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RCA Special-Line Series of Photomultiplier Tubes

- Integral Voltage-Divider Networks
- Integral Shielding
- S-1, S-11, S-20, or Bialkali Photocathode Types

The RCA Special-Line Series of photomultiplier tubes is made up of 3/4"-, 1-1/2"-, and 2"-diameter head-on type photomultiplier tubes having integral encapsulated voltage-divider networks. Tubes in the Special Line are available in two mechanical configurations and a choice of three different voltage-divider networks.

Tubes having mechanical Configuration 1 are supplied with "potted" voltage-divider networks only, while those having Configuration 2 are supplied with "potted" voltage-divider networks and integral electrostatic and magnetic shielding.

The three available voltage-divider networks allow a choice in power-supply requirements. Voltage divider A employs high resistance values and is intended for applications requiring minimum power-supply drain. This network limits the value of average anode current that can be drawn from the tube. Divider network B has intermediate resistance values and is intended for use in most applications. Divider network C employs low resistance values and is designed for applications requiring high linear average output current capabilities.

The voltage-divider networks used by the various tube types in this line provide the recommended interstage voltage distributions of the prototype photomultiplier tubes and have capacitors across the latter stages of the tubes to insure proper operation in short pulse service. Other networks having different resistance values and tapered networks, i.e., increasing resistor values toward the output end of the tubes to reduce space-charge limited output current can also be provided on request.

Tubes in this Special Line as well as many other "potted" variants of standard line RCA photomultiplier tubes are available only on special request. Such requests should be directed to the sales offices listed on page 12 of this brochure.

RCA Prototype Photomultiplier Tube♦	RCA Special-Line Photomultiplier Tubes: Types Having Integral Voltage-Divider Networks Only	RCA Special-Line Photomultiplier Tubes: Types Having Integral Voltage-Divider Networks and Electrostatic and Magnetic Shielding
3/4"-Diameter Head-On Types		
4460	4460/1A, 1B, 1C	4460/2A, 2B, 2C
4516	4516/1A, 1B, 1C	4516/2A, 2B, 2C
7767	7767/1A, 1B, 1C	7767/2A, 2B, 2C
8644	8644/1A, 1B, 1C	8644/2A, 2B, (*)
C70102B	C70102B/1A, 1B, 1C	C70102B/2A, 2B, 2C
1-1/2"-Diameter Head-On Types		
4438	4438/1A, 1B, 1C	4438/2A, 2B, 2C
4517	4517/1A, 1B, 1C	4517/2A, 2B, 2C
6199	6199/1A, 1B, 1C	6199/2A, 2B, 2C
7102	7102/1A, 1B, 1C	7102/2A, 2B, 2C
2"-Diameter Head-On Types		
4459	4459/1A, 1B, 1C	4459/2A, 2B, 2C
4518	4518/1A, 1B, 1C	4518/2A, 2B, 2C
6342A	6342A/1A, 1B, 1C	6342A/2A, 2B, 2C
6655A	6655A/1A, 1B, 1C	6655A/2A, 2B, 2C
6810A	6810A/1A, 1B, 1C	–
7265	7265/1A, 1B, 1C	–
7326	7326/1A, 1B, 1C	–
7850	7850/1A, 1B, 1C	7850/2A, 2B, 2C
C70007A	C70007A/1A, 1B, 1C	C70007A/2A, 2B, 2C

*Type 8645 is available having an integral voltage-divider network and electrostatic and magnetic shielding.

♦Type numbers with prefix C are developmental types. Each of these C numbers identifies a particular laboratory tube design but the number and the identifying data are subject to change. No obligations are assumed as to future manufacture unless otherwise arranged.

RCA Electronic Components

PIT-705A *Supersedes PIT-705 8-66*

Printed in U.S.A. | 8-68

Ratings and Characteristics

Commercial or Developmental Type	Spectral Response	Wavelength of Max. Response[a] Angstroms	Window Material[b]	Window Shape	Photocathode Material	Dynodes Secondary-Emitting Surface	Dynodes Structure
3/4"-Diameter Head-On Types							
4460/[f]	S-11	4400	0080	Plano-Concave	Cs-Sb	Be-O	In-Line
4516/	(i)	4000	0080	Plano-Concave	Cs-K-Sb	Be-O	In-Line
7767/	S-11	4400	0080	Plano-Concave	Cs-Sb	Be-O	In-Line
8644/	S-20	4200	7056	Plano-Concave	K-Na-Cs-Sb	Be-O	In-Line
C70102B/[f]	S-1	8000	0080	Plano-Concave	Ag-O-Cs	Be-O	In-Line
1-1/2"-Diameter Head-On Types							
4438/	S-11	4400	0080	Plano-Plano	Cs-Sb	Cs-Sb	Circular-Cage
4517/	(i)	4000	0080	Plano-Plano	Cs-K-Sb	Be-O	Circular-Cage
6199/	S-11	4400	0080	Plano-Plano	Cs-Sb	Cs-Sb	Circular-Cage
7102/	S-1	8000	0080	Plano-Plano	Ag-O-Cs	Be-O	Circular-Cage
2"-Diameter Head-On Types							
4459/	S-20	4200	7056	Spherical-Section	K-Na-Cs-Sb	Be-O	In-Line
4518/	(i)	4000	0080	Plano-Concave	Cs-K-Sb	Be-O	Circular-Cage
6342A/	S-11	4400	0080	Plano-Concave	Cs-Sb	Be-O	Circular-Cage
6655A/	S-11	4400	0080	Plano-Concave	Cs-Sb	Cs-Sb	Circular-Cage
6810A/	S-11	4400	0080	Plano-Concave	Cs-Sb	Be-O	In-Line
7265/	S-20	4200	0080	Plano-Concave	K-Na-Cs-Sb	Be-O	In-Line
7326/	S-20	4200	0080	Plano-Concave	K-Na-Cs-Sb	Be-O	In-Line
7850/	S-11	4400	0080	Spherical-Section	Cs-Sb	Be-O	In-Line
C70007A/	S-1	8000	0080	Spherical-Section	Ag-O-Cs	Be-O	In-Line

[a] Measured in amperes/watt.

[b] 0080 = Corning Lime Glass
7056 = Corning Borosilicate Glass, or equivalent materials.

[c] Operation at room temperature or below is recommended. The specified range applies for tube types having Configuration 2, but only applies to the "potted" portion of tubes having Configuration 1. The ambient temperature range of the "unpotted" portion of tubes having Configuration 1 is specified for the prototype tubes in their respective data sheets.

[d] At wavelength of maximum response.

[e] Light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2870° K.

[f] A "ruggedized" type.

[g] With the following cathode-to-anode voltage distribution; 1.2, 1.2, 1.7, 1, 1, 1, 1, 1, 1, 1, and 1.

[h] With supply voltage adjusted to give a luminous sensitivity of 7.5 amperes/lumen.

[i] Bialkali photocathode type.

[k] With supply voltage adjusted to give a luminous sensitivity of 7 amperes/lumen.

[m] With supply voltage adjusted to give a luminous sensitivity of 30 amperes/lumen.

Maximum Ratings		Typical Characteristics at Specified Voltage and 22° C							
			Sensitivity						
			Radiant[d]		Luminous[e]				
Power Supply Voltage Volts	Ambient Temp.[c] °C	Power Supply Voltage Volts	Cathode A/W	Anode A/W	Cathode A/lm	Anode A/lm	Current Amplification	EADCI lm	ENI lm
1500	−40 to +55	1250[g]	0.048	6×10^{3}	6×10^{-5}	7.5	1.25×10^{5}	8×10^{-10}[h]	3×10^{-12}
1800		1500[g]	0.079	3.2×10^{4}	6.7×10^{-5}	27	4×10^{5}	2.9×10^{-11}[k]	–
1500		1250[g]	0.048	1.28×10^{4}	6×10^{-5}	16	2.67×10^{5}	5×10^{-10}[h]	3×10^{-12}
2100		1500[g]	0.064	5.1×10^{3}	1.5×10^{-4}	12	8×10^{4}	4×10^{-11}[m]	2.5×10^{-12}
1500		1250[g]	0.0028	3.1×10^{2}	3×10^{-5}	3.3	1.1×10^{5}	2×10^{-7}[n]	1.2×10^{-10}
1250	−40 to +55	1000[p]	0.036	2.2×10^{4}	4.5×10^{-5}	27	6×10^{5}	8×10^{-10}[q]	4×10^{-12}
1800		1500[p]	0.079	3.9×10^{4}	6.7×10^{-5}	33	5×10^{5}	4.3×10^{-11}[k]	–
1250		1000[p]	0.036	3.6×10^{4}	4.5×10^{-5}	45	1×10^{6}	2.3×10^{-10}[q]	4×10^{-12}
1500		1250[p]	0.0027	4.2×10^{2}	3×10^{-5}	4.5	1.5×10^{5}	4.3×10^{-7}[n]	3×10^{-11}
2800	−40 to +55	1800[r]	0.064	4.3×10^{4}	1.5×10^{-4}	100	6.6×10^{5}	1×10^{-10}[s]	1.1×10^{-12}
2000		1500[t]	0.079	3.9×10^{4}	6.7×10^{-5}	33	5×10^{5}	3×10^{-11}[k]	–
1500		1250[t]	0.064	2.5×10^{4}	8×10^{-5}	31	3.9×10^{5}	2×10^{-10}[q]	7×10^{-12}
1250		1000[t]	0.061	9.6×10^{4}	7.6×10^{-5}	120	1.6×10^{6}	3×10^{-10}[q]	8×10^{-13}
2400		2000[u]	0.056	2.4×10^{6}	7×10^{-5}	3000	4.3×10^{7}	5×10^{-10}[v]	3.3×10^{-12}
3000		2400[u]	0.073	3×10^{6}	1.7×10^{-4}	7200	4.2×10^{7}	5×10^{-11}[w]	5.5×10^{-13}
2400		1800[x]	0.064	3.8×10^{4}	1.5×10^{-4}	88	5.9×10^{5}	1.5×10^{-10}[q]	1.1×10^{-12}
2600		2300[r]	0.056	2.1×10^{7}	7×10^{-5}	2.6×10^{4}	3.7×10^{8}	4×10^{-10}[y]	2×10^{-12}
2000		1250[r]	0.0028	9.4×10^{2}	3×10^{-5}	10	3.3×10^{5}	1×10^{-7}[n]	1.6×10^{-10}

[n] With supply voltage adjusted to give a luminous sensitivity of 4 amperes/lumen.

[p] With the following cathode-to-anode voltage distribution: 1.7, 1.3, 1.3, 1, 1, 1, 1, 1, 1, 1, and 1.

[q] With supply voltage adjusted to give a luminous sensitivity of 20 amperes/lumen.

[r] With the following cathode-to-anode voltage distribution; 2, 1.4, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, and 1.

[s] With supply voltage adjusted to give a luminous sensitivity of 300 amperes/lumen.

[t] With the following cathode-to-anode voltage distribution; 1.8, 1.4, 1.5, 1.2, 1, 1, 1, 1, 1, 1, and 1.

[u] With the following cathode-to-anode voltage distribution; 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1.25, 1.5, 1.75, and 2.

[v] With supply voltage adjusted to give a luminous sensitivity of 2000 amperes/lumen.

[w] With supply voltage adjusted to give a luminous sensitivity of 1000 amperes/lumen.

[x] Supply voltage (E) is across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode. If focusing electrode is employed, it may be connected to dynode-No.1 potential.

[y] With supply voltage adjusted to give a luminous sensitivity of 6000 amperes/lumen.

RCA Tube Types	Maximum Tube Dimensions – Inches				
	Configuration 1			Configuration 2	
	Dimension			Dimension	
	W	X	Y	W	Y
3/4"-Diameter Head-On Types					
4460/	0.78	2.8	4.2	0.95	4.2
4516/	0.78	3.4	4.8	0.95	4.8
7767/	0.78	3.4	4.8	0.95	4.8
8644/	0.78	3.4	4.8	0.95	4.8
C70102B/	0.78	2.8	4.2	0.95	4.2
1-1/2"-Diameter Head-On Types					
4438/	1.56	3.4	5.1	1.75	5.1
4517/	1.56	3.4	5.1	1.75	5.1
6199/	1.56	3.4	5.1	1.75	5.1
7102/	1.56	3.4	5.1	1.75	5.1
2"-Diameter Head-On Types					
4459/	2.06	4.4	6.4	2.25	6.5
4518/	2.06	4.5	6.5	2.25	6.5
6342A/	2.06	4.5	6.5	2.25	6.5
6655A/	2.06	4.5	6.5	2.25	6.5
6810A/	2.38	5.6	8.0	–	–
7265/	2.38	5.6	8.0	–	–
7326/	2.38	4.7	7.2	–	–
7850/	2.06	4.4	6.4	2.25	6.5
C70007A/	2.06	4.4	6.4	2.25	6.5

Voltage-Divider Network Data

Tube Types	Number of Stages	Typical Power Supply Voltage Volts	Voltage-Divider Network			
			Resistors See Page 8	A* Interstage Resistor Value MΩ±5%	B* Interstage Resistor Value MΩ±5%	C* Interstage Resistor Value MΩ±5%

3/4"-Diameter Head-On Types

Tube Types	Number of Stages	Typical Power Supply Voltage Volts	Resistors	A	B	C
4460/	10	1250	R_1-R_2	6.2	1.2	0.12
			R_3	9.1	1.8	0.18
			R_4-R_{11}	5.1	1	0.10
4516/	10	1500	R_1-R_2	7.5	1.5	0.15
			R_3	11	2.2	0.22
			R_4-R_{11}	6.2	1.2	0.12
7767/	10	1250	R_1-R_2	6.2	1.2	0.12
			R_3	9.1	1.8	0.18
			R_4-R_{11}	5.1	1	0.10
8644/	10	1500	R_1-R_2	7.5	1.5	0.15
			R_3	11	2.2	0.22
			R_4-R_{11}	6.2	1.2	0.12
C70102B/	10	1250	R_1 - R_2	6.2	1.2	0.12
			R_3	9.1	1.8	0.18
			R_4-R_{11}	5.1	1	0.10

1-1/2"-Diameter Head-On Types

Tube Types	Number of Stages	Typical Power Supply Voltage Volts	Resistors	A	B	C
4438/	10	1000	R_1	6.8	1.3	0.13
			R_2	5.1	1.1	0.11
			R_3	5.1	1.1	0.11
			R_4-R_{11}	3.9	0.82	0.082

*Divider network current is approximately 20 μA for network A, 100 μA for network B, and 1000 μA for network C with the typical power supply voltage for the particular tube type applied. The voltage-divider current should be at least 10 times greater than the maximum average anode current to provide linear variation of anode current with respect to light input.

Voltage-Divider Network Data

Tube Types	Number of Stages	Typical Power Supply Voltage Volts	Voltage-Divider Network			
			Resistors See Page 8	A* Interstage Resistor Value MΩ ± 5%	B* Interstage Resistor Value MΩ ± 5%	C* Interstage Resistor Value MΩ ± 5%

1-1/2"-Diameter Head-On Types (Continued)

4517/	10	1500	R_1	10	2	0.20
			R_2	7.5	1.6	0.16
			R_3	7.5	1.6	0.16
			R_4-R_{11}	6.2	1.2	0.12
6199/	10	1000	R_1	6.8	1.3	0.13
			R_2	5.1	1.1	0.11
			R_3	5.1	1.1	0.11
			R_4-R_{11}	3.9	0.82	0.082
7102/	10	1250	R_1	9.1	1.8	0.18
			R_2	6.8	1.3	0.13
			R_3	6.8	1.3	0.13
			R_4-R_{11}	5.1	1	0.10

2"-Diameter Head-On Types

4459/	12	1800	R_1	12	2.4	0.24
			R_2	8.2	1.8	0.18
			R_3-R_{13}	6.2	1.2	0.12
4518/	10	1500	R_1	10	2	0.20
			R_2	8.2	1.6	0.16
			R_3	9.1	1.8	0.18
			R_4	6.8	1.3	0.13
			R_5-R_{11}	5.6	1.2	0.12
6342A/	10	1250	R_1	9.1	1.8	0.18
			R_2	6.8	1.3	0.13
			R_3	7.5	1.5	0.15
			R_4	5.6	1.1	0.11
			R_5-R_{11}	4.7	1	0.10

*Divider network current is approximately 20 μA for network A, 100 μA for network B, and 1000 μA for network C with the typical power supply voltage for the particular tube type applied. The voltage-divider current should be at least 10 times greater than the maximum average anode current to provide linear variation of anode current with respect to light input.

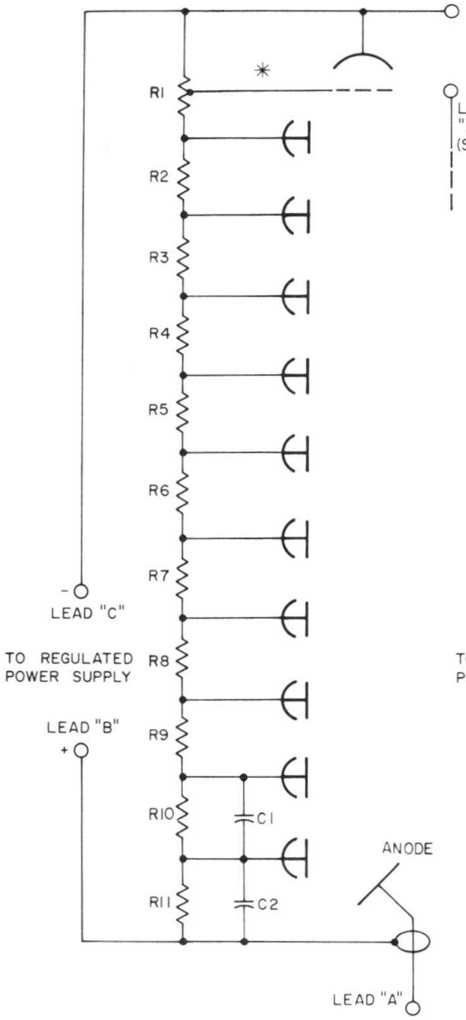
Voltage-Divider Network Data

Tube Types	Number of Stages	Typical Power Supply Voltage Volts	Voltage-Divider Network			
			Resistors See Page 8	A* Interstage Resistor Value MΩ ± 5%	B* Interstage Resistor Value MΩ ± 5%	C* Interstage Resistor Value MΩ ± 5%
2"-Diameter Head-On Types (Continued)						
6655A/	10	1000	R_1	6.8	1.3	0.13
			R_2	5.1	1.1	0.11
			R_3	5.6	1.2	0.12
			R_4	4.7	0.91	0.091
			R_5 - R_{11}	3.9	0.75	0.075
6810A/	14	2000	R_1	11	2.2	0.22
			R_2 - R_{11}	5.6	1.1	0.11
			R_{12}	6.8	1.3	0.13
			R_{13}	8.2	1.6	0.16
			R_{14}	9.1	2	0.20
			R_{15}	11	2.2	0.22
7265/	14	2400	R_1	13	2.7	0.27
			R_2 - R_{11}	6.2	1.3	0.13
			R_{12}	8.2	1.6	0.16
			R_{13}	10	2	0.20
			R_{14}	11	2.2	0.22
			R_{15}	13	2.7	0.27
7326/	10	1800	R_1	15	3	0.30
			R_2 - R_{11}	7.5	1.5	0.15
7850/	12	2300	R_1	16	3.3	0.33
			R_2	11	2.2	0.22
			R_3 - R_{13}	8.2	1.6	0.16
C70007A/	12	1250	R_1	9.1	1.8	0.18
			R_2	6.2	1.2	0.12
			R_3 - R_{13}	4.3	0.82	0.082

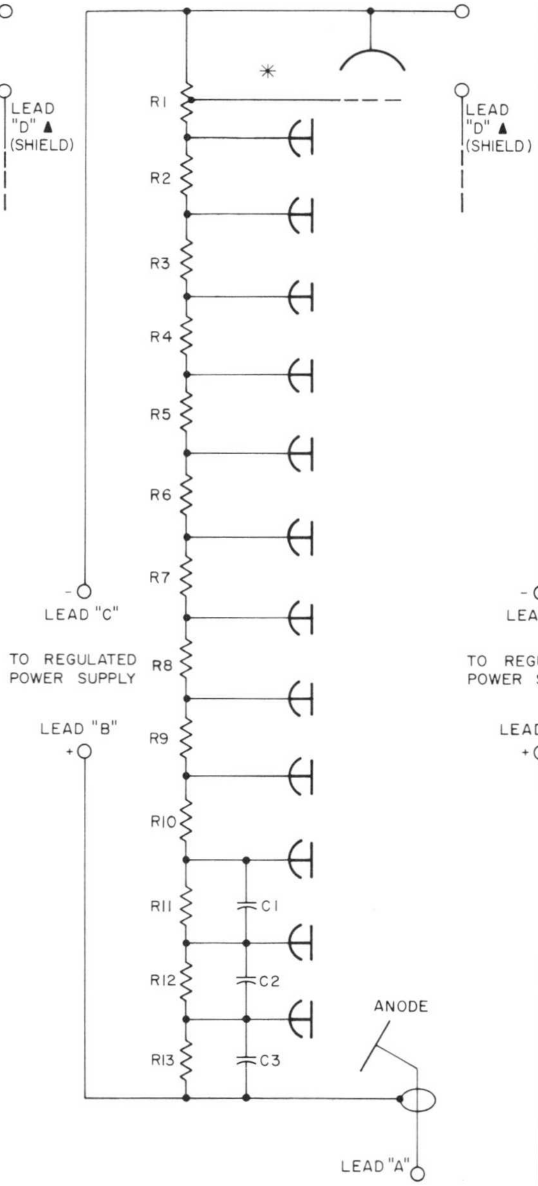
*Divider network current is approximately 20 μA for network A, 100 μA for network B, and 1000 μA for network C with the typical power supply voltage for the particular tube type applied. The voltage-divider current should be at least 10 times greater than the maximum average anode current to provide linear variation of anode current with respect to light input.

Schematic Arrangements

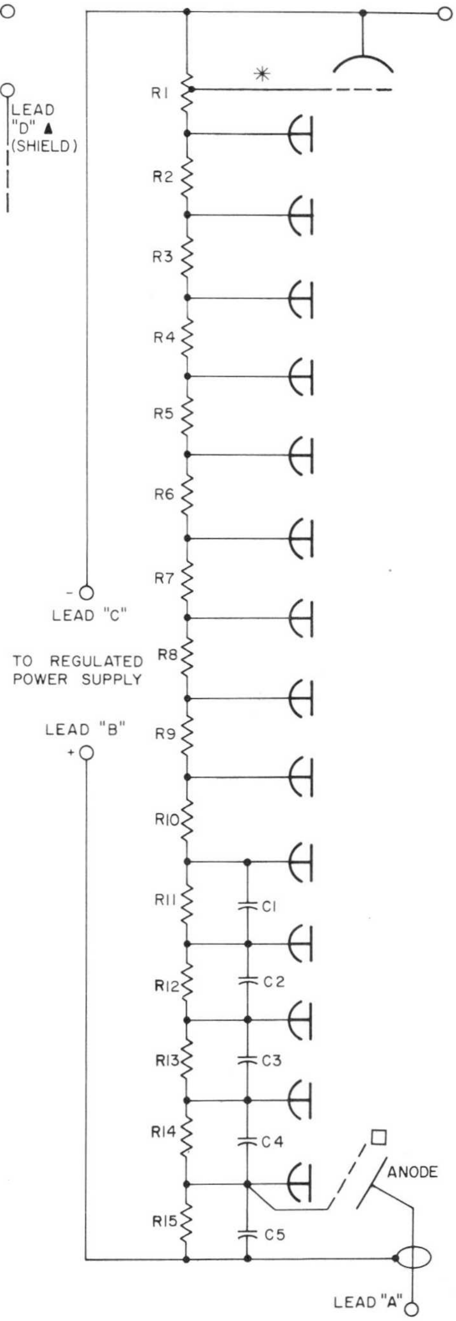
10-Stage Types



12-Stage Types



14-Stage Types



92LL-1595R1

C_1: 200 pF ± 20%, 500 V
C_2: 750 pF ± 20%, 500 V

C_1: 200 pF ± 20%, 500 V
C_2: 750 pF ± 20%, 500 V
C_3: 3000 pF ± 20%, 500 V

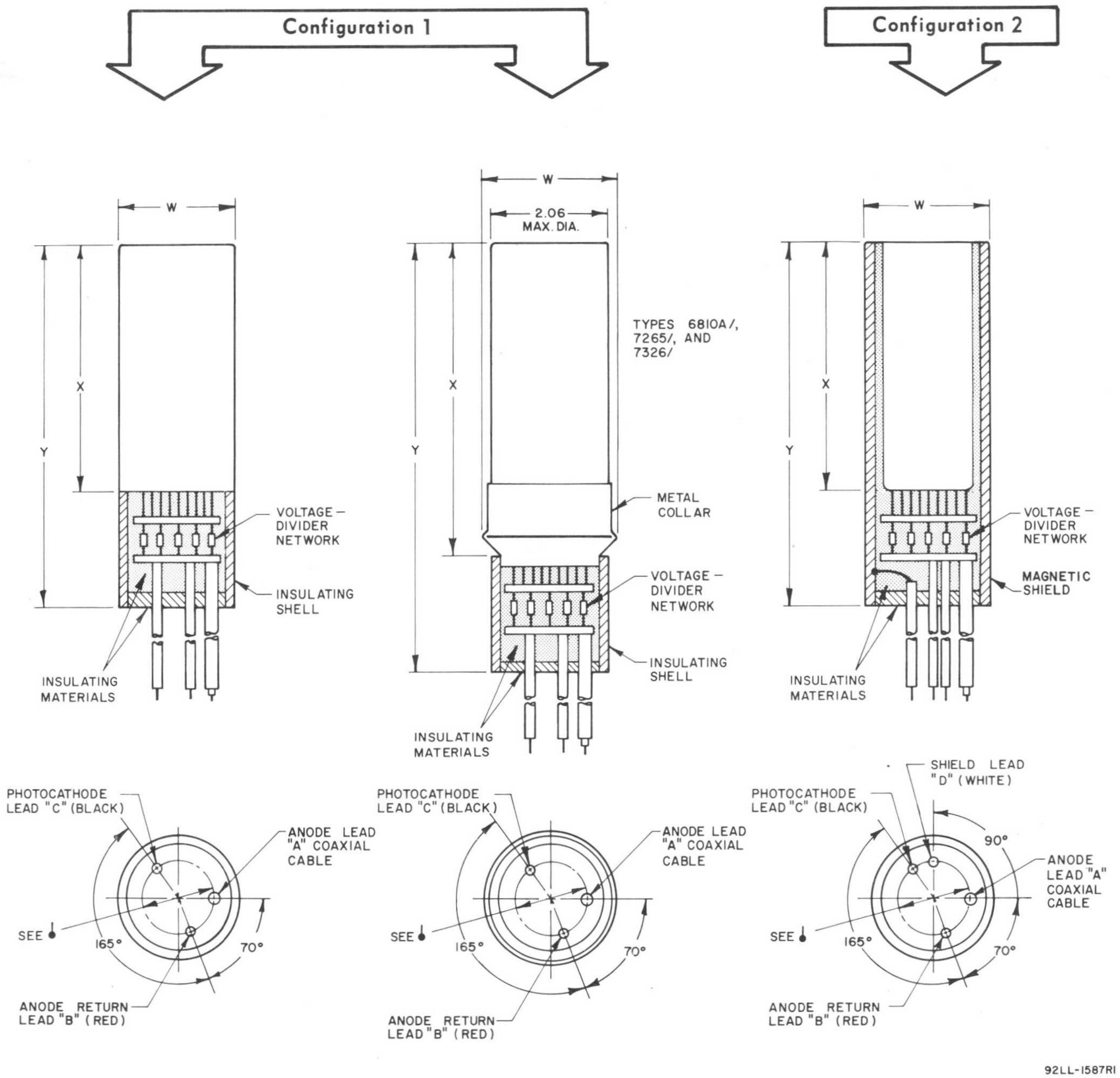
C_1: 200 pF ± 20%, 1 kV
C_2: 0.001 μF ± 20%, 1 kV
C_3: 0.002 μF ± 20%, 1 kV
C_4: 0.005 μF ± 20%, 1 kV
C_5: 0.02 μF ± 20%, 1 kV

*Focusing electrode, if employed, is internally set at that potential between cathode and dynode No.1 which provides maximum anode current.

▲Shielding, if employed, should be externally connected to cathode potential.

□Accelerating electrode, if employed, is internally connected to the final dynode.

Dimensional Outlines



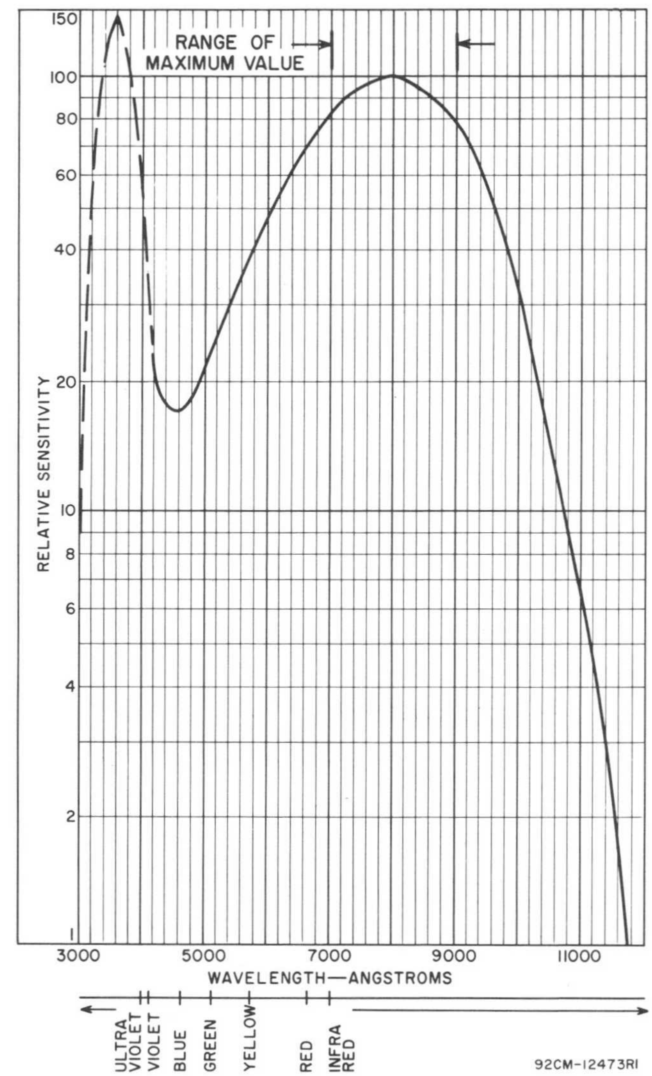
Lead Description For All Types

Anode Lead "A"	Anode Return Lead "B"	Photocathode Lead "C"	Shield Lead "D"
Coaxial Cable RG 195/U	(Red)	(Black)	(White)
	No.24 AWG (19 Strands of No.36 Wire, Insulated)	No.24 AWG (19 Strands of No.36 Wire, Insulated)	No.24 AWG (19 Strands of No.36 Wire, Insulated)

♦The lead-circle diameter for 3/4"-diameter tube types is 0.5"; for 1-1/2"-diameter tube types, 1.0"; and for 2"-diameter tube types, 1.25".

Lead length for all tube types is a minimum of 24".

Typical S-1 Spectral Response



The dashed portion shown in the above curve of the spectral response is not controlled.

Figure 1

Typical S-11 Spectral Response

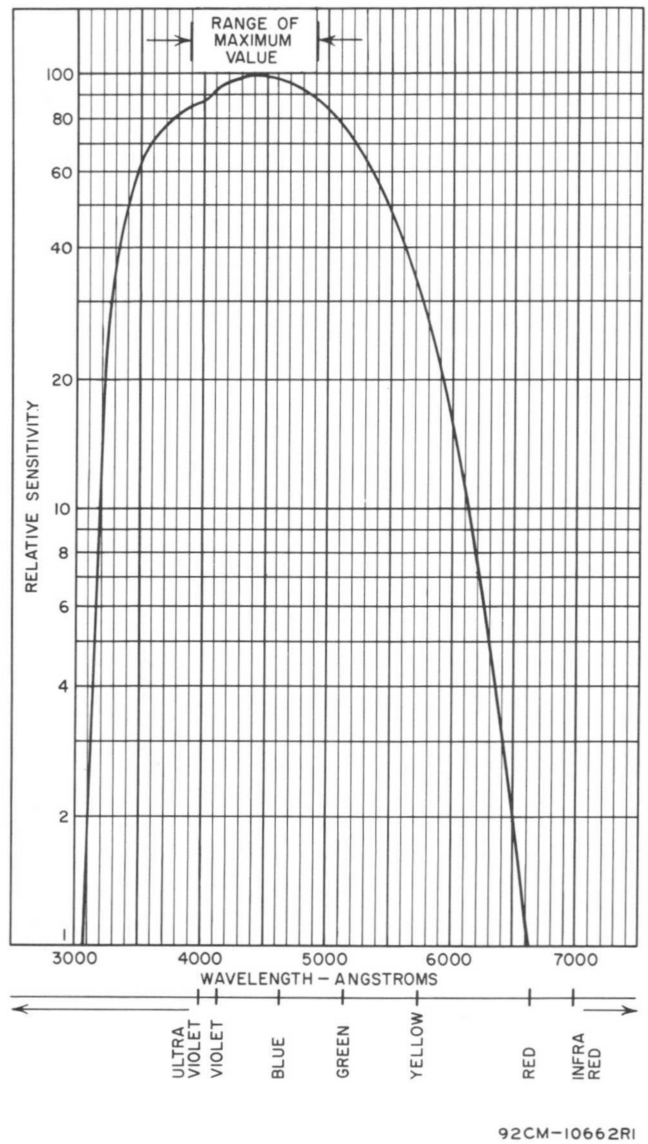


Figure 2

Typical S-20 Spectral Response

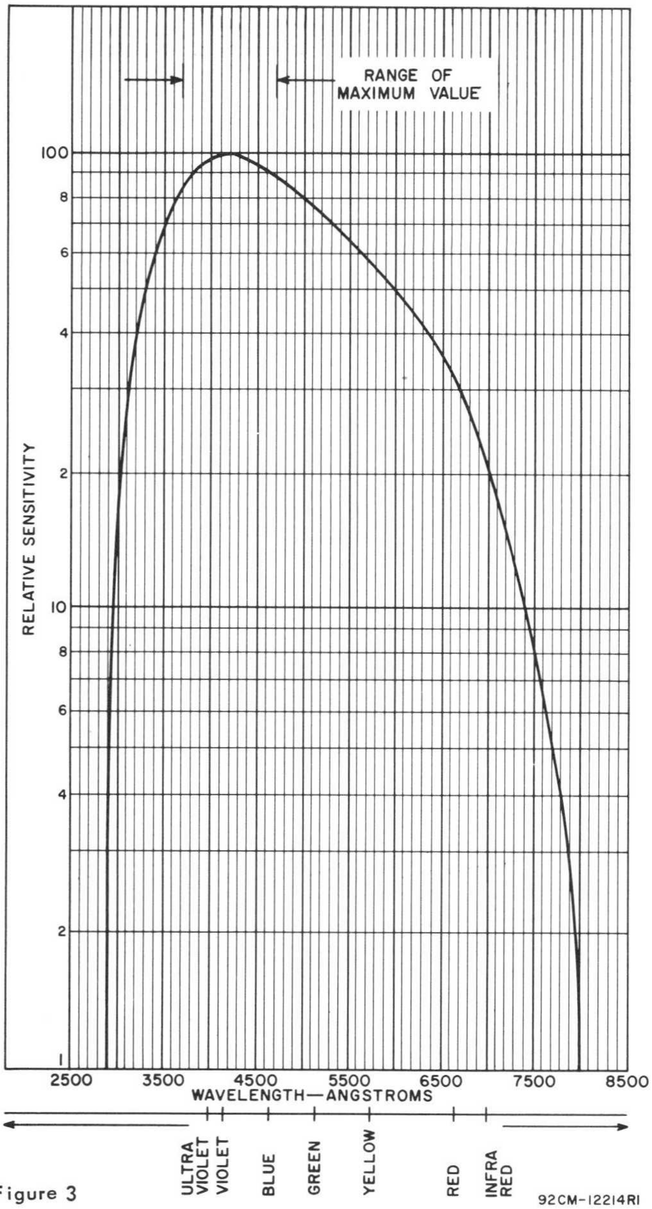


Figure 3

Typical Spectral Response of Tubes Having a Bialkali Photocathode

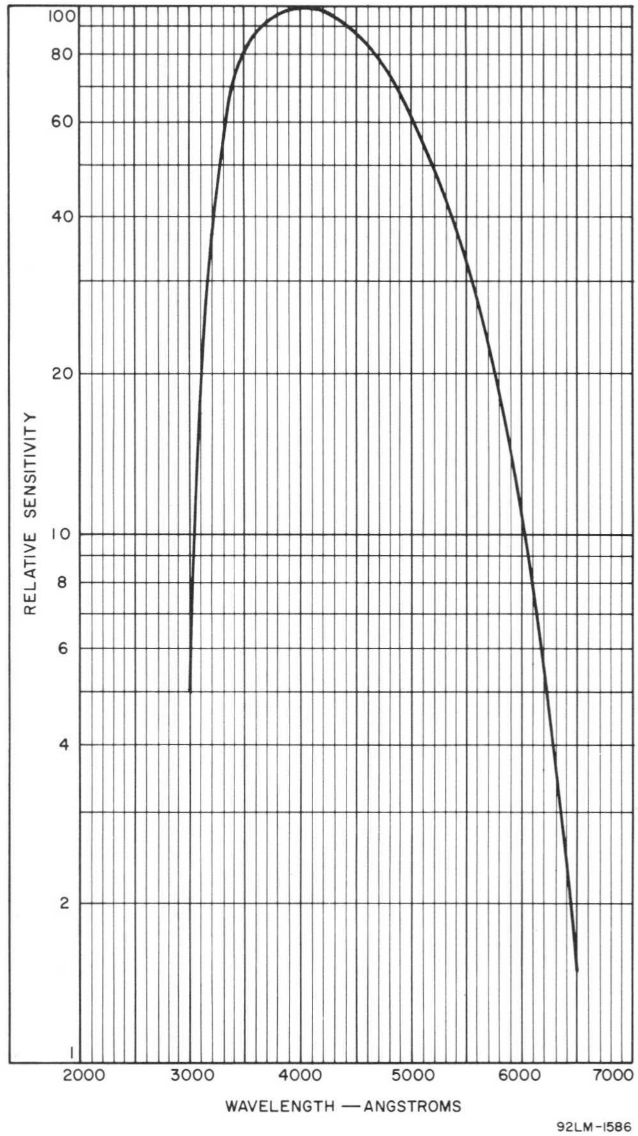


Figure 4

Quantum efficiency in per cent at any given wavelength can be calculated from the following formula:

$$QE = S_k\left(\frac{12395}{\lambda_x}\right)(100)$$

where QE is the quantum efficiency in per cent at λ_x
S_k is the cathode radiant sensitivity at λ_x in amperes/watt
λ_x is the wavelength in angstroms

As an example in the use of this formula consider type 4517 which has a bialkali photocathode. This tube has a typical cathode radiant sensitivity of 0.079 amperes per watt at 4000 angstroms as specified in the Cathode Radiant Sensitivity column on page 3. Therefore,

$$QE = 0.079\left(\frac{12395}{4000}\right)(100) \approx 24\%$$

Referring to **Figure 4**, it is seen that the relative response is about 80% at 3500 angstroms. Accordingly, at 3500 angstroms,

$$QE = 0.079\left(\frac{12395}{3500}\right)(80) \approx 22\%$$

RCA

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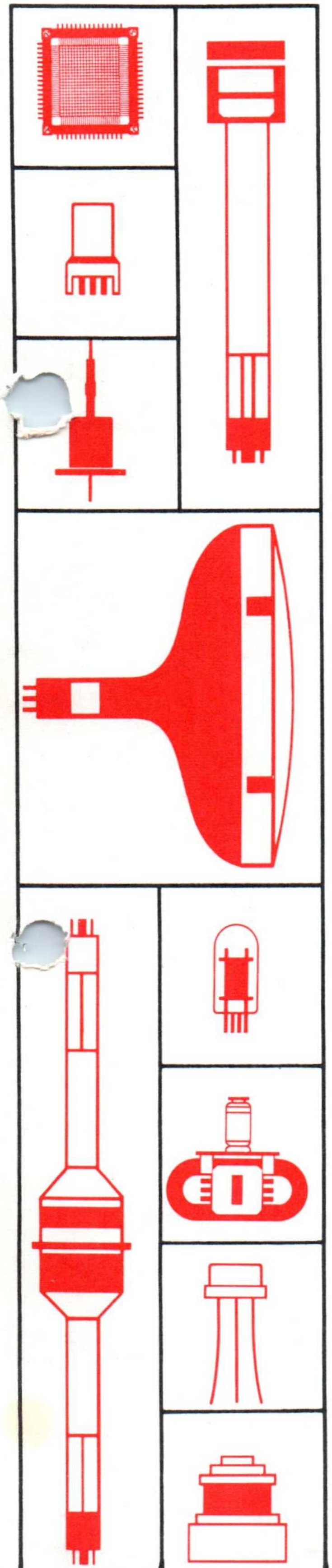
NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION HARRISON, N. J.

