: Anode
- Pin 11: Photocathode



**Figure 13 - Basing Diagram - Bottom View**

# PF1041N, PF1041P, PF1042, PF1043 Power Supply Assemblies



## Accessories for BURLE Side-Window Photomultipliers

**PF1041N, PF1041P -  
High Voltage Power Supply**

**PF1042, PF1043 -  
High Voltage Power Supply,  
Dynode Divider, and Tube  
Socket**

- Low Cost
- Reliable
- Up to 1500 Volts
- Compact, Solid State Design

BURLE PF1041N and PF1041P are small, low-cost solid-state power supplies capable of providing up to 1500 volts DC output at 1 milliampere.

The PF1041N is designed primarily for use with photomultipliers operating in the negative voltage mode; the PF1041P, for photomultipliers operating in the positive voltage mode. However, either can be used in any application requiring a stable, efficient, low-ripple power supply for output loads of up to 1.5 watts. A variable voltage, 0 to 10 volts DC, is needed for supply operation. High voltage output is proportional to DC input.

BURLE PF1042 and PF1043 are small, low-cost solid-state power supply assemblies designed for use with side-window photomultipliers such as the 931A. These devices have an integral voltage-divider network of approximately 5 megohms,

no by-pass capacitors, and an integral socket which fits all 28-mm (1-1/8") diameter, 9-stage, side-window photomultipliers having small-shell submagnal bases.

BURLE PF1042 provides a regulated output voltage (-500 to -1250 volts) that may be controlled by either resistance or voltage programming.

The PF1043 provides an output voltage (0 to -1250 volts) that varies directly with input voltage.

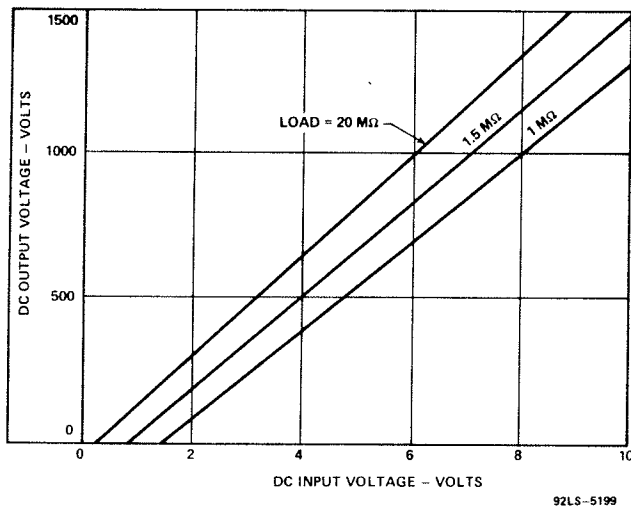


Figure 1 - Typical Input-Output Voltage Characteristics - PF1041N, PF1041P

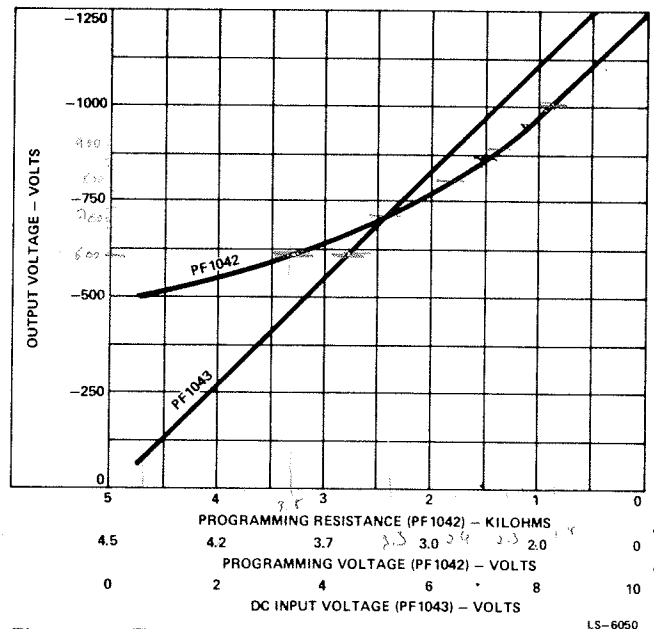
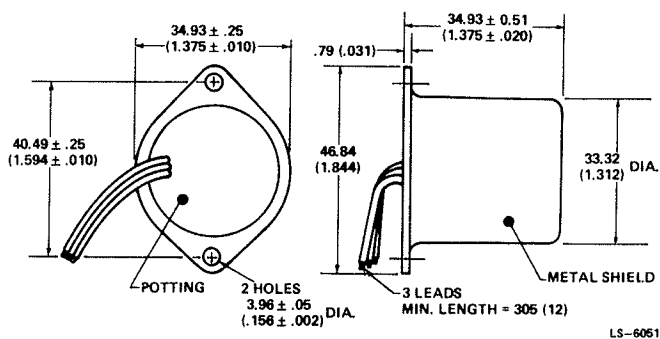


