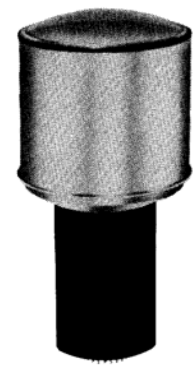
8854
Photomultiplier

129-mm (5-inch) Diameter, 14-stage QUANTACON™ Type Having a Bialkali Photocathode and High-Gain Gallium-Phosphide Dynodes

- **Extremely High Gain Gallium - Phosphide, GaP (Cs), First Dynode**
- **Low Dark Noise at 22 °C Efficiency: (Typical) - Dark Pulse Summation**
  16 Photoelectrons Pulse Rise Time
  $\sum \approx$ 1000 counts per second V
  1/8 Photoelectron Transit Time
- **114-mm (4.5 inch) Minimum Diameter Bialkali Photocathode**
- **UV Response to 220 nm**
- **Quantum Efficiency:**
  22.5% at 385 nm
- **Time Resolution Characteristics:**
- **Anode-Pulse Rise Time-**
  2.9×10^{9} s at 3000 V
- **Electron Transit Time -**
  6.6×10^{-8} s 3000 V



BURLE 8854 is a 129-mm (5")-diameter, 14-stage head-on QUANTACON photomultiplier having a bialkali photocathode of high quantum efficiency and an extremely high gain cesiated gallium-phosphide first dynode followed by high-stability copper beryllium dynodes in the succeeding stages. The 8854 features high quantum efficiency, ultraviolet response, uniform electron collection from the major portion of the photocathode, fast time response, and high current amplification. This tube is intended for nuclear physics applications such as photon and low energy scintillation counting application systems.

The first dynode of 8854 tube provides up to an order of magnitude increase in secondary emission ratio over conventional dynode materials. This high ratio provides a pulse height resolving capability that permits the discrimination of up to five or more photoelectron events.

The extremely high secondary emission ratio of the first dynode is instrumental in providing a decrease in noise induced in signal current by approximately 20 percent.

General Data

Spectral Response	**See Figure 1**
Wavelength of Maximum Response	385 nm
Cathode, Semitransparent	Potassium-Cesium-Antimony (Bialkali)
Minimum projected area	103 cm^2 (16 in^2)
Minimum diameter	11.4 cm (4.5 in)
Window	UV-Transmitting Glass, Corning[a] No.9741, or equivalent
Shape	Spherical section
Index of refraction at 404.7 nanometers	1.48
Dynode No. 1:	
Secondary-emitting surface	Cesiated Gallium-Phosphide, GaP (Cs)
Dynode No.2 through 14:	
Secondary emitting surface	Beryllium-oxide
Dynode Structure	In-line, Electrostatic-Focus Types
Direct Interelectrode Capacitances (Approx):	
Anode to dynode No.14	5.5 pF
Anode to all other electrodes	7.0 pF
Maximum Overall Length	298.5 mm (11.75 in)
Maximum Diameter	129 mm (5.08 in)
Base	BURLE 21-Pin
Socket	BURLE AJ2144A, AJ2145A
Magnetic Shield	BURLE AJ2255
Operating Position	Any
Weight (Approx.)	965g (34 oz)

ISO 9001

BURLE

Maximum and Minimum Ratings, Absolute Maximum Values[c]

DC Supply Voltage:			
Between anode and cathode:			
With voltage distribution A or B, shown in Table 1…………	3000	max.	V
Between anode and dynode No.14.	600	max.	V
Between dynode No.14 and dynode No.12……………..…………………..	800	max.	V
Between other adjacent dynodes….	400	max.	V
Between dynode No.1 and cathode	1000	max.	V
	300[d]	min.	V
Average Anode Current[e]…………….	0.2	max.	mA
Ambient-Temperature Range[f]	-50 to + 80		°C

Performance Data

Under conditions with a DC supply voltage (E) across a voltage divider providing the electrode voltages shown in Table 1, Column A, and at a temperature of 22 °C

With E = 2000 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[g] at 385 nm…….	-	3.6×10^{6}	-	A/W
Luminous[h] (2856° K)…...	-	2850	-	A/lm
Blue response[J] (1×10^{-7} lm from a tungsten-filament lamp incident on a Corning CS. No.5-58 filter, ½ stock thickness) ………………….	100	400	-	A/ incident lm
Cathode Sensitivity:				
Radiant[k] at 385 nm…	-	0.070	-	A/W
Luminous[m] (2856° K)...	-	5.6×10^{-5}	-	A/lm
Blue response[n] (1×10^{-4} lm from a tungsten-filament lamp incident a Corning C.S. on No.5-58 filter, 1/2 stock thickness. 500 V between cathode and all other electrodes connected as anode)……………..	6.2×10^{-6}	7.8×10^{-6}	-	A/ incident lm
Quantum efficiency At 385 nm……………	-	22.5	-	%
Current Amplification…	-	5.1×10^{7}	-	-
Anode Dark Current[p] at 2000 A/lm…………….	-	6×10^{-8}	6×10^{-7}	A
Equivalent Anode Dark Current Input[P] at 2000 A/lm………………………	-	3×10^{-11}	3×10^{-10}	lm
		2.4×10^{-14}[q]	2.4×10^{-13}[q]	W

