MULTIPLIER PHOTOTUBE
9-STAGE TYPE WITH S-4 RESPONSE
For applications involving very low light levels◆
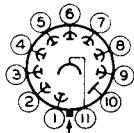
DATA

General:

Spectral Response. S-4
Wavelength of Maximum Response . . . . 4000 ± 500 angstroms
Cathode:
  Minimum Projected Length*. . . . . 15/16"
  Minimum Projected Width* . . . . 5/16"
Direct Interelectrode Capacitances:
  Anode to Dynode No.9 . . . . 4 μμf
  Anode to All Other Electrodes. . . . . 6.5 μμf
Maximum Overall Length . . . . 3-11/16"
Maximum Seated Length. . . . . 3-1/8"
Seated Length to Center of Cathode . . . . 1-15/16" ± 3/32"
Maximum Diameter . . . . 1-5/16"
Bulb T-9
Mounting Position. . . . . Any
Base . . . . Small-Shell Submagnal 11-Pin,
Non-Hygroscopic
  Basing Designation for BOTTOM VIEW 11K

Pin 1 – Dynode No.1   Pin 7 – Dynode No.7
Pin 2 – Dynode No.2   Pin 8 – Dynode No.8
Pin 3 – Dynode No.3   Pin 9 – Dynode No.9
Pin 4 – Dynode No.4   Pin 10 – Anode
Pin 5 – Dynode No.5   Pin 11 – Cathode
Pin 6 – Dynode No.6

DIRECTION OF LIGHT

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC or Peak AC)□. .   1250 max.   volts
SUPPLY VOLTAGE BETWEEN DYNODE No.9
            and ANODE (DC or Peak AC). .   250 max.   volts
PEAK ANODE CURRENT . . . .   1 max.   ma
AVERAGE ANODE CURRENT○ . . . .   0.1 max.   ma
AMBIENT TEMPERATURE. . . . .   75 max.   °C

Characteristics:
*With 100 volts per dynode stage and
100 volts between dynode No.9 and anode*●

	Min.	Av.	Max.	
Anode Dark Current#● . . .	–	–	0.1	μamp
Sensitivity:				
At 4000 Angstroms. . . .	–	74000	–	μamp/μwatt
Luminous▲.	40	80	–	amp/lumen
Current Amplification■ . .	–	2000000	–	
Equivalent Noise Input*. .	–	5×10^{-13}	–	lumen

◆ For the more usual applications, the 931-A is recommended.

⊕ The use of about 50 volts between dynode No.9 and anode will give improved operating stability without sacrifice in sensitivity as explained in note under Type 931-A.

* On plane perpendicular to indicated direction of incident light.

□, ○, #, ●, ▲, ■, ▲: See next page.   ←Indicates a change.

1P21

(RCA)

1P21

MULTIPLIER PHOTOTUBE

→ Characteristics:

*With 75 volts per dynode stage
and 50 volts between dynode No.9 and anode*

	Av.	
Sensitivity:		
At 4000 Angstroms.	11000	$\mu amp/\mu watt$
Luminous▲.	12	amp/lumen
Current Amplification■	300000	

□ Referred to cathode.

○ Averaged over any interval of 30 seconds maximum.

\# Dark current due to thermionic emission and ion feedback may be reduced by the use of refrigerants.

● For maximum signal-to-noise ratio, operation below 1000 volts is recommended.

▲ Measured under conditions specified on sheet "PHOTOTUBE SENSITIVITY and MEASUREMENTS" at the front of this Section.

■ Ratio of anode sensitivity to cathode sensitivity.

★ Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: 100 volts per stage, 25°C tube temperature, bandwidth of 1 cycle per second, tungsten light source at 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. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

OUTLINE DIMENSIONS for Type 1P21
are the same as those for Type 931-A

SPECTRAL-SENSITIVITY CHARACTERISTIC
of Phototube having S-4 Response
is shown at the front of this Section

→ Indicates a change.