Figure 2 - Typical Programming Characteristic (Programming Lead to Ground) - PF1042  
Typical Input-Output Voltage Characteristic - PF1043

*Use this scale*

## Electrical Characteristics

	PF1041N	PF1041P	PF1042	PF1043	Units
DC Output Voltage ( $V_{out}$ )	0 to -1500	0 to +1500	-500 to -1250	0 to -1250	V
DC Output Current at Full Load	Up to 1	Up to 1	--	--	mA
DC Input Voltage ( $V_{in}$ )	0 to 10	0 to 10	12 to 15	0 to 9	V
Input Current ( $I_{in}$ ) at Max. $V_{out}$	--	--	<100	<100	mA
Efficiency at Full Load	>65	>65	--	--	%
Peak-to-Peak Ripple at Max. $V_{out}$ and Full Load	<0.05	<0.05	<0.05	<0.05	%
Line Regulation	--	--	<0.1	--	%
Load Regulation	--	--	<0.1	--	%
Typical Temperature Coefficient	0.01	0.01	0.01	0.01	%/°C
Weight (Approx.)	79 (2.8)	79 (2.8)	65 (2.3)	65 (2.3)	g (oz)
Operating Temperature Range	-10 to +60	-10 to +60	-10 to +60	-10 to +60	°C
Total Resistance of Integral Voltage-Divider Network	--	--	5.1	5.1	M ohm



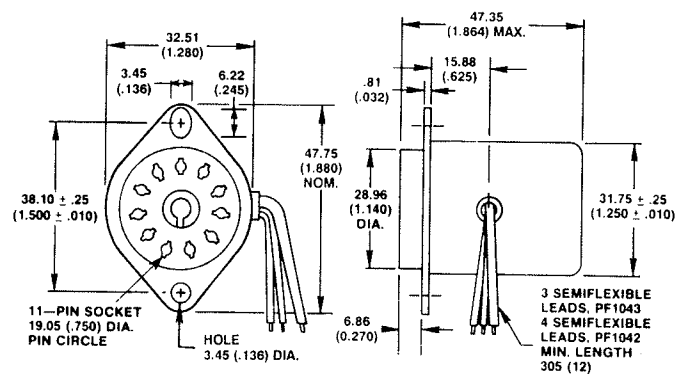
Dimensions in millimeters. Dimensions in parentheses are in inches.

### Lead Connections

Positive DC Input Voltage ( $V_{in}$ ) <sup>1</sup>	Red
Ground <sup>2</sup>	Black
DC Output Voltage (HV)	Orange

1. The input may be current limited or fused for 250 mA for short circuit protection.
2. The black lead is common for both  $V_{in}$  and HV. The shield is intentionally ungrounded; it should obtain ground from its mounting in the system to minimize oscillator radiation.

Figure 3 - Dimensional Outline - PF1041N, PF1041P



Dimensions in millimeters. Dimensions in parentheses are in inches.

### Lead Connections

Positive DC Input Voltage ( $V_{in}$ )	Red
Ground <sup>1</sup>	Black
Anode Output Signal <sup>2</sup>	Coax
Programming (PF1042 only) <sup>3</sup>	Yellow

1. The ground (black) lead is common to the shield of the anode-output coaxial lead.
2. The center conductor connects directly to the tube anode. There is no internal load.
3. Programming adjustments are accomplished between yellow and black leads.

Figure 4 - Dimensional Outline - PF1042, PF1043

### WARNING - Personal Safety Hazards

**Electrical Shock** - The output voltages developed by these devices present a shock hazard.

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