With E = 3000 volts

Pulse Current:[r]…………				
Linear[s]………………	-	0.13	-	A
Saturated……………	-	0.32	-	A

Under conditions with a DC supply voltage(E) across a voltage divider providing the electrode voltages shown in Table 1, Column B, and at a temperature of 22 °C.

With E varied as noted

	Min.	Typical	Max.	
Peak-to-Valley Ratio Between Single and Double Photoelectron Pulse Height[t]	1.4	1.5	-	
Dark Pulse Summation[u] 1/8 to 16 photoelectrons	-	1000	1333	cps

With E = 3000 volts

Distribution Column A, Table 1

Anode Pulse Rise Time[v]	-	2.9×10^{-9}	-	s
Electron Transit Time[w]	-	6.6×10^{-8}	-	s

Table 1		
Voltage Distribution		
Between the following Electrodes: Cathode (K) Dynode (Dy) and Anode (P)	**A** 5.9% of K-P Voltage (E) Multiplied by:	**B** 6.9% of Dyl-P Voltage (E) Multiplied by:
K-Dy1	3	*
Dy1-Dy2	1	1
Dy2-Dy3	1	1.5
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-Dyl0	1	1
Dy10-Dy11	1	1
Dy11-Dy12	1	1
Dy12-Dy13	1	1
Dy13-Dy14	1	1
Dy14-P	1	1
Dy1-P	-	14.5
K-P	17	-

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

a Made by Corning Glass Works, Corning, NY 14930.

b The AJ2145A is ordinarily supplied with the tube and is designed specifically for chassis mounting. The AJ2144A is designed for use in any desired mounting arrangement. It is supplied with an unattached clamping 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 In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.

d To take full advantage of the performance capability of the 8854, tube operation at voltages above this minimum value should be employed.

e Averaged over any interval of 30 seconds maximum.

f Tube operation at 22 °C or below is recommended. The use of Teflon sockets with the 8854 at temperatures below the minimum temperature rating of –50 °C can destroy the 8854.

g This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1250 lumens per watt.

h These values are calculated as shown below.

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode blue response (A/incident lm)}}{0.14}$$

The value of 0.14 is an average value. It is the ratio of the cathode current measured under the conditions specified in footnote (n) to the cathode current measured under the same conditions but with the blue filter removed.

j Light incident on the cathode is transmitted through a blue filter (Corning CS. No.5-58 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2856 K. The value of light flux incident on the filter is 0.1 microlumen.

k This value is calculated from the typical cathode luminous sensitivity rating using a conversion of 1250 lumens per watt.

m These values are calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode blue response (A/incident lm)}}{0.14}$$

The value of 0.14 is an average value. It is the ratio of the cathode current measured under the conditions specified in footnote (n) to the cathode current measured under the same conditions but with the blue filter removed.

n 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 2856° K. The value of light flux incident on the filter is 100 microlumens and 500 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 CS. 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 26 microamperes. Luminous sensitivity of the tube under these conditions is approximately equivalent to 2000 amperes per lumen. Dark current is measured with incident light removed.

Equivalent Anode Dark Current Input is the quotient of anode dark current at a given anode luminous sensitivity by the anode luminous sensitivity.

q At 385 nanometers. These values are calculated from the EADCI values in lumens using a conversion factor of 1250 lumens per watt.

r Using a pulsed light source having a pulse duration of 0.5 microsecond and repetition rate of 30 pulses per second. The interstage voltages of the tubes should not deviate more than 2 percent from the recommended voltage distribution shown by Voltage Distribution A of Table 1. Capacitors are connected across the individual resistors making up the voltage-divider arrangement to insure this operating condition.

s Maximum deviation from linearity is 5 percent.

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 560 nanometers. The diode is pulsed at a rate of 7000 to 8000 pps; pulse duration is approximately 0.4 us; anode circuit integrating time is approximately 10 us. 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, second, and third photoelectron peaks. A Multichannel Pulse-Height Analyzer having 256 channels is employed. Gain of the tube is approximately 2×10^8.

u Measured with the tube in complete darkness. The pulse height for the single photoelectron equivalent is determined by using a light source 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. The light is removed before the dark pulse summation is measured. The supply voltage is adjusted so that the peak of the single electron distribution lies in channel No.8. This corresponds to a tube gain of approximately 2×10^8.

v 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.