RCA

IP21

AVERAGE ANODE CHARACTERISTICS
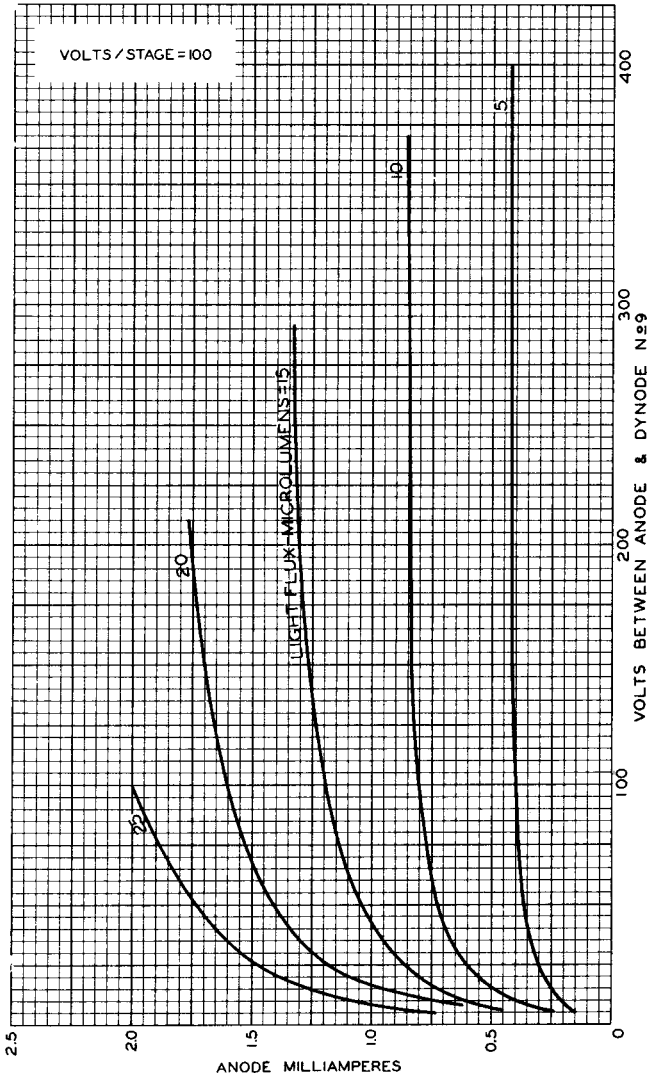
VOLTS / STAGE = 100

LIGHT FLUX-MICROLUMENS=15

VOLTS BETWEEN ANODE & DYNODE No.9

ANODE MILLIAMPERES

OCT. 26,1949 **TUBE DEPARTMENT** 92CM-6456R3
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

IP2I

®RCA

IP2I

AVERAGE CHARACTERISTICS
DC OPERATION

OCT. 26, 1949   TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY   92CL-6454R2

(RCA)
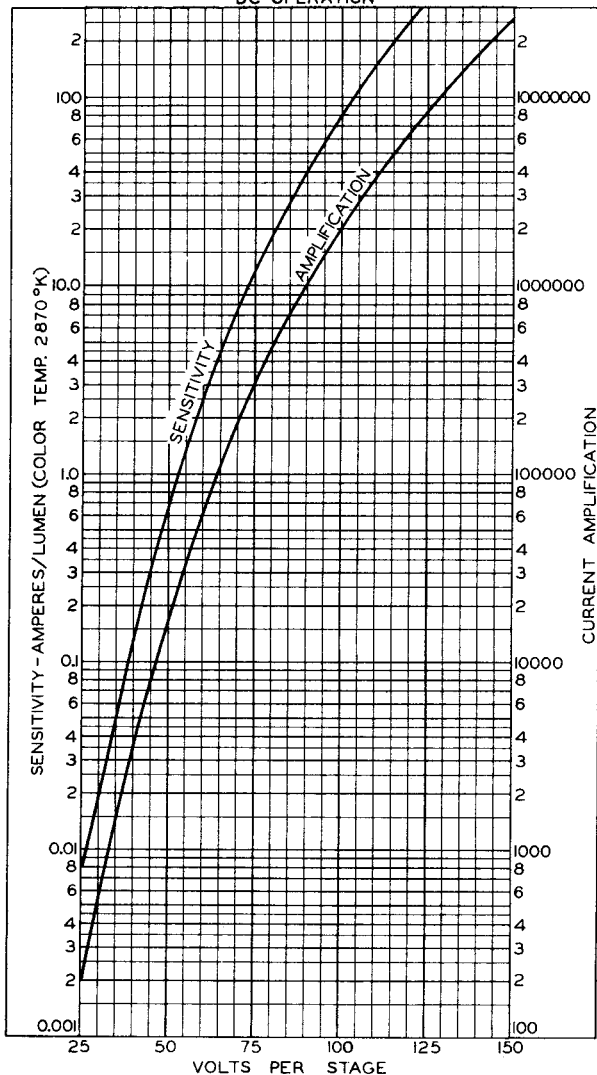
1P21

EQUIVALENT-NOISE-INPUT CHARACTERISTIC

100 VOLTS PER STAGE
BANDWIDTH: 1 CPS
LIGHT SOURCE: TUNGSTEN, AT 2870°K;
INTERRUPTED AT 90 CPS TO PRODUCE PULSES
ALTERNATING BETWEEN ZERO AND FLUX VALUE
SHOWN FOR ANY GIVEN TUBE TEMPERATURE;
"ON" PERIOD OF PULSE EQUAL TO "OFF" PERIOD;
RMS SIGNAL CURRENT ≐ RMS NOISE CURRENT.

