4552

Photomultiplier Tube

1-1/8" Diameter, Side-On Type
Having Bialkali Photocathode

GENERAL DATA

Spectral Response	See **Figure 2**
Wavelength of Maximum Response	400 ± 50 nm
Cathode, Opaque	Potassium-Cesium-Antimony (Bialkali)
Minimum projected length[a]	0.94 in (2.4 cm)
Minimum projected width[a]	0.31 in (0.8 cm)
Window	Lime Glass (Corning[b] No.0080), or equivalent
Index of refraction at 436 nanometers	1.523
Dynodes:	
Substrate	Nickel
Secondary-Emitting Surface	Cesium-Antimony
Structure	Circular-Cage, Electrostatic-Focus Type
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.9	4.4 pF
Anode to all other electrodes	6.0 pF
Maximum Overall Length	3.10 in (7.8 cm)
Seated Length	2.55 in (6.48 cm)
Maximum Diameter	1.18 in (3 cm)
Bulb	T9
Base	12-Pin Duodecar
Socket	Cinch-Jones[c] No.12CS-M, or equivalent
Magnetic Shield	See footnote d
Operating Position	Any
Weight (Approx.)	1 oz

MAXIMUM RATINGS, Absolute-Maximum Values:

DC Supply Voltage:		
Between anode and cathode	1250 max.	V
Between anode and dynode No.9	250 max.	V
Between consecutive dynodes	250 max.	V
Between dynode No.1 and cathode	250 max.	V
Average Anode Current[f]	0.5 max.	mA
Ambient Temperature Range[g]	−80 to +85	°C

Characteristics Range Values for Equipment Design:

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, and at a temperature of 22° C.

With E = 1000 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[h] at 400 nanometers. . . .	–	8.4×10^{4}	–	A/W
Luminous[j] (2870° K)	10	100	1500	A/lm
Cathode Sensitivity:				
Radiant[k] at 400 nanometers	–	0.054	–	A/W
Luminous[m] (2870° K)	3.5×10^{-5}	6.5×10^{-5}	–	A/lm
Quantum Efficiency at 400 nanometers. . . .	–	17	–	%
Current Amplification.	–	1.5×10^{6}	–	
Anode Dark Current[n] at 20 A/lm	–	8×10^{-10}	1×10^{-8}	A
Equivalent Anode Dark Current Input[n]	–	4×10^{-11}	5×10^{-10}	lm
	–	4.8×10^{-14}[p]	6×10^{-13}[p]	W
Equivalent Noise Input[q]	–	1.5×10^{-12}	–	lm
	–	1.8×10^{-15}[r]	–	W
Anode-Pulse Rise Time[s] at 1250 V	–	1.6×10^{-9}	–	s
Electron Transit Time[t] at 1250 V	–	1.6×10^{-8}	–	s

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a On plane perpendicular to the indicated direction of incident light and passing through the major axis of the tube.

b Made by Corning Glass Works, Corning, NY 14830.

c Made by Cinch-Jones Distributor Division, 1501 Morse Avenue, Elk Grove Village, IL 60007.

d Magnetic shielding material in the form of foil or tape as available from the Magnetic Shield Division, Perfection Mica Company, 1322 N. Elston Avenue, Chicago, IL 60622, or equivalent.

f Averaged over any interval of 30 seconds maximum.

g Tube operation at 22° C or below is recommended.

h This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 837 lumens per watt.

j 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 10 microlumens is used.

k This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 837 lumens per watt.

m 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 100 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 20 amperes per lumen. Dark current caused by thermionic emission may be reduced by use of a refrigerant.

p At 400 nanometers. These values are calculated from the EADCI values in lumens using a conversion factor of 837 lumens per watt.

q Under the following conditions: 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 400 nanometers. This value is calculated from the ENI value in lumens using a conversion factor of 837 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.

Operating Considerations

Operating Stability

The operating stability of the 4552 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 maximum stability is required, operation at an average anode current of 1 microampere is suggested.

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.

Tube Orientation

The sensitivity of the photocathode surface varies with respect to the position of the light spot on the surface. **Figure 3a** shows the variation in sensitivity 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 3b** shows how the sensitivity 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 sensitivity.

When an application involves use of light flux which covers essentially the entire cathode area, consideration should be given to the effect on luminous sensitivity caused by angular position of the cathode with respect to the direction of incident light. This effect is shown in **Figure 4.** As the tube is rotated from the position of maximum sensitivity (approximately + 13° as shown in **Figure 4**), 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 sensitivity very small.

Shielding

Electrostatic and/or magnetic shielding of the 4552 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 4552 to a minimum.

It is to be 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 negative-potential source. If the shield is not so connected, extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.

Magnetic shielding of the 4552 is necessary if it is operated in the presence of strong magnetic fields. The curve in **Figure 8** shows the effect on anode current of variation in magnetic field strength under the conditions indicated. 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 4552.

Dynode Modulation

Current amplification may also be controlled or the output signal may be modulated by adjustment of the voltage applied to a single or to two consecutive central dynodes with the voltages on the other stages held constant. The curve in **Figure 5a** shows the effect on output current as the voltage applied to dynode No.6 is varied. Similar results may be obtained by adjusting the voltage on dynodes No.2 and No. 4. Somewhat less control is obtained by adjusting the voltage on dynodes No.3, No.5, or No.7.

The curve in **Figure 5b** shows the effect on output current as dynodes No.5 and No.6 are modulated simultaneously but with a constant 100 volt difference maintained between these dynodes during modulation. Similar results may be obtained by simultaneous modulation of dynode No.3 and No.4 and dynode No.7 and No.8.