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.

Operating Considerations

Cathode Current

Peak cathode current of 1 x 10^{-8} ampere at a tube temperature of 22 °C or 1 x 10^{-10} ampere at –50 °C should not be exceeded. Because of the resistivity of the photocathode, the voltage drop caused by higher peak cathode currents may produce radial electric fields on the photocathode which can result in poor photoelectron collection in the first dynode. Photosurface resistivity increases with decreasing temperature.

Shielding

The metal portion of the tube envelope is internally connected to the photocathode. The application of high voltage, with respect to cathode, to insulating or other materials supporting or shielding the tube in contact with the faceplate should not be permitted unless such materials are chosen to limit leakage current to the tube faceplate to 1 x 10^{-12} ampere or less.

In addition to increasing dark current and noise output because of voltage gradients developed across the faceplate, such high voltage may produce minute leakage current to the cathode, through the tube faceplate and insulating materials, which can permanently damage the tube.

Ambient Atmosphere

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

Anode Dark Current

The 8854 is intended for use in systems requiring very low dark current. Accordingly, the base of the tube and its socket should never be allowed to become contaminated by handling. Such contamination produces leakage and dark current.

A temporary increase in anode dark current by as much as 3 orders of magnitude may occur if the tube is exposed momentarily to high-intensity ultraviolet radiation from sources such as fluorescent room lighting even though voltage is not applied to the tube. The increase in dark current may persist for a period up to 48 hours following such irradiation.

Socket Warning

The use of Teflon sockets, such as the AJ2144A, AJ2145A, with the 8854 at temperatures is not recommended for operation below –50 °C.

Mechanical Considerations

Handling

The tube must be handled with care at all times. When transporting the tube, it must be protected from rough handling that might damage the seals or other parts. Extreme care should be given to the glass-to-metal seal at the outer edge of the faceplate.

Appropriate eye protection (such as goggles or mask) should be used when handling this tube.

Mounting

Care must be taken in mounting the tube so that the tube envelope is not subjected to excessive pressure which could strip the glass-to-metal seals. In no case should mounting supports be used in the shaded areas indicated on the Dimensional Outline.