LICENSEE SERVICE



July 17, 1964

ANNOUNCING NOVAR TUBES WITH BOTTOM EXHAUST
For Compact New Equipment Designs

For Color and Black-and-White TV Receivers; High-Fidelity Monophonic and Stereophonic Equipment; Electronic Organs; Broadcast and Communications Radio Receivers; and Other Entertainment and Commercial Equipment.

Each Nover Tube in RCA's comprehensive line of 34 types will soon be supplied with the exhaust tip in the base. These new tubes, which are completely interchangeable with their novar prototypes having exhaust tips on the top of the bulb, will have reduced overall length, and thus permit the design of new equipment having greater compactness.

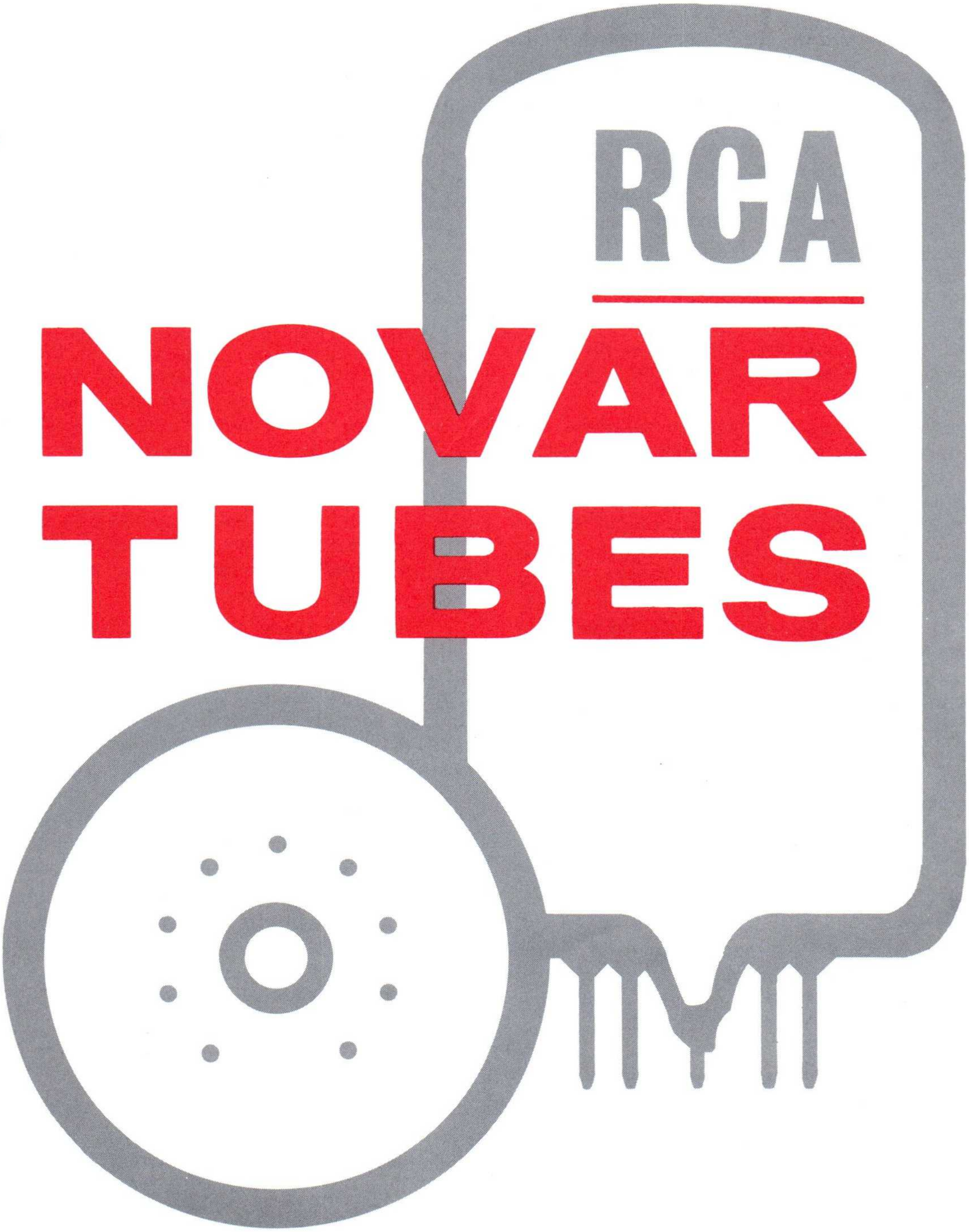
Novar tubes with bottom exhaust, like their industry-proved novar prototypes, offer equipment designers the following advantages:

- low cost — no need for a separate molded base.
- 9 pins — for great flexibility of circuit design, high-dissipation capability, and reduced lead inductance.
- large pin-circle diameter — permits use of large glass envelopes (T9 and T12 types)
  — provides for firm retention of tube in socket.
- wide spacing between pins -- minimizes interelectrode leakage; minimizes the possibility of breakdown under high electrode voltage conditions, hence contributes to high reliability.
- short, large-diameter internal leads — provides exceptionally strong cage support; high thermal conductivity for very effective heat dissipation.
- RCA Bonded Cathode — incorporated in types for Damper and Horizontal-Deflection Service — for top performance and high reliability in circuits operating under severe conditions.
- RCA Dark Heater (in heater-cathode types) — for long and dependable performance.

A technical booklet giving basic information on the 34 novar tubes is attached.

RCA THE MOST TRUSTED NAME IN ELECTRONICS

RCA NOVAR TUBES



For –

- Color and Black-and-White TV Receivers
- High-Fidelity Monophonic and Stereophonic Equipment
- Electronic Organs
- Broadcast & Communications Receivers
- Other Entertainment & Commercial Equipment

RADIO CORPORATION OF AMERICA
ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N.J.

RCA NOVAR TUBES

For Color and Black-and-White TV Receivers, High-Fidelity Monophonic & Stereophonic Equipment, Electronic Organs, Broadcast & Communications Radio Receivers, and other Entertainment & Commercial Equipment

RCA's novar concept of tube design represents a logical and realistic approach to the design of quantity-produced, large-size, entertainment-type (receiving) electron tubes. This concept grew out of the need for a tube which would offer the following advantages: (1) be highly reliable and efficient, have high dissipation capability, be economical and of simple construction, and (2) utilize RCA's high-reliability glass-handling and processing techniques. A 9-pin basing arrangement for this family of tubes was considered by RCA to be the optimum basing arrangement from the standpoints of cost, reliability, circuit design capability, interelectrode leakage, and resistance to voltage breakdown.

The novar design -- incorporating an all-glass envelope with an integral, nine-pin all-glass base -- has been applied to a wide variety of tubes including TV vertical and horizontal-deflection tubes, damper tubes, low-voltage rectifier tubes, and audio output tubes.

This new family of tubes was first announced by RCA for commercial sale in November 1960. It now includes a comprehensive group of 34 types which many leading electronic equipment manufacturers have already designed into a wide variety of consumer entertainment-type equipment -- color and black-and-white TV receivers, high-fidelity monophonic and stereophonic equipment, electronic organs, broadcast and communications radio receivers, etc.

RCA novar tubes offer equipment designers the following advantages:

- low cost -- no need for a separate molded base.
- 9 pins -- to provide great flexibility of circuit design, better dissipation capability, and reduced lead inductance.
- large pin-circle diameter -- permits use of large glass envelopes (T9 and T12 types).
  -- provides for firm retention of tube in socket.
- wide spacing between pins -- minimizes interelectrode leakage, and minimizes the possibility of breakdown under high electrode voltage conditions, hence contributes to greater reliability.
- short, large-diameter internal leads -- provide strong cage support; high thermal conductivity for very effective heat dissipation.
- RCA Dark Heater (in heater-cathode types) -- for long and dependable performance.

Most of the original RCA novar types are now being made with the exhaust tip in the base. This feature provides for a reduction in the overall length of the tube. Programs have now been established to manufacture all the novar tubes with the exhaust tip in the base. All novar tubes with bottom exhaust tips are completely interchangeable with their novar prototypes having exhaust tips on the top of the bulb. The new novar tube with bottom exhaust is especially useful for compact new equipment designs where the smaller overall dimensions of the new tube are a primary design requirement.

All novar types except the filamentary-type 5BC3 full-wave vacuum rectifier utilize the RCA Dark Heater for long life and dependable performance. All novar types for TV damper service and for horizontal-deflection service feature the RCA Bonded Cathode. The Bonded Cathode is so designed that the emissive oxide coating permanently adheres to the cathode base sleeve even after extended service under high-voltage, high-temperature conditions. This feature contributes to the top performance and high reliability of novar tubes in equipment operating under severe conditions.

All novar types use the novar 9-contact socket which is commercially available. Information on these sockets and on the variations in casting materials, contact materials, and finishes available can be obtained from socket manufacturers.

INDEX

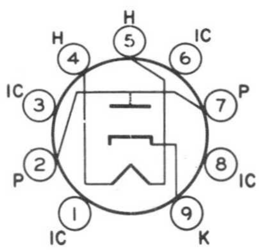
Printed in U.S.A. 7-64

HALF-WAVE VACUUM RECTIFIERS -- For TV Damper Service

Type	RCA DARK HEATER			MAXIMUM RATINGS -- DAMPER SERVICE[a] Design-Maximum Values						CHARACTERISTICS Instantaneous Value		
	Volts	Amp	Warm-up Time Sec.	Peak Inverse Plate Volts[b]	Peak Plate ma.	DC Plate ma.	Plate Dissipation Watts	Peak Heater-Cathode Volts −	Peak Heater-Cathode Volts +	Tube Voltage Drop Volts	Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)
6AY3B	6.3	1.2	-	5000	1100	175	6.5	5000[c]	300[d]	32 for plate ma. =350	9HP[e]	1-2
12AY3A	12.6	0.6	11	*For series-string circuits. For other data, see type 6AY3B.*								
17AY3A	16.8	0.45	11	*For series-string circuits. For other data, see type 6AY3B.*								
6BA3	6.3	1.2	-	5000	1000	165	5.3	5000[c]	300[d]	32 for plate ma. =250	9HP	2-1
6BH3A	6.3	1.6	-	5500	1100	180	6.5	5500[c]	300[d]	32 for plate ma. =350	9HP[e]	1-2
17BH3A	17.0	0.6	11	*For series-string circuits. For other data, see type 6BH3A.*								
22BH3A	22.4	0.45	11	*For series-string circuits. For other data, see type 6BH3A.*								
6BS3A	6.3	1.2	-	5000	1100	200	6	5000[c]	300[d]	12 for plate ma. = 140	9HP[e]	1-2
12BS3A	12.6	0.6	11	*For series-string circuits. For other data, see type 6BS3A.*								
17BS3A	16.8	0.45	11	*For series-string circuits. For other data, see type 6BS3A.*								
6DW4B	6.3	1.2	-	5500	1300	250	8.5	5000[c]	300[d]	25 for plate ma. = 350	9HP[e]	1-2

FULL-WAVE VACUUM RECTIFIER -- For Power Supplies having High DC Output

Type	FILAMENT		MAXIMUM RATINGS -- RECTIFIER SERVICE Design-Maximum Values			TYPICAL OPERATION as Full-Wave Rectifier			
	Volts	Amp	Peak Inverse Plate Volts	Peak Plate Amp per Plate	Hot-Switching Transient Plate Amp per Plate	With Capacitor-Input Filter[f] 40 µf	With Choke-Input Filter 10 henries	Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)
5BC3A	5.0 AC	3.0	1700	1	5	AC supply volts per plate (RMS) = 450 for load ma. = 275 and DC output volts at input to filter = 460 (Approx.).	AC supply volts per plate (RMS) = 550 for load ma. = 275 and DC output volts at input to filter = 440 (Approx.)	9QJ	3-3



JEDEC 9HP

Pin 1 - Do Not Use
Pin 2 - Plate
Pin 3 - Do Not Use
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Do Not Use
Pin 7 - Plate
Pin 8 - Do Not Use
Pin 9 - Cathode

[a] For operation in a 525-line, 30-frame system, as described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission.

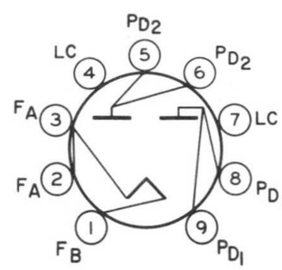
[b] This rating is applicable where the duration of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

[c] The dc component must not exceed 900 volts.

[d] The dc component must not exceed 100 volts.

[e] Socket terminals 1, 3, 6, and 8 should not be used as tie points. It is recommended that the socket clips for these pins be removed to reduce the possibility of arc-over and to minimize leakage.

[f] Higher values of capacitance may be used, provided the effective plate supply impedance is increased to prevent exceeding the maximum peak plate current rating.



JEDEC 9QJ

Pin 1 - Filament End B
Pin 2 - Filament End A
Pin 3 - Filament End A
Pin 4 - See Note
Pin 5 - Plate No.2
Pin 6 - Plate No.2
Pin 7 - See Note
Pin 8 - Plate No.1
Pin 9 - Plate No.1

NOTE: May be used as tie point for ac line providing the peak value of the ac voltage does not exceed 200 volts.

BEAM POWER TUBES -- For TV Horizontal-Deflection Amplifier Service

Type	RCA DARK HEATER Volts	Amp	Warm-up Time Sec.	MAXIMUM RATINGS -- HORIZONTAL-DEFLECTION AMPLIFIER[a] Design-Maximum Values: DC Plate Supply Volts	Peak Positive-Pulse Plate Volts[c]	Peak Negative-Pulse Plate Volts	DC Grid-No.3 Volts	DC Grid-No.2 Volts	DC Grid-No.1 (Negative-bias) Volts	Peak Negative-Pulse Grid-No.1 Volts	Peak Cathode ma	Average Cathode ma	Grid-No.2 Input Watts	Plate Dissipation Watts[d]	Bulb Temperature[h] °C	Maximum Grid-No.1-Circuit Resistance[b] Megohms
6GJ5A	6.3	1.2	–	770	6500	1500	-	220	55	330	550	175	3.5	17.5	240	1
17GJ5A	16.8	0.45	11	*For series-string circuits. For other data, see type 6GJ5A.*												
6GT5A	6.3	1.2	–	770	6500	1500	-	220	55	330	550	175	3.5	17.5	240	1
12GT5A	12.6	0.6	11	*For series-string circuits. For other data, see type 6GT5A.*												
17GT5A	16.8	0.45	11	*For series-string circuits. For other data, see type 6GT5A.*												
6JB6A	6.3	1.2	–	770	6500	1500	70[e]	220	55	330	550	175	3.5	17.5	240	1
12JB6A	12.6	0.6	11	*For series-string circuits. For other data, see type 6JB6A.*												
17JB6A	16.8	0.45	11	*For series-string circuits. For other data, see type 6JB6A.*												
6JE6A	6.3	2.5	–	990	7000	1100	75[e]	190	–	250	1100	315	3.2	24	240	0.47[f]
6JG6A	6.3	1.6	–	770	6500	1500	75[e]	220	55	330	950	275	3.5	17	220	2.2
17JG6A	16.8	0.6	11	*For series-string circuits. For other data, see type 6JG6A.*												
22JG6A	22.0	0.45	11	*For series-string circuits. For other data, see type 6JG6A.*												
6JT6A	6.3	1.2	–	770	6500	1500	70[e]	220	55	330	550	175	3.5	17.5	240	1
12JT6A	12.6	0.6	11	*For series-string circuits. For other data, see type 6JT6A.*												
17JT6A	16.8	0.45	11	*For series-string circuits. For other data, see type 6JT6A.*												
22JU6	22.0	0.45	11	770	6500	1500	75[e]	220	55	330	950	275	3.5	17	220	0.47[f]

[a] For operation in a 525-line, 30-frame system, as described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission.

[b] For grid-No.1-resistor-bias operation.

[c] This rating is applicable where the duration of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

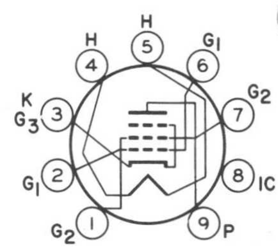
[d] An adequate bias resistor or other means is required to protect the tube in the absence of excitation.

[e] A positive voltage may be applied to grid No.3 to reduce interference from "snivets" which may occur in television receivers. A typical value for this voltage is 30 volts.

[f] 10 max. megohms for plate-pulsed operation (horizontal-deflection circuits only).

[g] This value can be measured by a method involving a recurrent wave form such that the maximum ratings of the tube will not be exceeded.

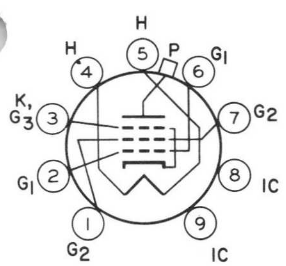
[h] At hottest point on bulb surface.



JEDEC 9NZ

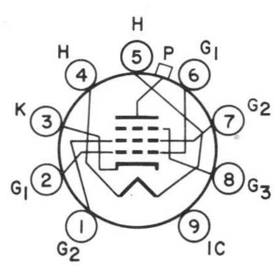
Pin 1 - Grid No.2
Pin 2 - Grid No.1
Pin 3 - Cathode, Grid No.3
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Grid No.1
Pin 7 - Grid No.2
Pin 8 - Do Not Use
Pin 9 - Plate

CHARACTERISTICS, CLASS A_1 AMPLIFIER									Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)	Curves of Average Characteristics	Remarks	RCA Type
Plate Volts	Grid-No.3 Volts	Grid-No.2 Volts	Grid-No.1 Volts	Plate Resistance (Approx.) Ohms	Trans-conductance µmhos	Plate ma.	Grid-No. 2 ma.	Cutoff Grid Volts for plate ma. =1					
60	-	150	0	-	-	390[g]	32[g]	-					
250	-	150	-22.5	15000	7100	70	2.1	-42	9QK	4-1	page 9	Double-ended type. For black-and-white TV.	6GJ5A
													17GJ5A
60	-	150	0	-	-	390[g]	32[g]	-					
250	-	150	-22.5	15000	7100	70	2.1	-42	9NZ	3-1	page 9	Single-ended type. For black-and-white TV.	6GT5A
													12GT5A
													17GT5A
60	0	150	0	-	-	390[g]	32[g]	-					
250	0	150	-22.5	15000	7100	70	2.1	-42	9QL	4-1	page 9	Double-ended type with separate base-pin connection to grid No.3. For black-and-white TV.	6JB6A
													12JB6A
													17JB6A
70	0	125	0	-	-	580[g]	40[g]	-					
175	0	125	-25	5500	10500	115	5	-55	9QL	5-1	page 10	Double-ended type with separate base-pin connection to grid No.3. For color TV.	6JE6A
50	0	125	0	-	-	525[g]	32[g]	-					
130	0	125	-20	12000	10000	80	2.5	-40	9QU	3-2	page 10	Single-ended type with separate base-pin connection to grid No.3. For low B+ black-and-white TV.	6JG6A
													17JG6A
													22JG6A
60	0	150	0	-	-	390[g]	32[g]	-					
250	0	150	-22.5	15000	7100	70	2.1	-42	9QU	3-1	page 11	Single-ended type with separate base-pin connection to grid No.3. For black-and-white TV.	6JT6A
													12JT6A
													17JT6A
50	0	125	0	-	-	470[g]	32[g]	-					
130	0	125	-20	18000	7000	45	1.5	-32	9QL	6-1	page 12	Double-ended type with separate base-pin connection to grid No.3. For low B+ black-and-white TV.	22JU6



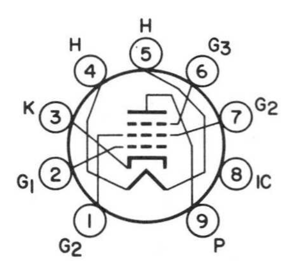
JEDEC 9QK

Pin 1 - Grid No.2
Pin 2 - Grid No.1
Pin 3 - Cathode, Grid No.3
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Grid No.1
Pin 7 - Grid No.2
Pin 8 - No Internal Connection
Pin 9 - Do Not Use
Cap - Plate



JEDEC 9QL

Pin 1 - Grid No.2
Pin 2 - Grid No.1
Pin 3 - Cathode
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Grid No.1
Pin 7 - Grid No.2
Pin 8 - Grid No.3
Pin 9 - Do Not Use
Cap - Plate



JEDEC 9QU

Pin 1 - Grid No.2
Pin 2 - Grid No.1
Pin 3 - Cathode
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Grid No.3
Pin 7 - Grid No.2
Pin 8 - Do Not Use
Pin 9 - Plate

DUAL TRIODES -- For Vertical-Deflection Oscillator and Amplifier Service

Type	RCA DARK HEATER			MAXIMUM RATINGS -- VERTICAL-DEFLECTION OSCILLATOR AND AMPLIFIER[a] Design-Maximum Values													Maximum Grid-Circuit Resistance
				Oscillator (Unit No.1)					Amplifier (Unit No.2)						Each Unit		
	Volts	Amp	Warm-up Time Sec.	DC Plate Volts	Peak Negative-Pulse Grid Volts	Peak Cathode ma.	Average Cathode ma.	Plate Dissi-pation Watts	DC Plate Volts	Peak Positive-Pulse Plate Volts	Peak Negative-Pulse Grid Volts	Peak Cathode ma.	Average Cathode ma.	Plate Dissi-pation Watts	Peak Heater-Cathode Volts -	+	For Cathode- or Grid-Resistor-Bias Operation Megohms
6GF7A	6.3	0.985	-	330	400	77	22	1.5	330	1500[b]	250	175	50	11	200	200[c]	2.2
10GF7A	9.7	0.6	11	*For series-string circuits. For other data, see type 6GF7A.*													
13GF7A	13.0	0.45	11	*For series-string circuits. For other data, see type 6GF7A.*													

HIGH-MU TRIODE--BEAM POWER TUBES -- For Vertical-Deflection Oscillator and Amplifier Service

Type	RCA DARK HEATER			MAXIMUM RATINGS -- VERTICAL-DEFLECTION OSCILLATOR AND AMPLIFIER[a] Design-Maximum Values													Maximum Grid-No. 1-Circuit Resistance
				Oscillator (Triode Unit)					Amplifier (Beam Power Unit)								Each Unit
	Volts	Amp	Warm-up Time Sec.	DC Plate Volts	Peak Negative-Pulse Grid Volts	Peak Cathode ma.	Average Cathode ma.	Plate Dissi-pation Watts	DC Plate Volts	Peak Positive-Pulse Plate Volts	DC Grid-No. 2 Volts	Peak Negative-Pulse Grid No. 1 Volts	Peak Cathode ma.	Average Cathode ma.	Plate Dissi-pation Watts	Grid-No. 2 Input Watts	For Grid-No. 1-Resistor-Bias Operation Megohms
6KY8A	6.3	1.1	-	330	400	77	22	1.5	300	2000[b]	150	250	200	70	12	1.9	2.2
15KY8A	15.0	0.45	11	*For series-string circuits. For other data, see type 6KY8A.*													

POWER PENTODE -- For High-Fidelity Audio Applications

Type	RCA DARK HEATER		MAXIMUM RATINGS, Design-Maximum Values SINGLE-TUBE AF POWER AMPLIFIER -- Class A_1 & PUSH-PULL AF POWER AMPLIFIER -- Class AB_1								Maximum Grid-No. 1-Circuit Resistance	
	Volts	Amp	Plate Volts	Grid-No. 2 Volts	Plate Dissi-pation Watts	Grid-No. 2 Input Watts	DC Cathode ma.	Peak Heater-Cathode Volts -	+	Bulb Temper-ature[d] °C	For Fixed-Bias Operation Megohm	For Cath-ode-Bias Operation Megohm
7868	6.3	0.8	550	440	19	3.3[e]	90	200	200[c]	240	0.3	1

[a] For operation in a 525-line, 30-frame system, as described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission.

[b] Absolute value. This rating is applicable where the duration of the voltage pulse does not exceed 15 per cent of one vertical scanning cycle. In a 525-line, 30-frame system, 15 per cent of one vertical scanning cycle is 2.5 milliseconds.

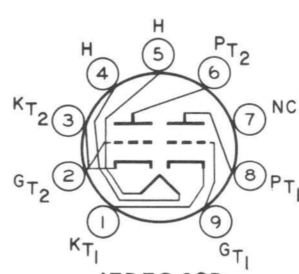
[c] The dc component must not exceed 100 volts.

[d] At hottest point on bulb surface.

[e] Grid-No.2 input may reach 6 watts during peak levels of speech and music signals.

[f] This value can be measured by a method involving a recurrent wave form such that the maximum ratings of the tube will not be exceeded.

[g] Plate to plate.



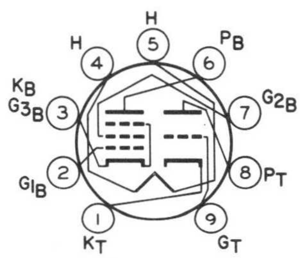
JEDEC 9QD

Pin 1 - Cathode of Triode Unit No.1
Pin 2 - Grid of Triode Unit No.2
Pin 3 - Cathode of Triode Unit No.2
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Plate of Triode Unit No.2
Pin 7 - No Internal Connection
Pin 8 - Plate of Triode Unit No.1
Pin 9 - Grid of Triode Unit No.1

CHARACTERISTICS, CLASS A_1 AMPLIFIER																	RCA
Unit No.1							Unit No.2										
Plate Volts	Grid Volts	Amplification Factor	Plate Resistance (Approx.) Ohms	Transconductance µmhos	Plate ma.	Cutoff Grid Volts for Plate µa = 10	Plate Volts	Grid Volts	Amplification Factor	Plate Resistance (Approx.) Ohms	Transconductance µmhos	Plate ma.	Cutof Grid Volts for Plate µa = 100	Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)	Curves of Avg. Characteristics	Type
250	-3	64	40000	1600	1.4	-5.5	150	-20	5.4	750	7200	50	-45	9QD	1-1	page 9	**6GF7A** **10GF7A** **13GF7A**

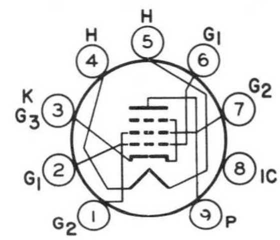
CHARACTERISTICS, CLASS A_1 AMPLIFIER																	RCA
Triode Unit						Beam Power Unit											
Plate Volts	Grid Volts	Amplification Factor	Plate Resistance (Approx.) Ohms	Transconductance µmhos	Plate ma.	Plate Volts	Grid-No. 2 Volts	Grid-No. 1 Volts	Plate Resistance (Approx.) Ohms	Transconductance µmhos	Plate ma.	Grid-No. 2 ma.	Cutoff Grid Volts for Plate ma. = 1	Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)	Curves of Avg. Characteristics	Type
250	-3	64	40000	1600	1.4	50 135	120 120	0 -10	- 18000	- 8400	170^f 39	20^f 3	- -24	9QT	1-1	page 11	**6KY8A** **15KY8A**

TYPICAL OPERATION -- PUSH-PULL AF POWER AMPLIFIER -- CLASS AB_1 (Values are for two tubes)														RCA
Plate Volts	Grid-No. 2 Volts	Grid-No. 1 Volts	Peak AF Grid-No.1-to-Grid-No.1 Volts	Zero-Signal Plate ma.	Max.-Signal Plate ma.	Zero-Signal Grid-No.2 ma.	Max.-Signal Grid-No.2 ma.	Effective Load Resistance[g] Ohms	Total Harmonic Distortion %	Max.-Signal Power Output Watts	Terminal Diagram (JEDEC No.)	Dimensional Outline (page 8)	Curves of Average Characteristics	Type
350 450	350 400	-15.5 -21	31 42	72 40	130 145	9.5 5	32 30	6600 6600	2.5 5	30 44	9NZ	2-2	page 12	**7868**



JEDEC 9QT

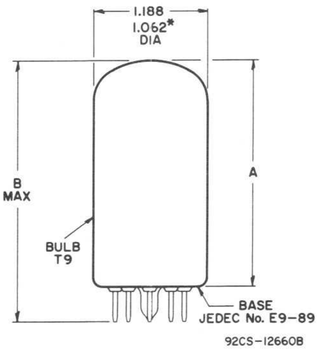
Pin 1 - Triode Cathode
Pin 2 - Beam Power Grid No.1
Pin 3 - Beam Power Cathode & Grid No.3
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Beam Power Plate
Pin 7 - Beam Power Grid No.2
Pin 8 - Triode Plate
Pin 9 - Triode Grid



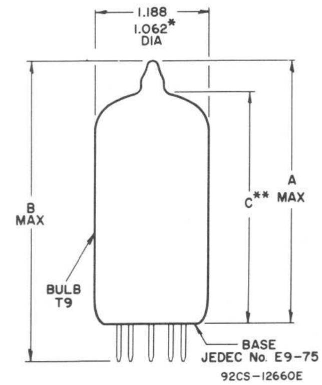
JEDEC 9NZ

Pin 1 - Grid No.2
Pin 2 - Grid No.1
Pin 3 - Cathode, Grid No.3
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Grid No.1
Pin 7 - Grid No.2
Pin 8 - Do Not Use
Pin 9 - Plate

DIMENSIONAL OUTLINES
Dimensions in Inches

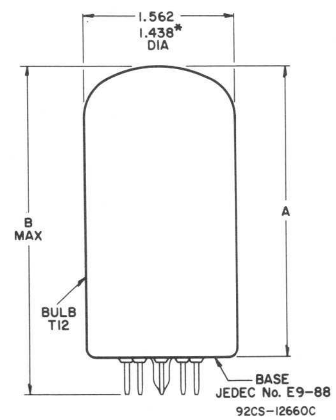


Outline	A	B	JEDEC No.
1-1	1.750 to 2.000	2.380	9-107
1-2	2.375 to 2.625	3.005	-

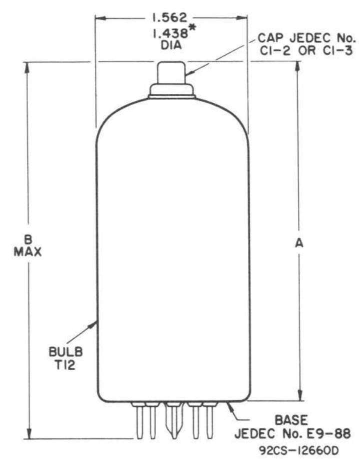


Bottom-exhaust type has the same A & B dimensions as top-exhaust type shown

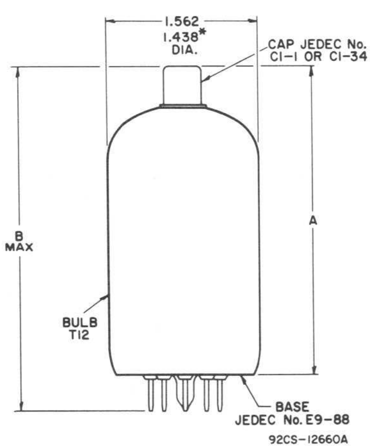
Outline	A	B	C	JEDEC No.
2-1	2.700	3.080	2.050 to 2.230	-
2-2	2.730	3.110	2.405 to 2.585	-



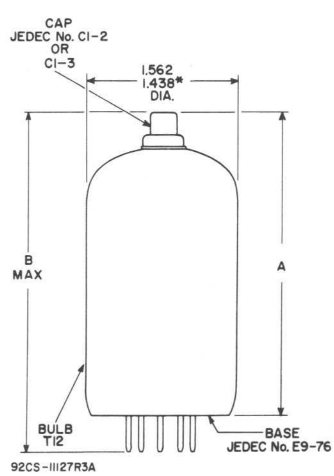
Outline	A	B	JEDEC No.
3-1	2.250 to 2.500	2.880	12-95
3-2	2.500 to 2.750	3.130	12-96
3-3	3.250 to 3.500	3.880	12-99

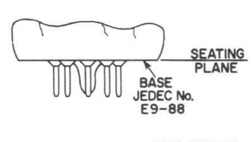


Outline	A	B	JEDEC No.
4-1	2.875 to 3.125	3.505	-



Outline	A	B	JEDEC No.
5-1	3.500 to 3.750	4.130	12-116





Outline	A	B	JEDEC No.
6-1	2.910 to 3.170	3.550	12-70 for E9-76 base

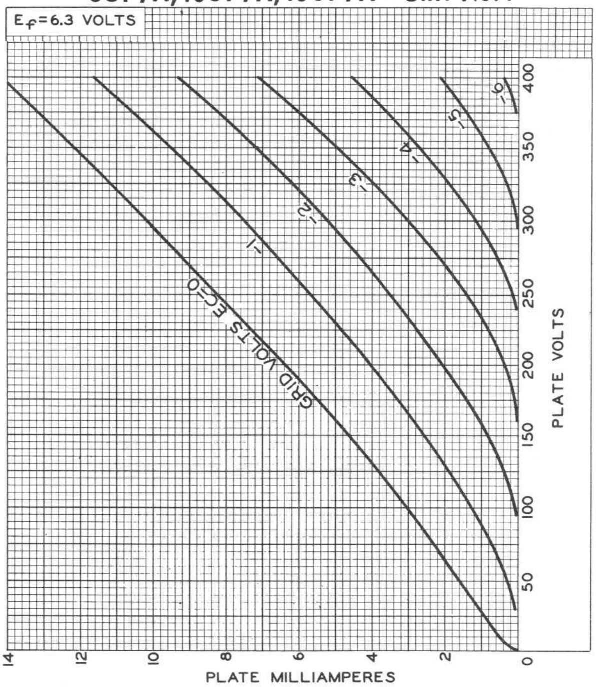
* Applies to the minimum diameter except in the area of the seal.

** Measured from the base seat to bulb-top line as determined by a ring gauge of 0.600" I.D.

AVERAGE CHARACTERISTICS

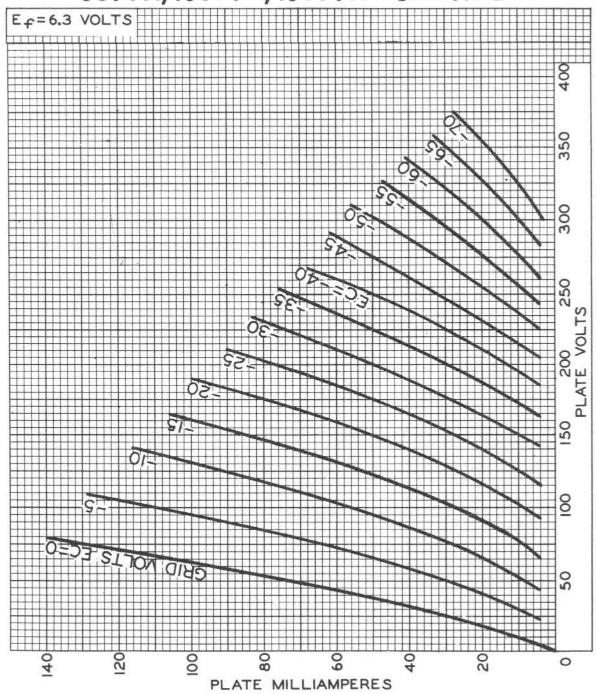
Except for differences in heater voltage, the curves shown apply to the types listed above each curve.