EQUIVALENT NOISE INPUT-LUMENS

TUBE TEMPERATURE-DEGREES CENTIGRADE
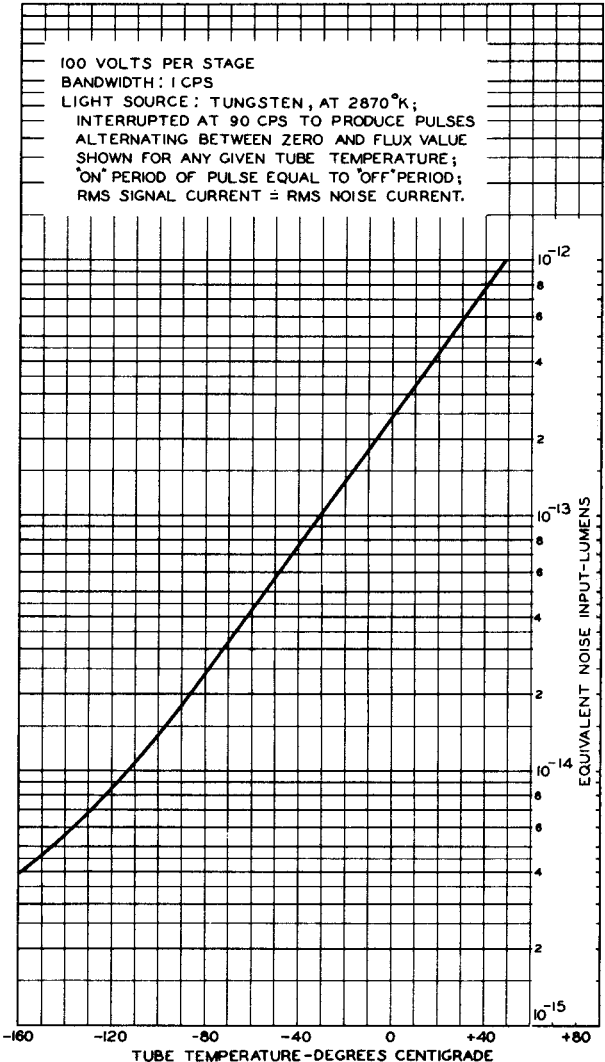
OCT. 27, 1949

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

92CM-7018R1

Photomultiplier Tube

9-Stage, Side-On Type
Having S-4 Spectral Response

GENERAL

Spectral Response S-4

Wavelength of Maximum Response. . 4000 ± 500 angstroms

Cathode, Opaque . . . . Cesium-Antimony

   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 4360 angstroms 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 . . . . 3.68 in (9.3 cm)

Seated Length . . . . 3.12 in (7.9 cm)

Maximum Diameter . . . . 1.31 in (3.3 cm)

Bulb T9

Base . . Small-Shell Submagnal 11 Pin, (JEDEC Group 2, No.B11-88), Non-hygroscopic

   Socket . . . . Amphenol[c] No.78S11T, or equivalent

Magnetic Shield . . . . . Millen[d] No.80801B, or equivalent

Operating Position . . . . Any

Weight (Approx.) . . . . 1.6 oz

ABSOLUTE-MAXIMUM RATINGS

DC or Peak AC 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] . . . . 0.1 max. mA

Ambient Temperature[g] . . . . +75 max. °C

1P21

→ CHARACTERISTICS RANGE VALUES

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.

With E = 1000 volts (Except as noted)

	Min.	Typical	Max.	
Anode Sensitivity:				
Radiant[h] at 4000 angstroms	–	1.2×10^5	–	A/W
Luminous[i] (2870° K)	40	120	800	A/lm
Cathode Sensitivity:				
Radiant[k] at 4000 angstroms	–	0.04	–	A/W
Luminous[m] (2870° K)	2×10^{-5}	4×10^{-5}	–	A/lm
Quantum Efficiency at 3800 angstroms	–	13	–	%
Current Amplification	–	3×10^6	–	
Anode Dark Current[n]	–	1×10^{-9}	1×10^{-8}	A
Equivalent Anode Dark Current Input[n]	–	5×10^{-11}	5×10^{-10}	lm
	–	4.8×10^{-14}[p]	4.8×10^{-13}[p]	W
Equivalent Noise Input[q]	–	6.7×10^{-13}	–	lm
	–	6.4×10^{-16}[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

[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 Amphenol Electronics Corporation, 1830 South 54th Avenue, Chicago 50, IL 60650.