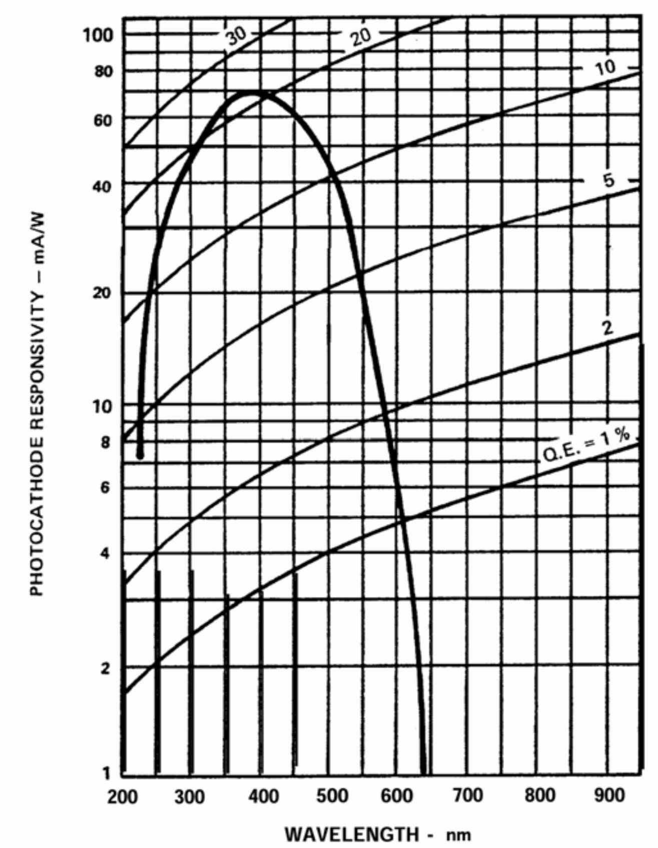


Figure 1 - Typical Spectral Response Characteristics

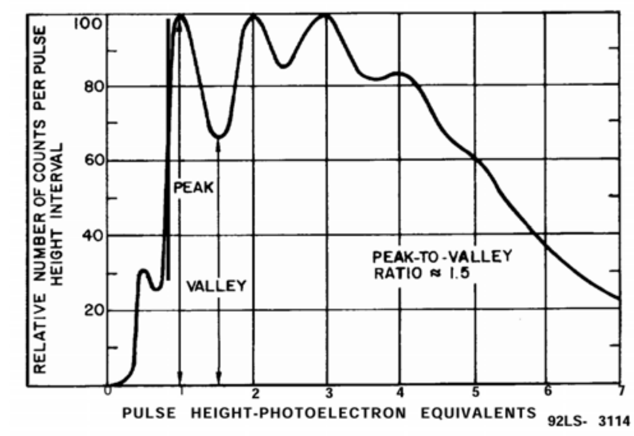


Figure 2 - Typical Photoelectron Pulse Height Spectrum

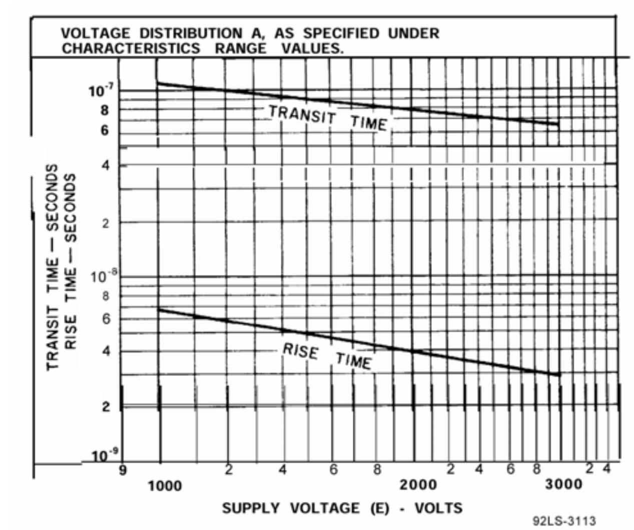


Figure 3 – Typical Time Resolution Characteristics

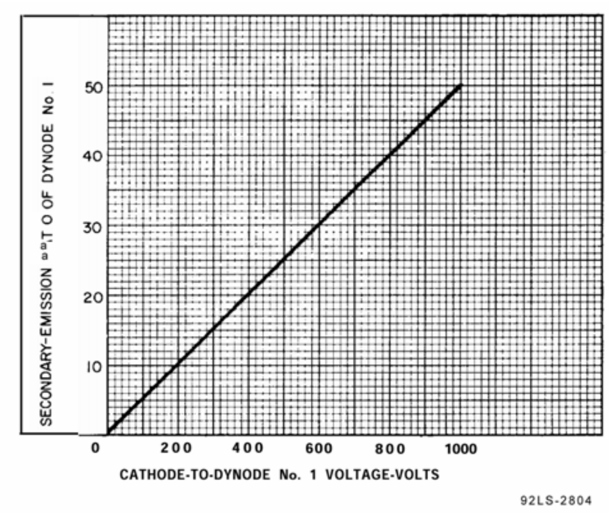


Figure 4 - Typical Secondary-Emission Ratio of First Dynode as a Function of Cathode-to-Dynode No.1 Voltage