Dark Current

The use of a refrigerant, such as dry ice, to cool the 4552 is recommended in those applications where maximum current amplification with minimum dark current is required.

Typical ENI as a function of tube temperature is shown in **Figure 6.**

Typical anode dark current and EADCI as a function of luminous sensitivity at a temperature of + 22^{o} C is shown in **Figure 7.**

The resistor values of the voltage divider should be adequate to prevent variation of dynode potentials by signal current. To assure a high degree of linearity, the values of the resistors making up the voltage-divider network should be such that the current through the network, for the selected operating supply voltage, is at least 10 times greater than the maximum average anode current required. Resistor values greater than 10 megohms should not be employed between adjacent tube elements. Location of the voltage divider arrangement should be such that the power dissipated in the resistor string does not increase the temperature of the tube.

A typical voltage divider arrangement for use with the 4552 is shown in **Figure 1.** The choice of resistance values for the voltage divider string is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the supply and the required wattage rating of the resistors increase. Phototube noise may also increase, due to heating, if the divider is mounted near the tube. The use of high values of resistance 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 average anode current and may limit anode current response to pulsed light.

When the ratio of peak anode current to average anode current is high, non-inductive capacitors should be employed across the latter stages of the tube. The values of these capacitors should be chosen so that sufficient charge is available to prevent a change of more than a few per cent in interstage voltages throughout the pulse duration.

Leads to all capacitors should be as short as possible to minimize inductance effects. The capacitor values will depend upon the shape and the amplitude of 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:

$$C = 100 \frac{i \cdot t}{V}$$

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 approximately 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·t) and the following formula applies:

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

The high voltages at which these tubes are 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.

In the use of the 4552 as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT

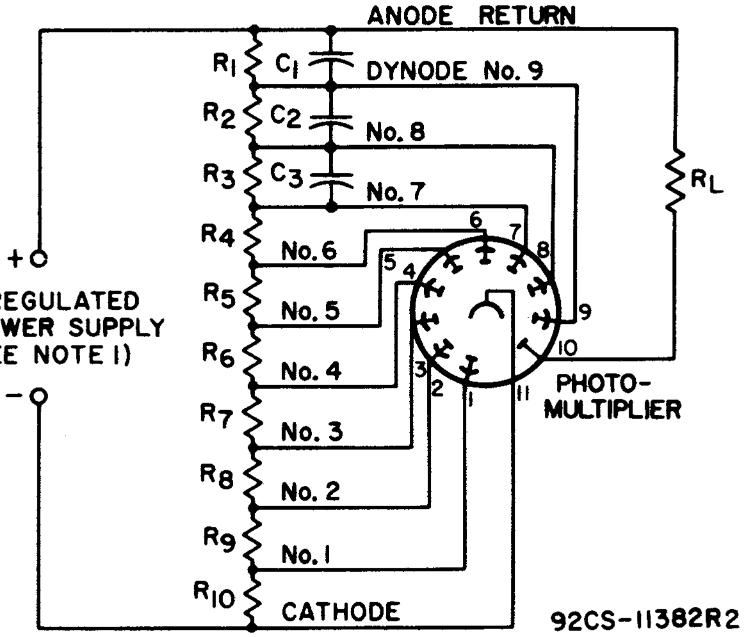


Figure 1

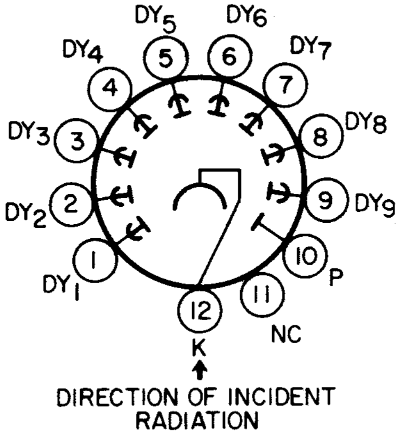
R_1 through R_{10} = 20,000 to 1,000,000 ohms

Note 1— Adjustable between approximately 500 and 1250 volts.

Note 2— Capacitors C_1 through C_3 should be connected at tube socket for optimum high-frequency performance.

BASING DIAGRAM, (Bottom View)

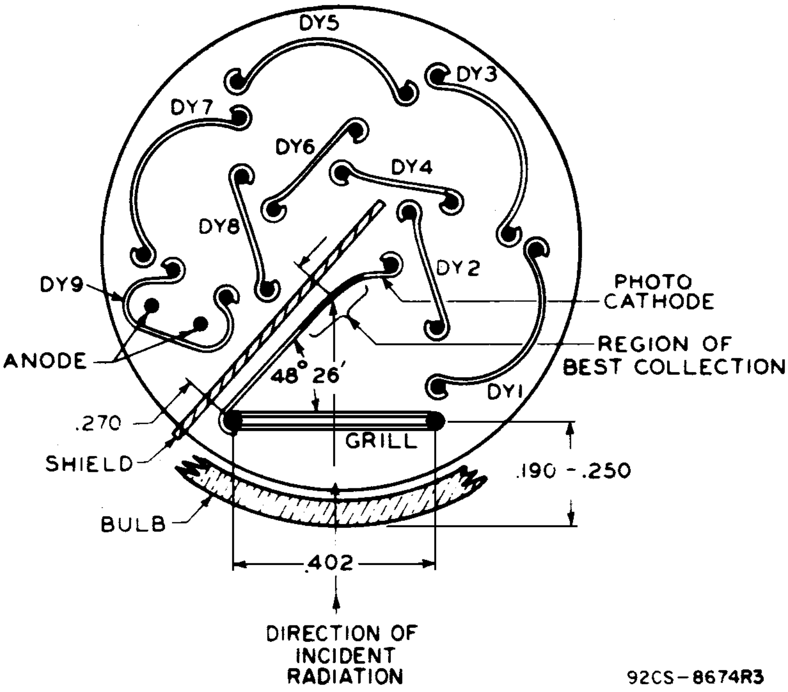
Note: The tube should be rotated about its major axis to provide maximum anode current.