6GF7A, 10GF7A, 13GF7A - Unit No. 1



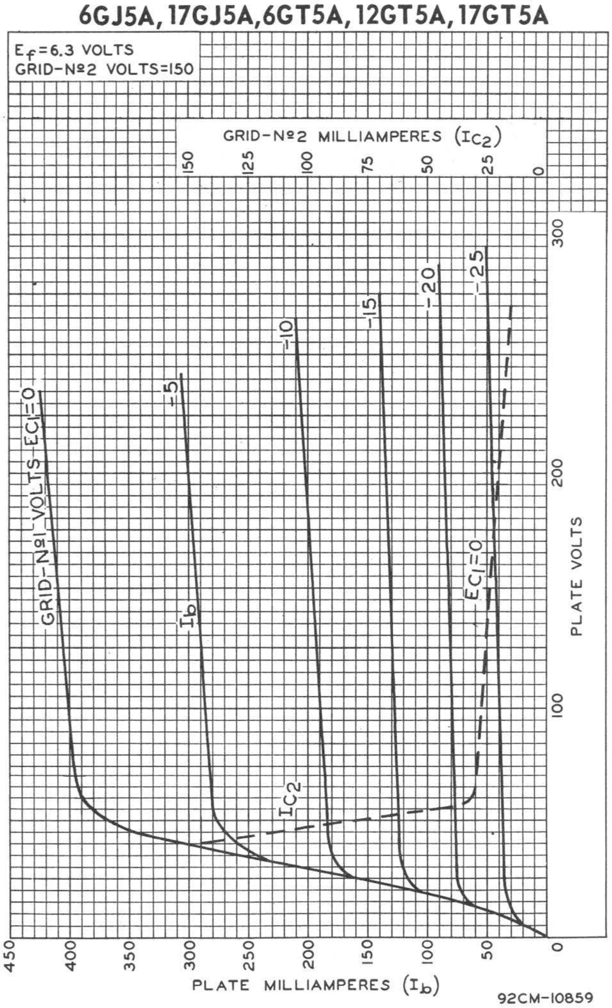
92CM-9912

6GF7A, 10GF7A, 13GF7A - Unit No. 2



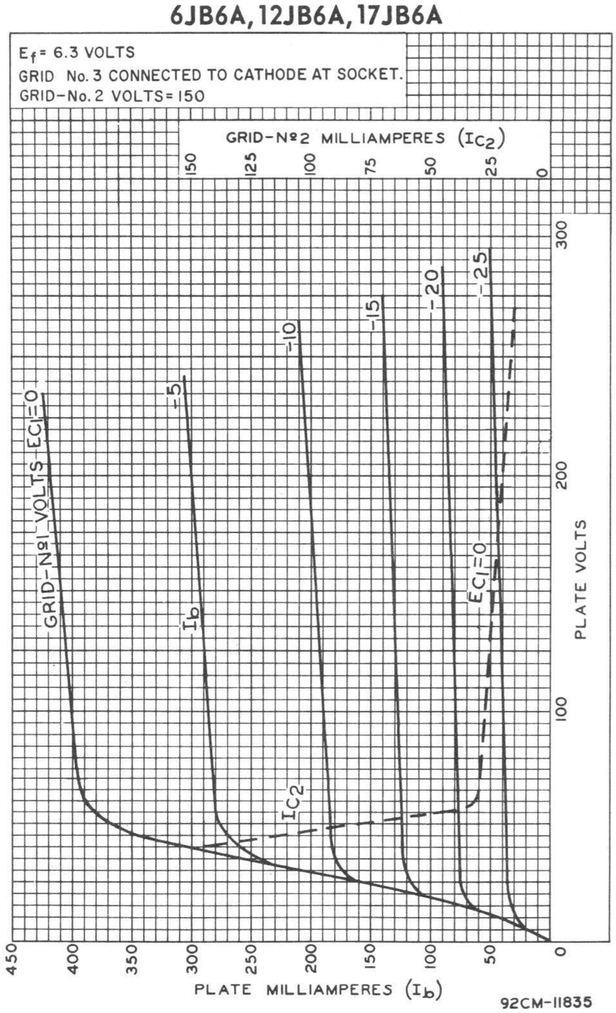
92CM-10466

6GJ5A, 17GJ5A, 6GT5A, 12GT5A, 17GT5A



92CM-10859

6JB6A, 12JB6A, 17JB6A

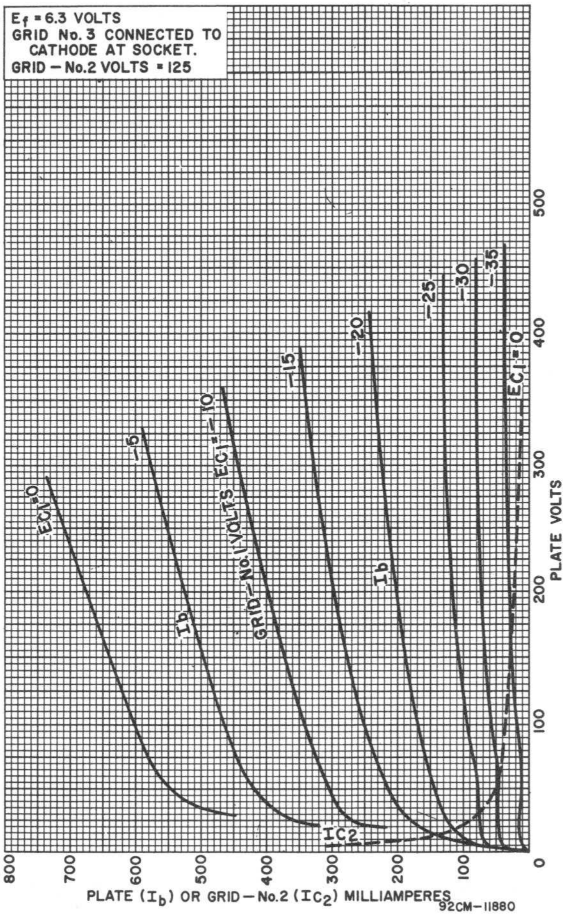


92CM-11835

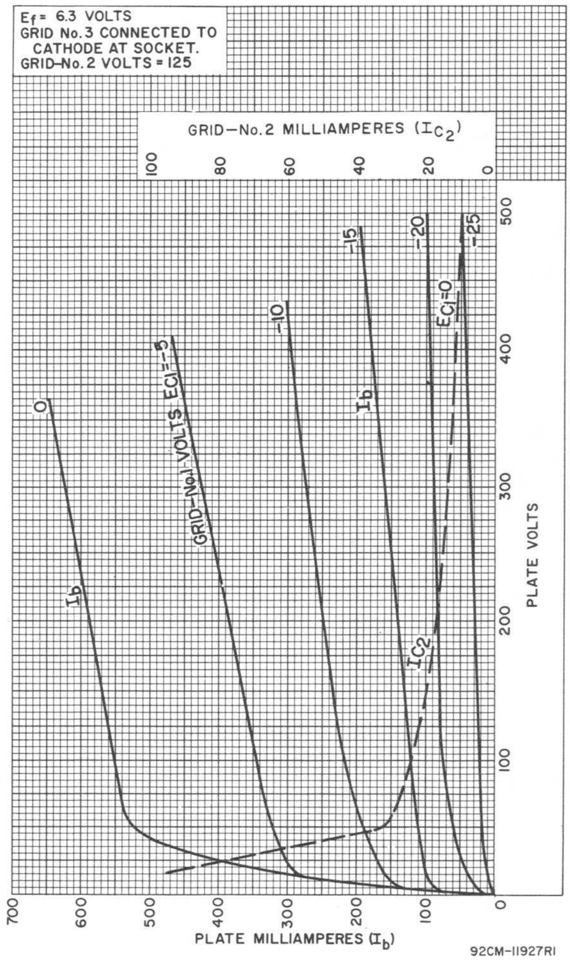
AVERAGE CHARACTERISTICS

Except for differences in heater voltage, the curves shown apply to the types listed above each curve.

6JE6A



6JG6A, 17JG6A, 22JG6A



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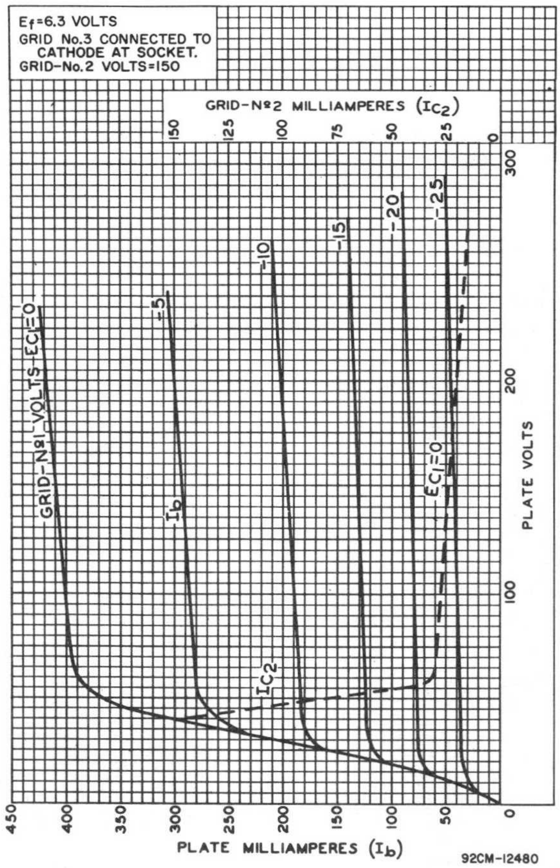
AVERAGE CHARACTERISTICS

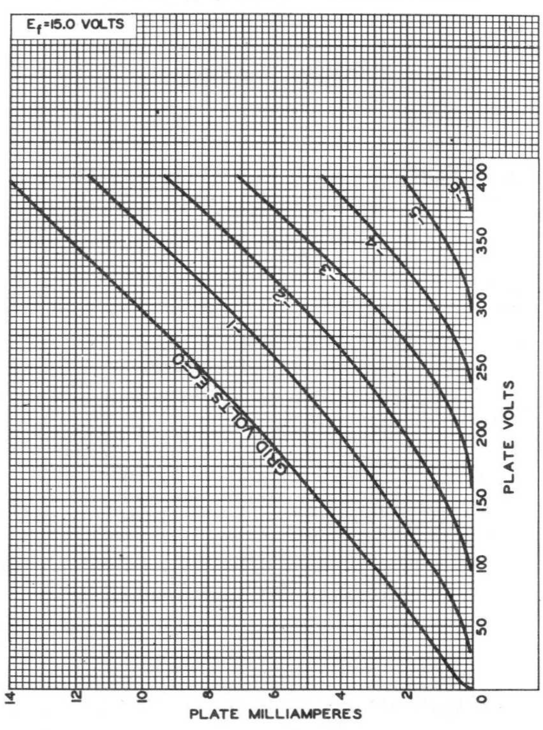
Except for differences in heater voltage, the curves shown apply to the types listed above each curve.

6JT6A, 12JT6A, 17JT6A



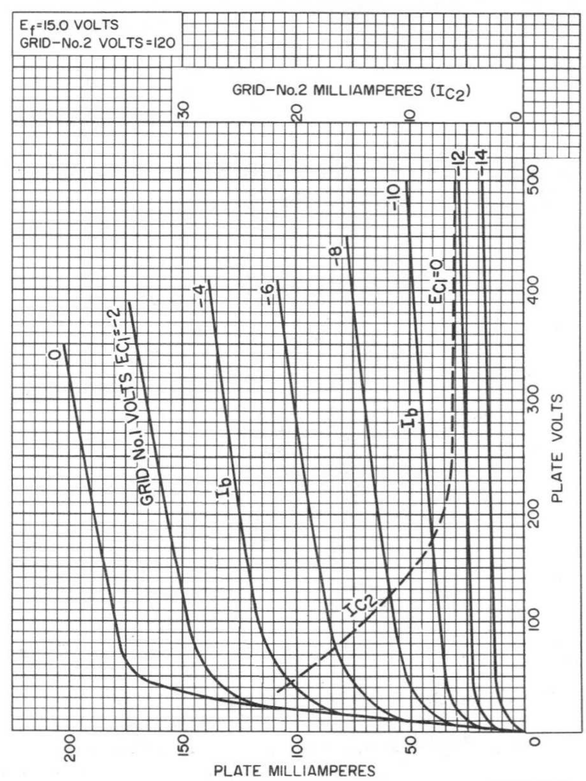
92CM-12480

6KY8A, 15KY8A - TRIODE UNIT



92CM-11944

6KY8A, 15KY8A - BEAM POWER UNIT

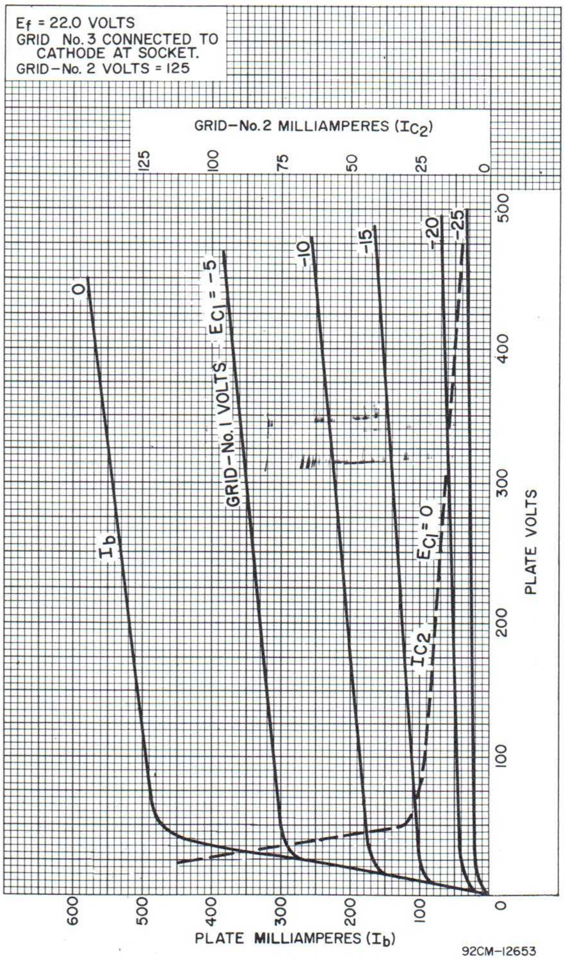


92CM-11942

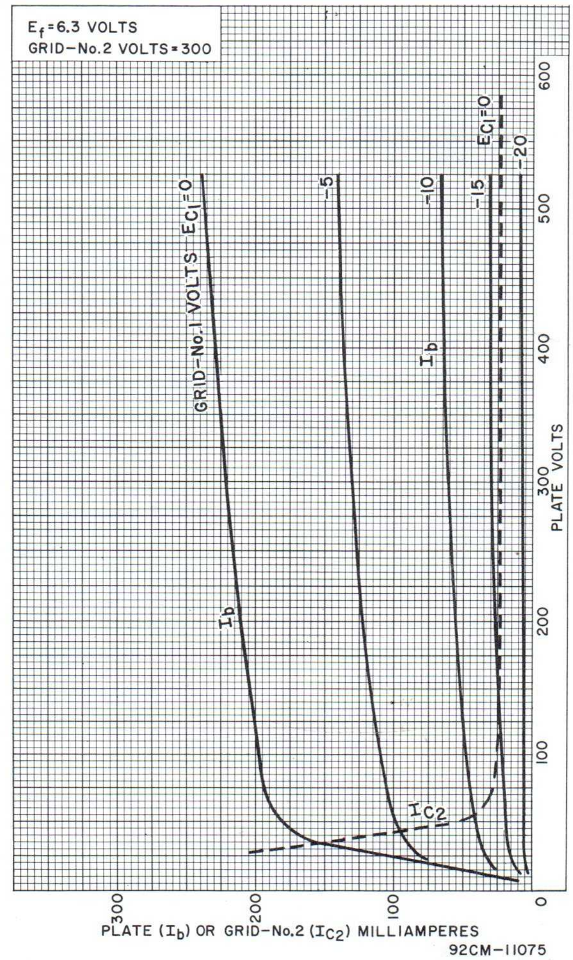
RCA NOVAR TUBES

AVERAGE CHARACTERISTICS

22JU6

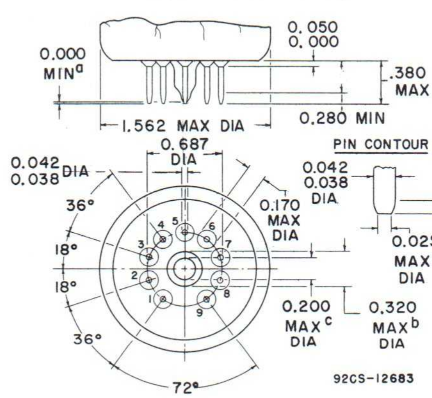


7868

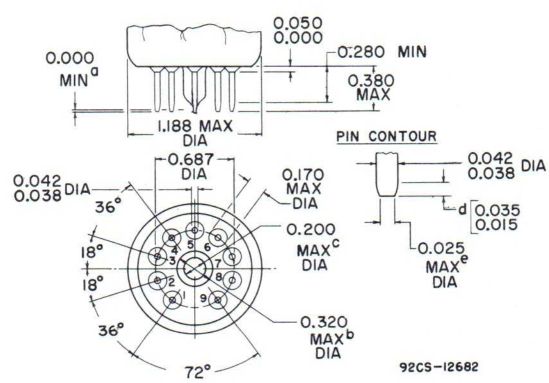


BASES

LARGE-BUTTON NOVAR 9-PIN WITH EXHAUST TIP
JEDEC No. E9-88



SMALL-BUTTON NOVAR 9-PIN WITH EXHAUST TIP
JEDEC No. E9-89



Dimensions in Inches

For pin alignment use gauge JEDEC No.GE9-6.

For pin alignment use gauge JEDEC No.GE9-5.

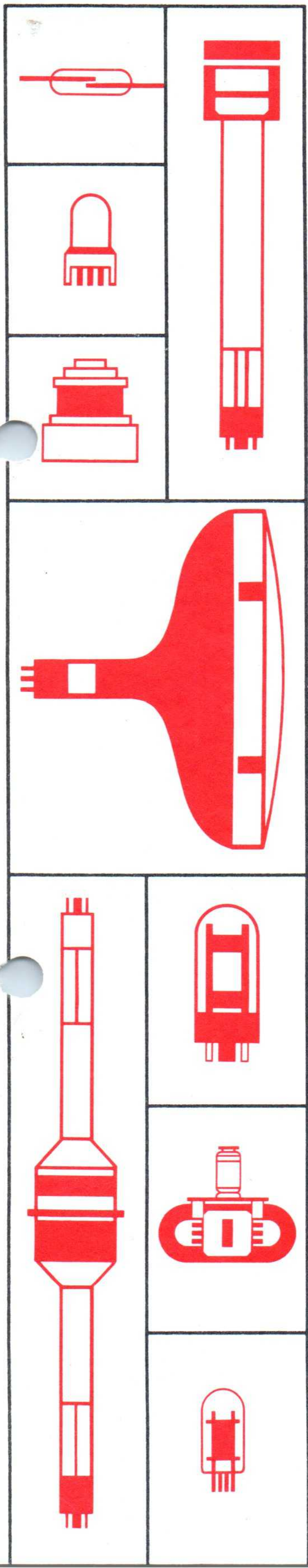
[a] The exhaust tip shall not extend beyond the plane of the base pin ends. [b] Limit of exhaust tube fillet diameter. [c] Exhaust tube maximum diameter. [d] This dimension may vary within the limits shown around the periphery of any individual pin. This surface of the pin shall be convex or conical in shape and shall not be brought to a sharp point. [e] The surface shall be flat.

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-0A3A, 0C3A, 0D3A

NEW VOLTAGE-REGULATOR TUBES

Compact, Glass-Octal Types For Industrial Equipment

RCA announces three voltage-regulator tubes — 0A3A, 0C3A, and 0D3A for industrial and military equipment. These glass-octal, gas-filled tubes have all the desirable features of their industry-accepted prototypes 0A3, 0C3, and 0D3, but utilize a smaller envelope (length, 3-1/16"; dia. 1-9/32") for use in equipment where compactness is a prime consideration.

The 0A3A, 0C3A, and 0D3A are recommended for new equipment designs, and are unilaterally interchangeable in existing equipment with their respective prototypes.

A technical bulletin giving ratings and characteristics, and featuring detailed information on principles of operation, operating considerations, and applications is attached.

June 10, 1963

RCA-OA3A, OC3A, OD3A

VOLTAGE-REGULATOR TUBES

Glass-Octal, Gas-Filled, Cold-Cathode, Glow-Discharge Types Having DC-Cathode-Current Range of 5 to 40 ma.

75 Volts (OA3A)
105 Volts (OC3A)
150 Volts (OD3A)

Max. Overall Length 3-1/16"
Max. Diameter 1-9/32"
T9 Bulb

RCA-OA3A, OC3A, and OD3A are voltage-regulator (VR) tubes of the glass-octal, gas-filled, cold-cathode, glow-discharge type. These tubes are useful in voltage-regulator applications in which a relatively constant dc output voltage is required, independent of load and supply-voltage variations.

The OA3A, OC3A, and OD3A are similar electrically to their respective prototypes, OA3, OC3, and OD3, but employ a T9 instead of an ST12 bulb and are, therefore, more compact.

These "A" versions are recommended for new-equipment design. They are unilaterally interchangeable, in existing equipment, with their respective prototypes. Where clamping devices have been used, however, slight modifications may be required in the clamps because of the smaller size of the "A" versions.

GENERAL DATA

Mechanical:

Operating Position	Any
Type of Cathode	Cold
Maximum Overall Length	3-1/16"
Maximum Seated Length	2-1/2"
Maximum Diameter	1-9/32"
Dimensional Outline	JEDEC No.9-7
Bulb	T9
Base	Intermediate-Shell Octal 6-Pin, Arrangement 1 (JEDEC Group 1, No.B6-8)

VOLTAGE REGULATOR

Maximum and Minimum Ratings, *Absolute-Maximum Values:*

Average Cathode Starting Current[a]	100 max.	ma
DC Cathode Current	40 max. / 5 min.	ma / ma
DC or AC Jumper Current (See *Terminal Diagram*)	2 max.	amp
Ambient-Temperature Range	-55 to +90	°C

Circuit Values:

Shunt Capacitor	0.1 max.	µf
Series Resistor	See *Operating Considerations*	

PRINCIPLES OF OPERATION

Voltage-regulator (VR) tubes of the gas-filled, cold-cathode, glow-discharge type, such as the OA3A, OC3A, and OD3A, are useful in dc-power-supply applications in which it is necessary to minimize variations in output voltage resulting from fluctuations in the load, in the power supply itself, and in the supply voltage.

The voltage-current characteristic of a typical VR tube is shown in Fig.1.

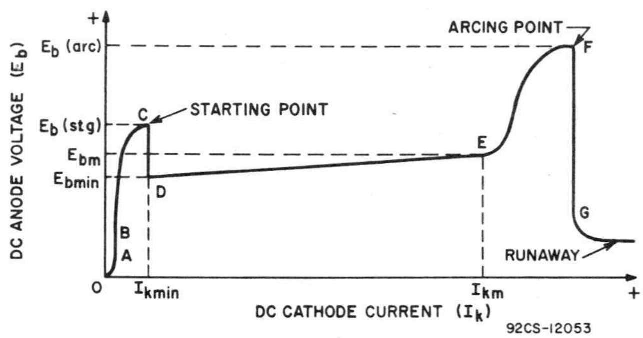


Fig.1

When the dc anode voltage, E_b, is increased in the positive direction from zero, a small amount of dc cathode current, I_k, begins to flow. This current results from the migration of "residual" ions in the gas. These residual ions are the result of ambient radiation, such as cosmic rays, visible light, infrared radiation, etc. The magnitude of this cathode current depends on the rate at which the ions are produced and the rate at which they are collected depends on the magnitude of E_b. This cathode current is sometimes called "dark current" because it does not produce visible

[a] Averaged over starting period not exceeding 10 seconds. When starting currents greatly in excess of the maximum dc-cathode-current rating of 40 milliamperes are encountered, it may be necessary to operate these tubes as much as 20 minutes under steady-state conditions to assure stable operation.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are initial unless otherwise specified

CHARACTERISTIC	LIMITS									UNITS
	OA3A			OC3A			OD3A			
	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	
DC Anode Supply Voltage	b	-	-	b	-	-	b	-	-	volts
DC Anode Starting Voltage in: Total darkness	-	-	160	-	-	210	-	-	225	volts
Normal ambient light (5 to 50 footcandles)	-	100	105	-	115	127	-	160	180	volts
Anode Voltage Drop for dc cathode current of: 5 ma.	70	-	-	105	-	-	145	-	-	volts
30 ma.	70	76	79	105	109	111	145	149	160	volts
40 ma.	70	78	81	105	110	112	145	150	162	volts
Regulation[c] for dc-cathode-current range of: 5 to 30 ma.	-	3	4.5	-	1	2	-	2	4	volts
5 to 40 ma.	-	5	6.5	-	2	4	-	4	5.5	volts
Tube Noise for dc cathode current of 40 ma.	-	-	5	-	-	15	-	-	15	rms mv
DC Leakage Current for dc anode supply voltage of 50 volts and anode resistor of 3000 ohms	-	-	10	-	-	10	-	-	10	μa

[b] The minimum value to insure starting throughout useful tube life must be equal to the dc anode starting voltage plus the voltage drop across the series resistor at the maximum value of the load current.

[c] The maximum values apply throughout useful tube life.

radiation. The relationship between E_b and dark current is shown by the portion "OAB" of the curve in Fig.1. The fact that an increase of E_b over the range "AB" causes no increase in I_k indicates that the residual ions are being removed by the electric field at the same rate as they are being created. The increase of I_k above point "B" is the result of ionization of gas molecules by collision with electrons that have been accelerated by the applied electric field. Appreciable ionization does not occur until E_b greatly exceeds the ionization potential of the gas.

As E_b is further increased, I_k increases more rapidly. When E_b reaches a value equal to the dc anode starting voltage, $E_{b(stg)}$, at point "C", I_k increases substantially without further increase in E_b. At this point, the gas "breaks down", the tube "discharges", and E_b falls abruptly to some lower value, E_{bmin}. Between points "D" and "E", a very small change in E_b produces a large change in I_k up to the point designated I_{km}. Beyond point "E", a much larger change in E_b is required to produce a given change in I_k.

In the vicinity of point "F", I_k is so large that, if it is maintained for an appreciable time, the cathode becomes hot enough to emit electrons. This thermionic emission reduces E_b, causing I_k to increase to a value which may exceed the current-carrying capability of the tube.

If, at point "D", E_b is decreased from E_{bmin}, I_k will decrease until a point is reached where the tube will "extinguish". This condition has no damaging effect on the tube.

If I_k is maintained between the limiting values I_{kmin} and I_{km}, the discharge will be self-sustaining, and E_b will be maintained by the tube between the limiting values E_{bmin} and E_{bm}.

In the region between points "B" and "F", the discharge is characterized by relatively low I_k and high E_b, and is accompanied by a "glow". Beyond point "G", the discharge is characterized by high I_k and low E_b, and is accompanied by a destructive "arc".

OPERATING CONSIDERATIONS

The circuit diagram of Fig.2 shows a basic circuit arrangement for gas-filled, glow-discharge, voltage-regulator tubes.

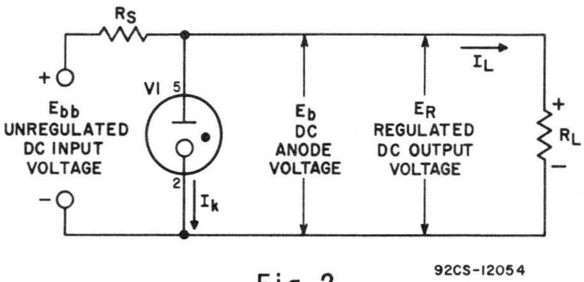


Fig.2

In this circuit, E_{bb} is the unregulated dc input voltage obtained from a rectifier-filter system, or other source, R_S is the external-circuit resistance in series with the tube, and E_b is the dc anode voltage equal to E_R, the regulated dc output voltage across the load, R_L. I_k is the dc cathode current (through the tube), and I_L is the dc load current. V1 is a VR tube such as the OA3A, OC3A, or OD3A.

Because this type of circuit arrangement involves several independent parameters, several calculations are generally necessary to determine circuit values and regulation. It is necessary first to select a regulator tube which is capable of providing the required performance, and then to determine whether the tube will be operated within its maximum ratings under the given conditions. If its ratings will be exceeded, another tube having adequate ratings must be selected.

In any given application, the following two considerations must be met to assure safe and reliable operation:

1. The dc cathode current must be kept within the minimum (I_{kmin}) and maximum (I_{km}) ratings.
2. The dc anode starting voltage, $E_{b(stg)}$, must be available under the worst probable conditions.

The dc cathode current is given by

$$I_k = \frac{E_{bb} - E_b}{R_S} - I_L \tag{1}$$

where I, E, and R are in amperes, volts, and ohms, respectively.

This current will be a maximum, I_{km}, when:

E_{bb} is a maximum, E_{bbm},
E_b is the minimum that can occur with any tube operating at I_{km}, E_{bbmin},
I_L is a minimum, I_{LMIN}, and
R_S is a minimum, R_{SMIN}.

When these values are substituted in equation (1), the minimum value of R_S is

$$R_{SMIN} > \frac{E_{bbm} - E_{bmin}}{I_{km} + I_{LMIN}} \tag{2}$$

Similarly, the cathode current will be a minimum, I_{kmin}, when:

E_{bb} is a minimum, E_{bbmin},
E_b is the maximum that can occur with any tube operating at I_{kmin}, E_{bbm},
I_L is a maximum, I_{LM}, and
R_S is a maximum, R_{SM}.

The maximum value of R_S is then given by

$$R_{SM} < \frac{E_{bbmin} - E_{bm}}{I_{kmin} + I_{LM}} \tag{3}$$

The *minimum* and *maximum* values of R_S calculated from equations (2) and (3) above will assure operation of the VR tubes within the maximum and minimum dc-cathode-current ratings. These values take into account variations in supply voltage, anode voltage drop, and load current.

To assure sufficient dc anode voltage to start the tube throughout life either under normal ambient-light conditions or in total darkness for a given dc anode supply voltage, the equipment designer must select a maximum value of R_S such that

$$R'_{SM} < \frac{E_{bbmin} - E_{bm(stg)}}{I_{LM}} \tag{4}$$

where $E_{bm(stg)}$ is the maximum value of the dc anode starting voltage under normal ambient-light conditions or in total darkness obtained from *Characteristics Range Values*.

To obtain the suitable value of R_S, select a value between R_{SMIN} calculated from equation (2) and R_{SM} from equation (3) or R'_{SM} from equation (4), whichever is lower. This value of R_S, of course, must take into account resistor tolerances.

If R_{SMIN} from equation (2) is greater than either R_{SM} from equation (3) or R'_{SM} from equation (4), the external circuit conditions are such that the VR tube will be operated beyond the limits of its capability.

If R_{SMIN} equals R_{SM} or R'_{SM}, whichever is lower, it is an indication that the VR tube will be operated at its maximum capability.

The maximum *dc load current* that can be regulated by a VR tube, under given external circuit conditions, is given by

$$I_{LM} = \frac{E_{bbm} - E_{bmin}}{R_S} - I_{kmin}$$

where E_{bmin} is the minimum value of the dc anode voltage that can occur with any tube operating at I_{kmin}, the minimum dc-cathode-current rating.

Series connection of VR tubes may be employed to obtain dc regulated voltages greater than those obtainable from a single tube. Different types may be used provided the series current is kept within the maximum dc-cathode-current rating of the lowest-rated tube. The value of the required series resistance, R_S, is calculated in the manner previously described for a single tube except that the values of E_{bmin}, E_{bm}, and $E_{bm(stg)}$, are the sum of the values for each of the VR tubes employed.

Parallel connection of VR tubes may be employed where it is necessary to obtain dc load currents greater than those obtainable from a single tube. Such parallel operation, however, requires that a resistor be used in series with each tube. Because use of such resistors impairs the regulation, parallel connection is not recommended.

Combinations of regulated dc voltages may also be obtained by series connection of VR tubes with tapped output as shown in the typical circuit in Fig. 3. In this circuit, an OA3A and an OD3A are used to obtain regulated dc voltages of approximately 75 and 225 volts, simultaneously.

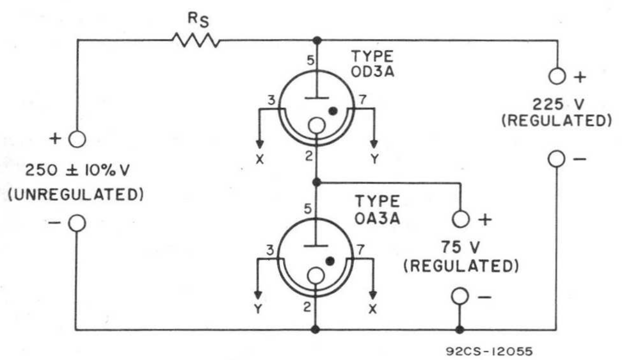


Fig. 3

To determine the value of the series resistor for small load currents in a circuit of this type, disconnect the loads and adjust the series resistor for a tube current of not more than 40 milliamperes.

Regulated bias voltages may also be obtained as shown in the typical circuit in Fig. 4. In this circuit, a single OA3A can supply a regulated dc voltage of -75 volts.

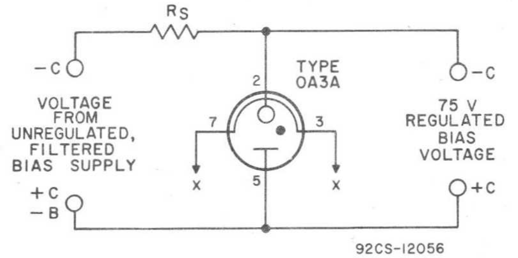


Fig. 4

The *jumper* between pins 3 and 7 inside the base of types OA3A, OC3A, and OD3A, with suitable socket connections, makes it possible to open power-supply circuits to protect circuit components when one of the VR tubes is removed from its socket. A typical disconnect arrangement utilizing the jumper connections is shown by the symbols "XX" in Figs. 3 and 4. These terminals, when connected to the terminals "XX" in Fig. 5, will assure removal of source voltage when VR tube is taken from its socket.

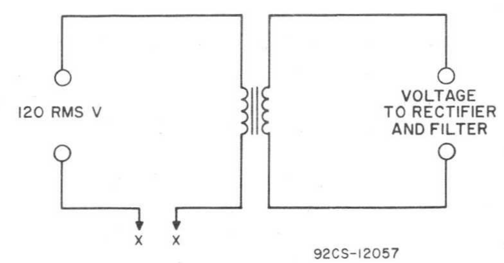


Fig. 5

Instantaneous cathode starting currents in excess of the maximum dc-cathode-current rating (40 milliamperes) are permissible as indicated under *Maximum and Minimum Ratings*. When the tubes are subjected to such high starting currents, as much as 20 minutes may be required for the regulated dc voltage to reach its normal operating value. This characteristic is typical of VR tubes of the gas-filled, cold-cathode, glow-discharge type. The regulated dc voltage is also affected by changes in dc cathode current within the operating current range. For example, the regulated dc voltage of a tube operated for a long period at 5 milliamperes and then operated at 35 milliamperes may be somewhat different from the value that would be obtained after a long period of operation at 35 milliamperes. The regulated dc voltage may also change after long idle periods. To assure a constant regulated voltage a single value of operating current should be maintained.

A *cold-cathode VR tube* consists basically of two electrodes—a small anode in the form of a wire surrounded by a cylindrical cathode. This electrode structure is mounted in an envelope containing an inert gas. The characteristics of the tube are determined by the dimensions and spacing of the electrodes and the type and pressure of the inert gas within the envelope. Operation is such that, with increased dc cathode current, more of the cathode surface is utilized with the result that a more intense glow is observed between the electrodes when the cathode current is increased.

Another effect associated with VR tubes is "spot jump", sometimes referred to as "jitter". This phenomenon is an instantaneous shift of the glow on the surface of the cathode and is responsible for small instantaneous changes in anode voltage drop. These changes can be minimized by operating the OA3A, OC3A, and OD3A at dc cathode currents sufficiently above the minimum dc-cathode-current rating (5 milliamperes) to assure that the glow covers a substantial portion of the cathode surface.

The OA3A, OC3A, and OD3A, in simple voltage-regulator circuits, are capable of providing good regulation. In critical applications, however, where the smallest possible variation in voltage is required, use of a voltage-reference tube such as the RCA-5651A is recommended.

The level of ambient radiation directly affects the dc anode starting voltage of VR tubes. The maximum values required to start any tube under normal ambient-light conditions and in total darkness are given, for each type, in *Characteristics Range Values*. When these VR tubes are operated in the presence of strong, varying, magnetic, electromagnetic, or nuclear-radiation fields, consideration should be given to the use of shielding to assure proper performance.

Operation of these VR tubes outside of the rated ambient-temperature range (-55 to +90 °C) may adversely affect regulation. To minimize voltage drift, it is necessary to keep the ambient temperature relatively constant. If necessary, the tubes should be shielded from drafts and located away from other components or equipment having varying heat dissipation.

Coupling effects can be minimized by shunting the VR tube with a capacitor. Capacitors in shunt with these VR tubes, however, should be limited to 0.1 μf. Larger values may cause the tubes to oscillate and thus produce unstable regulation.

REFERENCES

F.A. Benson, "Characteristics and Applications of Glow-Discharge Tubes," *Electronic Engineering*, June 1961 (Part 1) and July 1961 (Part 2).

W.R. Jones, "Voltage-Regulator Tubes," *Electronics*, May, 1954.

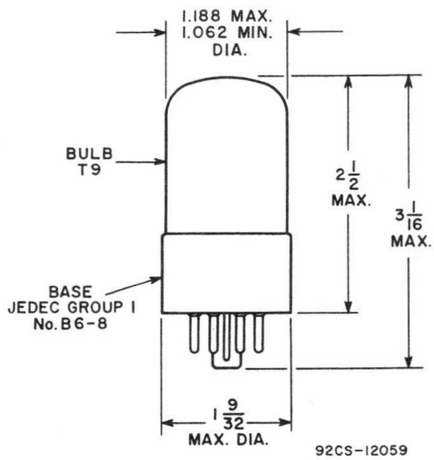
R.C. Miles, "How to Design Voltage-Regulator Tube Circuits," *Electronics*, October, 1952.

D.L. Edwards, "Relaxation Oscillations in Voltage-Regulator Tubes," *Proceedings of IRE*, December, 1953.

E.J. Handly, "Temperature Effects on Voltage Regulator Operation," *Electronics Design*, March 15, 1956.

D.M. Sanger and H.V. Houghton, "Regulating Medium and Low Voltages," *Automatic Control*, January, 1957.

DIMENSIONAL OUTLINE JEDEC No.9-7
All Dimensions in Inches

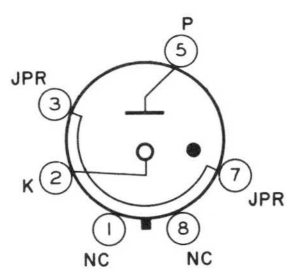


TERMINAL DIAGRAM
Bottom View

Pin 1 – No Internal Connection

Pin 2 – Cathode

Pin 3 – Jumper[d]



Pin 5 – Anode

Pin 7 – Jumper[d]

Pin 8 – No Internal Connection

JEDEC 4AJ

[d] With suitable socket connections, the jumper within the tube base (between pins 3 and 7) provides for opening the power-supply circuit to protect circuit components when the voltage-regulator tube is removed from its socket.

RCA

H-411R1

Photomultiplier Tube

RCA-1P21

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

RCA-1P21 is a 9-stage, side-on type of photomultiplier tube intended for use in critical applications involving the detection and measurement of extremely low light levels. It features a combination of high photosensitivity and low dark current.

The 1P21 is recommended for use in photoelectric spectrometers, astronomical telescopes, and other types of equipment employing light beams that are essentially collimated.