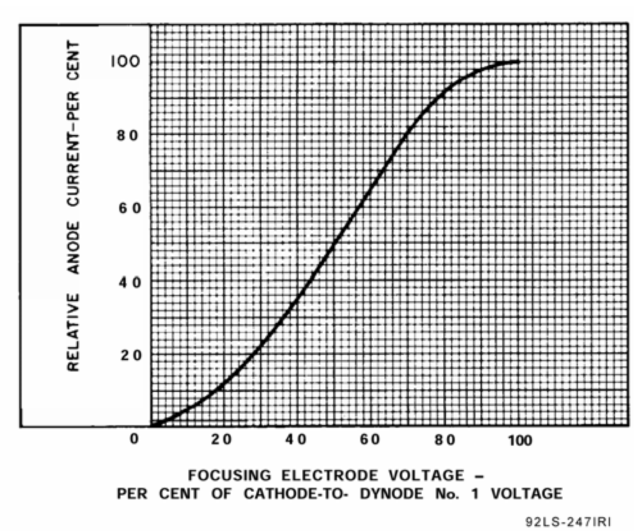


Figure 5 – Typical Focusing Electrode Characteristic

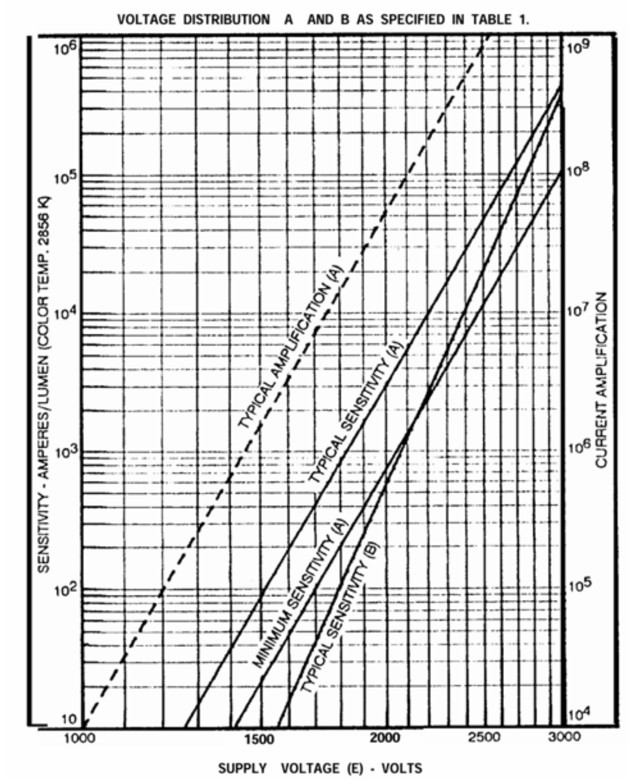


Figure 6 - Sensitivity and Current Amplification Characteristics

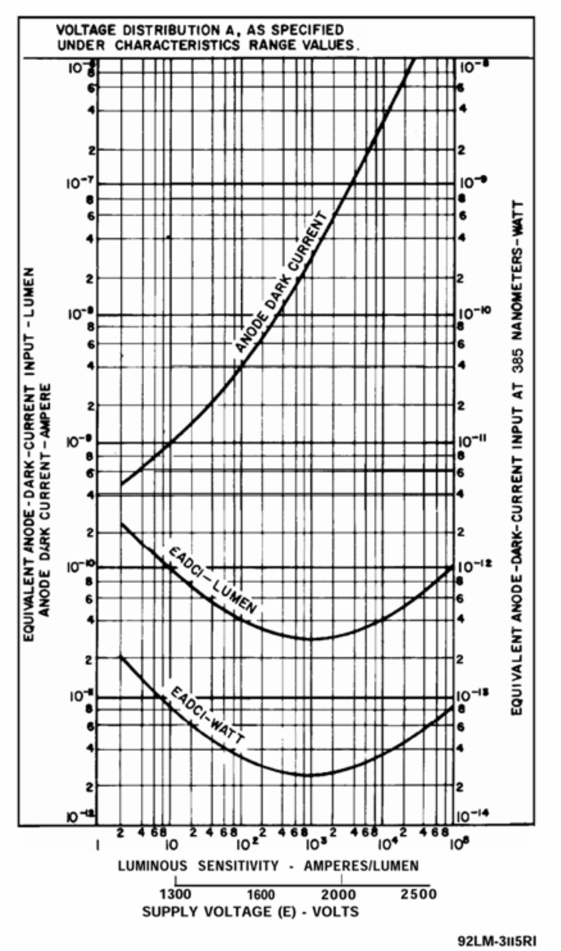


Figure 7 - Typical EADCI and Anode Dark Current Characteristics

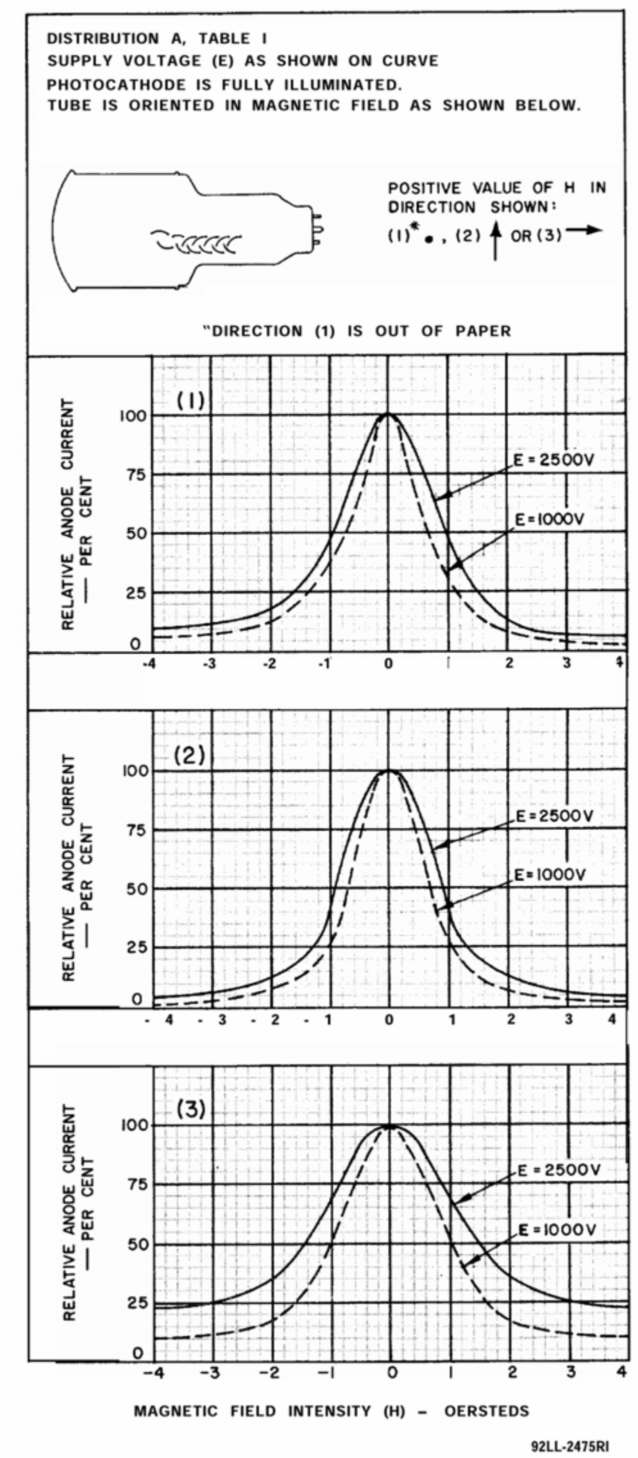


Figure 8 - Typical Effect of Indicated Magnetic Field on Anode Current

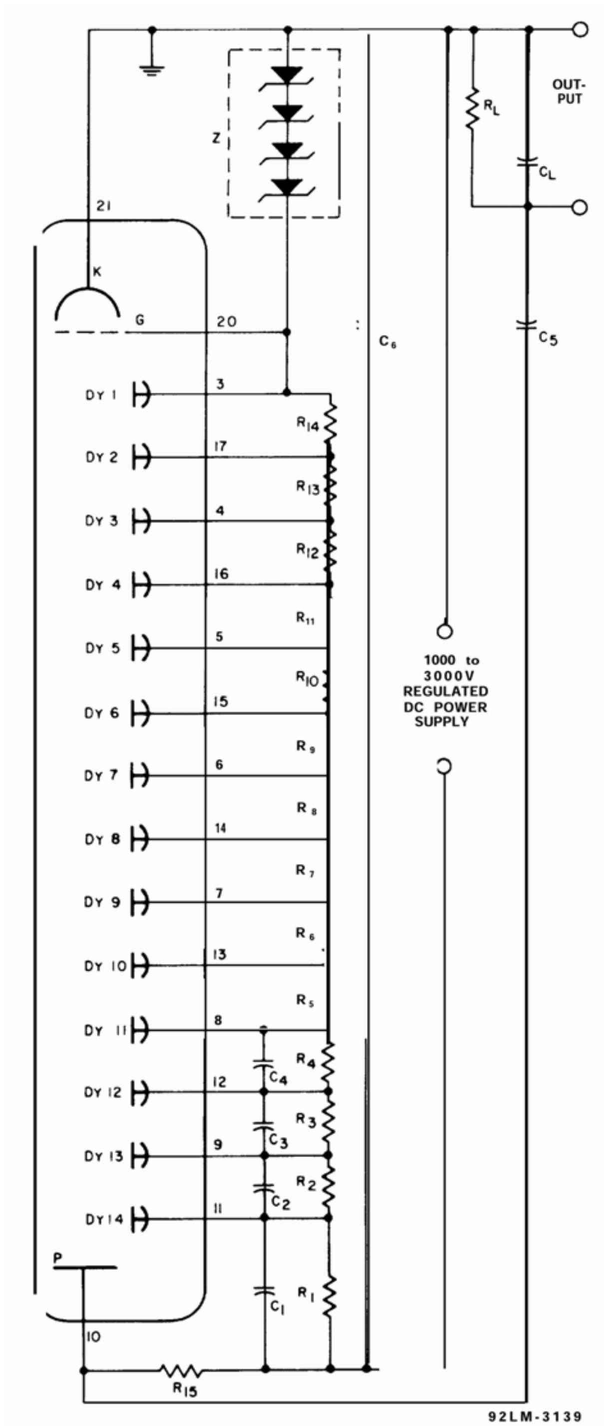


Figure 9 - Typical Circuit Arrangement for Scintillation-Counting Applications

C_1:0.05 uF, 20%, 500 V dc Ceramic-Disc Type
C_2:0.02 uF, 20%, 500 V dc Ceramic-Disc Type
C_3:0.01 uF, 20%, 500 V dc Ceramic-Disc Type
C_4:0.005 uF, 20%, 500 V dc Ceramic-Disc Type
C_5 & C_6: 0.0047 uF, 20%, 6000 V dc Ceramic-Disc Type

R_1 through R_{12}: 51 K ohms, 5% 1 W
R_{13}:75 K ohms, 5% 1 W
R_{14}:51 K ohms, 5% 1 W
R_{15}:100 K ohms, 5% 1/2W

Z: (2)-150 V, 2 W zener diodes, or equivalent
(2)-180 V, 2 W zener diodes, or equivalent

Note - The value of the load elements, R_L and C_L, depend on the application. For most applications, $R_L \times C_L = 10$ microseconds. It is to be noted that R_{15} is in parallel with R_L and must be considered when selecting the R_L value.