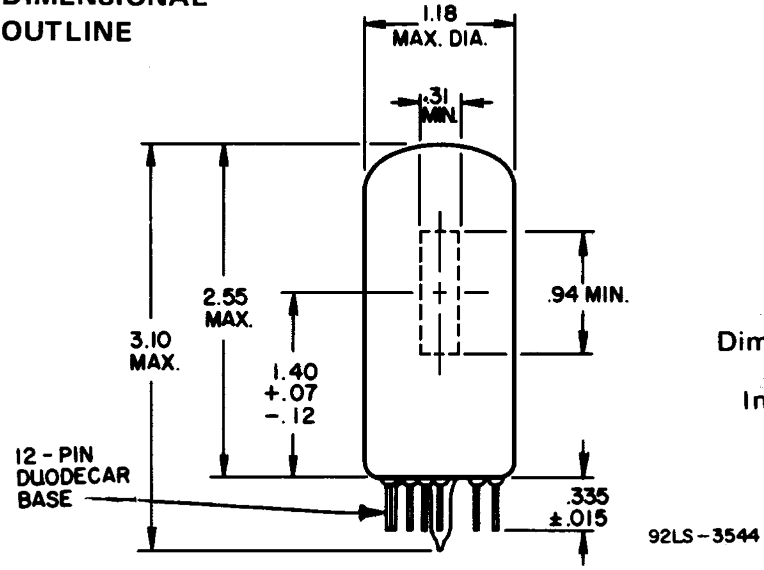
Pin 1— Dynode No.1
Pin 2— Dynode No.2
Pin 3— Dynode No.3
Pin 4— Dynode No.4
Pin 5— Dynode No.5
Pin 6— Dynode No.6
Pin 7— Dynode No.7
Pin 8— Dynode No.8
Pin 9— Dynode No.9
Pin 10— Anode
Pin 11— No Internal Connection*
Pin 12— Photocathode

* The socket terminal for Pin 11 may be used as a tie point for the voltage-divider resistor from dynode No.9 to the positive dc supply voltage and the load resistor from the anode to the positive dc supply voltage.

SCHEMATIC REPRESENTATION OF TUBE STRUCTURE

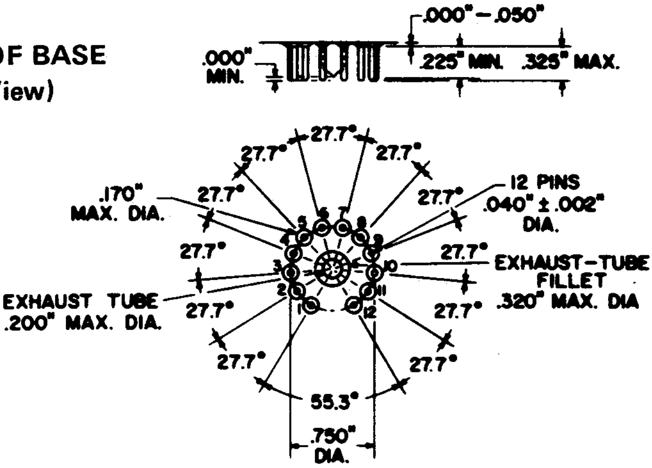


DIMENSIONAL OUTLINE

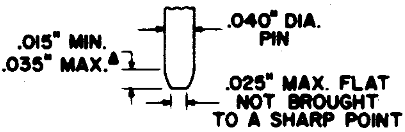


Dimensions in Inches

DETAIL OF BASE (Bottom View)



Duodecar-Base-Pin Contour



Base-pin positions are held to tolerances such that entire length of pins will, without undue force, pass into and disengage from flat-plate gauge having a thickness of 0.250" and thirteen holes with diameters of 0.0520" ± 0.0005" so located on a 0.7500" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.1795" ± 0.0005". Gauge is also provided with a hole 0.375" + 0.005" − 0.000" diameter concentric with the pin circle.