- **S-4 Spectral Response**
- **Circular-Cage Electrostatic-Focus Type**
- **Low Dark Current:**
  1×10^{-9} A at 20 A/lm and 22° C
- **Fast Time Resolution Characteristics:**
  Anode-Pulse Rise Time
  1.6×10^{-9} second at 1250 volts
  Electron Transit Time
  1.6×10^{-8} second at 1250 volts

Data

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)

Typical Spectral Response Characteristics

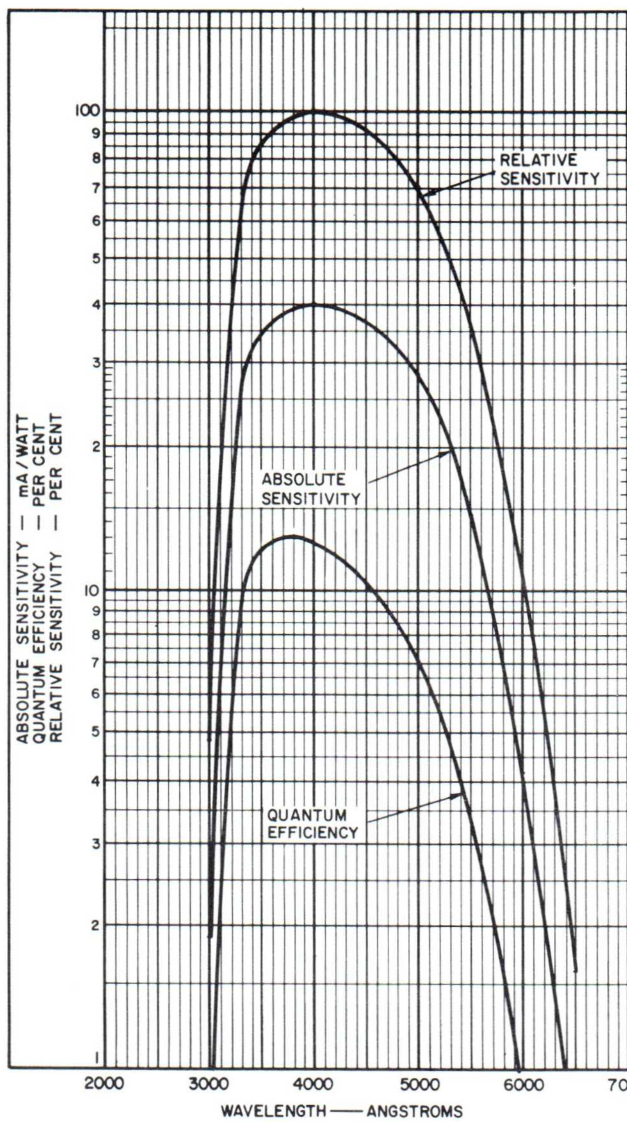


Figure 1

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

Maximum Ratings, *Absolute-Maximum Values*[e]**:**

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

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.

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.

→ Indicates a change or addition

[e] The maximum ratings in the tabulated data are established in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[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.

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

Terminal Connections

The base pins of the 1P21 fit the submagnal 11-contact socket, such as the Amphenol No.78S11T, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

Operating Stability

The operating stability of the 1P21 is dependent on the magnitude of the anode current. The use of an average anode current well below the maximum rated value of 0.1 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 through 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

Schematic Arrangement of Structure

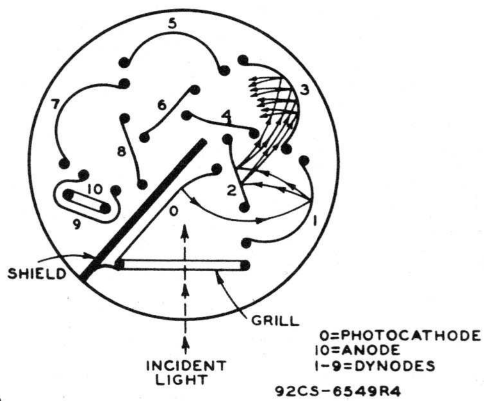


Figure 2

Typical Variation of Photocathode Sensitivity Along Tube Length

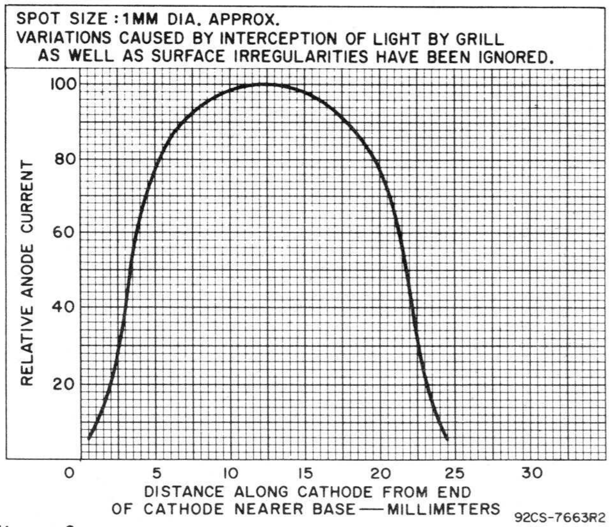


Figure 3a

Typical Variation of Photocathode Sensitivity Across Projected Width in Plane of Grill

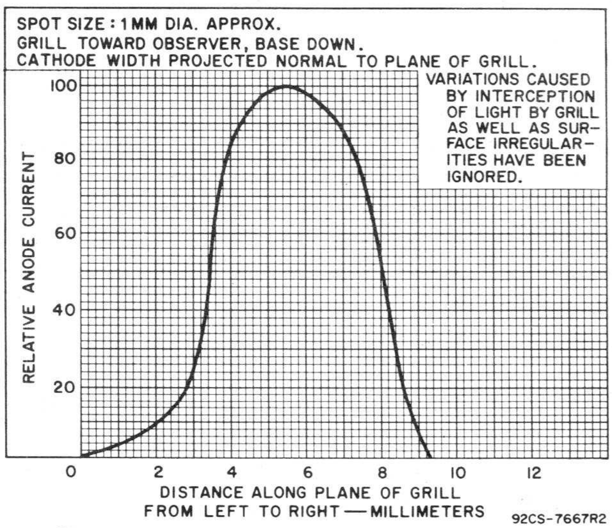


Figure 3b

Typical Variation of Sensitivity as Tube is Rotated With Respect to Fixed Light Beam

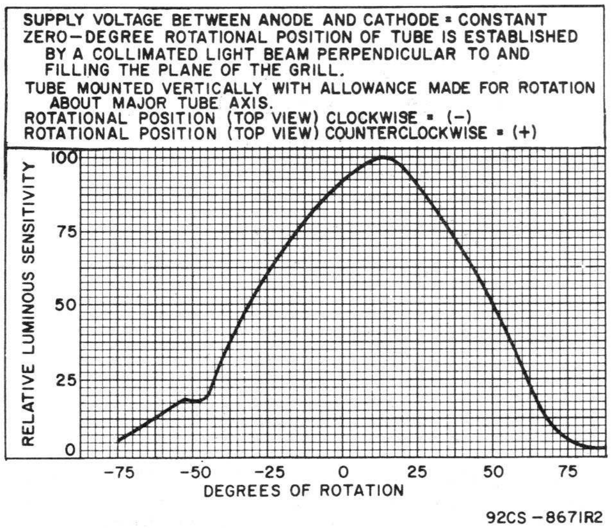


Figure 4

Typical Characteristic of Output Current as a Function of Dynode-No.6 Volts

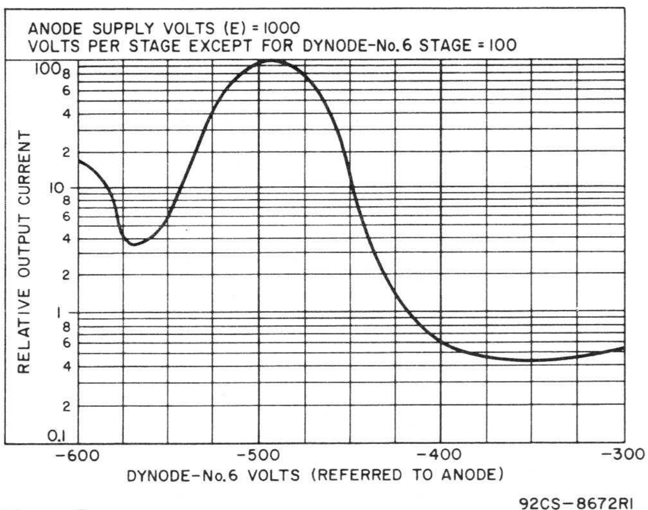


Figure 5a

Typical Characteristic of Output Current as a Function of Simultaneous Modulation of Dynodes No.5 and No.6

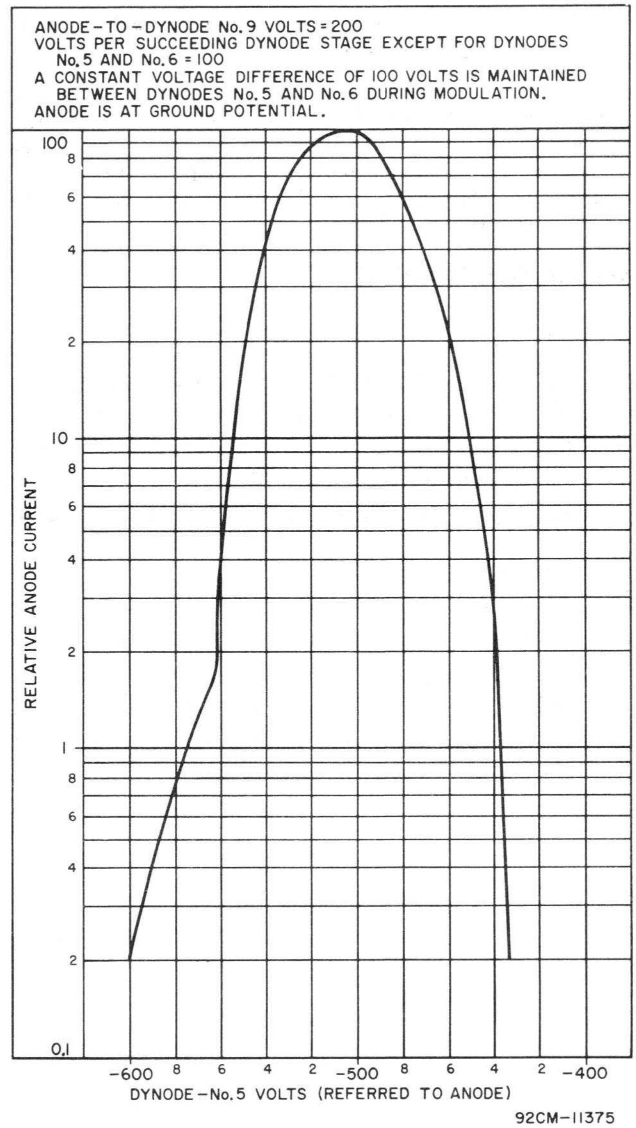


Figure 5b

position of maximum sensitivity (approximately + 13^{o} 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 1P21 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 1P21 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.

Sensitivity and Current Amplification Characteristics

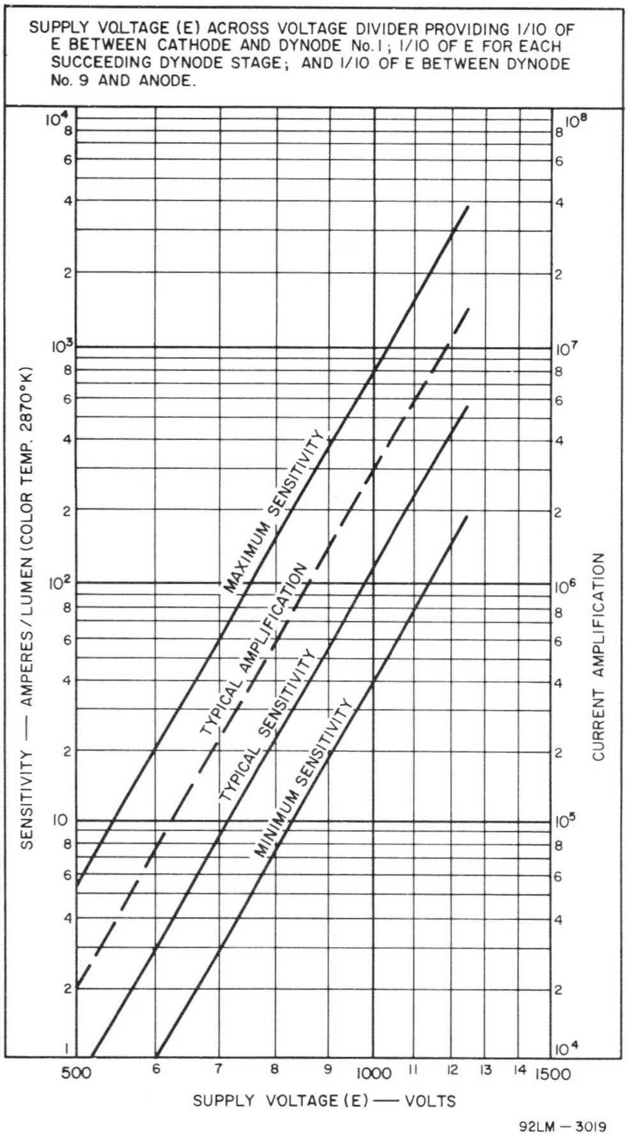


Figure 6

ENI Characteristic as a Function of Tube Temperature

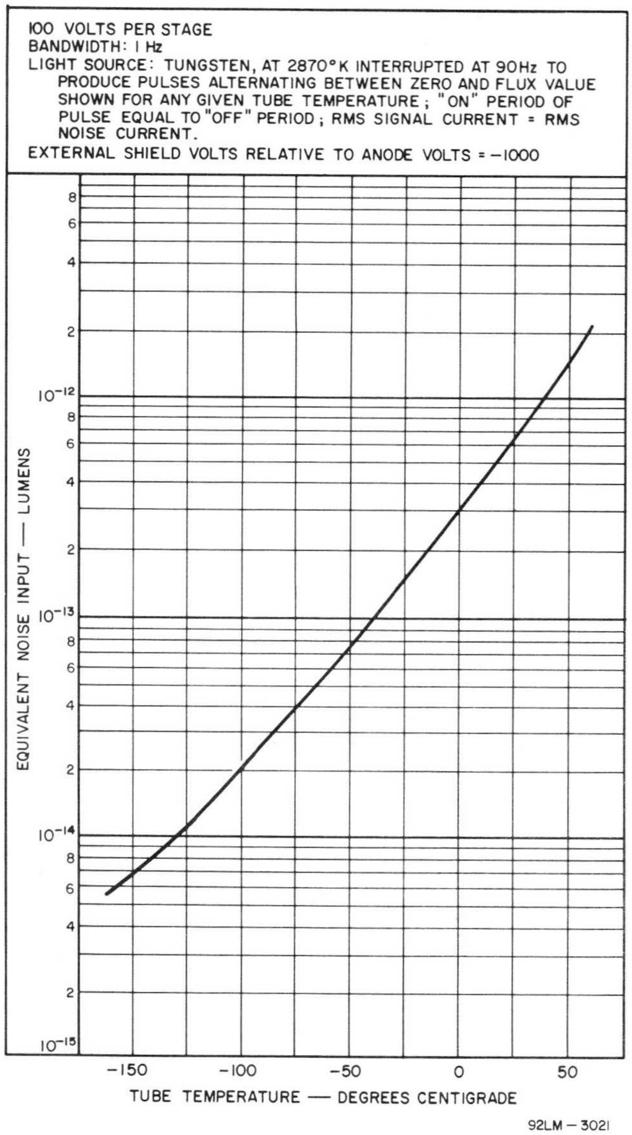


Figure 7

Magnetic shielding of the 1P21 is necessary if it is operated in the presence of strong magnetic fields. The curve in **Figure 9** 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 1P21.

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 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.

Typical EADCI and Dark Current Characteristics

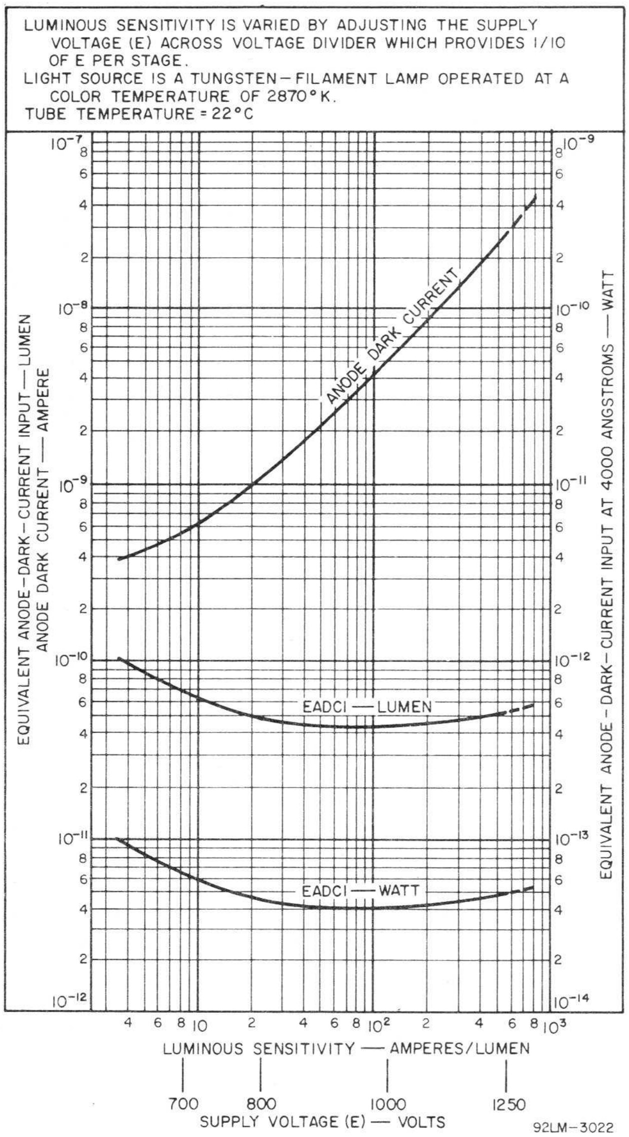


Figure 8

Typical Effect of Magnetic Field on Anode Current

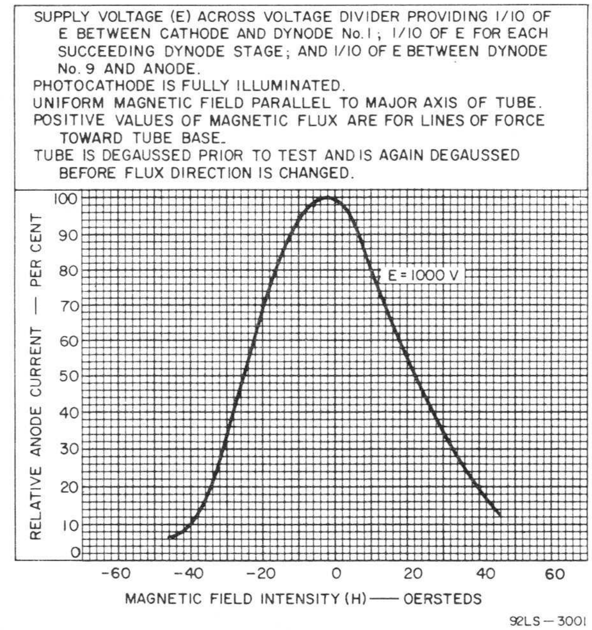


Figure 9

Typical Time-Resolution Characteristics

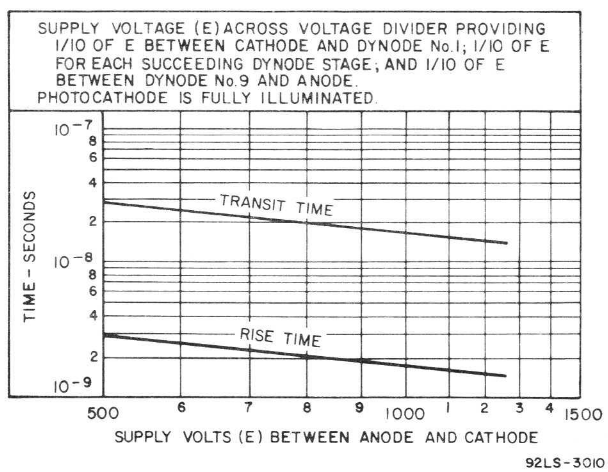


Figure 10

Dark Current

The use of a refrigerant, such as dry ice or liquid air, to cool the 1P21 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 7.**

Typical anode dark current and EADCI as a function of luminous sensitivity at a temperature of +22° C is shown in **Figure 8.**

Operating Voltages

The recommended operating voltages for the 1P21 are as follows: the successive stages of the 1P21 are operated at voltages increasing in equal steps from the photocathode to the 9th dynode. The steps are generally chosen as 75 to 100 volts per stage. The operating voltage between dynode No 9 and anode should be kept as low as possible in order to reduce ohmic leakage current to the anode to a low level but large enough to take into account the voltage drop across a particular output load. For the higher light

Typical Anode Characteristics

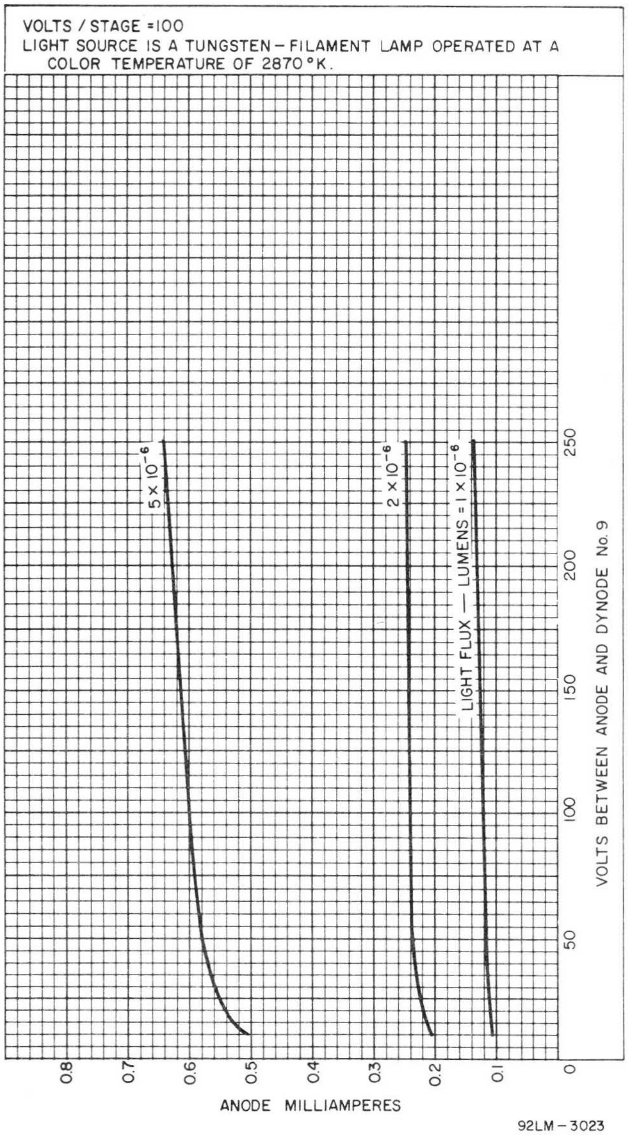


Figure 11

levels shown in **Figure 11** for pulse service, higher voltage between dynode No.9 and anode will be required because of saturation due to space charge limitations.

In general, the current in the divider should be at least 10 times greater than the maximum average value of anode current. The resistance value of the voltage divider should be adequate to prevent variation of dynode potentials by signal current. Resistance 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.

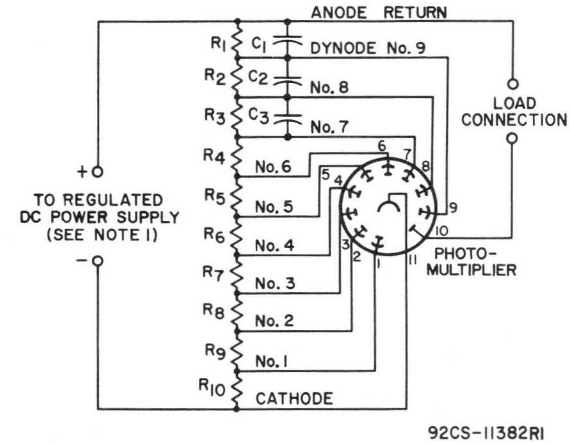
A typical voltage divider arrangement for use with the 1P21 is shown in **Figure 12.** The choice of resistance values for the voltage divider string is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the supply and the required wattage rating of the resistors 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.

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 1P21 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



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

Note 1: Adjustable between approximately 500 and 1250 volts.

Note 2: Capacitors $C_1^{\blacklozenge}$ through $C_3^{\blacklozenge}$ 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.

Figure 12

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

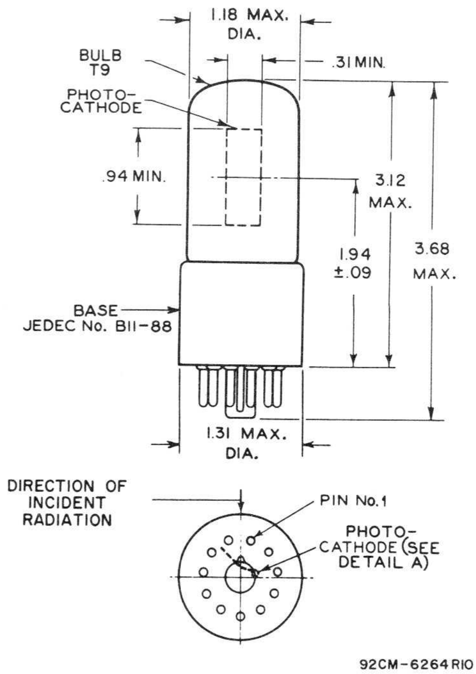
This formula applies for the anode-to-final dynode capacitor. The factor 100 is used to limit the voltage change across the capacitor to 1% maximum during a pulse. Capacitor values for preceding stages should take into account the smaller values of dynode currents in these stages. Conservatively, a factor 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:

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

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

Dimensional Outline

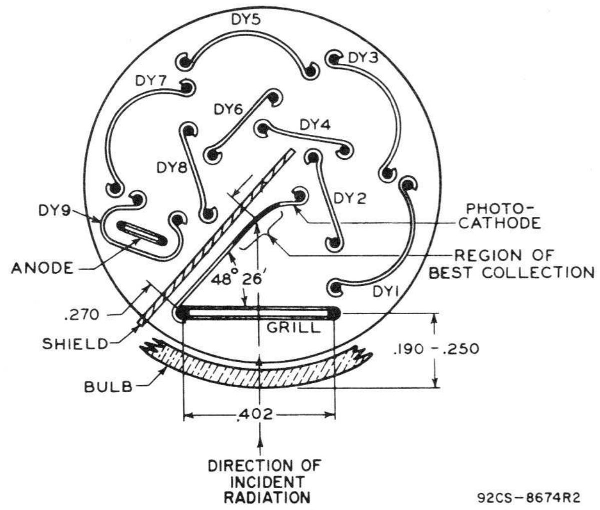


℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at center of bottom of base.

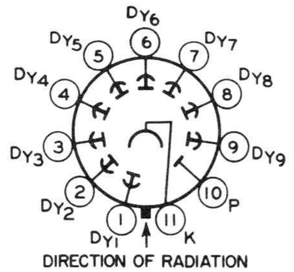
Dimensions are in inches unless otherwise stated. Dimensions tabulated below are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

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

Detail A
Top View

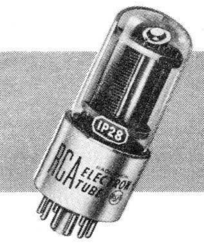


Basing Diagram
Bottom View



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

RCA-1P28



PHOTOMULTIPLIER TUBE

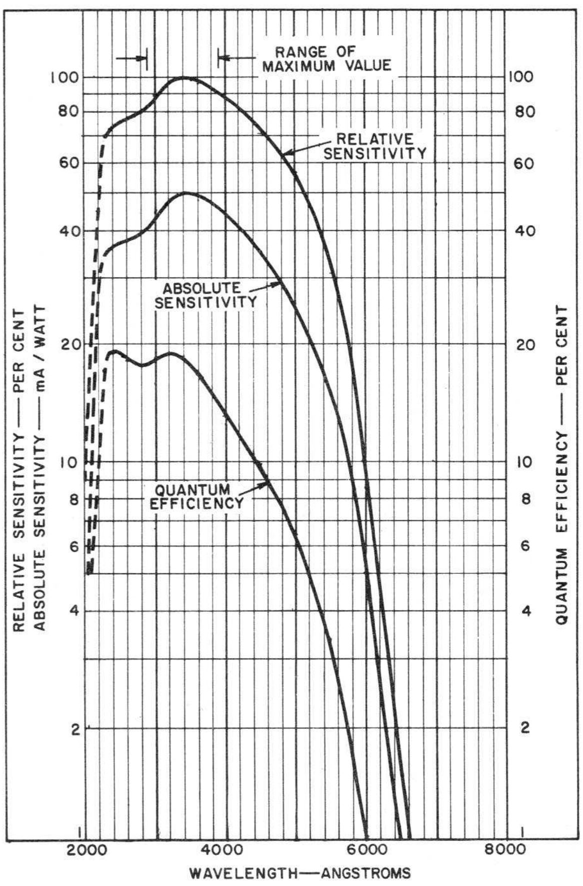
9-Stage, Side-On Type
S-5 Spectral Response

RCA-1P28 is a 9-stage, side-on type photomultiplier tube designed especially for the detection and measurement of ultraviolet and visible radiation. It employs an ultraviolet-transmitting glass bulb which transmits radiant energy in the ultraviolet down to about 2000 angstroms.

The 1P28 is well suited for use in applications such as spectrophotometry, scientific research, and other systems involving very low levels of ultraviolet radiation.

Spectral response characteristics for the 1P28 are shown in Fig.1. Maximum response occurs at about 3400 angstroms.

SPECTRAL RESPONSE CHARACTERISTICS



92LM–1205

Fig. 1

FEATURES

- **Ultraviolet Detection Capability to about 2000 Angstroms**
- **High Anode Sensitivity**
- **Fast Time Resolution Characteristics:**
  Anode-Pulse Rise Time
  1.6×10^{-9} second at 1250 volts
  Electron Transit Time
  1.6×10^{-8} second at 1250 volts
- **Low Dark Current**
  5×10^{-9} ampere at a sensitivity of 20 A/lm and 22° C

DATA

General:

Spectral Response	S-5
Wavelength of Maximum Response	3400 ± 500 angstroms
Cathode, Opaque	Cesium-Antimony
Minimum projected length[a]	15/16"
Minimum projected width[a]	5/16"
Window	Ultraviolet-Transmitting Glass (Corning[b] No.9741), or equivalent
Index of Refraction at 5893 angstroms	1.47
Dynodes:	
Substrate	Nickel
Secondary-Emitting Surface	Cesium-Antimony
Structure	Circular Cage
Direct Interelectrode Capacitances (Approx.):	
Anode to Dynode No.9	4.4 pF
Anode to all other electrodes	6.0 pF
Maximum Overall Length	3-11/16"
Maximum Seated Length	3-1/8"
Length from Base Seat to Center of Useful Cathode Area	1-15/16" ± 3/32"
Maximum Diameter	1-5/16"
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] Part No.80801B, or equivalent
Operating Position	Any
Weight (Approx.)	1.6 oz

Maximum Ratings, *Absolute-Maximum Values[e]:*

Supply Voltage (DC or Peak AC):	
Between Anode and Cathode	1250 max. volts
Between Dynode No.9 and Anode	250 max. volts
Between Consecutive Dynodes	250 max. volts
Between Dynode No.1 and Cathode	250 max. volts
Average Anode Current[f]	0.5 max. mA
Ambient Temperature[g]	75 max. °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.

With E = 1000 volts (Except as noted)

	Min.	Typical	Max.	
Sensitivity:				
Radiant,[h] at 3400 angstroms	–	1.2×10^{5}	–	A/W
Cathode radiant,[i] at 3400 angstroms	–	0.05	–	A/W
Luminous[k]	17.5	100	500	A/lm
Cathode luminous[m]	1×10^{-5}	4×10^{-5}	–	A/lm
Quantum Efficiency at 3200 angstroms	–	19	–	%
Current Amplification	–	2.5×10^{6}	–	
Equivalent Anode-Dark-Current Input[p]	–	2.5×10^{-10}[n]	1.25×10^{-9}[n]	lm
	–	2×10^{-13}[q]	1×10^{-12}[q]	W
Anode Dark Current at 20 A/lm[n,p]	–	5×10^{-9}	2.5×10^{-8}	A
Equivalent Noise Input[r]	–	7.5×10^{-13}	–	lm
	–	6×10^{-16}[q]	–	W
Anode-Pulse Rise Time[s]	–	1.9×10^{-9}	–	sec
Electron Transit Time[t]	–	1.7×10^{-8}	–	sec

[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, New York.

[c]Made by Amphenol Electronics Corporation, 1830 South 54th Avenue, Chicago 50, Illinois.

[d]Made by James Millen Manufacturing Company, 150 Exchange Street, Malden 48, Mass.

[e]The *maximum ratings* in the tabulated data are established in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[g]Tube operation at room temperature or below is recommended.

[h]This value is calculated from the typical luminous sensitivity rating using a conversion factor of 1252 lumens per watt.

[i]This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1252 lumens per watt.

[k]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.

[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 and with supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current may re reduced by use of a refrigerant.

[p]For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

[q]At 3400 angstroms. This value is calculated from the rating in lumen using a conversion factor of 1252 lumens/watt.

[r]Under the following conditions: Supply voltage (E) is as shown, 22° 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.

[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.

OPERATING CONSIDERATIONS

TERMINAL CONNECTIONS

The *base pins of the* 1P28 fit the submagnal 11-contact socket, such as the Amphenol No.78S11T, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

OPERATING STABILITY

The *operating stability* of the 1P28 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 0.5 microampere is suggested.

SCHEMATIC ARRANGEMENT OF STRUCTURE

Top View

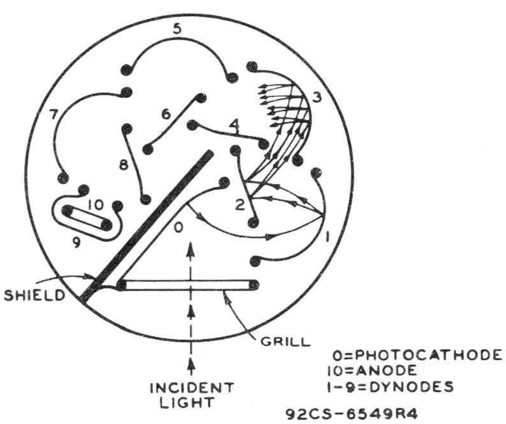


Fig. 2

TUBE ORIENTATION

The *sensitivity of the photocathode surface* varies with respect to the position of the light spot on the surface. Fig.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 Fig.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.

TYPICAL VARIATION OF PHOTOCATHODE SENSITIVITY ALONG TUBE LENGTH

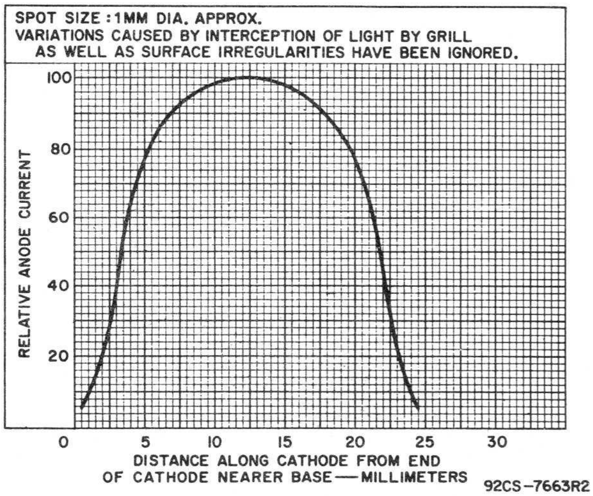


Fig. 3a

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

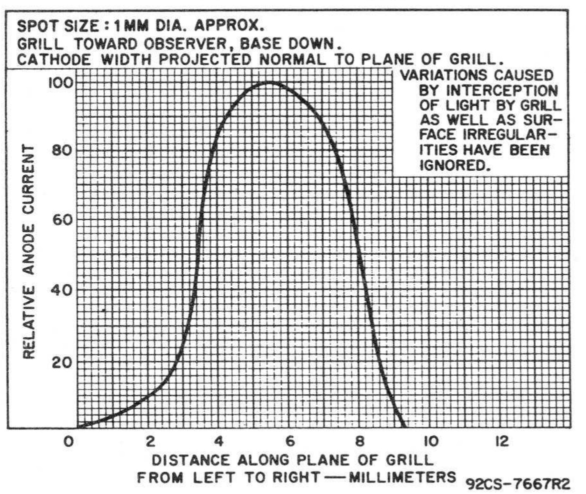


Fig. 3b

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 Fig.4. As the tube is rotated from the position of maximum sensitivity (approximately + 13° as shown in Fig.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.

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

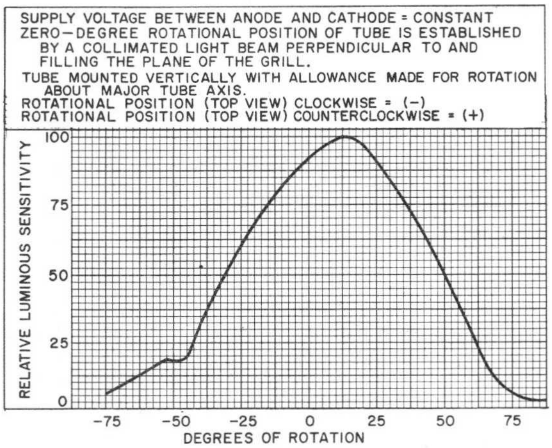


Fig. 4

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 Fig.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 Fig.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.