Leads to all capacitors should be as short as possible to minimize inductance effects. The location and spacing of capacitors is critical and may require adjustment for optimum results.

The capacitor values will depend upon the shape of the output pulse, the amplitude of the anode-current pulse, and the time duration of the pulse, or train of pulses. When the output pulse is assumed to be rectangular in shape, the following formula applies:

$$C = 100\,\frac{i\text{-}t}{V}$$

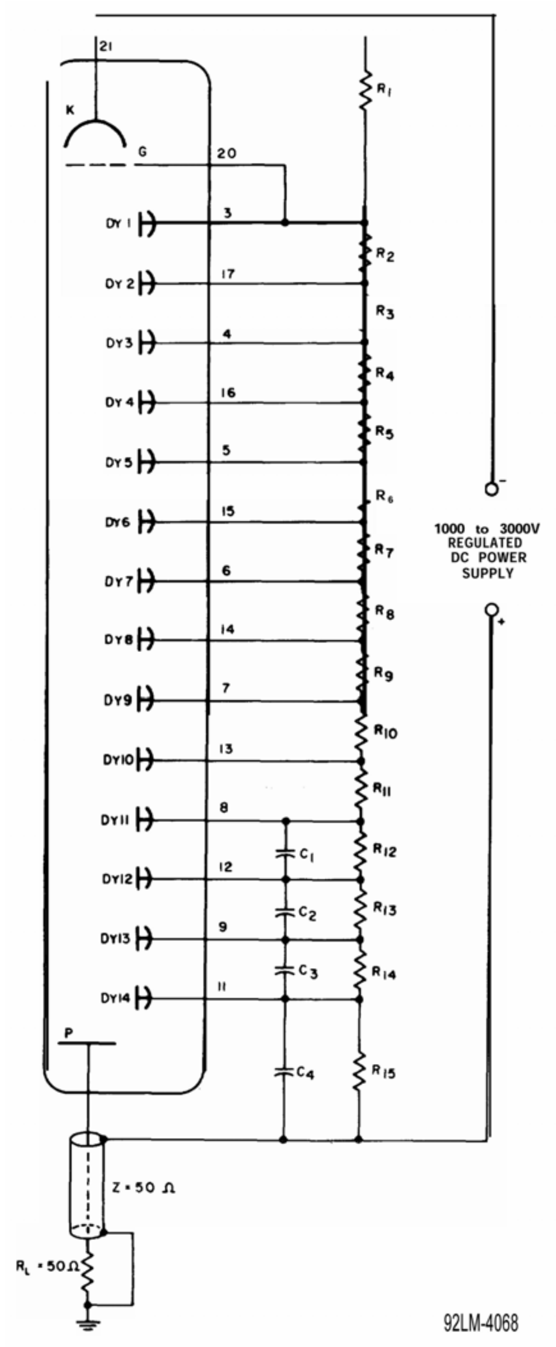
where C is in farads
i is the amplitude of anode current in amperes
V is the voltage across the capacitor in volts
and t is the time duration of the pulse in seconds.

This formula applies for the anode-to-final dynode capacitor. The factor 100 is used to limit the voltage change across the capacitor to 1% maximum during a pulse. Capacitor values for preceding stages should take into account the smaller values of dynode currents in these stages. Conservatively a factor of 2 per stage is used. Capacitors are not required across those dynode stages where the dynode current is less than 1/10 of the current through the voltage divider network.

For other shaped pulses or for a train of pulses, the total charge q should be substituted for ($i \cdot t$) and the following formula applies:

$$C = 100\,\frac{q}{V}$$

where $q = \int i(t)\,dt$ coulombs



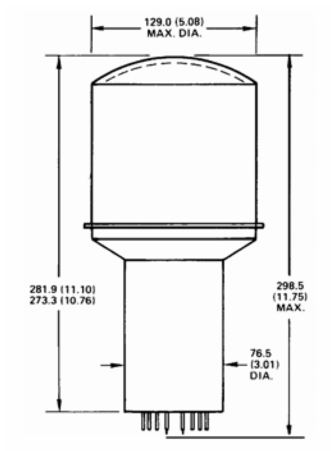
Fast Pulse Response Applications

C_1: 0.005 µF, Ceramic Disc, 500 V
C_2: 0.01 µF, Ceramic Disc, 500 V
C_3: 0.02 µF, Ceramic Disc, 500 V
C_4: 0.05 µF, Ceramic Disc, 500 V
R_1: 300 K ohmn (3-100 K ohms, 5%, 1/2 Win series)
R_2 through R_{15}: 100 K ohms, 5%, 1/2 W