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS

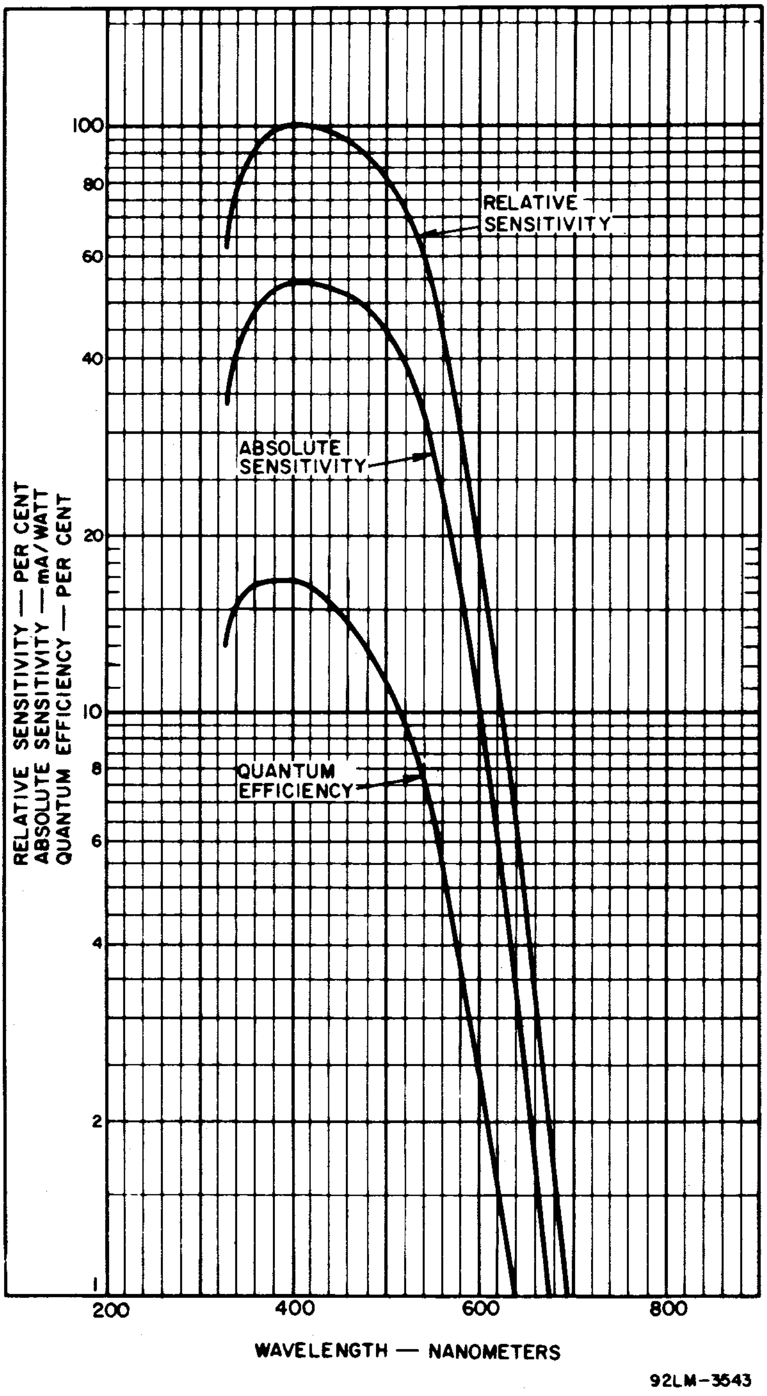


Figure 2

TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ALONG TUBE LENGTH

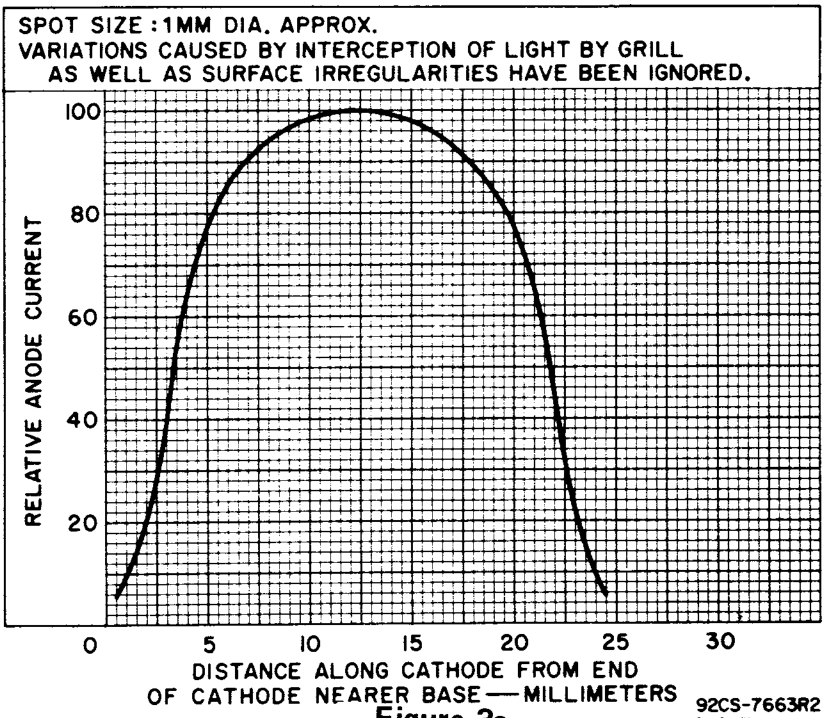


Figure 3a

TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ACROSS PROJECTED WIDTH IN PLANE OF GRILL