DYNODE MODULATION CHARACTERISTICS

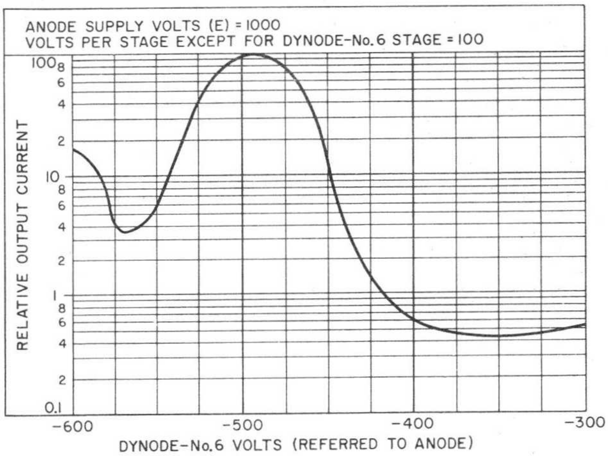


Fig. 5a

Typical Characteristic of Output Current as a Function of Dynode-No.6 Volts

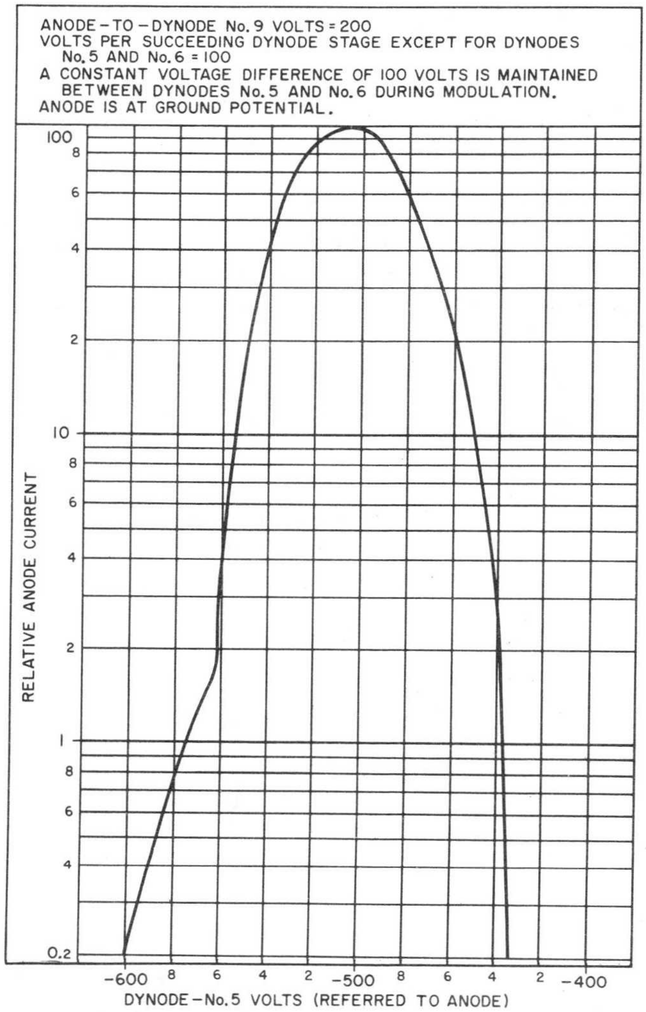


Fig. 5b

Typical Characteristic of Output Current as a Function of Simultaneous Modulation of Dynodes No.5 and No.6

SHIELDING

Electrostatic and/or magnetic shielding of the 1P28 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 1P28 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 1P28 is necessary if it is operated in the presence of strong magnetic fields.

The curves in Fig.6 show 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 1P28.

TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

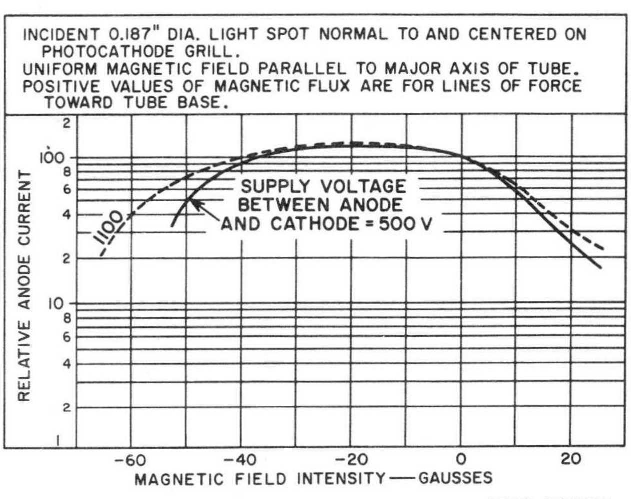


Fig. 6

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

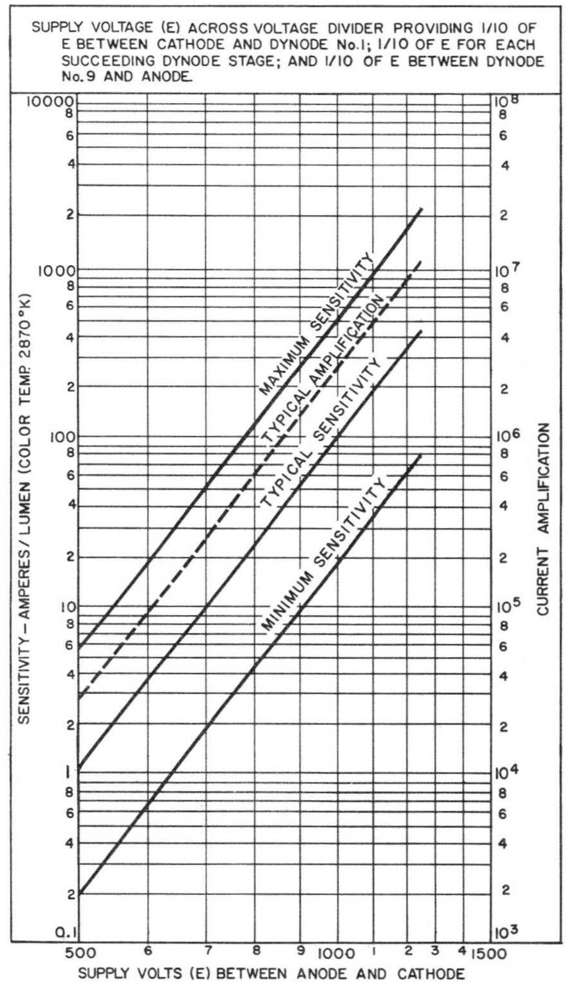


Fig. 7

TYPICAL TIME-RESOLUTION CHARACTERISTICS

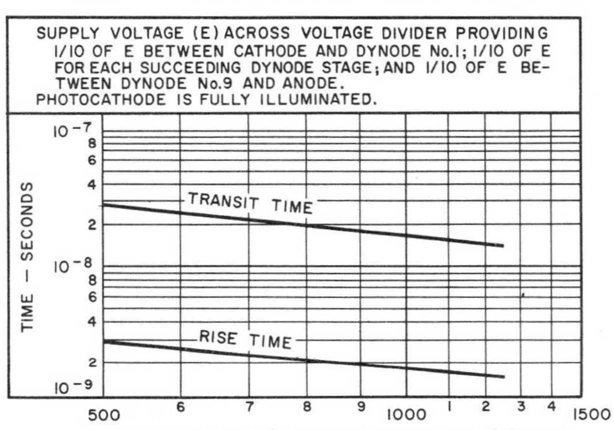


Fig. 8

DARK CURRENT

The *use of a refrigerant,* such as dry ice or liquid air, to cool the 1P28 is recommended in those applications where maximum current amplification with minimum dark current is required.

The *equivalent noise input as a function of the temperature* of the 1P28 is shown in Fig.9.

TYPICAL EQUIVALENT NOISE INPUT CHARACTERISTIC

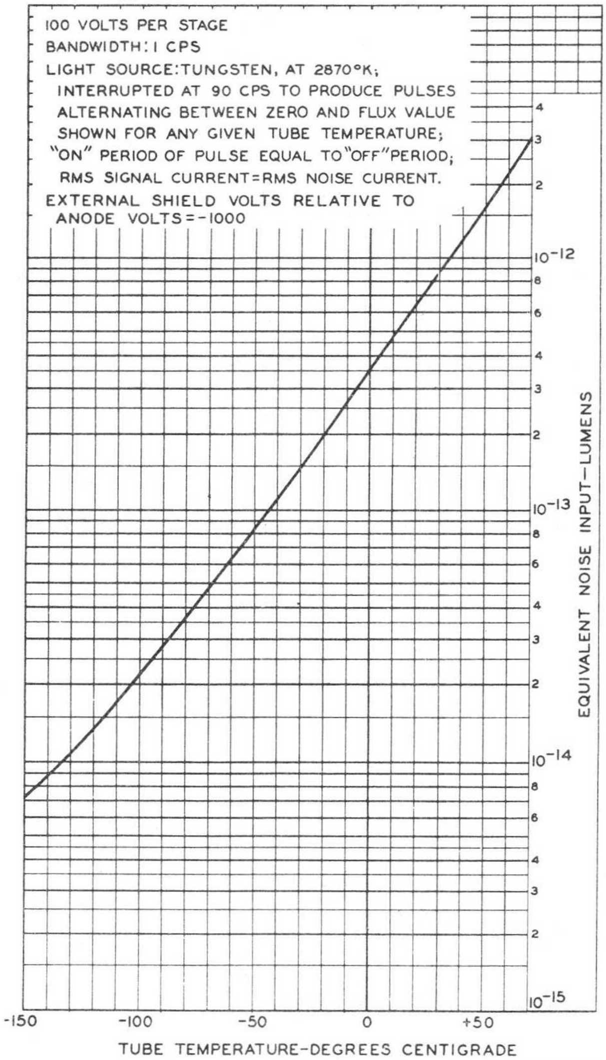


Fig. 9

OUTPUT CIRCUIT LEAD LENGTH

Whenever frequency response is important, the leads from the 1P28 to the amplifier should be short so as to minimize the effects of distributed inductance and capacitance of the leads.

OPERATING VOLTAGES

The recommended *operating voltages* for the 1P28 are as follows: the successive stages of the 1P28 are operated at voltages increasing in equal steps from the photocathode to the 9th dynode. The steps are generally chosen as 75 to 100 volts per stage. The operating voltage between dynode No.9 and anode should be kept as low as possible in order to reduce ohmic leakage

TYPICAL ANODE CHARACTERISTICS

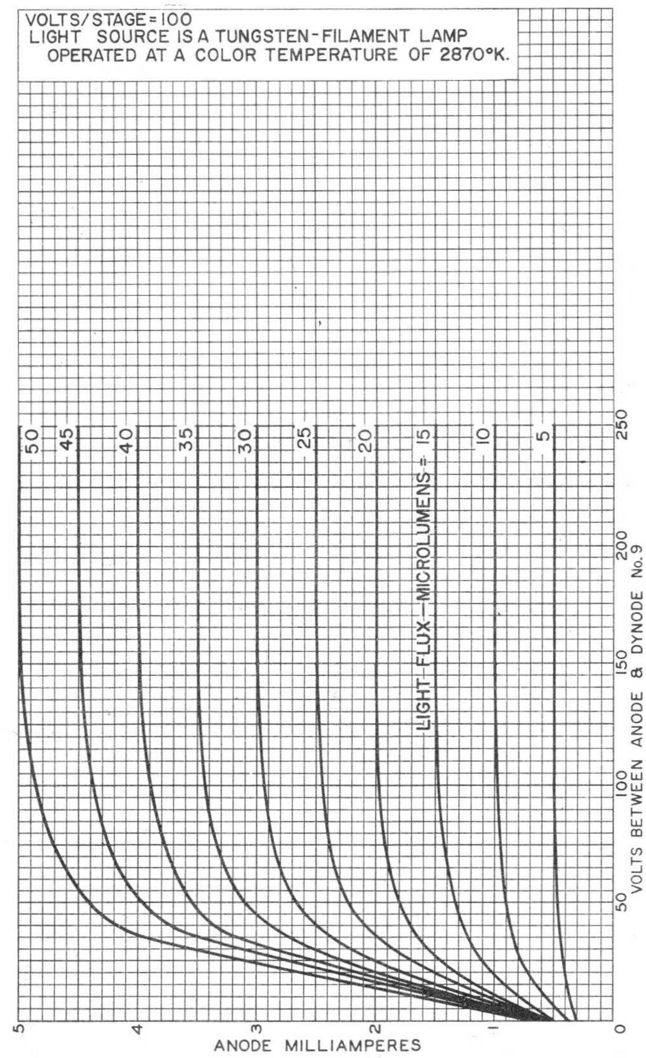


Fig. 10

current to the anode to a low level but large enough to take into account the voltage drop across a particular output load. For the higher light levels shown in Fig.10 for pulse service, higher voltage between dynode No.9 and anode will be required because of saturation due to space charge limitations.

In general, the current in the divider should be at least 10 times greater than the maximum average value of anode current. The resistance value of the voltage divider should be adequate to prevent variation of dynode potentials by signal current. Resistance values greater than 1 megohm 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.

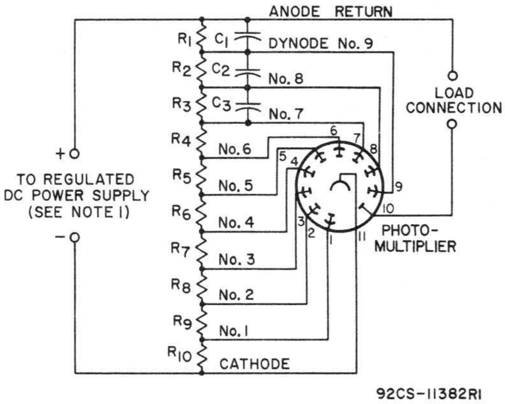
A typical voltage divider arrangement for use with the 1P28 is shown in Fig.11. The choice of resistance values for the voltage divider string is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the supply and the required wattage rating of the resistors 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.

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 1P28 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



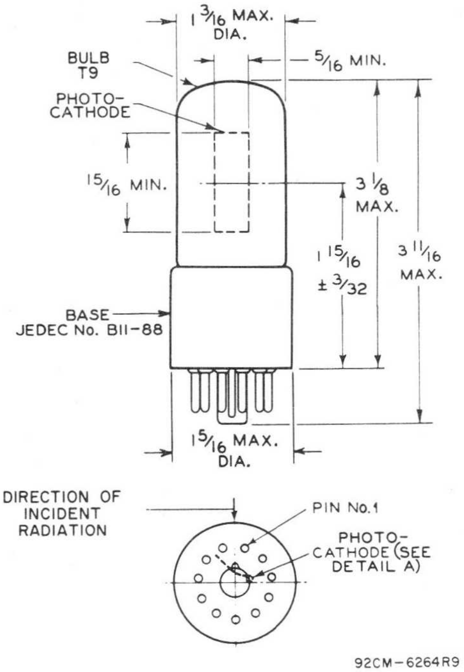
R_1 through R_{10} = 20,000 to 1,000,000 ohms

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.

Fig. 11

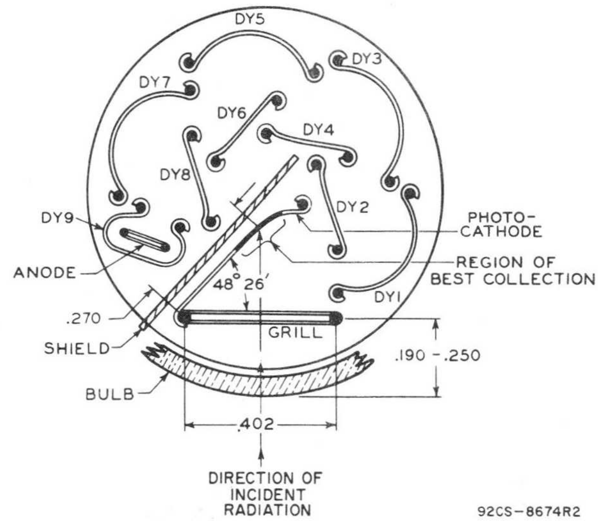
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at center of bottom of base.

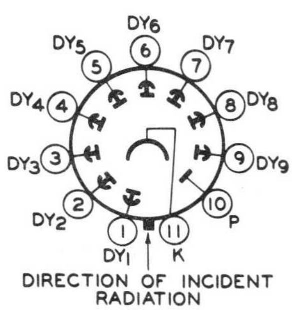
DETAIL A
Top View



DIMENSIONS IN INCHES

BASING DIAGRAM
Bottom 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

11K

RCA-1P28A

PHOTOMULTIPLIER TUBE

9-Stage, Side-On Type
S-5 Response

This bulletin is to be used in conjunction with the bulletin for RCA-1P28.

RCA-1P28A is a 9-stage, side-on type photomultiplier tube identical with the RCA-1P28 except that its luminous sensitivity rating is higher and its sensitivity above the wavelength of 5800 angstroms is controlled. This control is important in applications where a high-level of sensitivity in the red region of the spectral-response characteristic is required. The degree of this controlled sensitivity in the red region is specified by a "red-to-white" ratio of anode currents. Anode current is measured first using a tungsten-lamp source, and then measured with a red filter interposed between the light source and phototube. The "red-to-white" ratio is greater than 7% for the 1P28A.

The anode current comprising the "white" portion of this ratio is measured with a light input of 10 microlumens. The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870° K.

The anode current comprising the "red" portion of the ratio is measured under conditions identical with the "white" measurement except that the light input of 10 microlumens is transmitted through a red filter (Corning C.S. No.2-112–manufactured by the Corning Glass Works, Corning, N.Y., or equivalent) which has the following characteristics: the transmittance of all wavelengths from 3000 to 5790 angstroms is less than 0.5%; the 37% transmittance point lies between 6030 and 6070 angstroms; the transmittance from 6400 to 7000 angstroms is greater than 80%; and the difference between the wavelengths where transmittance is 15% and 60% is not greater than 150 angstroms.

DATA

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.

With E = 1000 volts

	Min.	*Typical*	*Max.*	
Sensitivity:				
Luminous[a]	35	200	500	A/lm
"Red-to-White" Ratio	7	–	–	%

[a]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.

H-411R1

Photomultiplier Tube | RCA-1P28/V1

Variant of Type 1P28 Having Negligible Anode-Current "Overshoot" and "Undershoot" (Hysteresis) and Extended S-5 Spectral Response.

RCA-1P28/V1 is a 9-stage side-on type of photomultiplier tube designed for the detection and measurement of ultraviolet and visible radiation. It employs an ultraviolet-transmitting glass bulb which transmits radiant energy in the ultraviolet down to about 2000 angstroms.

The 1P28/V1 has extended S-5 spectral response. Maximum wavelength of response is approximately 4500 angstroms and its sensitivity extends to about 7000 angstroms in the visible region of the spectrum.

A major feature of the 1P28/V1 is its anode-current stability which minimizes both "overshoot" and "undershoot" of anode current when voltage and incident radiation is initially applied. This design enhances the use of the 1P28/V1 in constant-current photomultiplier systems where overall voltage is changed.

The 1P28/V1 has extremely fast time-resolution characteristics and high anode sensitivity making it well suited for use in applications such as spectrophotometry, scientific research, and in other systems involving low-level ultraviolet and visible radiation.

- **Extended S-5 Spectral Response – Range Approximately 2000 to 7000 Å**
- **Negligible "Overshoot" and "Undershoot":**

  Anode current will be within 0.2% of its steady-state value within 1 second after application of tube voltage and incident radiation. Maximum allowable overshoot is 2%.
- **High Anode Sensitivity:**
  200 A/lm at 1000 V
- **Low Dark Current:**
  2×10^{-9} ampere at a sensitivity of 40 A/lm and 22°C
- **Fast Time Resolution Characteristics:**

  Anode-Pulse Rise Time
  1.6×10^{-9} second at 1250 volts

  Electron Transit Time
  1.6×10^{-8} second at 1250 volts

Spectral Response Characteristics

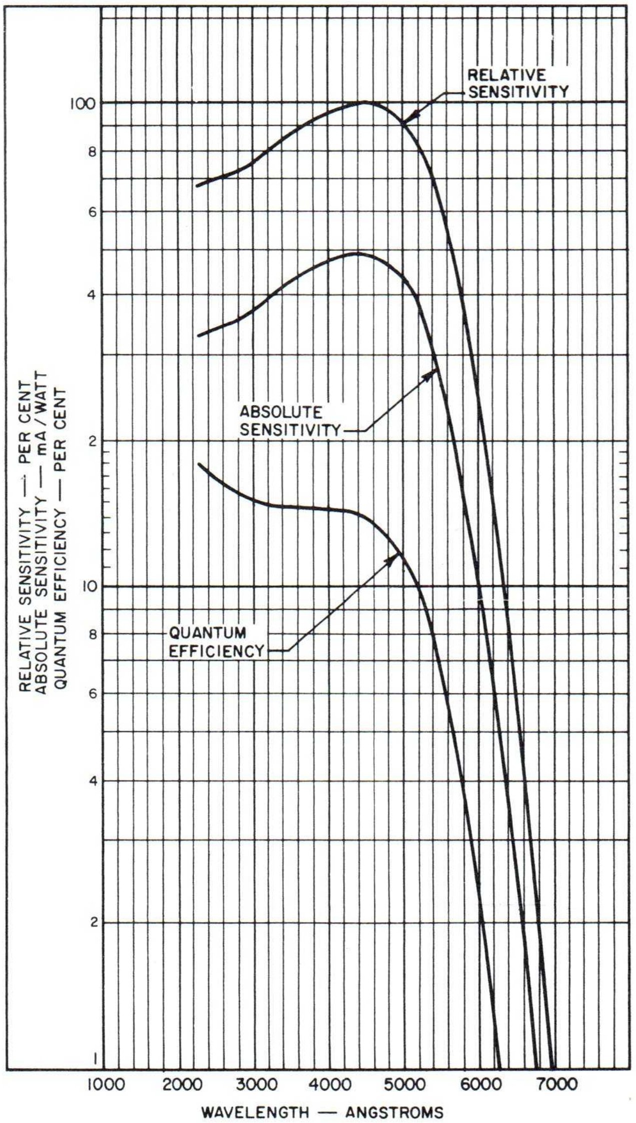


Figure 1

Data

General:

Spectral Response . . . . See **Figure 1**

Wavelength of Maximum Response. . . . 4500 ± 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. . . . . Ultraviolet-Transmitting Glass (Corning[b] No.9741, or equivalent

Index of Refraction at 4047 angstroms 1.48

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

Maximum Ratings, *Absolute-Maximum Values*[e]:

DC Supply Voltage:

Between Anode and Cathode	1250 max.	V
Between Dynode No.9 and Anode	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[g]	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with 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 4500 angstroms	–	$1.6x10^{5}$	–	A/W
Luminous[i]	35	200	1200	A/lm
Cathode Sensitivity:				
Radiant[k] at 4500 angstroms	–	$4.8x10^{-2}$	–	A/W
Luminous[m]	$2.5x10^{-5}$	$6x10^{-5}$	–	A/lm
Quantum Efficiency at 3500 angstroms	–	15	–	%
Anode-Current Stability, (Hysteresis):[n]				
Overshoot	–	–	2	%
Time for anode current to be within 0.2% of steady-state value	–	–	1	s
Undershoot				
Time for anode current to be within 0.2% of steady-state value	–	–	1	s
Current Amplification	–	$3.3x10^{6}$	–	
Anode Dark Current[p]	–	$2x10^{-9}$	$2x10^{-8}$	A
Equivalent Anode Dark Current Input[p]	–	$5x10^{-11}$	$5x10^{-10}$	lm
	–	$6.3x10^{-14}$[q]	$6.3x10^{-13}$[q]	W
Equivalent Noise Input[r]	–	$1.7x10^{-12}$	–	lm
	–	$2.2x10^{-15}$[s]	–	W
Anode-Pulse Rise Time[t] at 1250 V	–	$1.6x10^{-9}$	–	s
Electron Transit Time[u] at 1250 V	–	$1.6x10^{-8}$	–	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 Amphenol Electronics Corporation, 1830 South 54th Avenue, Chicago 50, IL 60650.

[d] Made by James Millen Manufacturing Company, 150 Exchange Street, Malden 48, MA 02148.

[e] The maximum ratings in the tabulated data are established in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[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 800 lumens per watt.

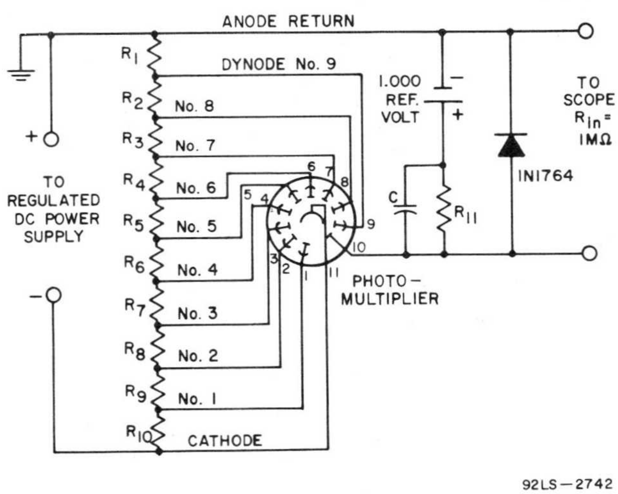
[i] Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870° K and a light input of 1 microlumen is used.

[k] This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 800 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] Anode-Current Stability (Hysteresis) is measured as follows in the test circuit shown below:

The dc power supply is adjusted to 300 volts. The photocathode of the tube is then illuminated to provide an anode current of sufficient magnitude (typically 1 microampere) to develop a voltage drop across resistor R_{11} that cancels the 1.000 volt reference voltage, and thereby provides zero deflection on the oscilloscope. Light is excluded from the tube and the supply voltage is quickly increased to 900 volts and maintained at this voltage for 10 seconds. The supply voltage is then quickly reduced to 300 volts and the photocathode is re-illuminated by the previously established light level. Anode current overshoot or undershoot is then measured. Because the oscilloscope has an input resistance of 1 megohm, a 2% increase in anode current (1.02 µA total anode current) develops a 0.01 volt deflection on the oscilloscope.



C: 0.05 µF, 20%, 200 vdc, ceramic disc
R_1 through R_{10}: 100 kΩ, 5%, 1/4 watt
R_{11}: 1 MΩ, 5%, 1/4 watt

[p] At a tube temperature of 22° C and with supply voltage (E) adjusted to give a luminous sensitivity of 40 amperes per lumen. Dark current is measured with no light incident on the tube and may be reduced by use of a refrigerant.

[q] At 4500 angstroms. These values are calculated from the EADCI values in lumens using a conversion factor of 800 lumens per watt.

[r] 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.

[s] At 4500 angstroms. This value is calculated from the ENI value in lumens using a conversion factor of 800 lumens per watt.

[t] 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.

[u] The electron transit time is the time interval between the arrival of a deltafunction 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

Terminal Connections

The base pins of the 1P28/V1 fit the submagnal 11-contact socket, such as the Amphenol No.78S11T, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

Operating Stability

The operating stability of the 1P28/V1 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 through the tube envelope and may lead to eventual tube destruction.

Schematic Arrangement of Structure

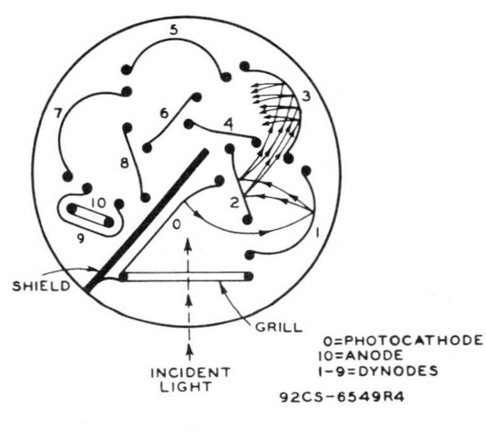


Figure 2

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.

Typical Variation of Photocathode Sensitivity Along Tube Length

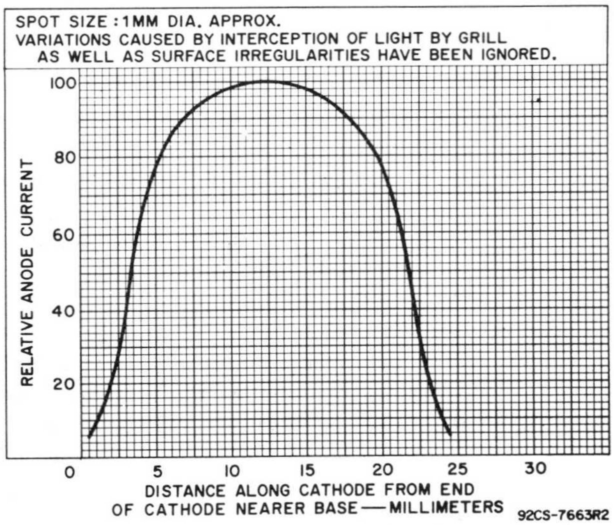


Figure 3a

Typical Variation of Photocathode Sensitivity Across Projected Width in Plane of Grill

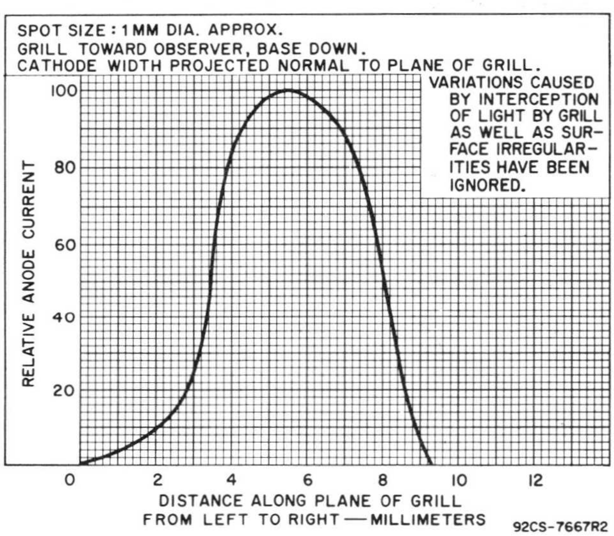


Figure 3b

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^{o} 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.

Typical Variation of Sensitivity as Tube is Rotated with Respect to Fixed Light Beam

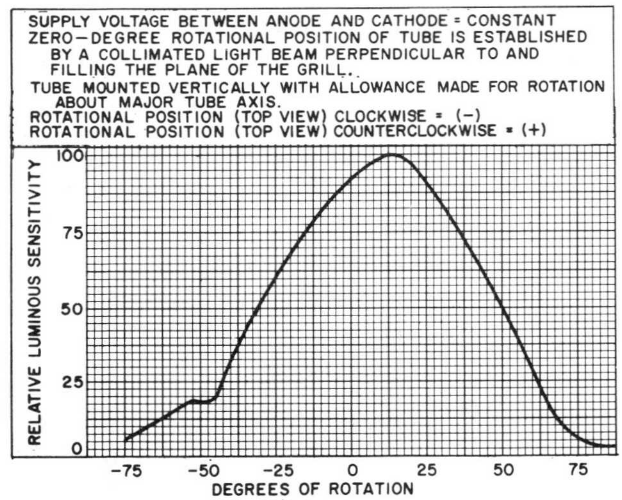


Figure 4

Typical Characteristic of Output Current as a Function of Dynode-No.6 Volts

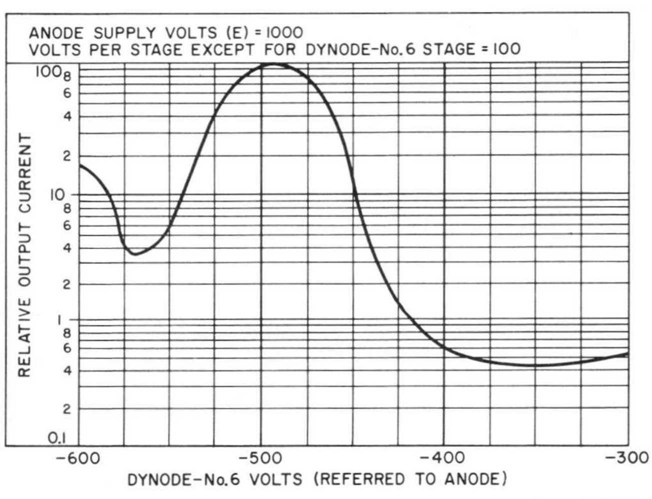


Figure 5a

Typical Characteristic of Output Current as a Function of Simultaneous Modulation of Dynodes No.5 and No.6

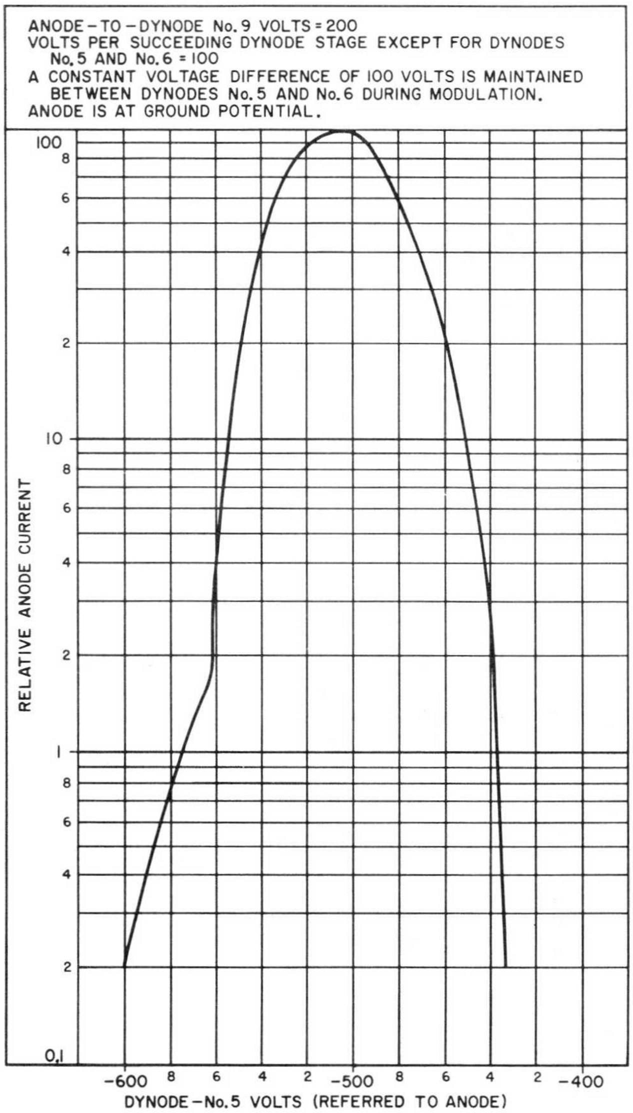


Figure 5b

Typical Sensitivity and Current Amplification Characteristics

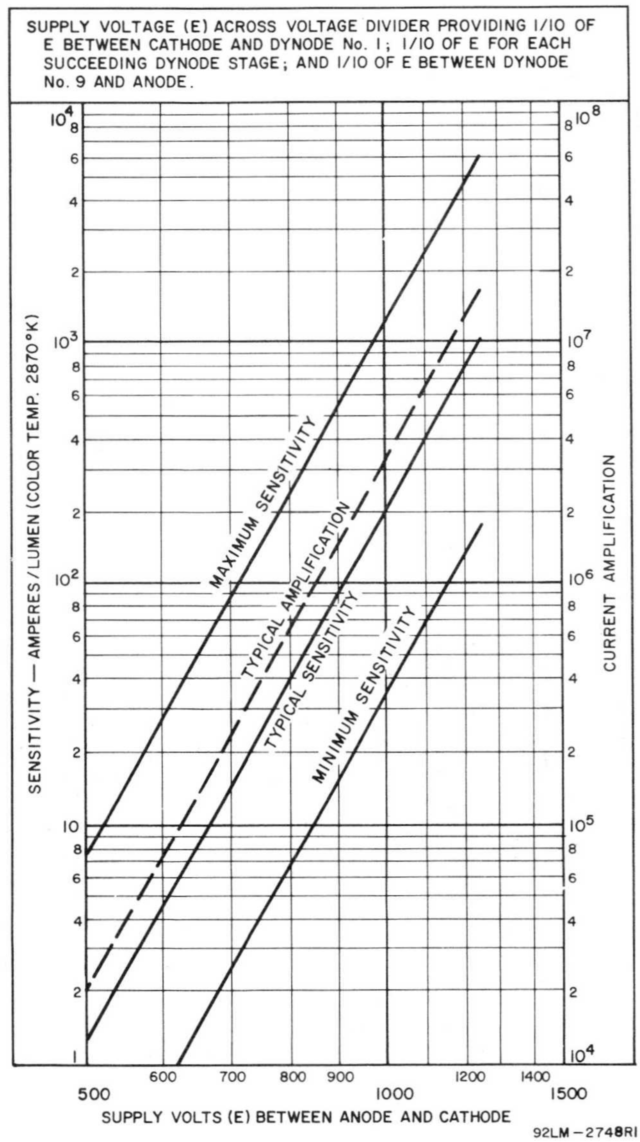


Figure 6

Shielding

Electrostatic and/or magnetic shielding of the 1P28/V1 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 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 1P28/V1 is necessary if it is operated in the presence of strong magnetic fields. The curve in **Figure 9** 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 tube.

Typical EADCI and Anode Dark Current Characteristics

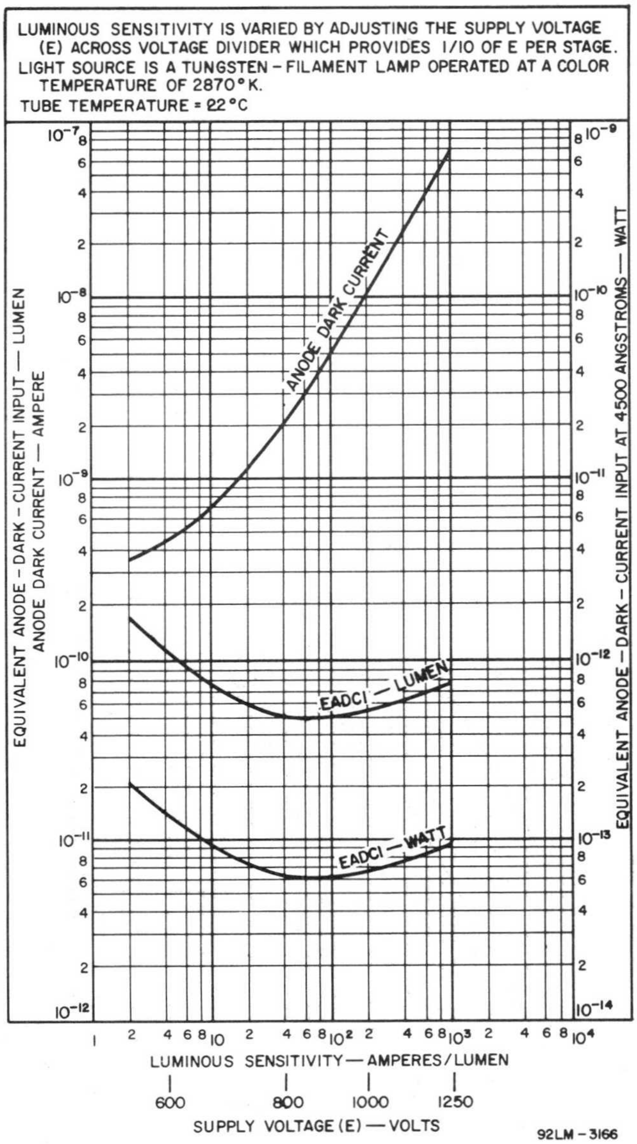


Figure 7

ENI Characteristic as a Function of Tube Temperature

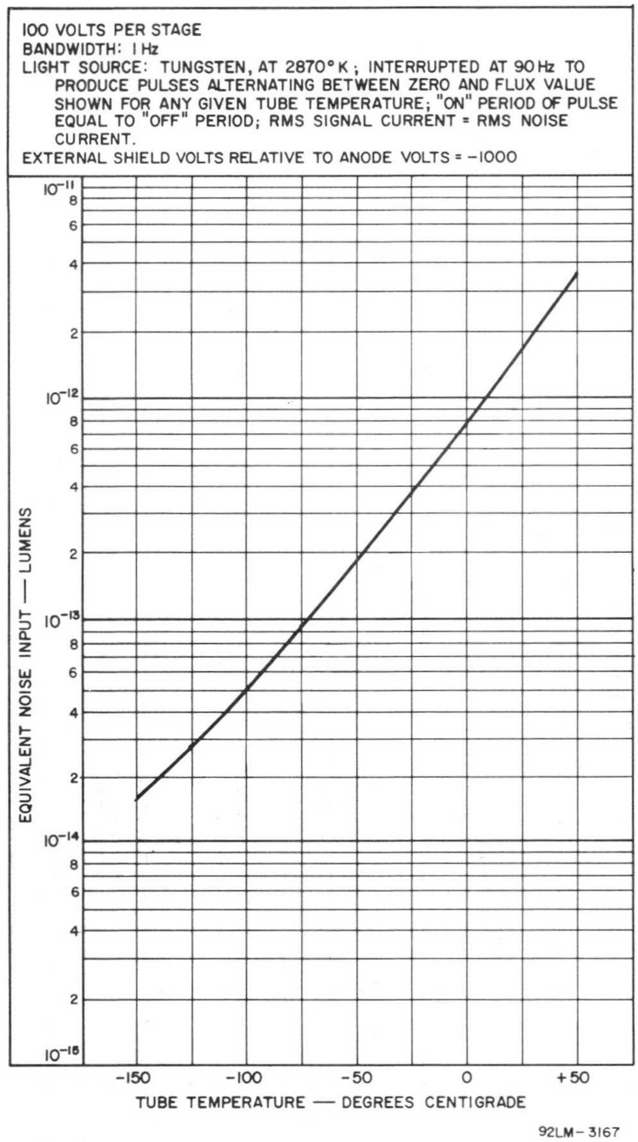


Figure 8

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 or liquid air, to cool the 1P28/V1 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 sensitivity at a temperature of +22° C is shown in **Figure 7**.