High Peak Current Applications

C_1: 0.005 µF, Ceramic Disc, 500 V
C_2: 0.01 µF, Ceramic Disc, 500 V
C_3: 0.02 µF, Ceramic Disc, 1000 V
C_4: 0.05 µF, Ceramic Disc, 500 V
R_1: 168 K ohms (3-56 K ohms, 5%, 2 W, in series)
R_2, R_4 through R_{11}: 27 K ohms, 5%, 1 W
R_3, R_{12}: 39 K ohms, 5%, 2 W
R_{13}, R_{15}: 54 K ohms (2-27 K ohms, 596, 1 W, in series)
R_{14}:108 K ohms (4-27 K ohms, 5%, 1 W, in series)

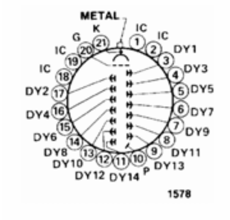
Figure 10 - Typical Circuit Arrangement for Fast Pulse Response and High Peak Current Application



Note 1 - Care must be taken in mounting the tube so that the tube envelope is not subjected to excessive pressure which could strip the glass-to-metal seals. In no case should mounting supports be used in these areas.

Dimensions are in millimeters unless otherwise stated. Dimensions in parentheses are in inches and are derived from the basic inch dimensions (1 inch = 25.4mm).

Figure 11 - **Dimensional Outline**



Pin No. 1: Internally connected - Do not use
Pin No. 2: Internally connected - Do not use
Pin No. 3: Dynode No.1
Pin No. 4: Dynode No. 3
Pin No. 5: Dynode No. 5
Pin No. 6: Dynode No. 7
Pin No. 7: Dynode No. 9
Pin No. 8: Dynode No. 11
Pin No. 9: Dynode No.13
Pin No.10: Anode
Pin No.11: Dynode No.14
Pin No.12: Dynode No.12
Pin No.13: Dynode No.10
Pin No.14: Dynode No.8
Pin No.15: Dynode No.6
Pin No.16: Dynode No. 4
Pin No.17: Dynode No. 2
Pin No.18: Internally connected - Do not use
Pin No.19: Internally connected - Do not use
Pin No. 20: Focusing Electrode
Pin No. 21: Photocathode and Tube Envelope

Figure 12 - **Basing Diagram (Bottom View)**

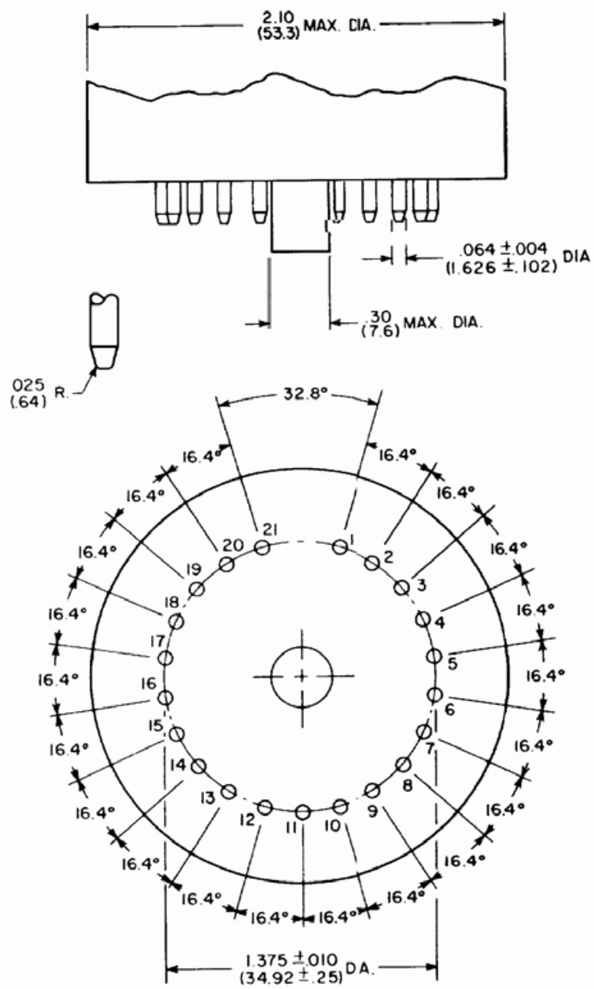


Figure 13 - Detail of Base

FOR ADDITIONAL INFORMATION, TELEPHONE IF IN THE U.S.A. OR CANADA 1-800-366-2875, AND ELSEWHERE, 1-717-295-6888, OR FAX REQUEST TO 1-717-290-1263. BURLE INDUSTRIES, INC., 1000 New Holland Avenue, Lancaster, Pennsylvania 17601-5688 U.S.A.