[d] Made by James Millen Manufacturing Company, 150 Exchange Street. Malden, MA 02148.

[f] Averaged over any interval of 30 seconds maximum.

→ Indicates a change.

g Tube operation at room temperature or below is recommended.

h This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1036 lumens per watt.

i 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 1036 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 4000 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 1036 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 4000 angstroms. This value is calculated from the ENI value in lumens using a conversion factor of 1036 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.

† 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.

DIMENSIONAL OUTLINE

92CM-6264R10
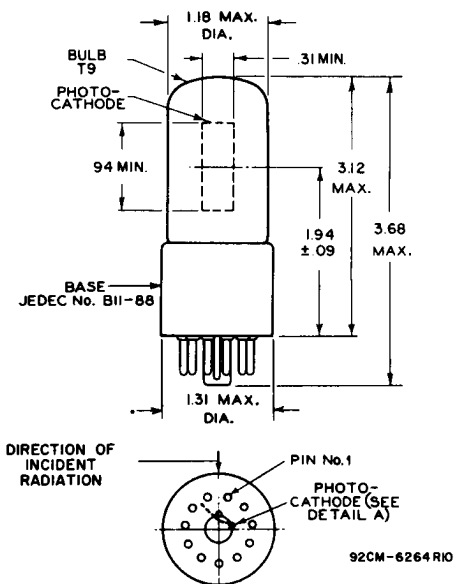
℄ of bulb will not deviate more than $2°$ in any direction from the perpendicular erected at center of bottom of base.

Dimensions are in inches unless otherwise stated. Dimensions tabulated below are in millimeters.

Inch Dimension Equivalents in Millimeters					
Inch	mm	Inch	mm	Inch	mm
.09	2.3	.31	7.9	1.31	33.2
.190	4.8	.402	10.2	1.94	49.2
.250	6.3	.94	23.8	3.12	79.2
.270	6.8	1.18	29.9	3.68	93.4

RCA Electronic Components

DATA 2

DETAIL A (Top View)
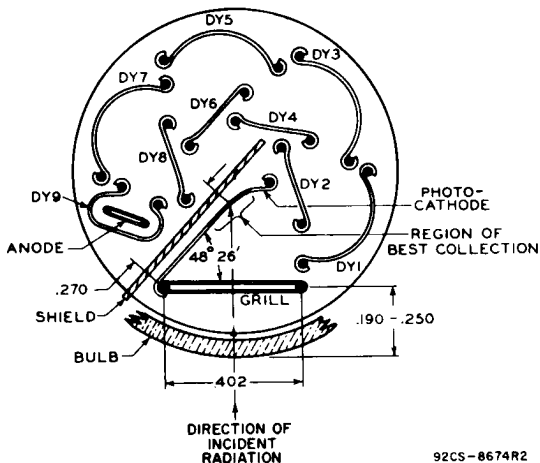
TERMINAL DIAGRAM (Bottom View)
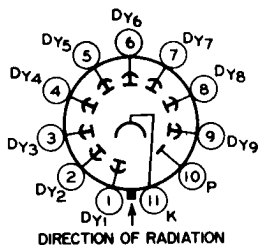
DIRECTION OF RADIATION

Pin 1: Dynode No.1   Pin 7: Dynode No.7
Pin 2: Dynode No.2   Pin 8: Dynode No.8
Pin 3: Dynode No.3   Pin 9: Dynode No.9
Pin 4: Dynode No.4   Pin 10: Anode
Pin 5: Dynode No.5   Pin 11: Photocathode
Pin 6: Dynode No.6

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT
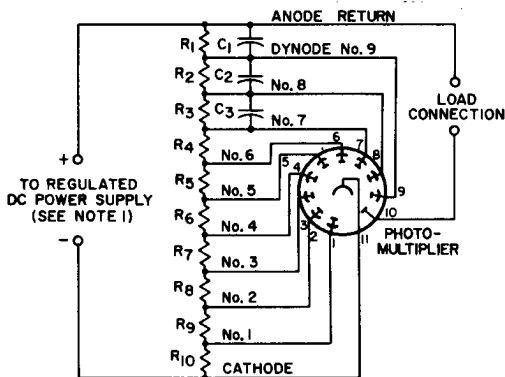
92CS-11382RI

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.