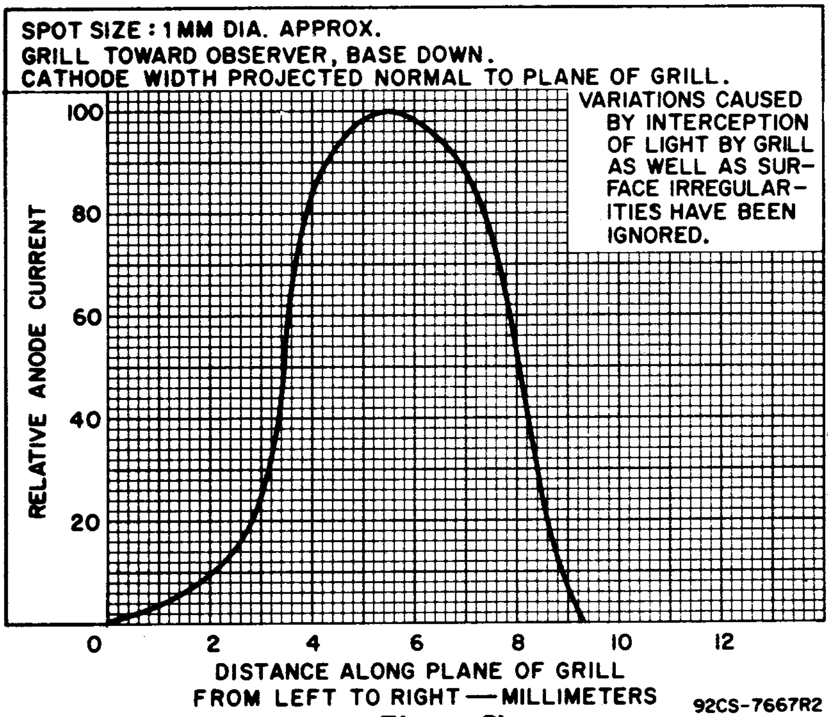


Figure 3b

TYPICAL VARIATION OF SENSITIVITY AS TUBE IS ROTATED WITH RESPECT TO FIXED LIGHT BEAM

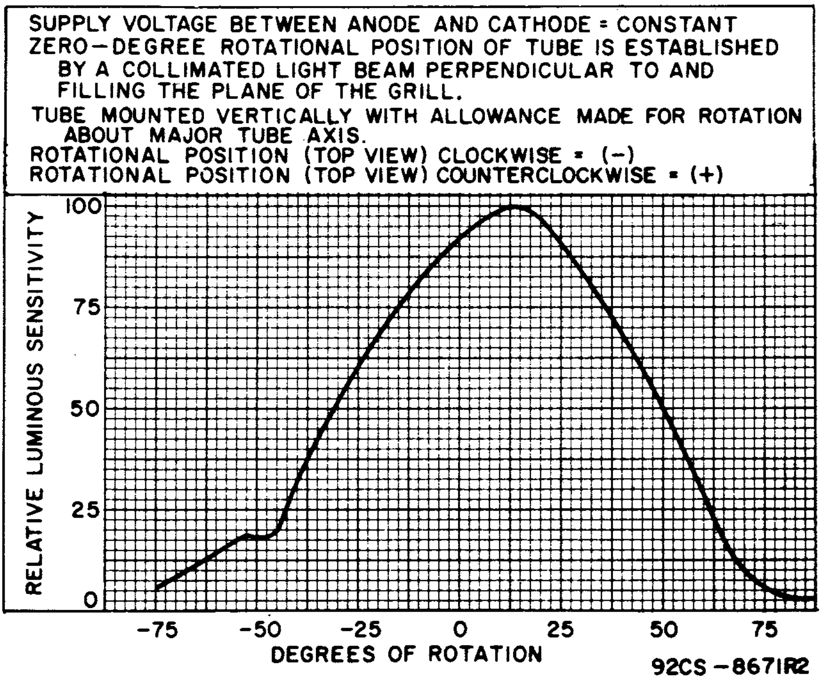


Figure 4

TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF DYNODE-NO. 6 VOLTS