Typical ENI as a function of tube temperature is shown in **Figure 8**.

Typical Effect of Magnetic Field on Anode Current

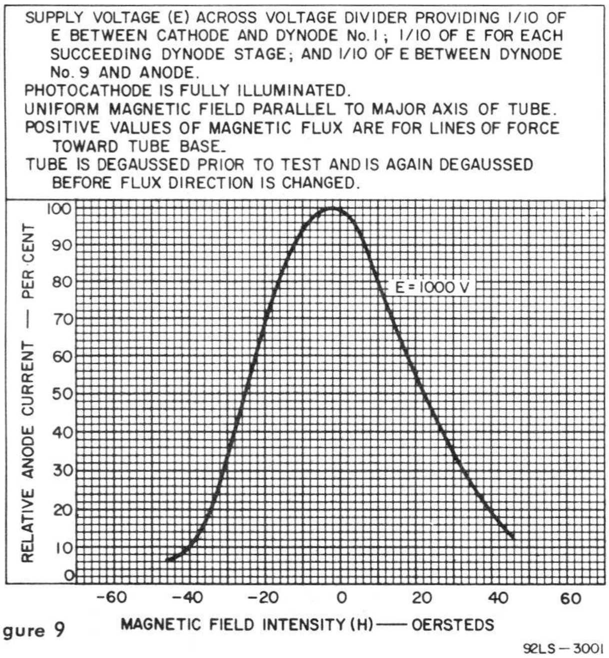


Figure 9

Typical Time-Resolution Characteristics

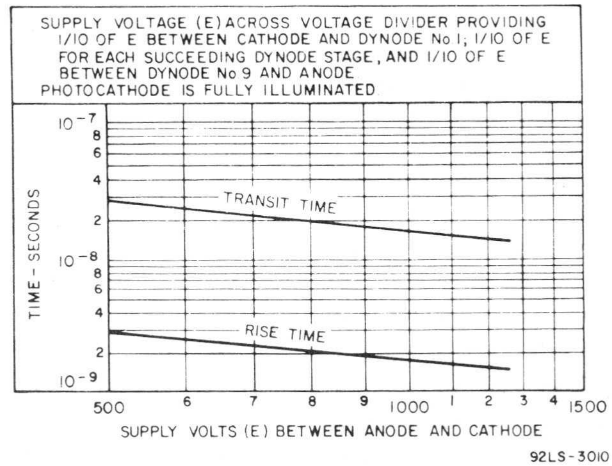


Figure 10

Output Circuit Lead Length

Whenever frequency response is important, the leads from the 1P28/V1 to the amplifier should be short so as to minimize the effects of distributed inductance and capacitance of the leads.

Operating Voltages

The recommended operating voltages for the 1P28/V1 are as follows: the successive stages of the tube are operated at voltages increasing in equal steps from the photocathode to the 9th dynode. The steps are generally chosen as 75 to 100 volts per stage. The operating voltage between dynode No.9 and anode should be kept as low as possible in order to reduce ohmic leakage current to the anode to a low level but large enough to take into account the voltage drop across a particular output load. For the higher light levels shown in **Figure 11** for pulse service, higher voltage between dynode No.9 and anode will be required because of saturation due to space charge limitations.

In general, the current in the divider should be at least 10 times greater than the maximum average value of anode current. The resistance value of the voltage divider should be adequate to prevent variation of dynode potentials by signal current. Resistance 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.

Typical Anode Characteristics

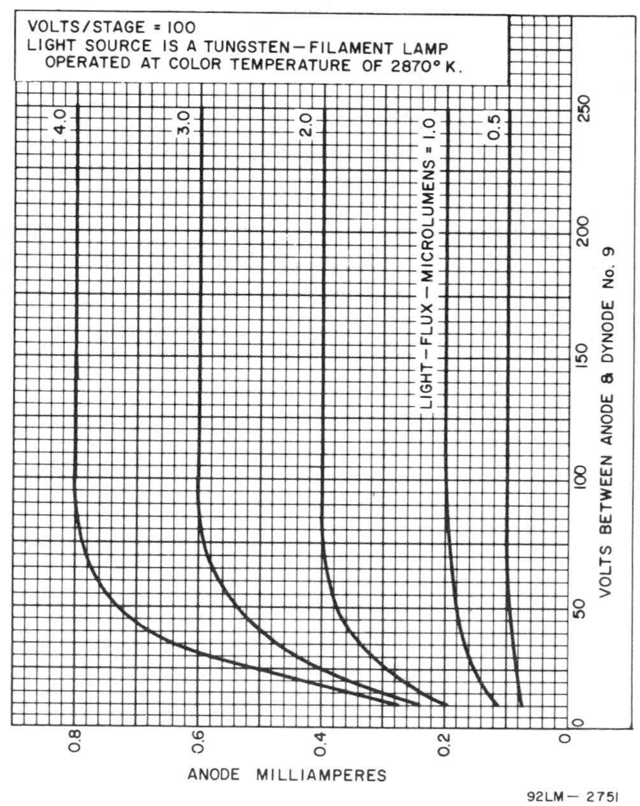


Figure 11

A typical voltage divider arrangement for use with the 1P28/V1 is shown in **Figure 12.** 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 at 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. The capacitor values across the dynode stages 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

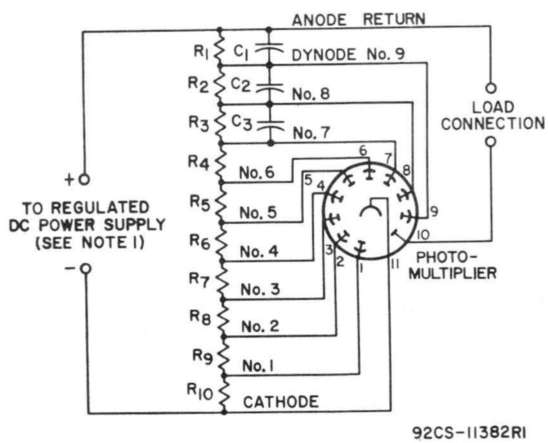
This formula applies for the anode-to-final dynode capacitor. The factor 100 is used to limit the voltage change across the capacitor to 1% maximum during a pulse. Capacitor values for preceding stages should take into account the smaller values of dynode currents in these stages. Conservatively, a factor 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:

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

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

Typical Voltage-Divider Arrangement



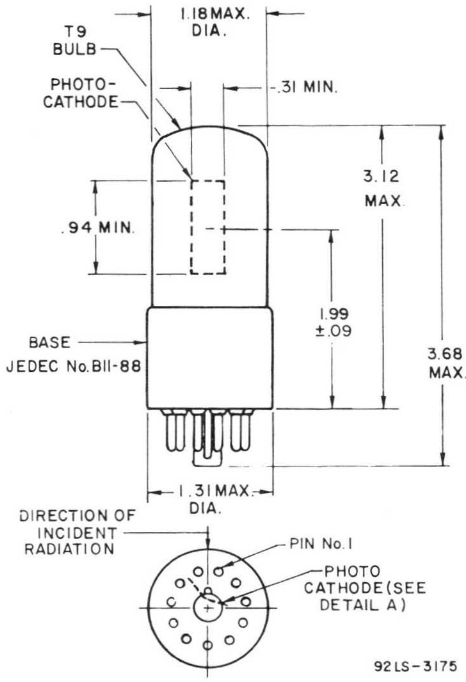
R_1 through R_{10} = 20,000 to 1,000,000 ohms

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.

Figure 12

Dimensional Outline

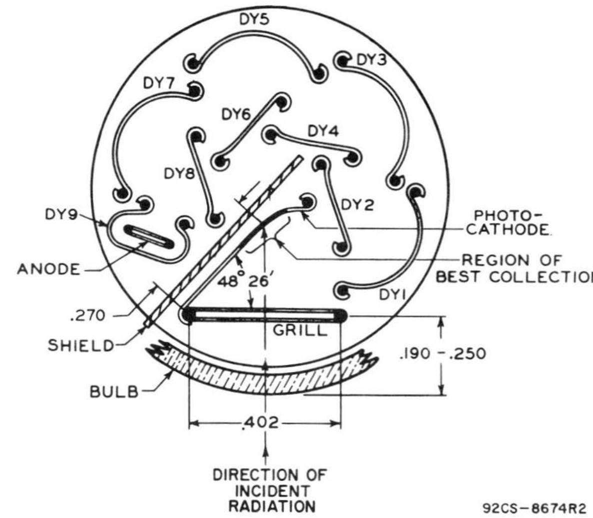


℄ of bulb will not deviate more than 2^{o} in any direction from the perpendicular erected at center of bottom of base.

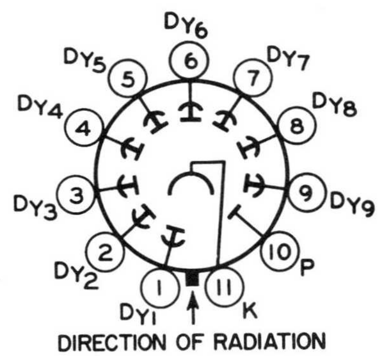
Dimensions are in inches unless otherwise stated. Dimensions tabulated below are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

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	1.99	50.5
.250	6.3	.94	23.8	3.12	79.2
.270	6.8	1.18	29.9	3.68	93.4

Detail A
Top View



Basing Diagram
Bottom 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

7NP4, 7WP4, 4486

PROJECTION KINESCOPES

Forced-Air Cooled
Electrostatic Focus
Magnetic Deflection
20' x 15' Projected Pictures

RCA-7NP4, -7WP4 and -4486 are 7"-diameter projection kinescopes intended for black-and-white projection systems in theater and closed-circuit television applications. The 4486 is identical in all respects to type 7NP4 except that it is supplied with a fitted high-voltage anode cable. These tubes are designed to operate with suitable reflective optical systems.

Each of these tubes will have an average brightness of 6500 footlamberts over a 5" x 3–3/4" raster on the tube face when operated at an anode voltage of 80 kV and a screen current of 1000 μA. Under these conditions and using the optical system of Fig.1, the 7NP4 and 4486 will provide an illumination of about 1 footcandle on a 20' x 15' viewing screen at a throw distance of about 60'. This illumination level results in an average viewing screen brightness of about 2 footlamberts on a directional (beaded) viewing screen, sufficient to provide a bright, clear television picture having a highlight brightness of about 7 footlamberts. The 7WP4 will provide slightly less illumination on the viewing screen at a throw distance of about 80'.

The 7NP4, 7WP4 and 4486 are designed for magnetic deflection of the beam through a relatively narrow angle in order to reduce the amount of deflecting energy required and to provide essentially uniform focus over the entire picture area.

Focusing is accomplished electrostatically. Electrostatic focus facilitates use of these types with a reflective optical system; furthermore, it can be maintained simply and automatically by the use of an associated voltage-control circuit in combination with a voltage-regulated dc power supply.

The electron gun in these types utilizes a grid No.2 to make the brightness adjustment independent of the focusing adjustment. Grid No.2 draws negligible current.

Other features of the 7NP4, 7WP4 and 4486 include (1) a bulb having a faceplate with good optical quality and corrugated side walls with transparent insulating coating to provide a long leakage path over its external surface, (2) an inner cone-neck section to provide adequate vacuum insulation between the internal bulb coating and the outer neck section, (3) an external conductive coating on the neck which, when grounded, prevents corona between neck and yoke and thus protects the yoke, and (4) only one high-voltage envelope connection – other connections including that of the high-voltage focusing electrode (grid No.3) are made through a plastic-filled, diphetal 14-pin base.

REFLECTIVE OPTICAL SYSTEM

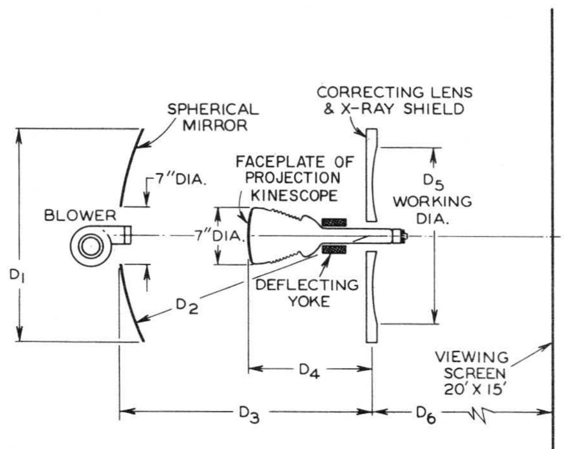


Fig. 1

DIMENSION	TYPE 7NP4 AND 4486	TYPE 7WP4
D_1	26" Dia.	27" Dia.
D_2	30" R.	40" R.
D_3	30"	40"
D_4	15"	20"
D_5	21.5"	24.5"
D_6	60'	80'

Arrangement of Typical Optical System and Air-Cooling System for Theater-Television Projector Using Reflective Optical Principles and 7NP4, 7WP4 or 4486 (Dimensions shown are approximate)

A suitable reflective optical system for use with the 7NP4, 7WP4 or 4486 is illustrated in Fig.1. It consists of a spherical collecting mirror and a correcting lens located at the center of curvature of the mirror. The illustration also shows the location of the faceplate of the projection kinescope, the location of the viewing screen with respect to the correcting lens, and the location of the blower for cooling the faceplate.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.6 ± 5% volts
Current	0.62 A
Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angle (Approx.)	35°
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	12 pF
Cathode to all other electrodes	6 pF

Optical:

Faceplate	Spherical, Non-Browning Glass
Quality Rectangle of Faceplate (See Dimensional Outline)	5" x 3-3/4"
Refractive Index of Faceplate	1.469

	7NP4 and 4486	7WP4	
Projection-Throw Distance for 20' x 15' Picture	60	80	feet

Phosphor	Aluminized P4 - Silicate-Sulfide Type
Luminescence	White
Persistence	Medium

Mechanical:

Air Flow to Face . . . . . 40 cfm

The specified air flow should be delivered perpendicularly from a nozzle having a diameter of about 2 inches onto the face of the tube while it is in operation. See Fig.1. In a typical system with air filter, the total system static pressure is approximately 0.25 inch of water. The cooling air must not contain water, dust, or other foreign matter. The air-cooling system should be electrically interconnected with the anode power supply to prevent operation of the tube without cooling.

Cooling of the tube by a tangential flow of air across its face is not recommended because the temperature gradient produced across the face may result in immediate or delayed cracking of the face.

	7NP4 and 4486	7WP4
Tube Dimensions:		
Overall Length	19-1/2" ± 5/8"	19-7/16" ± 5/8"
Greatest Diameter of Bulb (Excluding side cap or cable)	7" ± 3/16"	

Cap (For types 7NP4 and 7WP4)	Medium (JEDEC No.C1-5)
Base	Plastic-Filled, Small-Shell Diheptal 14-Pin (JEDEC No.B14-45)
Operating Position	Any

CATHODE-DRIVE[a] SERVICE

Maximum Ratings, *Absolute-Maximum Values:*[b]

ANODE-TO-GRID-No.1 VOLTAGE[c]	80000	max.	volts
GRID-No.3-TO-GRID-No.1 VOLTAGE	20000	max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	1300	max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:			
Positive bias value	250	max.	volts
Negative bias value	0	max.	volts
Peak negative value	2	max.	volts
AVERAGE ANODE CURRENT[c]	2	max.	mA
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode:			
During equipment warm-up period not exceeding 15 seconds	410	max.	volts
After equipment warm-up period	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Equipment Design Ranges:

With any anode-to-grid-No.1 voltage (E_{c4g1}) between 70000[d] *and 80000 volts and grid-No.2-to-grid-No.1 voltage (E_{c2g1}) between 400 and 850 volts*

Grid-No.3-to-Grid-No.1 Voltage for Focus	20% to 22.6% of E_{c4g1}	volts
Grid-No.2-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster when Circuit Design Utilizes Fixed Cathode-to-Grid-No.1 Voltage (E_{kg1})	2.58 to 3.87 times E_{kg1} plus E_{kg1} voltage	volts
Cathode-to-Grid-No.1 Video Drive From Raster Cutoff (Black Level) to White-Level Value	Same value as fixed cathode-to-grid-No.1 voltage except video drive is a negative voltage.	
Grid-No.3 Current	See footnote (e)	
Grid-No.2 Current	−15 to +15	µA

Examples of Use of Design Ranges:

For anode-to-grid-No.1 voltage of	*75000*	*volts*
Grid-No.3-to-Grid-No.1 Voltage for Focus	15000 to 17000	volts
Grid-No.2-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster When Circuit Design Utilizes Fixed Cathode-to-Grid-No.1 Voltage (E_{kg1}) of 125 volts	447 to 609	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level) to White-Level Value	−125	volts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance	1.5 max.	megohms

GRID-DRIVE[f] SERVICE

Maximum Ratings, *Absolute-Maximum Values:*[b]

ANODE-TO-CATHODE VOLTAGE[c]	80000	max.	volts
GRID-No.3-TO-CATHODE VOLTAGE	20000	max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	1050	max.	volts
GRID-No.1-TO-CATHODE VOLTAGE:			
Negative bias value	250	max.	volts
Positive bias value	0	max.	volts
Peak positive value	2	max.	volts
AVERAGE ANODE CURRENT[c]	2	max.	mA
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode:			
During equipment warm-up period not exceeding 15 seconds	410	max.	volts
After equipment warm-up period	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Equipment Design Ranges:

With any anode voltage (E_{c4k}) between 70000[d] *and 80000 volts and grid-No.2 voltage (E_{c2k}) between 400 and 600 volts*

Grid-No.3 Voltage for Focus	20% to 22.6% of E_{c4k}	volts
Grid-No.2 Voltage for Visual Extinction of Focused Raster When Circuit Design Utilizes Fixed Grid-No.1 Voltage (E_{c1k})	2.58 to 3.87 times E_{c1k}	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level) to White-Level Value	Same value as fixed grid-No.1 voltage except video drive is a positive voltage.	
Grid-No.3 Current	See footnote (e)	
Grid-No.2 Current	−15 to +15	µA

Examples of Use of Design Ranges:

For anode voltage of	*75000*	*volts*
Grid-No.3 Voltage for Focus	15000 to 17000	volts
Grid-No.2 Voltage for Visual Extinction of Focused Raster When Circuit Design Utilizes Fixed Grid-No.1 Voltage (E_{c1k}) of −155 Volts	400 to 600	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level) to White-Level Value	155	volts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance	1.5 max.	megohms

[a]Cathode drive is the operating condition in which the video signal varies the cathode potential.

[b]The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices. Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[c]The product of anode-to-grid-No.1 voltage, or anode-to-cathode voltage, and average anode current should be limited to 160 watts.

[d]Brilliance and definition decrease with decreasing anode-to-grid-No.1 voltage or anode-to-cathode voltage. In general, the anode-to-grid-No.1 voltage or the anode-to-cathode voltage should not be less than 70000 volts.

[e]Grid-No.3 current will be approximately 10% to 5%, or less, of anode current. However, a grid-No.3 leakage current of up to 15 μA may be present.

[f]Grid drive is the operating condition in which the video signal varies the grid-No.1 potential.

GENERAL CONSIDERATIONS

High-Voltage Precautions

The high voltages at which these types are operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required.

In the use of the 7NP4, 7WP4 or 4486, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of capacitor breakdown or incorrect circuit connections, and that the tube surface maintains a static charge for some time after the power has been turned off. Therefore, before any part of the circuit or the tube is touched, the power-supply switch should be turned off, both terminals of high-voltage capacitors should be grounded, and the terminals of the high-voltage power supply should be grounded. After these steps have been taken and before touching the tube, discharge the anode terminal, the surface of the faceplate, and the coated surface of the cone by use of a suitable wand which is connected to ground. It is to be noted that the entire surface of the cone and of the faceplate will not be discharged by touching the wand to a single point on either surface, because the surfaces have high resistance. Therefore, to discharge each surface, it will be necessary to sweep over the entire surface with the wand.

X-Radiation Warning

X-radiation is produced at the face of these tubes when they are operated at normal anode voltage.

These rays can constitute a health hazard unless the tube is adequately shielded. Make sure that the shielding provides the required protection against personal injury.

Tube Handling

Care should be exercised when handling these tubes to prevent tube breakage. The caution notice shown on page 5 incorporating the information shown above is included with each 7NP4, 7WP4 and 4486. It is recommended that a similar notice be prominently displayed on equipment using either of these tubes and be included in the equipment service bulletin.

Support

Support for either the 7NP4, 7WP4 or 4486 may be provided by the deflecting yoke fitted with a split clamping ring. The clamping ring should be designed to provide adjustment for alignment of the yoke on the neck, and should also provide sufficient pressure to hold the yoke firmly against the cone. The clamping ring, preferably fitted with rubber pads on the surfaces bearing on the neck, should be fastened only tight enough to obtain adequate mechanical support. If the ring is clamped very tight, resultant glass strains may eventually cause the neck to break.

Storage

During storage of these projection kinescopes, occluded gas may be released within the tube. When high voltage is applied, this gas may cause internal arcing with possible damage to the tube. To prevent such an occurrence, it is recommended that this kinescope be given the following treatment at intervals of about 2 months during storage, and at time of installation in equipment: With the beam cut off, apply normal anode voltage to the tube. Gradually increase the anode current in steps over a period of 15 minutes until one fourth of the operating anode-current value is reached. Operate at this reduced value of current for 1 hour, and then increase the anode current to full value for a few minutes before turning off the power.

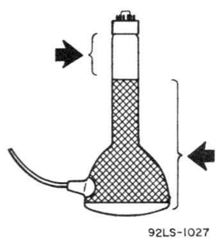
CAUTION-HIGH VOLTAGE

DO NOT TOUCH tube until POWER IS OFF and SIDE CAP and ENTIRE BULB SURFACE are GROUNDED with suitable wand.

X-RAY WARNING

This tube in operation produces X-rays which can constitute a health hazard unless the tube is adequately shielded for radiation.

Always Handle this tube by UNCOATED NECK



Never Handle this tube by that part of bulb having the INSULATING COATING

Fingerprints or dust on the insulating coating may cause electrical breakdown during humid weather.

HANDLE WITH CARE

Breakage of this tube, which contains a high vacuum, may result in injury from flying glass. Do not strike or scratch tube. Never subject it to more than moderate pressure when installing it in or removing it from equipment.

The Fluorescent Screen

The fluorescent screen, utilizing phosphor No.4 of the silicate-sulfide type, is aluminized. The white fluorescence of the screen has a color temperature of approximately 6300^{o} K. The spectral energy emission characteristic is shown in *Fig.2.* The persistence of the phosphorescence is such that its brightness does not exceed 7 per cent of the peak value in 33 milliseconds after excitation is removed.

Caution – Read Carefully!

The phosphor utilized in these tubes contains a small amount of beryllium. Human exposure to excessive amounts of this element is capable of causing beryllium intoxication. Adverse health reactions are most frequently associated with excessive inhalation of airborne beryllium particles. As the phosphor is within the envelope of the tube, the presence of beryllium presents no hazard when an intact tube is handled. Tests have indicated that even when a tube is imploded the concentration of respirable airborne beryllium in the vicinity of the tube is normally well below any level considered harmful to health. Nevertheless, to insure maximum protection against contact with or inhalation of contaminated dust when disposing of a broken tube, personnel should always wear safety goggles, rubber gloves, and an approved dust respirator. After use, such apparel should be cleaned or discarded, and personnel should wash their hands and faces with warm soapy water. In no instance should any person with an open wound attempt to dispose of or come in contact with a broken tube. Open wounds which have been contaminated with beryllium may ulcerate and heal slowly. Wounds suspected of being contaminated should be immediately treated by a physician.

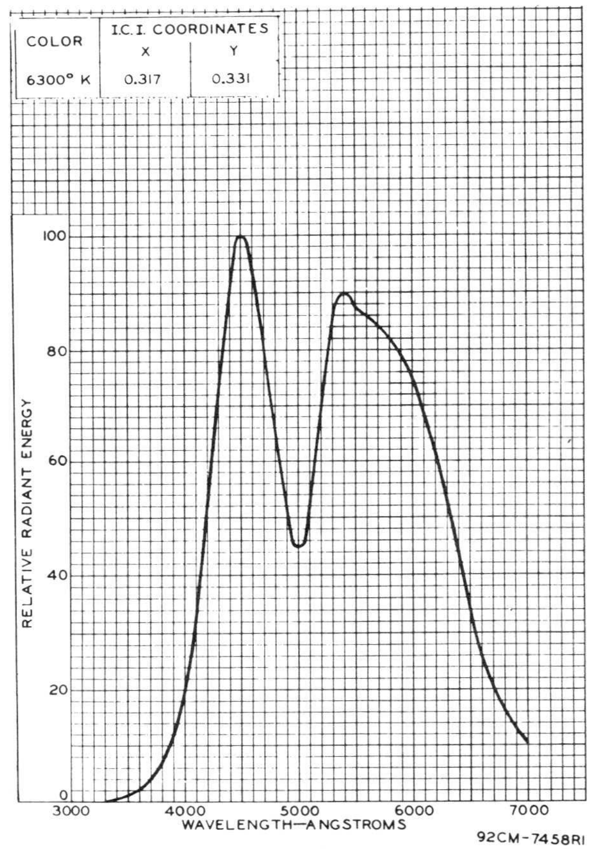


Fig. 2

Spectral-Energy Emission Characteristic of Phosphor No.4 – Silicate-Sulfide Type.

Darkening of Face

Darkening of face occurs during normal operation of the tubes with resulting decrease in the light transmitted by the face. The rate of darkening increases rapidly with increase in anode voltage, is proportional to the beam current, and is inversely proportional to the scanned area. The darkening develops rapidly during initial operation; thereafter, a gradual increase in the amount of darkening will be observed during the life of the tube.

DESIGN CONSIDERATIONS

Minimum Scan Size

The *quality rectangle* of the face is located with respect to the anode cap or cable as indicated on the *Dimensional Outline*. It is recommended that the scanned raster always completely fill the quality rectangle, the dimensions of which are 5 inches by 3–3/4 inches. Care should be taken to avoid underscanning the screen within the quality rectangle over a protracted period, because the underscanned area may be apparent in the picture when the scanning is again restored to the full size of the rectangle.

Electrostatic Focusing

Electrostatic focusing is employed to concentrate the electron beam into a focused spot at the screen. Focusing is controlled by adjustment of grid-No.3 voltage. The voltage range required for adjustment when the 7NP4, 7WP4 or 4486 is operated with an anode voltage of 75,000 volts is shown in the tabulated data. For methods of obtaining grid-No.3 voltage, refer to *DC Operating Voltages*.

Adjustment of Spot Size and Intensity

Adjustment of spot size and intensity is made by varying the focus voltage and anode current. Spot size is controlled by adjustment of the voltage applied to grid No.3. The current to the anode may be increased in grid-drive service by decreasing the negative bias applied to grid No.1, or in cathode-drive service by decreasing the positive bias applied to the cathode with respect to grid No.1. Also, an increase in the voltage applied to grid No.2 increases the anode current. However, higher grid-No.2 voltages require higher values of negative grid-No.1 voltage for beam cutoff and higher drive to provide a given brightness.

Screen Luminance

The curve of Fig.3 shows *screen luminance* as a function of anode current for these tubes when operated with either cathode drive or grid drive.

Video Drive

In practice, *video information* may be applied to either grid No.1, to the cathode, or to both electrodes. Typical drive characteristics are shown in Fig.4 and and Fig.5.

Excessive Power Input to the Screen

Excessive power input to the screen, particularly when suddenly applied or removed, or when concentrated in a small area, may produce thermal strain in the glass face. Such strain is caused by too rapid heating or cooling and may result in immediate or delayed cracking of the tube face.

Magnetic Deflection

A *deflecting yoke,* consisting of four electromagnetic coils, is required for deflecting the electron beam. These coils are used in pairs; the coils for each pair, located diametrically opposite each other, produce a field of approximately uniform flux density. The axes of the two fields ordinarily intersect at right angles to each other and to the tube axis. The deflection of the electron beam is at right angles to the magnetic field of each pair of coils. By the use of two pairs of coils at right angles, the beam may be deflected to any part of the screen.

The electron beam must be deflected through an angle of 35° which is the angle subtended by the diagonal of the quality rectangle. The deflecting yoke should be designed so that the effective center of deflection of the beam is 1–3/8 inches from the Reference Line (see *Dimensional Outline*). The 7NP4, 7WP4 and 4486 are designed to use a deflecting yoke having a maximum effective length of 2–13/16 inches. The yoke should be placed on the neck of the tube and pushed firmly against the cone.

Centering of the Raster

Centering of the raster in the quality rectangle of the screen is accomplished by passing direct current of the required value through each pair of deflecting coils.

Failure of Scanning

Because of the *high peak energy* in the beam during normal operation, the screen will be seriously damaged if the beam is allowed to remain stationary, even momentarily.

Provisions should be made, therefore, for automatic, high-speed cutoff of the beam current in case of scanning failure. When the grid-No.2 voltage and the grid-No.1 voltage are obtained as recommended under *DC Operating Voltages* and are applied (as shown in Fig. 6) through an electronic switch which is actuated by a portion of the pulse voltage developed not only across the vertical deflecting coils but also across the horizontal deflecting coils, the beam current will be automatically cut off in case of scanning failure.

Provisions should also be made in equipment

TYPICAL LUMINANCE CHARACTERISTIC

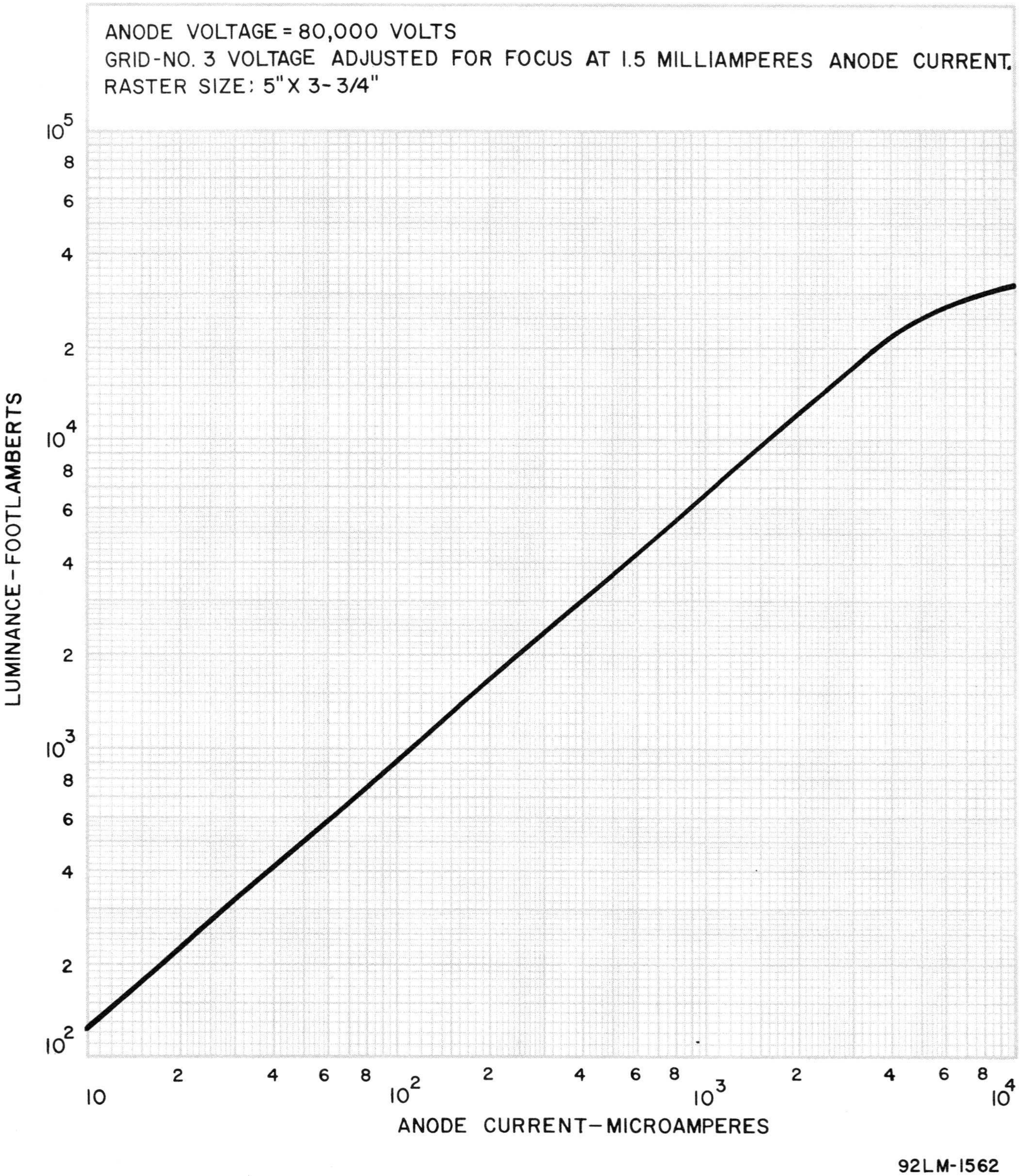


Fig. 3

design to insure that the anode voltage will drop as fast as the scanning current when the equipment is turned off; or to cut off the beam current when the equipment is turned off.

Humidity, Dust, Corona

Like other high-voltage devices, the 7NP4, 7WP4 and 4486 require that certain precautions be observed to minimize the possibility of failure caused by humidity, dust, and corona. These types have features designed to suppress corona, arc-over, and high-voltage leakage, but the following precautions should be observed to obtain optimum performance.

Humidity Considerations. The glass cone has a transparent, insulating, moisture-repellent coating to prevent formation of a continuous film of moisture over the glass surface when humidity is high. Such a film, when a high-voltage gradient is present, is conducive to the formation of corona and tends to produce sparking over the glass surface. Corona and high-voltage leakage over the bulb surface are further suppressed by the series of corrugations on the bulb surface.

The insulating coating must not be scratched and must be kept clean and free from dust or other contamination such as fingerprints. Any damage to the coating or any contamination on the surface may result in sparking over the bulb surface. The coated surface may be cleaned with a solution of a mild soapless detergent and water. It should then be rinsed with clean water and immediately dried.

Dust Considerations. The high voltage applied to these types increases the rate at which dust is deposited on the surface of the tube and on the adjacent components of the reflective optical system. The rate of deposition is accelerated in the presence of corona. Such dust not only decreases the insulating qualities of the bulb coating, but also reduces the amount of light transmitted through the bulb face as well as the efficiency of the optical system. It is recommended, therefore, that each of these types and its optical-system components be protected as much as possible from dust. Toward meeting this recommendation, it is essential that the cooling air delivered to the face of the tube be adequately filtered.

Corona Considerations. A high-voltage system may be subject to corona, especially when the humidity is high, unless suitable precautions are taken. Corona, which is an electrical discharge appearing near the surface of a conductor when the voltage gradient exceeds the breakdown value of air, causes deterioration of organic insulating materials, induces arc-over at points and sharp edges, and forms ozone, a gas which is deleterious to many insulating materials. Sharp points or other irregularities on any part of the high-voltage system many increase the possibility of corona and should be avoided. Instead, rounded corners and surfaces should be used.

In the design of associated equipment, sharp points or irregularities on grounded surfaces around the tube and its support must be avoided. A distance of at least 9 inches of air from the large end of the tube to any grounded element should be provided to prevent corona and arc-over when the tube is operated at the maximum anode voltage.

Further precautions to prevent corona must be observed in the design of the deflecting yoke, the anode-terminal connector for types 7NP4 and 7WP4, and the socket. The deflecting yoke surface on the end adjacent to the bulb cone should present a smooth electrical surface with respect to the anode terminal. The yoke should touch the cone near the Reference Line (see *Dimensional Outline*) and should follow the cone contour, departing gradually from it. The anode-terminal connector for the 7NP4 and 7WP4 should have a ball-type corona shield with a diameter of about 1–1/2 inches. The socket (see Socket) should be designed to prevent corona between pin No.9 and pins No.4 and No.13.

The Conductive Coating

The *conductive coating* on the exterior of the tube neck *must be grounded.* Connection to the coating may be made by using a flexible metal band fastened firmly around the neck at the base end of the coating. The The metal band should be fastened only tight enough to insure good contact. If the band is clamped very tight, resultant glass strains may eventually cause the neck to break. This coating must not be scratched and must never be washed with liquids likely to soften or dissolve lacquers.

The external coating on the neck serves to prevent corona between the neck and the yoke. Corona would damage the yoke insulation and cause breakdown in the glass of the neck. It is important that the yoke insulation be adequate for operation of the yoke against the external grounded coating. The resistance of the external conductive coating is sufficiently high so that damping of the yoke deflecting energy is negligible. Because of this high resistance, a contact area of at least 1/4 square inch should be used in making connection to the external coating.