♦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 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:

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

where C is in farads

     i is the amplitude of anode current in amperes

     V is the voltage across the capacitor in volts

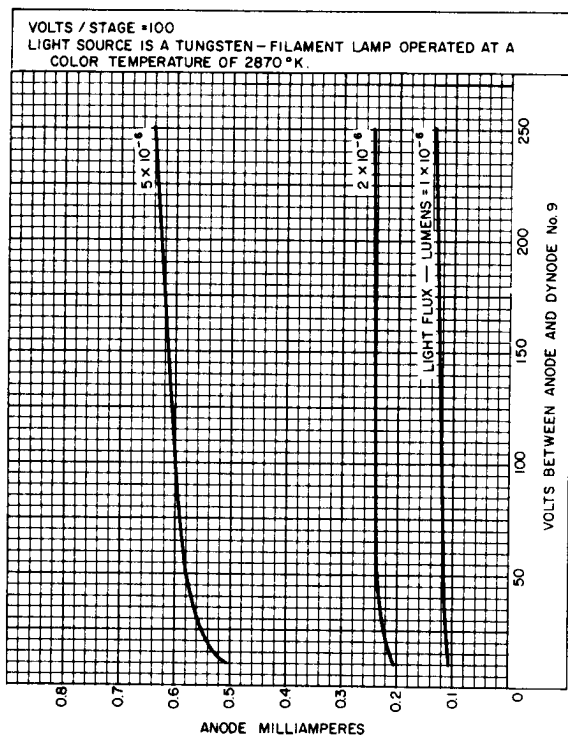and   t is the time duration of the pulse in seconds

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

RCA Electronic Components   DATA 3

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:
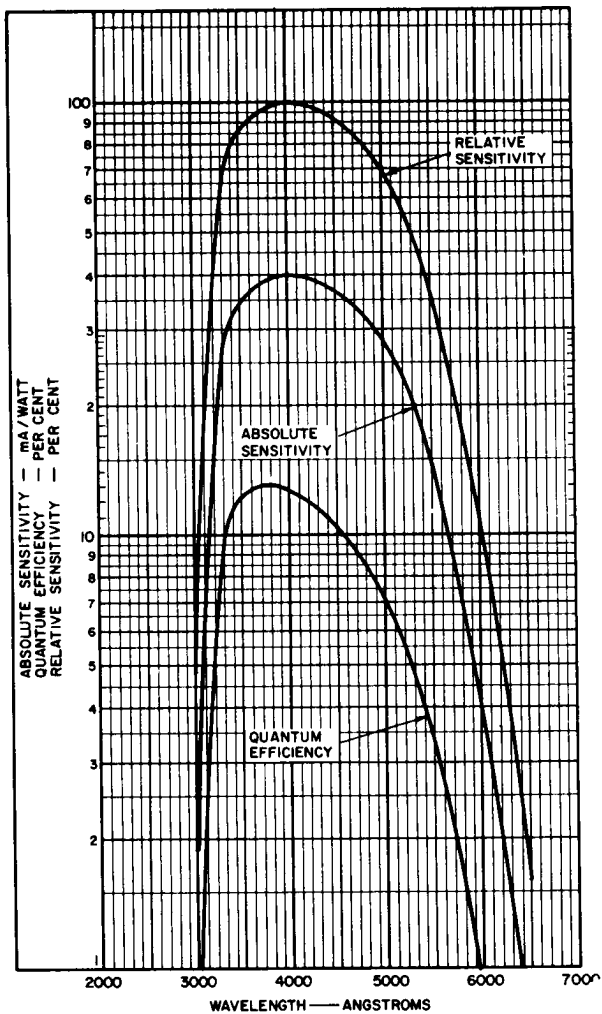
$$C = 100\,\frac{q}{V} \qquad \text{where } q = \int i(t)\,dt \text{ coulombs}$$
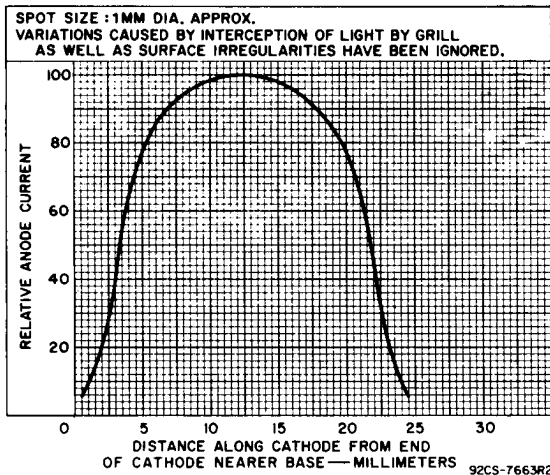
TYPICAL ANODE CHARACTERISTICS

VOLTS / STAGE =100
LIGHT SOURCE IS A TUNGSTEN – FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870 °K.