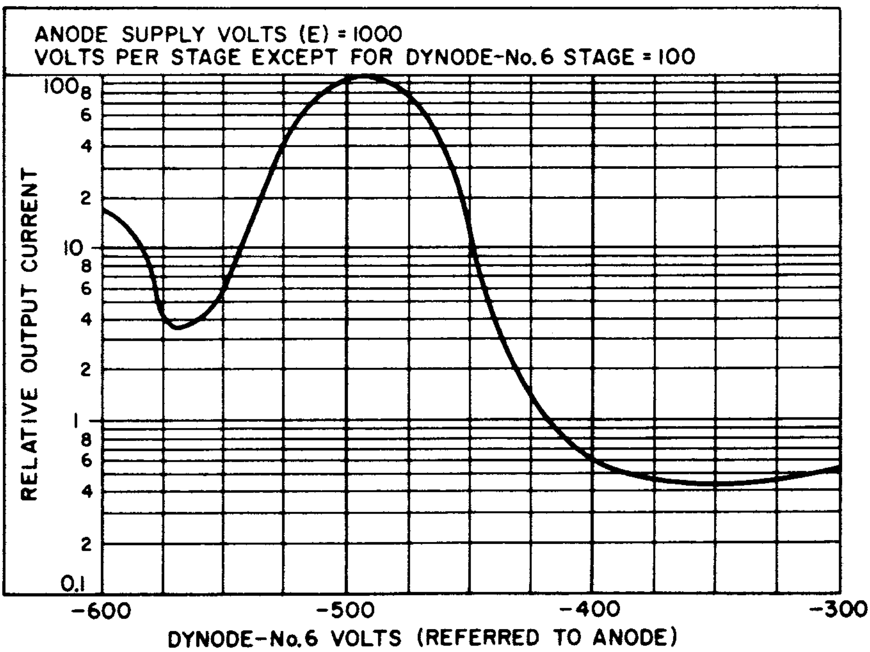


Figure 5a

92CS−8672R1

TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF SIMULTANEOUS MODULATION OF DYNODES NO. 5 AND NO. 6

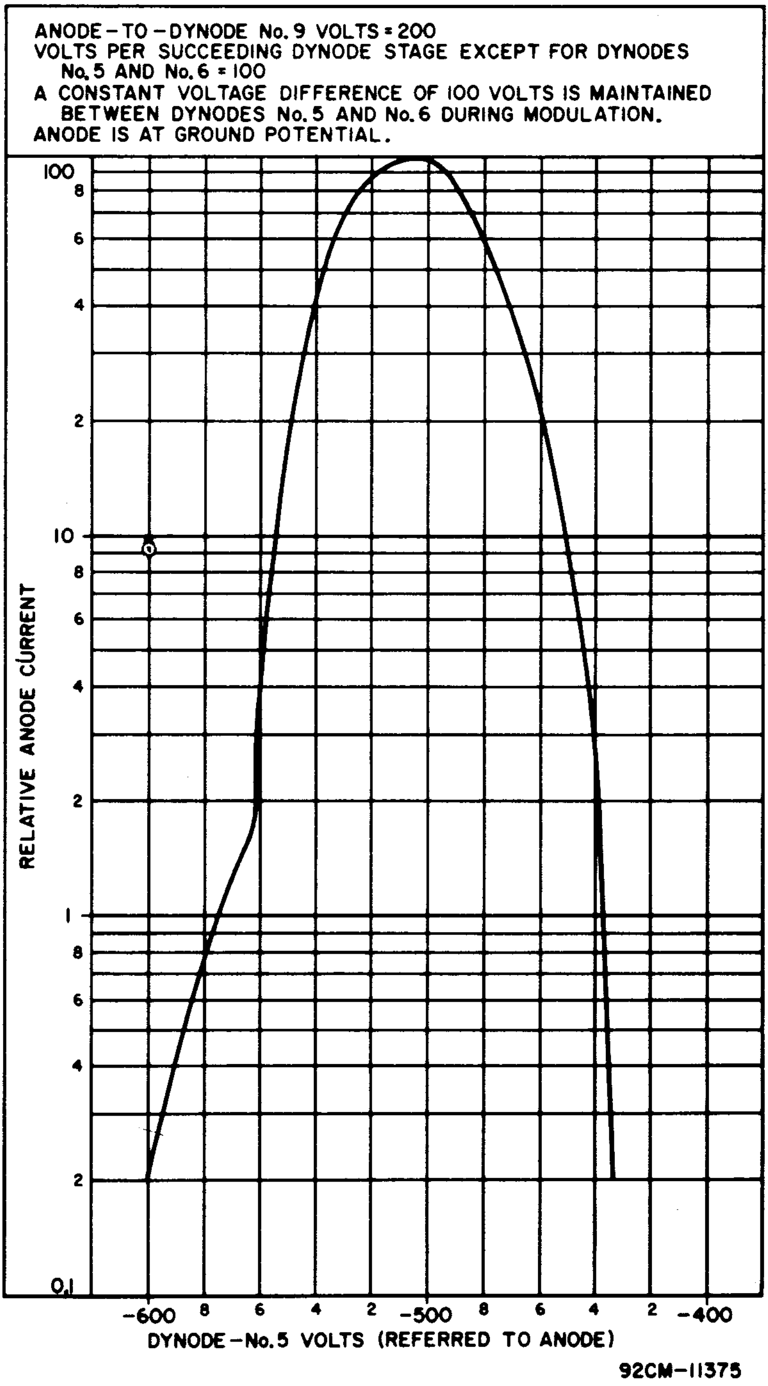
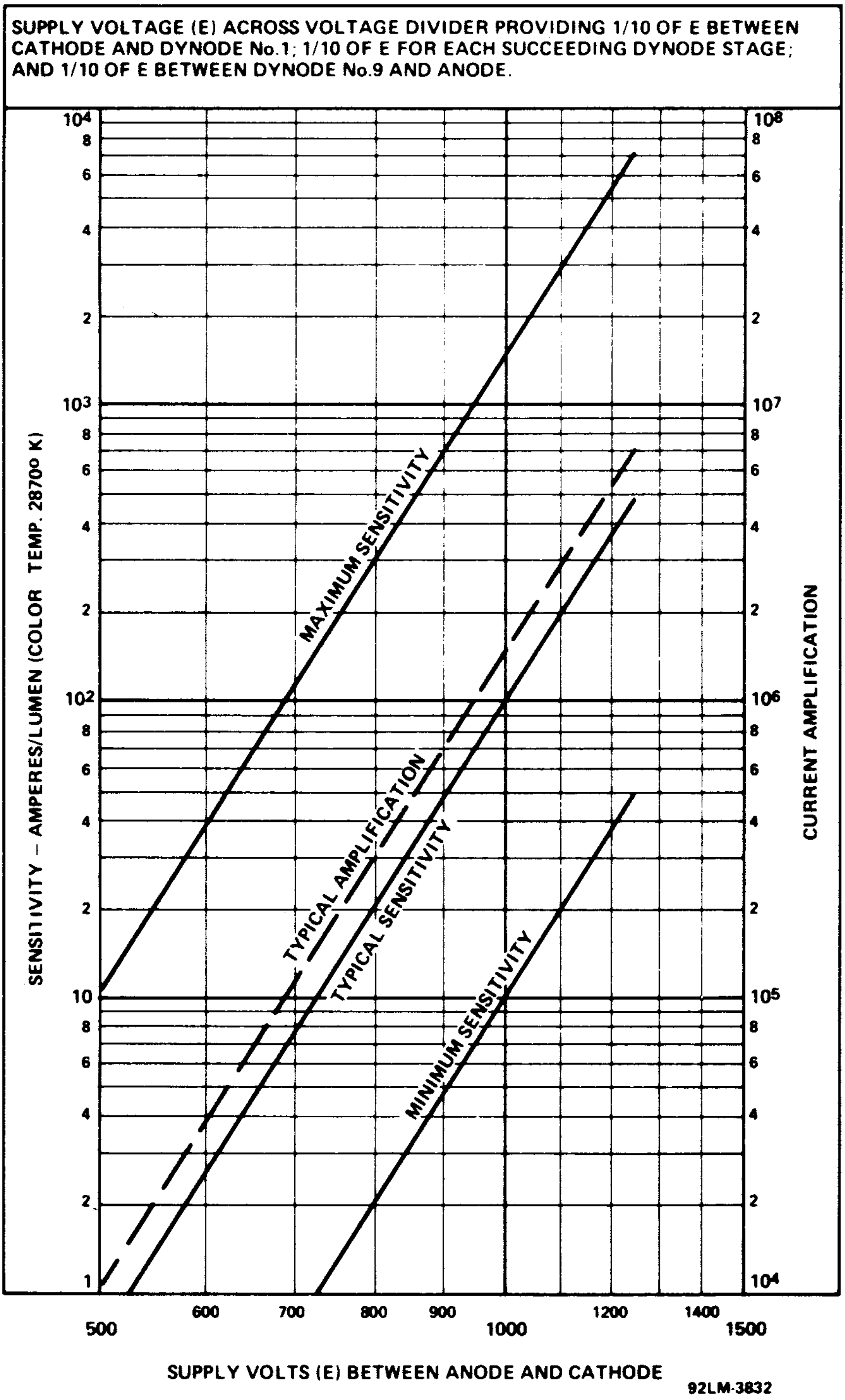