TYPICAL DRIVE CHARACTERISTICS
Grid-Drive Service

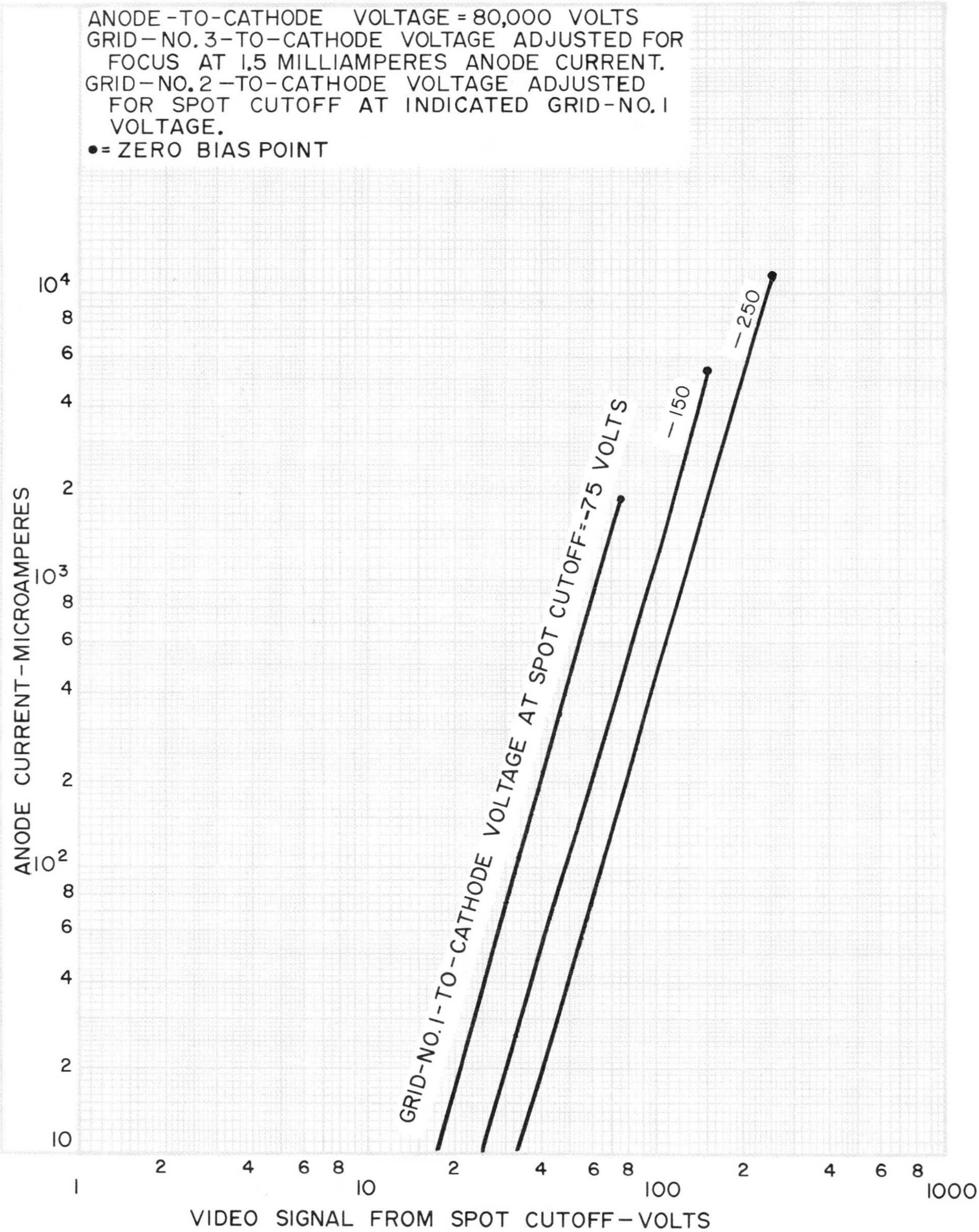


Fig. 4

TYPICAL DRIVE CHARACTERISTICS
Cathode-Drive Service

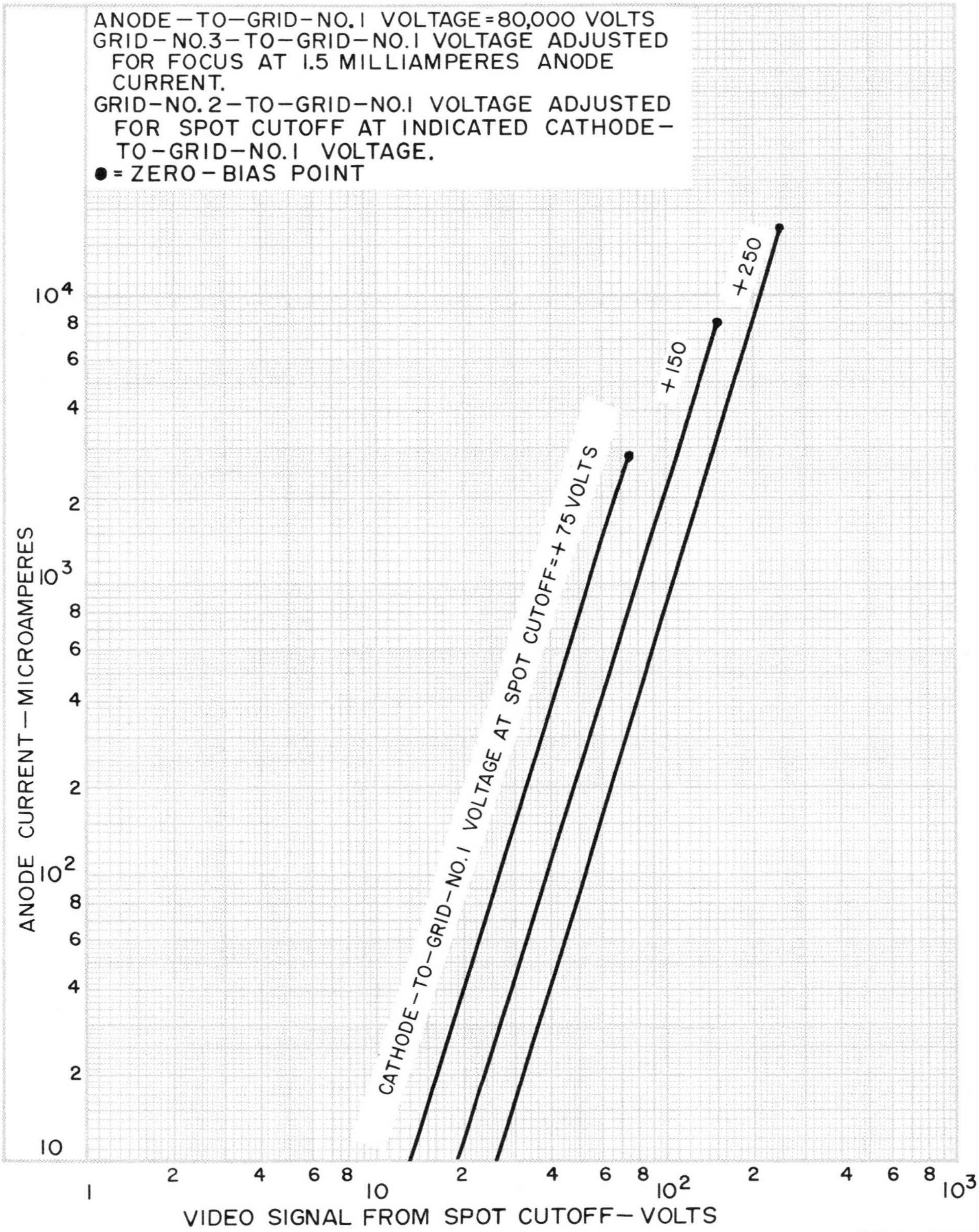


Fig. 5

Socket

The *base pins* fit a small diphetal 14-contact socket. It should be designed to prevent corona between pin No.9 and pin No.4, pin No.13, and any adjacent socket-assembly bolt. The usual commercially available diphetal sockets do not meet this requirement. Socket contacts for pins No.5, 6, 7, 8, 10, 11, 12, and 13 should be removed so that maximum insulation is provided for pin No.9. The socket should be made of high-grade low-leakage arc-resistant insulating material adequate to withstand 20,000 volts between the contact for pin No.9 and the contacts for pins No.4 and No.13. The socket should not be rigidly mounted; it should have flexible leads and be allowed to move freely.

DC OPERATING VOLTAGES

The Anode

The *anode connection* is made to the medium cap on the side of the bulb for types 7NP4 and 7WP4. Type 4486 has a fitted high-voltage anode cable. The anode connector for types 7NP4 and 7WP4 should have a ball-type corona shield with a diameter of about 1–1/2 inches in order to prevent corona.

An unbypassed series current-limiting resistor having a minimum value of 0.5 megohm (80 kV dc working volts) should be connected in series with the anode cap, or anode cable, and its supply source to prevent possible tube damage. See Fig.6. The anode voltage for these tubes may be obtained from a high-voltage, vacuum-tube rectifier circuit having good regulation. Adequate protective devices against abnormal operation, such as those shown in Fig.6, should be provided. The supply should be capable of delivering about 75,000 volts to the anode under load conditions. The maximum value of peak anode current and the maximum value of average anode current that will be required from the high-voltage power supply are 10 milliamperes and 2 milliamperes, respectively. If the anode and grid-No.3 voltages are obtained from a common supply, care must be taken to assure that the grid-No.3 circuit is well insulated from the anode voltage circuit. The anode voltage supply should have no overvoltages during turn-on or turn-off that exceed the maximum ratings of the tube.

Grid No.3

Grid No.3, which is the focusing electrode, is provided with a base-pin terminal (pin No.9), rather than a neck terminal, to facilitate installing the tube in equipment and removing it therefrom. Supplying the high focusing voltage through a base pin is made possible by the use of a base filled with plastic to insulate the grid-No.3 lead for the rated absolute maximum grid-No.3 voltage of 20,000 volts. If this value is exceeded, an arc may occur with resultant damage to base or socket. To prevent such a possibility, it is recommended that an unbypassed series current-limiting resistor having a value of 0.1 megohm (40 kV dc working volts) be connected in series with grid No.3 and its supply source and that a suitable hermetically sealed spark gap designed to break down at 20,000 volts be connected between grid No.3 and ground. See Fig.6.

The voltage for grid No.3 may be obtained from a potentiometer in the voltage divider connected across a portion of the high-voltage supply. This arrangement acts to maintain nearly automatic control of focus.

As mentioned previously, when the grid-No.3 and anode voltage are obtained from a common supply, the grid-No.3 circuit should be well insulated from the anode circuit. The grid-No.3 voltage supply should have no overvoltages during turn-on or turn-off that exceed the maximum ratings of the tube.

Grid No.2

Grid No.2 is incorporated in the design of the 7NP4, 7WP4 and 4486 to prevent interaction between the fields produced by grid No.3 and grid No.1. Grid No.2 may also be used to compensate for the normal variation to be expected in the grid-No.1 voltage for cutoff between individual tubes. By adjusting the voltage applied to grid No.2, with due consideration to its maximum rated value, it is possible to fix the grid-No.1 bias at a desired value and obtain approximately the same maximum anode current for individual tubes having different cutoff voltages. Adjusting anode-current cutoff in this way makes the drive characteristic more uniform for either cathode or grid drive. Grid No.2 draws at most only negligible leakage current.

For tube protection a resistor having a value of 10,000 ohms should be connected in series with grid No.2 and its voltage supply and a shunt capacitor having a value of 0.1 μF (1 kV dc working volts) should be connected to ground on the tube side of the resistor. See Fig.6.

The voltage for grid No.2 should be obtained from the dc power supply for the scanning circuits so that beam current will be automatically cut off in case of failure of this supply. See Fig.7.

Grid No.1

When cathode-drive service is employed, the DC voltage for grid No.1 may be obtained from a voltage

SCHEMATIC DIAGRAM OF CIRCUIT SHOWING PROTECTIVE ELEMENTS EMPLOYED TO PREVENT TUBE DAMAGE

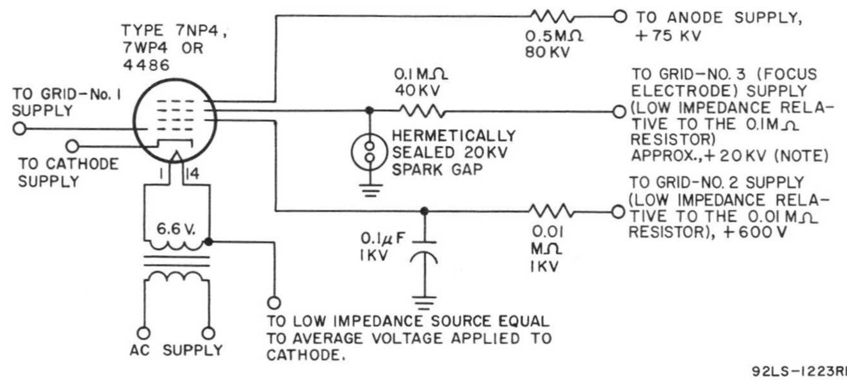


Fig. 6

divider across the voltage supply for the scanning circuit such as shown in Fig.7.

The Heater

The *heater* is designed to be operated at 6.6 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. Fluctuations from the rated value should not exceed ± 5 per cent.

Maximum values of peak heater-cathode voltage are specified in the tabulated data. When either type is operated with cathode drive, the mid-tap or one side of the heater winding should be connected to a potential source equal to the average voltage applied to the cathode. Precautions must be taken to minimize the possibility of damage to the tube produced by arcing between heater and cathode when a possible momentary internal arc might cause the voltage between heater and cathode to exceed the maximum heater-cathode ratings. When either type is operated with grid drive, it is recommended that the mid-tap or one side of the heater winding be connected directly to cathode. This connection avoids the possibility of damage in case of an internal arc between heater and cathode. In case the circuit design with grid drive is such that the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data. See Fig.6.

DRIVE CONSIDERATIONS

Grid Drive

Grid drive is the operating condition in which the video signal varies the grid-No.1 potential. The extent to which grid No.1 is driven in the positive direction from cutoff, should be limited on the maximum excursion above zero grid-No.1 bias to + 2 volts. The positive grid-No.1 excursions may be limited to the rated maximum value by utilizing a diode limiter, a series grid-No.1 resistor or some other suitable arrangement.

Cathode Drive

Cathode drive is the operating condition in which the video signal varies the cathode potential. This mode of operation provides more anode current for a given drive voltage above cutoff than grid drive. An additional feature is that the capacitance between cathode and all other electrodes is only one-half of that between grid No.1 and all other electrodes. Because of the lower input capacitance with cathode drive, better frequency response can be obtained from the video output stage.

In cathode-drive service, the cathode serves as the control electrode as well as the source of beam current. The control or video voltage, therefore, must be obtained from a supply capable of providing not only the required drive voltage but also the beam current demanded by the drive voltage. These requirements for cathode drive can be met, for example, when the video output stage is directly coupled to the cathode. Since with this arrangement the cathode potential is varied by the video signal, the cathode no longer serves as a fixed reference point to which other electrode voltages can conveniently be referred. Therefore, in cathode-drive operation of these types, electrode voltages including the bias and video voltage applied to the cathode are given

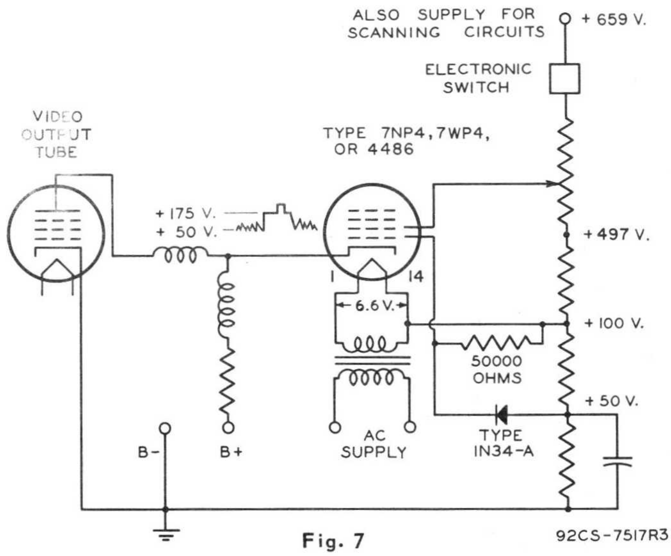


Fig. 7 92CS-7517R3

Schematic Diagram Showing Principles of Cathode Drive as Well as Method for Automatically Protecting the 7NP4, 7WP4 or 4486 Against Overdrive and Scanning Failure.

with respect to grid No.1 which operates at an essentially fixed potential. It should also be noted that the driving voltage is 180° out of phase with that in grid-drive service.

The extent to which the cathode is driven in the negative direction from cutoff should be limited on the maximum excursion to -2 volts below grid-No.1 voltage. The negative cathode excursions may be limited to the rated maximum value by utilizing a diode limiter, a series grid-No.1 resistor, or some other suitable arrangement, such as shown in Fig.7.

A schematic diagram illustrating the principles of cathode drive is given in Fig.7. The cathode of the 7NP4, 7WP4 or 4486 is directly coupled to the video output stage. A fixed positive cathode potential of 175 volts with respect to ground is provided by the video amplifier B-supply. This voltage biases the cathode positive with respect to grid No.1 by 125 volts, and corresponds to the black level when the peak positive video voltage is 0 volts. When the video signal swings to a peak negative value of 125 volts (white level), the resultant plate voltage applied to the video output stage is 50 volts.

Provision is made to compensate for the normal variation to be expected in the cutoff voltage, and hence the black level, between individual tubes by adjusting the voltage applied to grid No.2 between 450 and 650 volts (referred to ground).

The diode-resistor combination in the grid-No.1 circuit serves to limit the negative cathode excursions with respect to grid No.1 to the rated maximum value. When the cathode is positive with respect to grid No.1, the diode conducts and has an impedance of only about 100 ohms. Therefore, grid No.1 is at a potential of +50 volts with respect to ground. However, when the cathode swings negative with respect to grid No.1, current flows in the grid-No.1 circuit but is prevented from flowing through the diode by its high impedance in the direction opposite to that in which it conducts. Consequently, the current must flow through the 50,000-ohm resistor which will limit the negative cathode excursions to the rated maximum value.

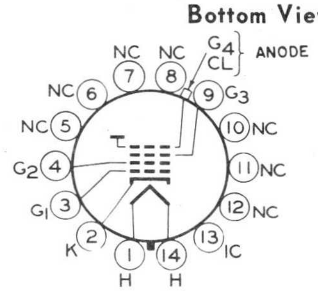
OPERATING HINTS

1. Never apply power input to the screen suddenly because immediate or delayed cracking of the face may result. Always increase or decrease the anode current gradually.
2. Never exceed the rated maximum anode current of 2 milliamperes.
3. Never overscan the screen because the beam will strike the neck and liberate occluded gas which may cause internal arcing.
4. Never fail to operate this tube in its equipment at intervals of about 2 months to keep the tube in condition.

SOCKET CONNECTIONS FOR 7NP4, 7WP4 OR 4486

Bottom View

Pin 1: Heater
Pin 2: Cathode
Pin 3: Grid No.1
Pin 4: Grid No.2
Pin 5: No Connection
Pin 6: No Connection
Pin 7: No Connection
Pin 8: No Connection

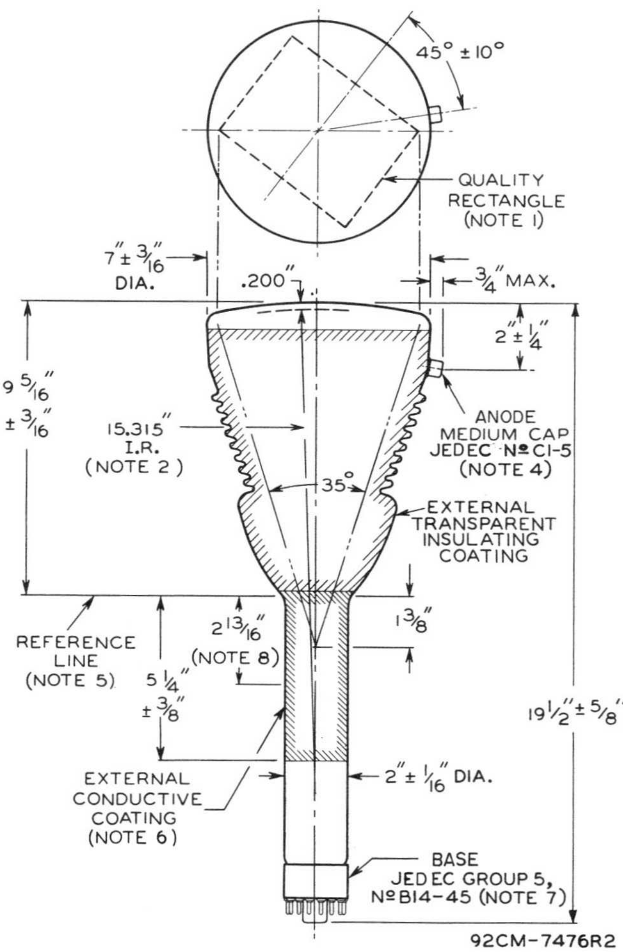


14N

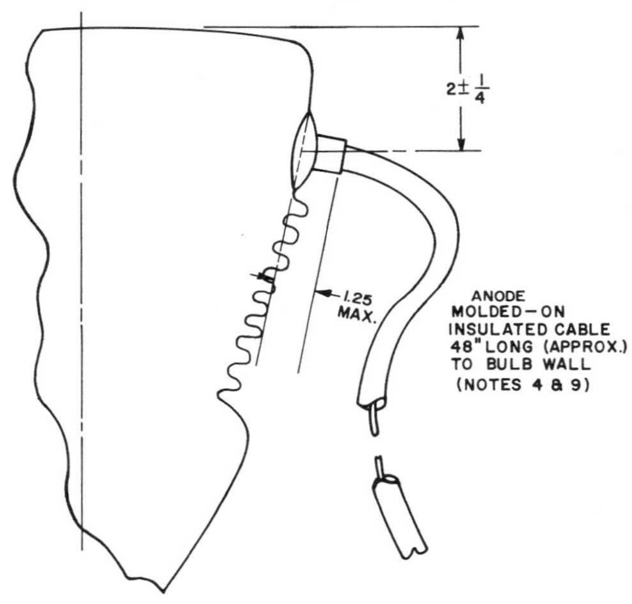
Pin 9: Grid No.3
Pin 10: No Connection
Pin 11: No Connection
Pin 12: No Connection
Pin 13: Internal Connection — Do Not Use
Pin 14: Heater
Cable or Cap: Anode (Grid No.4, Collector)

NOTE: Socket contacts for Pins No.5, 6, 7, 8, 10, 11, 12, and 13 should be removed so that maximum insulation is provided for Pin No.9.

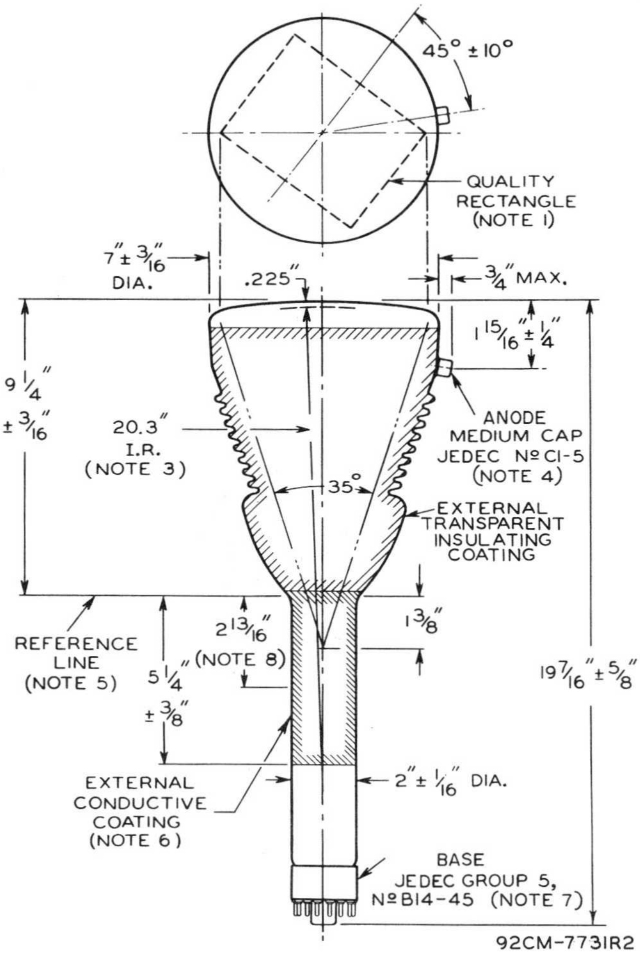
DIMENSIONAL OUTLINE
TYPE 7NP4



FOR TYPE 4486 ONLY
(Other dimensions are the same as those shown for Type 7NP4)



DIMENSIONAL OUTLINE
TYPE 7WP4



NOTE 1: When viewed from the face of the tube, the minor axis of the 5" x 3–3/4" quality rectangle is located 45° ± 10° in a counter-clockwise direction from a plane through the anode terminal and the tube axis.

NOTE 2: Inside surface of faceplate within the quality rectangle may vary ± 0.006" from the spherical surface having a 15.315" radius.

NOTE 3: Inside surface of faceplate within the quality rectangle may vary ± 0.006" from the spherical surface having a 20.3" radius.

NOTE 4: The plane through Base Pin No.9 and the tube axis may vary from the plane through the anode terminal and the tube axis by an angular tolerance (measured about the tube axis) of ± 10°. The anode terminal is on same side as Pin No.9.

NOTE 5: Reference line is determined by position where gauge 2.100" ± 0.001" I.D. and 3" long will rest on bulb cone.

NOTE 6: External conductive coating must be grounded.

NOTE 7: Socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. Socket contacts for Pins 5, 6, 7, 8, 10, 11, 12, and 13 should be removed in order to provide maximum insulation for Pin No.9.

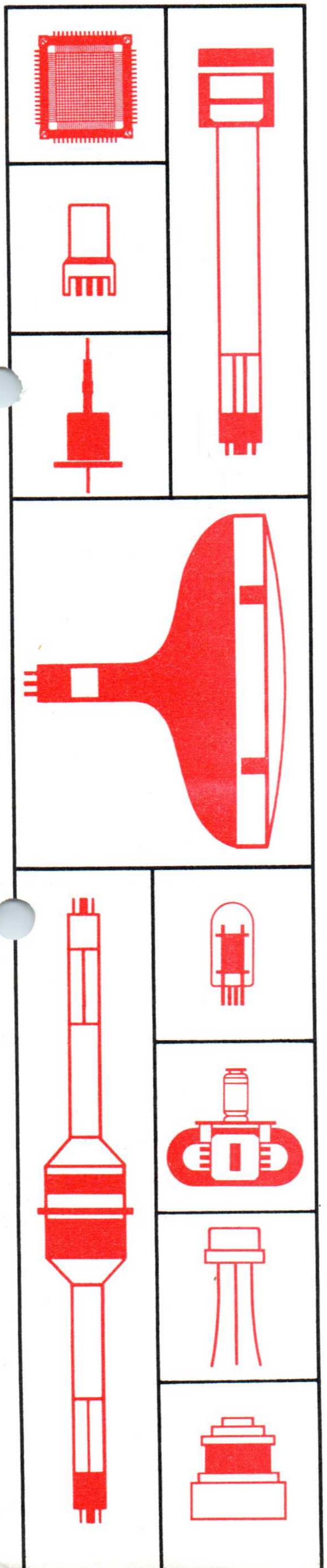
NOTE 8: Effective deflecting field must be within this space.

NOTE 9: Anode cable should not be sharply bent within 3" of bulb wall.

RCA

NEW PRODUCT ANNOUNCEMENT

INTERNATIONAL LICENSING / HARRISON, N. J.
LICENSEE SERVICE



22WP22

Perma-Chrome

90° Rectangular

HI-LITE Color Picture Tube

Announcing the RCA-22WP22, a 90° rectangular color picture tube. This new RCA 22" color picture tube employs Hi-Lite features such as the new improved rare-earth, red emitting phosphor, unity current ratios and Perma-Chrome. Unity current ratios allow brighter highlights and eliminate color fringing which was caused by red blooming.

Features of the 22WP22 include:

- **HI-LITE Screen – Brighter Pictures**
- **Rare-Earth (Red) Phosphor**
- **Unity Current Ratios – Red Blooming Eliminated**
- **Dark Tint Glass – Improved Picture Contrast**
- **Perma-Chrome – Locked-in Purity**
- **Integral Implosion Protection – Banded-Type**
- **Integral Mounting Lugs**

A technical bulletin on the RCA-22WP22 is attached.

May 15, 1969


H-1585

22WP22

Perma-Chrome

90° Rectangular HI-LITE Color Picture Tube

This data sheet is to be used in conjunction with data for RCA-22UP22.

RCA-22WP22 is a HI-LITE, 22-inch (55-cm), 90° rectangular color picture tube. It features integral implosion protection and integral mounting lugs. Implosion protection is provided by formed rim bands and a steel tension band around the periphery of the tube panel. This feature eliminates the need for either an integral protective window or a separate safety-glass window in the receiver. This new system also reduces the total weight of the color TV receiver. The panel is made of a dark-tint glass to improve picture contrast.

Other features which are the same as the 22UP22 are: PERMA-CHROME and the new, improved rare-earth, red-emitting phosphor and sulfide blue and green-emitting phosphors. This new group of color phosphors provides unity cathode current ratios for white-light output.

For description, operating principles, general data, maximum and minimum ratings, equipment design ranges, limiting circuit values, general considerations, operating characteristics, component considerations, and adjustment procedures of the 22WP22; refer to the technical bulletin for the 22UP22 except as noted below.

Data

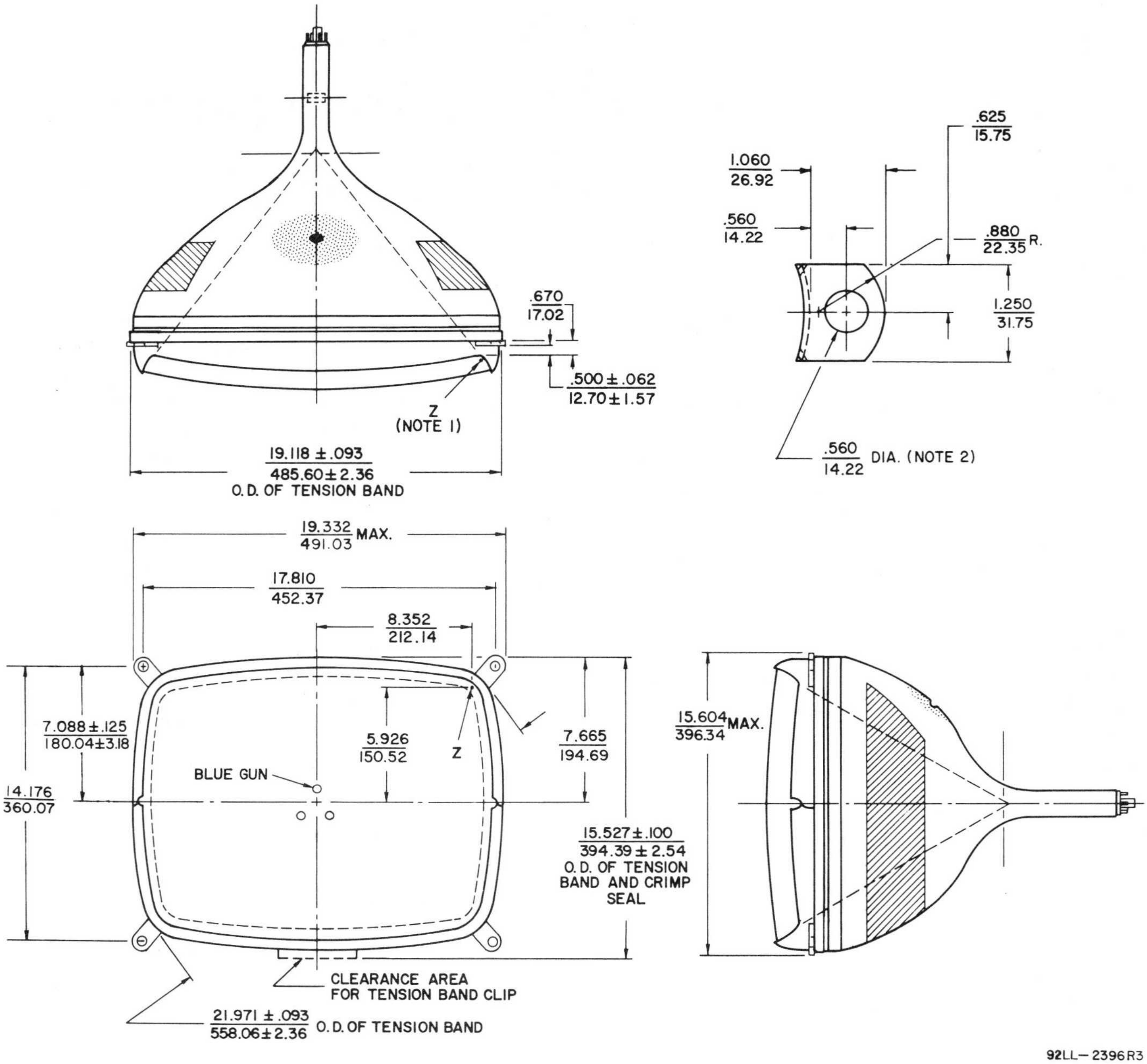
Mechanical:

Tube Dimensions (excluding mounting lugs):

Diagonal	21.971 ± .093 in (558.06 ± 2.36 mm)
Greatest Width	19.118 ± .093 in (485.60 ± 2.36 mm)
Greatest Height (including tension-band clip)	15.527 ± .100 in (394.39 ± 2.54 mm)
Weight (Approx.)	29 lb (13.3 kg)

Dimensional Outline

Dimensions shown are only those which are different from the corresponding dimensions for the 22UP22.



Note 1: "Z" is located on the outside surface of the faceplate, on the screen diagonal at a point .125" beyond the minimum screen. This point is used as a reference for the mounting lugs.

Note 2: The tolerance of the mounting lug holes will accommodate mounting screws up to 0.375 in (9.5 mm) in diameter when positioned on the true hole centers.

Dimensions in $\frac{\text{Inches}}{\text{mm}}$ unless otherwise noted

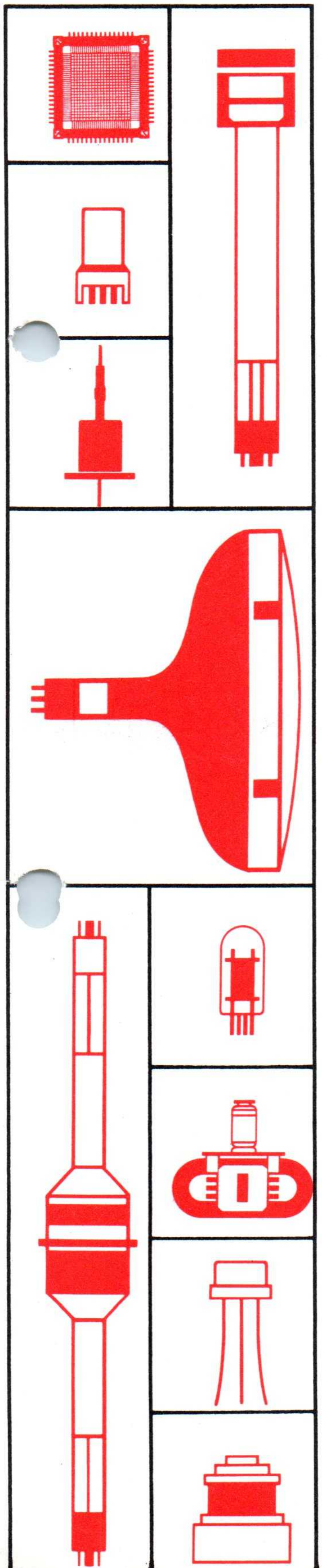
The millimeter dimensions are derived from the original inch dimensions (1 inch = 25.4 mm exactly).

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



NEW REVISED BROCHURE

"RCA PHOTOCONDUCTIVE CELLS"

CSS-801A

RCA is pleased to announce its newly developed line of cadmium sulfo-selenide polycrystalline photoconductive cells and provide the latest information on its current line of cadmium-sulfide cells. The new cadmium sulfo-selenide cells have a spectral response which peaks at about 6100 angstroms while the cadmium-sulfide cell types peak at about 5100 angstroms.

The new 6150-angstrom photocells are about 3 times faster than their cadmium-sulfide counterparts and complement the already extensive line of RCA solid-state photosensitive devices.

Both photocell materials are available in various glass-metal package designs and as flat plastic-coated types.

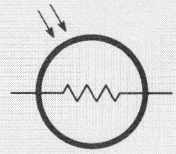
The characteristic curves shown in this brochure are based on the latest data for these two photocell materials and together with the tabulated data permit a quick comparison of the performance characteristics of the different photocell types.

Data for these new devices is given in the attached brochure.

April 28, 1966

RCA PHOTOCONDUCTIVE CELLS

CADMIUM-SULFIDE AND CADMIUM-SULFO-SELENIDE BROAD-AREA TYPES



Solid-State Photosensitive Devices
Photoconductive cells are also known as light dependent resistors or photoresistors

RCA polycrystalline cadmium-sulfide and cadmium-sulfo-selenide photoconductive cells are designed for use in a variety of light-operated control applications. Maximum response for the cadmium-sulfide photocell types occurs at approximately 5100 angstroms and for the cadmium sulfo-selenide photocells at approximately 6150 angstroms. Typical spectral response characteristics are shown in *Fig.1.*

The 5100-angstrom cadmium-sulfide cells are intended for general purpose use while the 6150-angstrom cadmium-sulfo-selenide cells are designed for applications where faster time response characteristics are required. The 6150-angstrom photocells are about three times faster than their 5100-angstrom counterparts.

TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

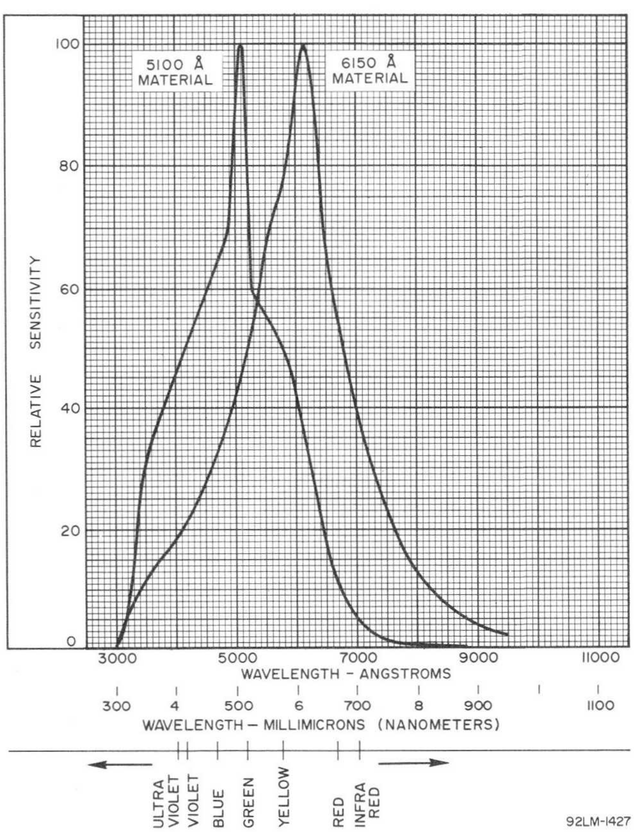


Fig. 1

RCA photoconductive cells are available in three basic package designs; glass-metal, all-glass, and flat plastic-coated designs. The glass-metal and all-glass types are hermetically sealed and may be subjected continuously to environmental conditions of high humidity and high temperature. The plastic-coated types, on the other hand, are designed for applications where prolonged exposure to extremes in humidity are not encountered.