92LM – 3023

TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

WAVELENGTH —— ANGSTROMS

92LM-2998

TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ALONG TUBE LENGTH

SPOT SIZE : 1MM DIA. APPROX.
VARIATIONS CAUSED BY INTERCEPTION OF LIGHT BY GRILL AS WELL AS SURFACE IRREGULARITIES HAVE BEEN IGNORED.

RELATIVE ANODE CURRENT

DISTANCE ALONG CATHODE FROM END OF CATHODE NEARER BASE — MILLIMETERS   92CS-7663R2

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

SPOT SIZE : 1MM DIA. APPROX.
GRILL TOWARD OBSERVER, BASE DOWN.
CATHODE WIDTH PROJECTED NORMAL TO PLANE OF GRILL.

VARIATIONS CAUSED BY INTERCEPTION OF LIGHT BY GRILL AS WELL AS SURFACE IRREGULARITIES HAVE BEEN IGNORED.

RELATIVE ANODE CURRENT

DISTANCE ALONG PLANE OF GRILL FROM LEFT TO RIGHT — MILLIMETERS   92CS-7667R2

1P21
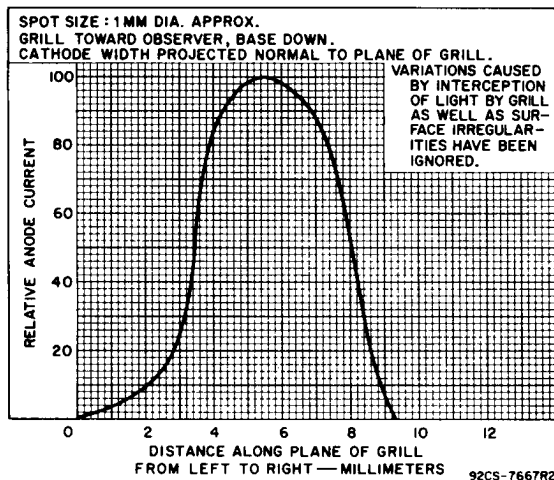
TYPICAL VARIATION OF SENSITIVITY AS TUBE IS ROTATED WITH RESPECT TO FIXED LIGHT BEAM

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE = CONSTANT
ZERO—DEGREE ROTATIONAL POSITION OF TUBE IS ESTABLISHED
BY A COLLIMATED LIGHT BEAM PERPENDICULAR TO AND
FILLING THE PLANE OF THE GRILL.
TUBE MOUNTED VERTICALLY WITH ALLOWANCE MADE FOR ROTATION
ABOUT MAJOR TUBE AXIS.
ROTATIONAL POSITION (TOP VIEW) CLOCKWISE = (−)
ROTATIONAL POSITION (TOP VIEW) COUNTERCLOCKWISE = (+)
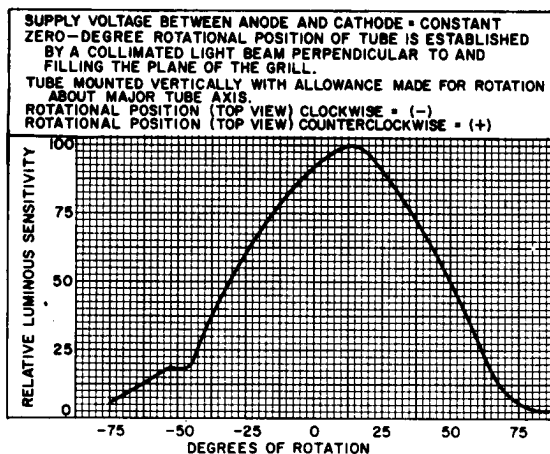
92CS−8671R2