Figure 5b

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS



ENI CHARACTERISTIC AS A FUNCTION OF TUBE TEMPERATURE

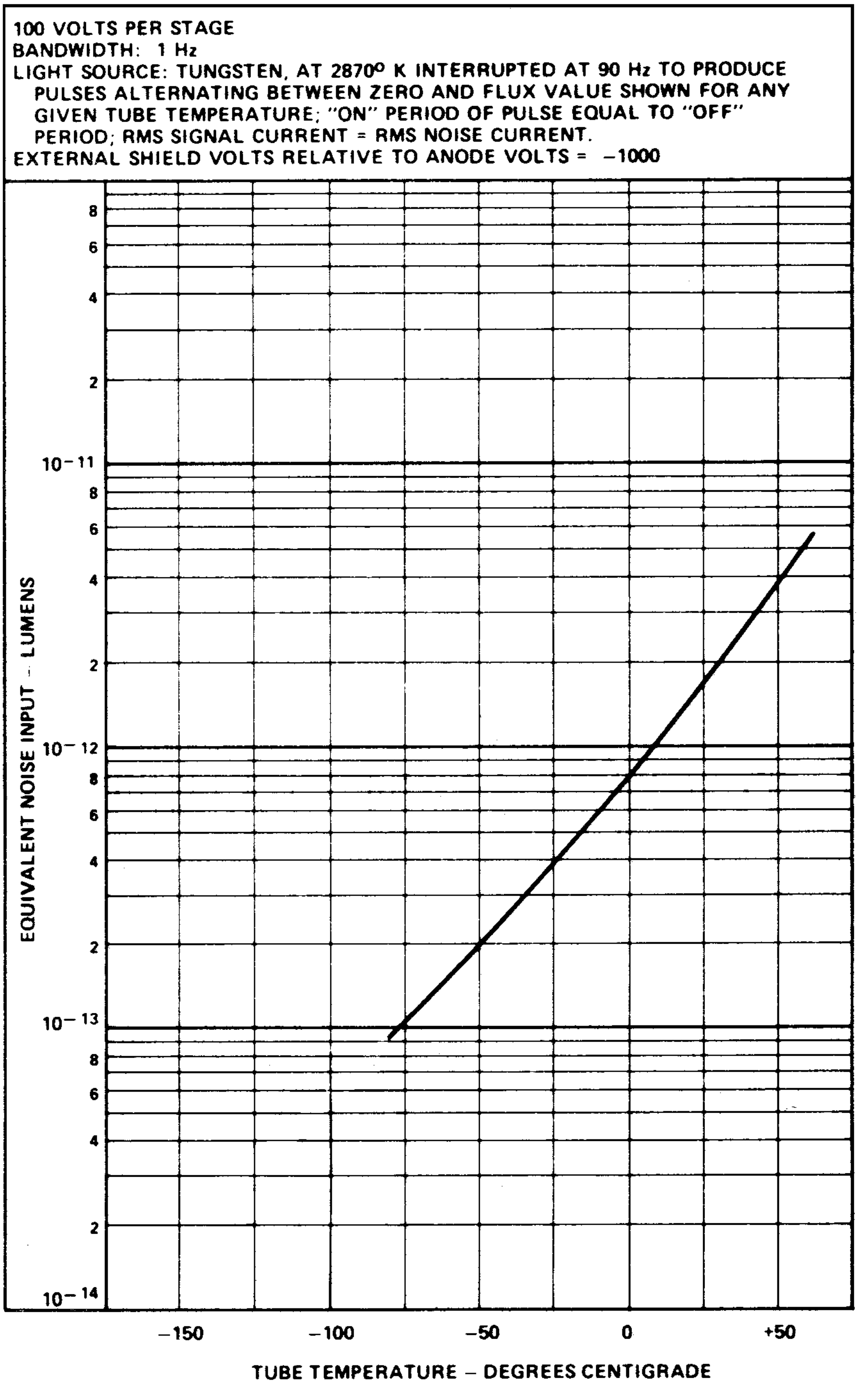


Figure 6

TYPICAL EADCI AND DARK CURRENT CHARACTERISTICS

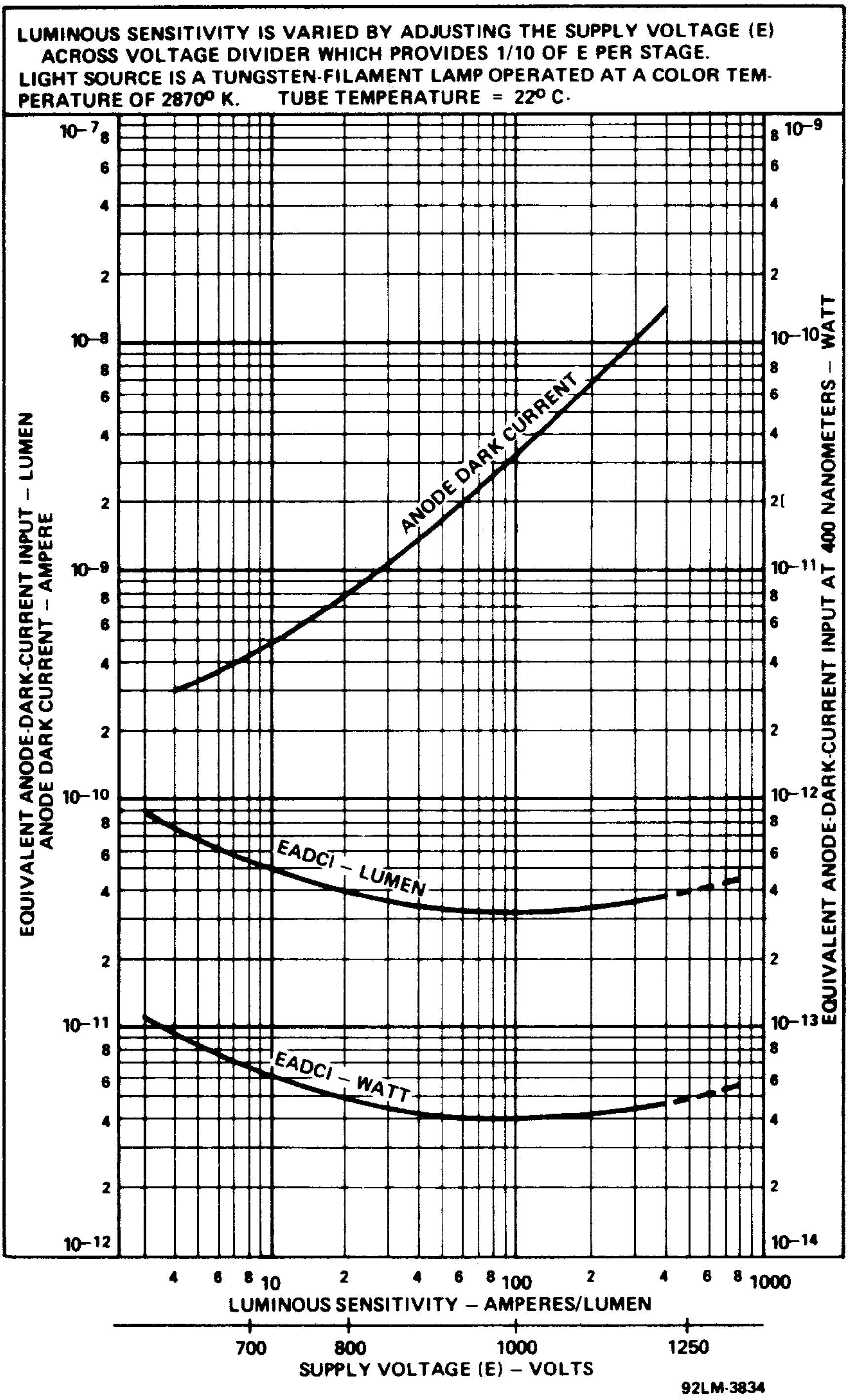


Figure 7

TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

SUPPLY VOLTAGE (E) ACROSS 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.
PHOTOCATHODE IS FULLY ILLUMINATED.