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

ANODE SUPPLY VOLTS (E) = 1000
VOLTS PER STAGE EXCEPT FOR DYNODE-No.6 STAGE = 100

92CS−8672RI

RC/A Electronic Components

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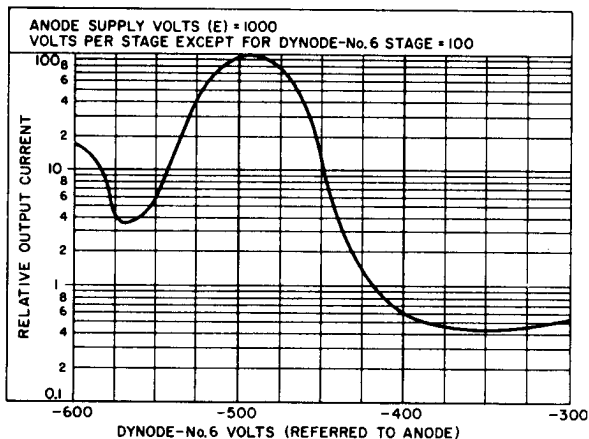
**TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A
FUNCTION OF SIMULTANEOUS MODULATION OF
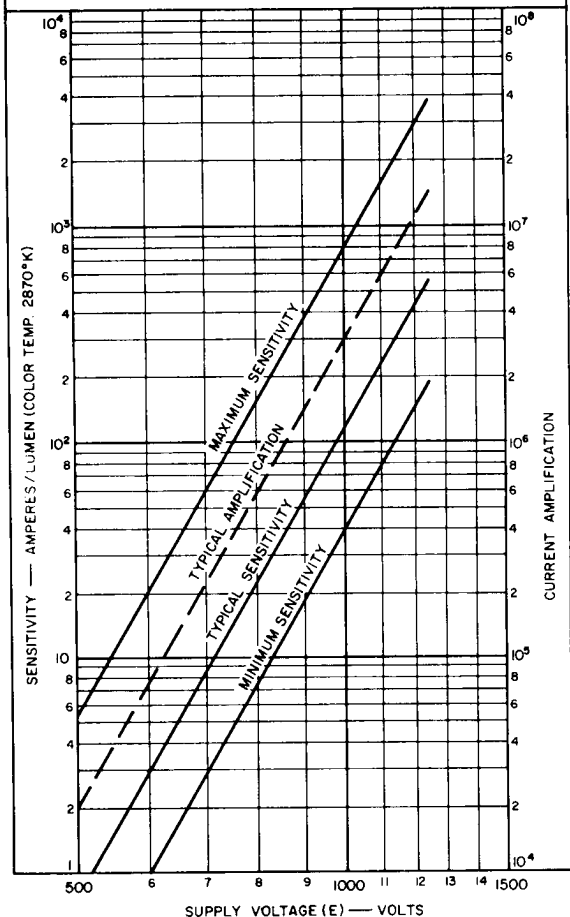DYNODES NO. 5 AND NO. 6**

ANODE – TO – DYNODE No. 9 VOLTS = 200
VOLTS PER SUCCEEDING DYNODE STAGE EXCEPT FOR DYNODES
  No. 5 AND No. 6 = 100
A CONSTANT VOLTAGE DIFFERENCE OF 100 VOLTS IS MAINTAINED
  BETWEEN DYNODES No. 5 AND No. 6 DURING MODULATION.
ANODE IS AT GROUND POTENTIAL.

RELATIVE ANODE CURRENT

DYNODE – No. 5 VOLTS (REFERRED TO ANODE)

92CM–11375

1P21
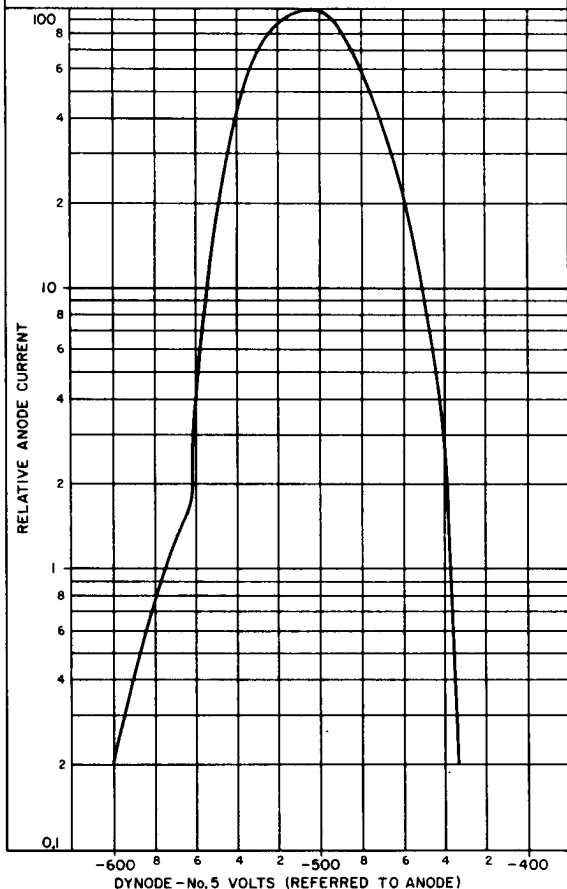
SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

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.