UNIFORM MAGNETIC FIELD PARALLEL TO MAJOR AXIS OF TUBE.
POSITIVE VALUES OF MAGNETIC FLUX ARE FOR LINES OF FORCE TOWARD TUBE BASE.
TUBE IS DEGAUSSED PRIOR TO TEST AND IS AGAIN DEGAUSSED BEFORE FLUX DIRECTION IS CHANGED.

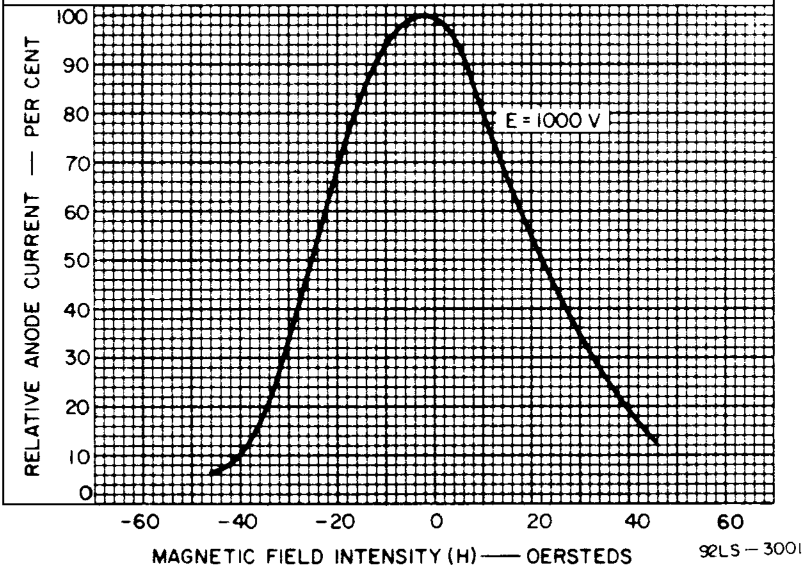


Figure 8

TYPICAL TIME-RESOLUTION CHARACTERISTICS

SUPPLY VOLTAGE (E) ACROSS 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.
PHOTOCATHODE IS FULLY ILLUMINATED.