SENSITIVITY — AMPERES/LUMEN (COLOR TEMP. 2870°K)

CURRENT AMPLIFICATION

SUPPLY VOLTAGE (E) — VOLTS

MAXIMUM SENSITIVITY

TYPICAL AMPLIFICATION

TYPICAL SENSITIVITY

MINIMUM SENSITIVITY

92LM — 3019

TYPICAL EADCI AND DARK CURRENT CHARACTERISTICS

LUMINOUS SENSITIVITY IS VARIED BY ADJUSTING THE SUPPLY
VOLTAGE (E) ACROSS VOLTAGE DIVIDER WHICH PROVIDES 1/10
OF E PER STAGE.
LIGHT SOURCE IS A TUNGSTEN–FILAMENT LAMP OPERATED AT A
COLOR TEMPERATURE OF 2870°K.
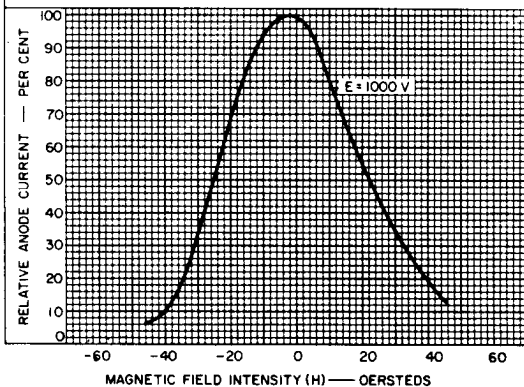TUBE TEMPERATURE = 22°C

92LM–3022

1P21
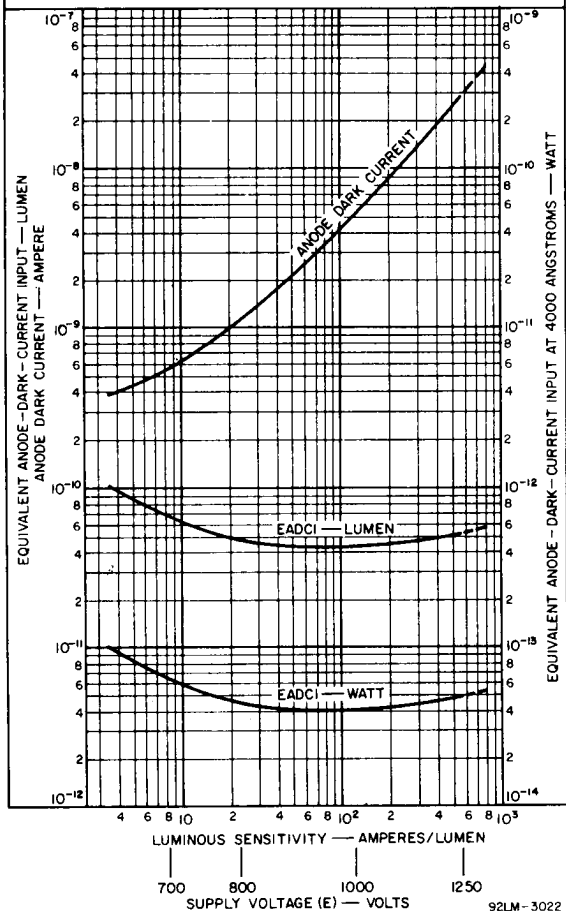
TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

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.
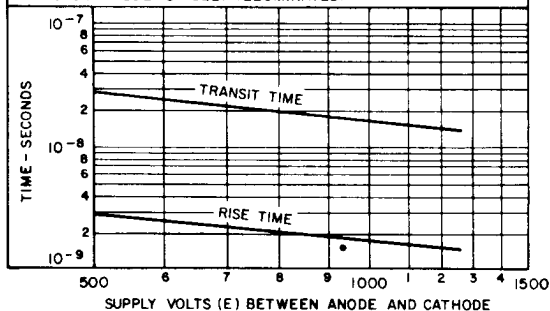POSITIVE VALUES OF MAGNETIC FLUX ARE FOR LINES OF FORCE
TOWARD TUBE BASE.
TUBE IS DEGAUSSED PRIOR TO TEST AND IS AGAIN DEGAUSSED
BEFORE FLUX DIRECTION IS CHANGED.

$E = 1000$ V

RELATIVE ANODE CURRENT — PER CENT

MAGNETIC FIELD INTENSITY (H) — OERSTEDS

92LS – 3001

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

TRANSIT TIME

RISE TIME

TIME — SECONDS

SUPPLY VOLTS (E) BETWEEN ANODE AND CATHODE

92LS – 3010