Typical Photocurrent Rise Characteristics for both types of cells are shown in *Fig.2.* These curves show the time in milliseconds required for the photocurrent to rise to 63.5 per cent of its steady-state value as a function of incident illumination levels. The solid curves show rise times after the cell has been stored in the dark, with voltage applied across the cell terminals, for a period of 5 seconds prior to application of illumination. The dashed curves are taken under similar conditions except the cells are stored in the dark for 5 minutes prior to application of illumination. The sensitive surface of the cell is fully illuminated.

TYPICAL PHOTOCURRENT RISE CHARACTERISTICS

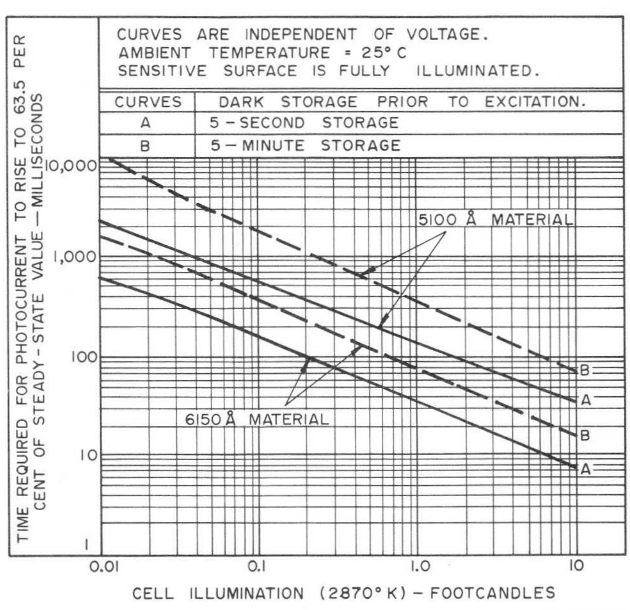


Fig. 2

Typical Photocurrent Decay Characteristics for both types of cells are shown in *Fig.3*. These curves show the time in milliseconds for photocurrent to decrease to 36.5 per cent of its initial steady-state value after illumination is removed. The sensitive surface of the cell is fully illuminated prior to removal of excitation.

TYPICAL PHOTOCURRENT DECAY CHARACTERISTICS

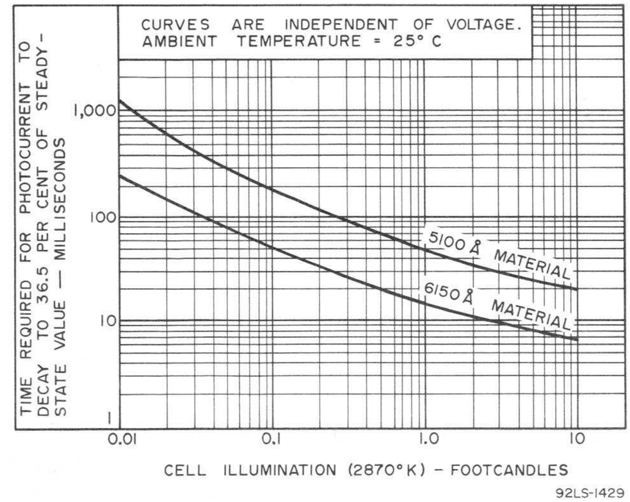


Fig. 3

Typical Photocell Response to Pulsed Light is shown in *Fig.4*. These curves indicate the number of light pulses per second for which a peak-to-valley ratio of 50 per cent will be obtained as a function of cell illumination. The "on-time" of the light pulses equals the "off-time".

TYPICAL RESPONSE CHARACTERISTICS TO PULSED LIGHT

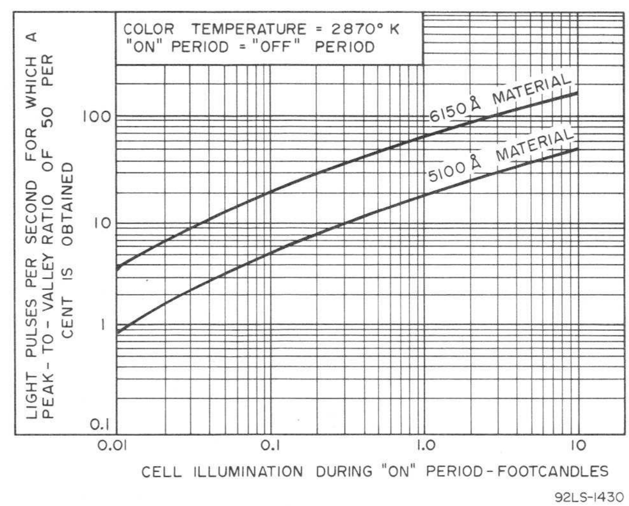


Fig. 4

The effect of *ambient temperature* on cell sensitivity is shown in *Fig.5* for 5100 Å material and in *Fig.6* for 6150 Å material.

The angle of view of the cell may be narrowed by use of a hood of the desired length placed in front of the sensitive surface.

TYPICAL TEMPERATURE CHARACTERISTICS
For 5100 Å Material

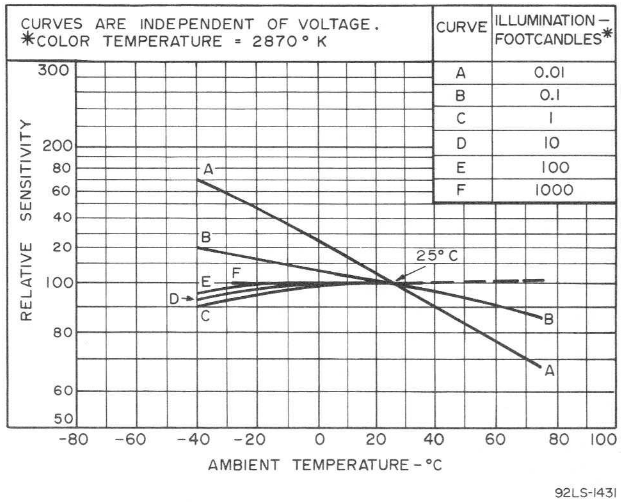


Fig. 5

If the source of radiation is some distance from the cell, the use of a light-collecting lens system may be desirable to utilize more effectively the available radiation. However, when such a system is used the radiation should not be focused onto such a small area that localized overheating of the sensitive surface may

TYPICAL TEMPERATURE CHARACTERISTICS
For 6150 Å Material

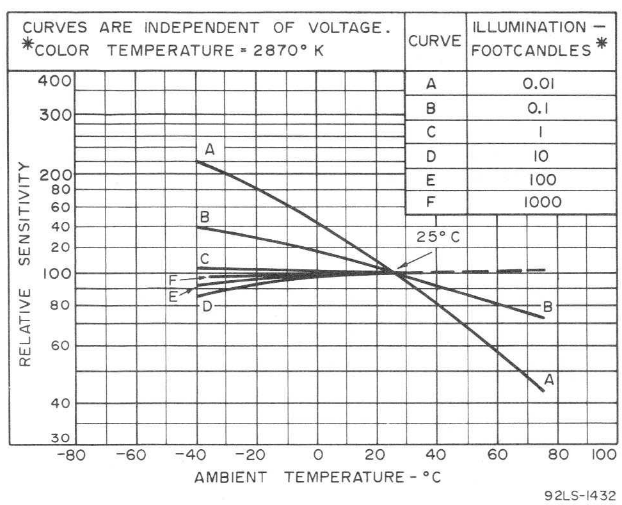
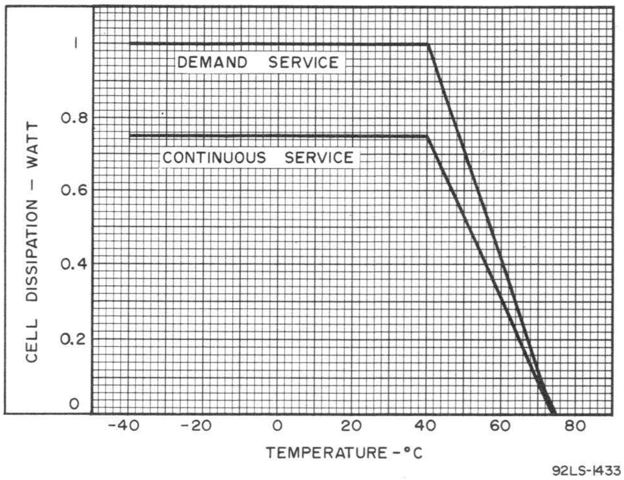
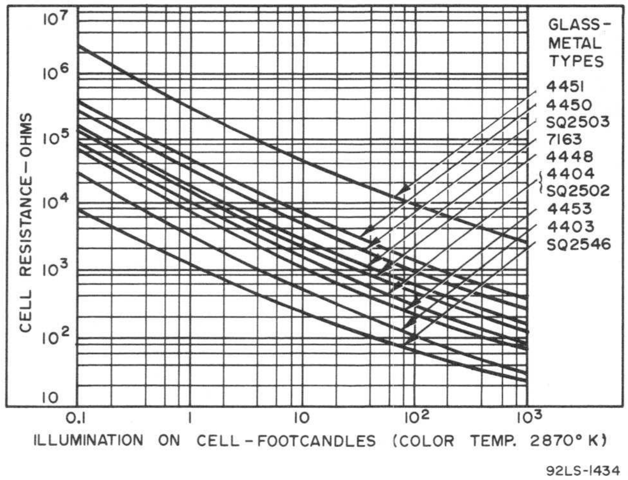


Fig. 6

1"-DIAMETER BROAD-AREA TYPES





1"-DIAMETER BROAD-AREA TYPES

RCA TYPES		MAXIMUM RATINGS				CHARACTERISTICS AT 25° C				
Glass-Metal Types[a]	Wavelength of Peak Response	Voltage Between Terminals DC or Peak AC	Power Dissipation[b] watt		Photo-current	Voltage Between Terminals	Illumination[d]	Photocurrent[e] mA		Max. Decay Current[f]
			Continuous Service	Demand Service[c]			foot-candles	Min.	Max.	
	angstroms	volts			mA	ac volts				µA
4451	5100	600	0.75	1.0	50	50	35	2	3.5	40
4450	5100	600	0.75	1.0	50	50	3.5	2	3.5	40
SQ2503	5100	600	0.75	1.0	50	50	1	0.8	1.7	40
7163	5100	600	0.75	1.0	50	50	1	1	3	40
4448	5100	600	0.75	1.0	50	50	1	1.5	4	40
4404 / SQ2502[g]	5100	600	0.75	1.0	50	50	1	2.5	5	40
4453	5100	600	0.75	1.0	50	50	1	3	7	40
4403	5100	250	0.75	1.0	50	50	1	8	16	78
SQ2546	6150	110	0.75	1.0	50	12 (dc)	1[h]	5	15	5

[a] The maximum ambient operating temperature range for these cells is −40° C to +75° C.

[b] With sensitive surface of cell fully illuminated. These dissipation ratings apply up to a temperature of +40° C from which point the cells are derated linearly to 0 watts at +75° C.

[c] The demand rating is a dissipation rating to which the cell may be exposed in outdoor applications. The rating may be utilized twice every 24 hours for a period of 20 minutes each time provided the interval between demand periods is not less than 4 hours.

[d] For conditions where light flux from a tungsten-filament lamp operated at a color temperature of 2870° K is transmitted through a filter (Corning C.S. No.1-62 which an effective transmission of luminous flux of 13.3%) onto the sensitive surface. The value of illumination incident on the sensitive surface is 7.5 footcandles measured before positioning the filter between the lamp and the cell. The sensitive surface of the cell is fully illuminated.

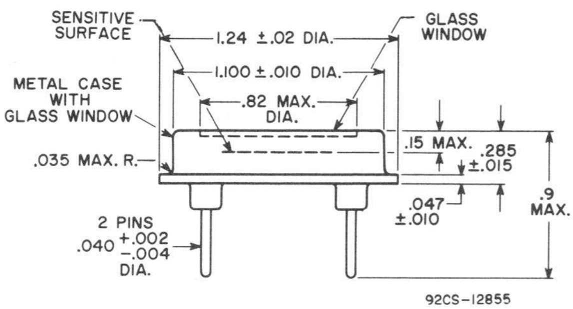
[e] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

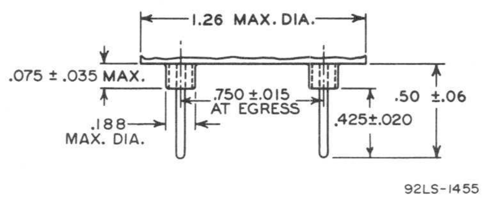
[f] Measured 10 seconds after removal of incident-illumination level.

[g] Type SQ2502 is not recommended for new equipment design. It is identical with type 4404 except it is supplied with attached Intermediate-Shell Octal 5-pin base (JEDEC No.B5-10).

[h] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

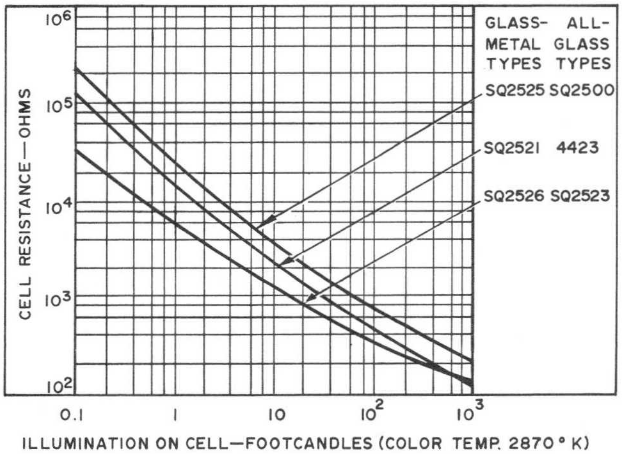
GLASS-METAL TYPES



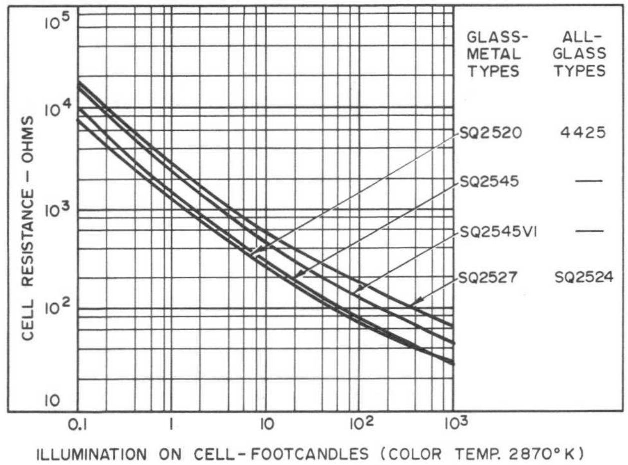


DIMENSIONS IN INCHES

1/2"-DIAMETER BROAD-AREA TYPES



92LS-1435



92LS-1450

1/2"-DIAMETER BROAD-AREA TYPES

RCA TYPES			MAXIMUM RATINGS			CHARACTERISTICS AT 25° C				
Glass-Metal Types[a]	All-Glass Types[a]	Wavelength of Peak Response	Voltage Between Terminals DC or Peak AC	Power Dissipation[b]	Photo-current	Voltage Between Terminals	Illumination[c]	Photocurrent[d] mA Min.	Photocurrent[d] mA Max.	Max. Decay Current[e]
		angstroms	volts	watt	mA	volts	foot-candles			µA
SQ2525	SQ2500	5100	250	0.2	20	12 (dc)	1	0.24	0.8	6
SQ2521	4423	5100	250	0.2	20	50 (ac)	1[f]	1.5[g]	4[g]	40
SQ2526	SQ2523	5100	110	0.2	50	12 (dc)	1	1	3	80
SQ2527	SQ2524	5100	110	0.2	50	12 (dc)	1	2	6	80
SQ2520	4425	5100	110	0.2	50	12 (dc)	1	3.6	14.5	80
SQ2545	–	6150	75	0.2	50	12 (dc)	1	4	12	15
SQ2545V1	–	6150	110	0.2	50	12 (dc)	1	2.5	7.5	7.5

[a] The maximum ambient operating temperature range for these cells is −40° C to +60° C.

[b] In continuous service with sensitive surface of cell fully illuminated. The power dissipation rating applies up to the maximum rated ambient operating temperature.

[c] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

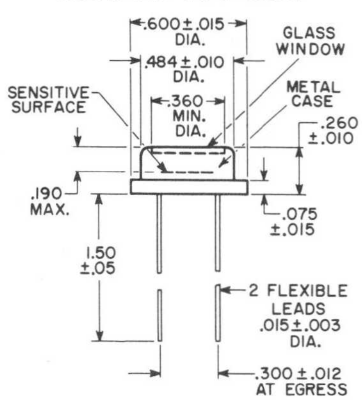
[d] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 50 to 100 foot-candle illumination (white fluorescent light).

[e] Measured 10 seconds after removal of incident-illumination level.

[f] For conditions where light flux from a tungsten-filament lamp operated at a color temperature of 2870° K is transmitted through a filter (Corning C.S. No.1-62 which has an effective transmission of luminous flux of 13.3%) onto the sensitive surface. The value of illumination incident on the sensitive surface is 7.5 footcandles measured before positioning the filter between the lamp and the cell. The sensitive surface of the cell is fully illuminated.

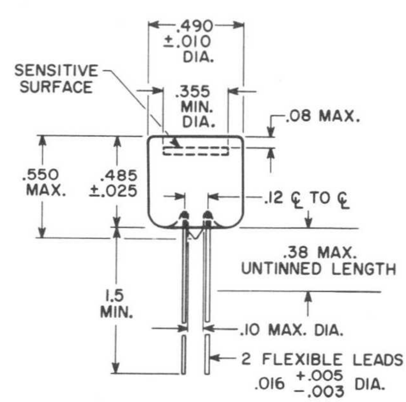
[g] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

GLASS-METAL TYPES
MODIFIED TO-8 CASE



92CS-12862

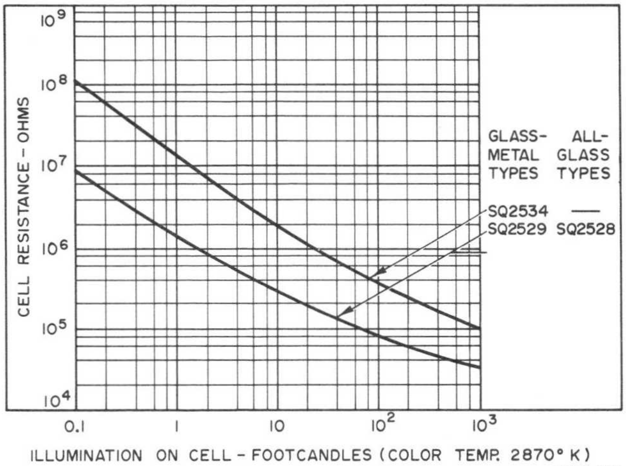
ALL-GLASS TYPES



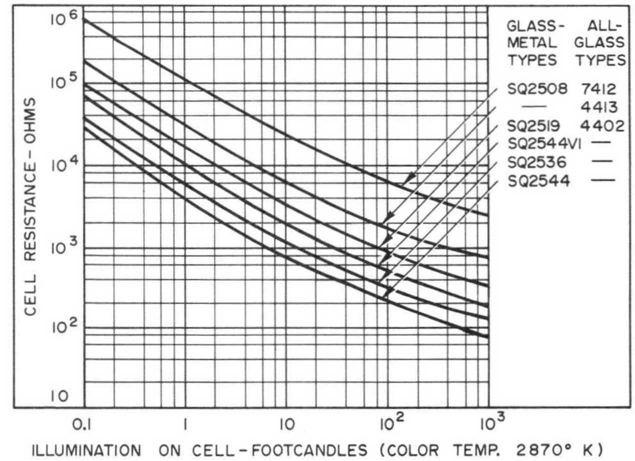
92CS-12864

DIMENSIONS IN INCHES

1/4"-DIAMETER BROAD-AREA TYPES



92LS-1451



92LS-1436

1/4"-DIAMETER BROAD-AREA TYPES

RCA TYPES			MAXIMUM RATINGS			CHARACTERISTICS AT 25° C				
Glass-Metal Types[a]	All-Glass Types[a]	Wavelength of Peak Response angstroms	Voltage Between Terminals DC or Peak AC volts	Power Dissipation[b] watt	Photocurrent mA	Voltage Between Terminals dc volts	Illumination[c] foot-candles	Photocurrent[d] mA Min.	Photocurrent[d] mA Max.	Max. Decay Current[e] μA
SQ2534	–	5100	150	0.03	5	90	30	0.057	0.65	0.1
SQ2529	SQ2528	5100	300	0.05	5	12	1	0.004	0.012	0.1
SQ2508	7412	5100	200	0.05	5	12	1	0.065	0.275	1
–	4413	5100	110	0.05	5	12	10	1.4	2.75	12
SQ2519	4402	5100	300	0.05	5	12	10	1.6[f]	–	12
SQ2536	–	5100	110	0.05	7	12	1	1	3	15
SQ2544	–	6150	60	0.05	7	12	1	1.5	4.5	2
SQ2544V1	–	6150	110	0.05	7	12	1	0.6	1.8	2

[a] The maximum ambient operating temperature range for these cells is −40° C to +60° C.

[b] In continuous service with sensitive surface of cell fully illuminated. The dissipation rating applies up to the maximum ambient operating temperature.

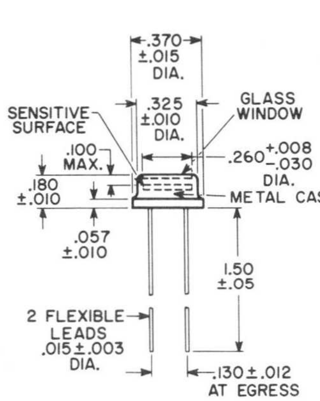
[c] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

[d] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

[e] Measured 10 seconds after removal of incident-illumination level.

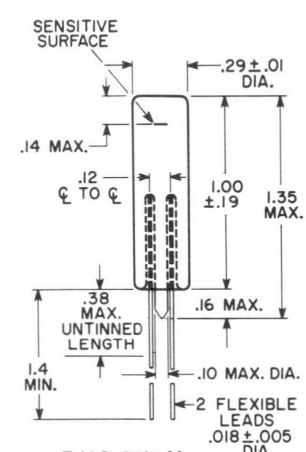
[f] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 50 to 100 footcandle illumination (white fluorescent light).

GLASS-METAL TYPES MODIFIED TO-5 CASE

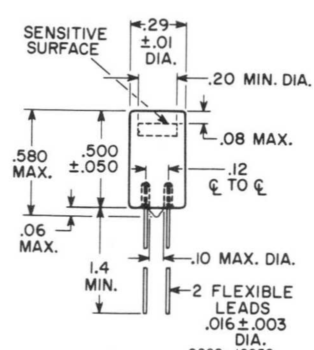


92CS-12861

ALL-GLASS TYPES



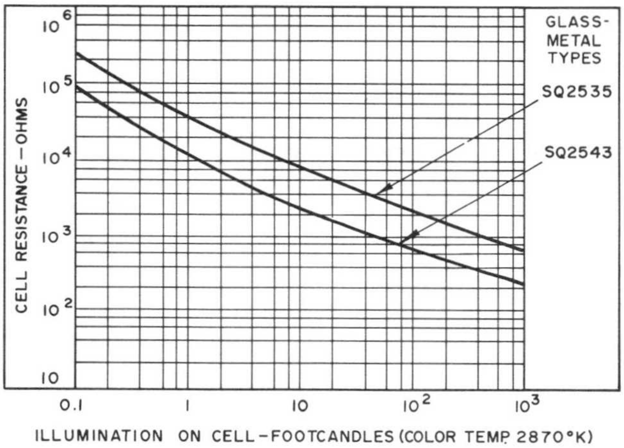
7412 ONLY
92CS-12858



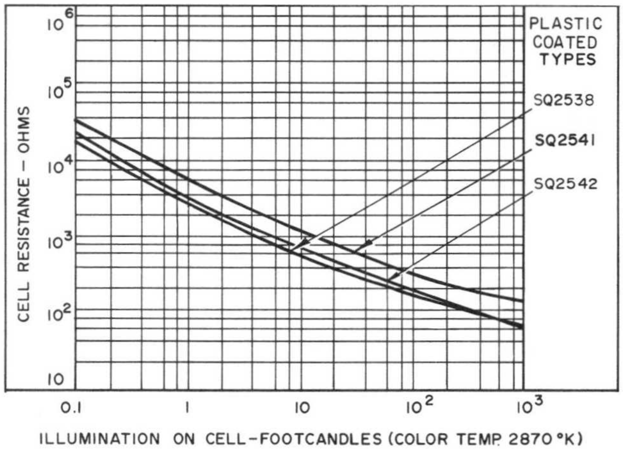
92CS-12859

DIMENSIONS IN INCHES

1/5"-DIAMETER BROAD-AREA TYPES and 3/4" x 1/2" FLAT PLASTIC-COATED TYPES



92LS-1437



92LS-1449

1/5"-DIAMETER BROAD-AREA TYPES

RCA TYPES		MAXIMUM RATINGS			CHARACTERISTICS AT 25° C				
Glass-Metal Types[a]	Wavelength of Peak Response angstroms	Voltage Between Terminals DC or Peak AC volts	Power Dissipation[b] watt	Photocurrent mA	Voltage Between Terminals dc volts	Illumination[c] foot-candles	Photocurrent[d] mA Min.	Photocurrent[d] mA Max.	Max. Decay Current[e] µA
SQ2535[f]	5100	50	0.02[g]	5	12	10	0.8	2.5	12
SQ2543	6150	75	0.02	5	12	1	0.45	1.35	0.5

3/4" x 1/2" FLAT PLASTIC-COATED TYPES

SQ2538	5100	300	0.75	50	50 (ac)	1[h]	8[i]	16[i]	78
SQ2541	5100	300	0.75	50	50 (ac)	1[h]	3[i]	9[i]	40
SQ2542	6150	300	0.5	50	12	1	1.75[i]	5.25[i]	10

[a] The maximum ambient operating temperature range for these cells is –40° C to +75° C.

[b] With sensitive surface of cell fully illuminated. These dissipation ratings apply up to a temperature of +40° C from which point the cells are derated linearly to 0 watts at +75°C.

[c] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

[d] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 50 to 100 foot-candle illumination (white fluorescent light).

[e] Measured 10 seconds after removal of incident-illumination level.

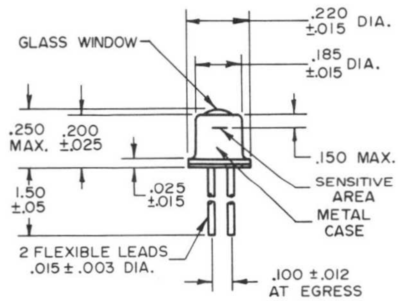
[f] The maximum ambient operating temperature range for these cells is –40° C to +60° C.

[g] In continuous service with sensitive surface of cell fully illuminated. The dissipation rating applies up to the maximum ambient operating temperature.

[h] For conditions where light flux from a tungsten-filament lamp operated at a color temperature of 2870° K is transmitted through a filter (Corning C.S. No.1-62 which has an effective transmission of luminous flux of 13.3%) onto the sensitive surface. The value of illumination incident on the sensitive surface is 7.5 footcandles measured before positioning the filter between the lamp and the cell. The sensitive surface of the cell is fully illuminated.

[i] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

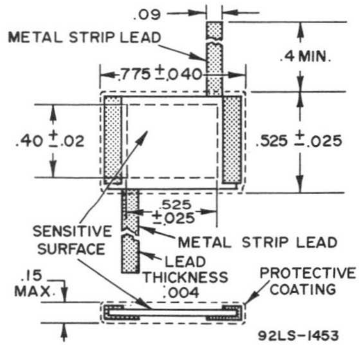
GLASS-METAL TYPES
Modified TO-18



92LS-1452

NOTE 1: Tab may protrude from base.

PLASTIC-COATED TYPES



92LS-1453

DIMENSIONS IN INCHES

result with consequent adverse effects on its characteristics. Exposure of these cells to radiation (even without voltage applied) so intense as to cause excessive heating of the cells may permanently damage them.

For a given illumination, the output current will have its highest value when the incident illumination is normal (angle of incidence is 0^{o}) to the face of the cell. For greater angles of incidence, the output current decreases. The decrease depends upon several factors including the angle of incidence of the illumination, the amount of illumination, and the area of sensitive surface illuminated.

RCA PHOTOCONDUCTIVE CELLS

RCA-2060

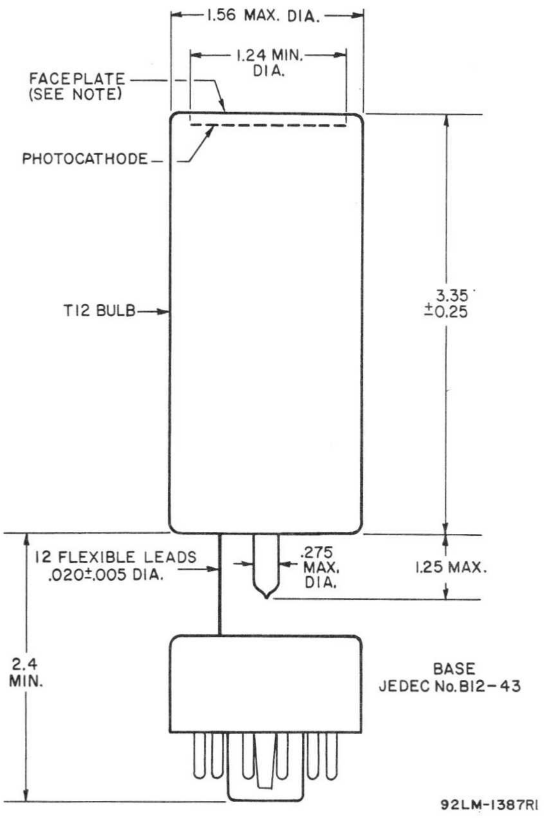
PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
1.56" Max. Diameter
S-11 Spectral Response

This bulletin is to be used in conjunction with the bulletin for RCA-6199.

RCA-2060 is a 1-1/2"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response. It is identical to RCA-6199 in all respects except that it is supplied with a small-shell duodecal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2060 in a given system.

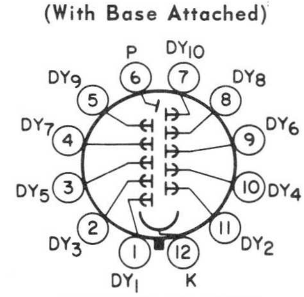
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

Note: Within 1.24" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

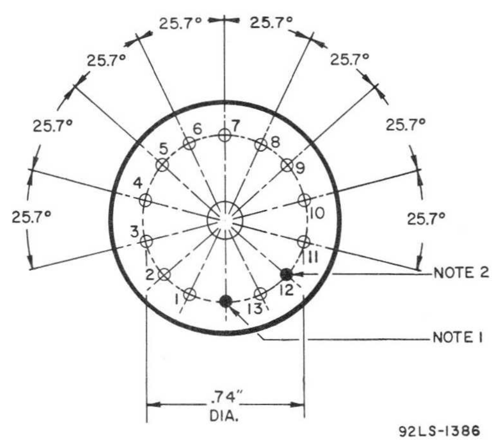
BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF LIGHT: INTO END OF BULB

Pin 1: Dynode No.1
Pin 2: Dynode No.3
Pin 3: Dynode No.5
Pin 4: Dynode No.7
Pin 5: Dynode No.9
Pin 6: Anode
Pin 7: Dynode No.10
Pin 8: Dynode No.8
Pin 9: Dynode No.6
Pin 10: Dynode No.4
Pin 11: Dynode No.2
Pin 12: Photocathode

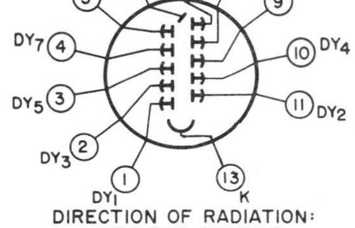
BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off near glass button for indexing.

Note 2: Lead is cut off near glass button.

TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



DIRECTION OF RADIATION: INTO END OF BULB

Lead 1: Dynode No.1
Lead 2: Dynode No.3
Lead 3: Dynode No.5
Lead 4: Dynode No.7
Lead 5: Dynode No.9
Lead 6: Anode
Lead 7: Dynode No.10
Lead 8: Dynode No.8
Lead 9: Dynode No.6
Lead 10: Dynode No.4
Lead 11: Dynode No.2
Lead 13: Photocathode

RCA-2061

PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
2.06" Max. Diameter
S-11 Spectral Response

This bulletin is to be used in conjunction with the bulletin for RCA-6342A.

RCA-2061 is a 2"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response. It is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2061 in a given system.

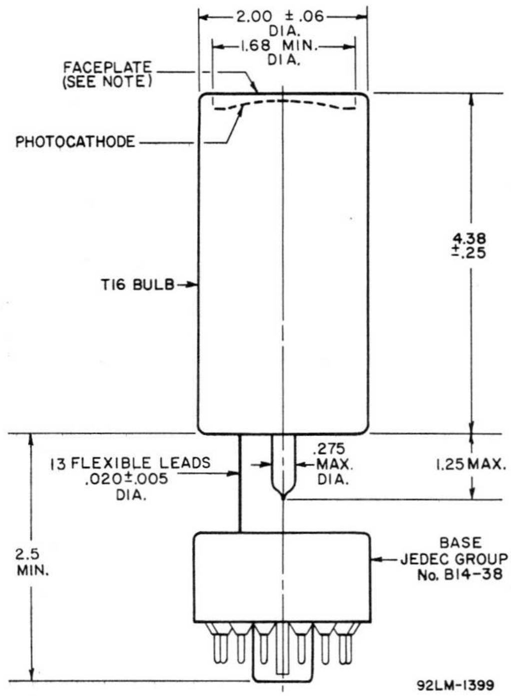
The 2061 is electrically similar to type 6342A except for the following performance characteristic and that the anode luminous sensitivity and equivalent noise input ratings shown on the attached bulletin do not apply for type 2061.

Performance Characteristic

Minimum Pulse Height[a] . . . . 0.13 volt

[a]Pulse height is defined as the amplitude of the anode pulse voltage (referred to anode) measured across a 100 $\pm$ 5% kilohm resistor and a total capacitance of 92 $\pm$ 3% pF in parallel. An anode-to-cathode voltage of 1130 volts is applied across a voltage-divider network having a 1.5 $\pm$ 5% megohm resistor between cathode and dynode No.1, 450 $\pm$ 5% kilohm resistors between each succeeding stage including dynode No.10 to anode. The focusing electrode is adjusted to that value between 0% and 60% of dynode No.1 potential (referred to cathode) which will provide maximum anode current. The 662 KeV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 2" x 2" thallium-activated sodium-iodide scintillator [NaI(T1)] type 8D8, or equivalent are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97th Street, Cleveland 6, Ohio. The Cs^{137} is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 2061 by a coupling fluid such as Dow Corning Corp., Type DC200 (Viscosity of 100 centipoise) manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

DIMENSIONAL OUTLINE

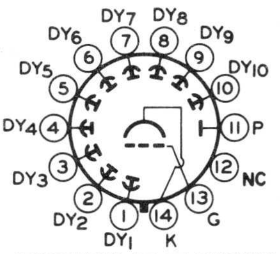


DIMENSIONS IN INCHES

Note: Within 1.68" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

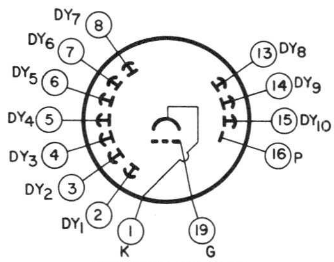
Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF RADIATION:
INTO END OF BULB

TERMINAL CONNECTIONS
Bottom View
(With Base Removed)

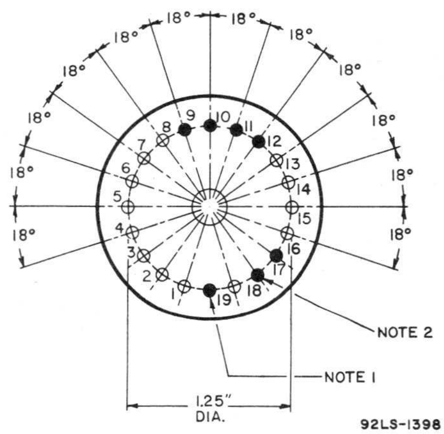


DIRECTION OF LIGHT:
INTO END OF BULB

92LS-1397

Pin 1: Dynode No.1	Pin 8: Dynode No.8	Lead 1: Photocathode	Lead 8: Dynode No.7
Pin 2: Dynode No.2	Pin 9: Dynode No.9	Lead 2: Dynode No.1	Lead 13: Dynode No.8
Pin 3: Dynode No.3	Pin 10: Dynode No.10	Lead 3: Dynode No.2	Lead 14: Dynode No.9
Pin 4: Dynode No.4	Pin 11: Anode	Lead 4: Dynode No.3	Lead 15: Dynode No.10
Pin 5: Dynode No.5	Pin 12: No Connection	Lead 5: Dynode No.4	Lead 16: Anode
Pin 6: Dynode No.6	Pin 13: Focusing Electrode	Lead 6: Dynode No.5	Lead 19: Focusing Electrode
Pin 7: Dynode No.7	Pin 14: Photocathode	Lead 7: Dynode No.6	

BASE ARRANGEMENT
Bottom View



92LS-1398

Note 1: Lead is cut off near glass button for indexing.

Note 2: Leads 9, 10, 11, 12, 17, and 18 are cut off near glass button.

RCA-2062

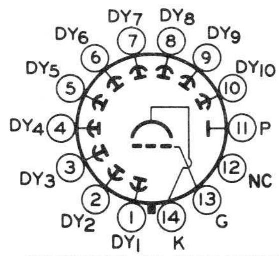
PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
2.06" Max. Diameter
S-11 Spectral Response

This bulletin is to be used in conjunction with the bulletin for RCA-6655A.

RCA-2062 is a 2"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response. It is identical to RCA-6655A in all respects except that it is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2062 in a given system.

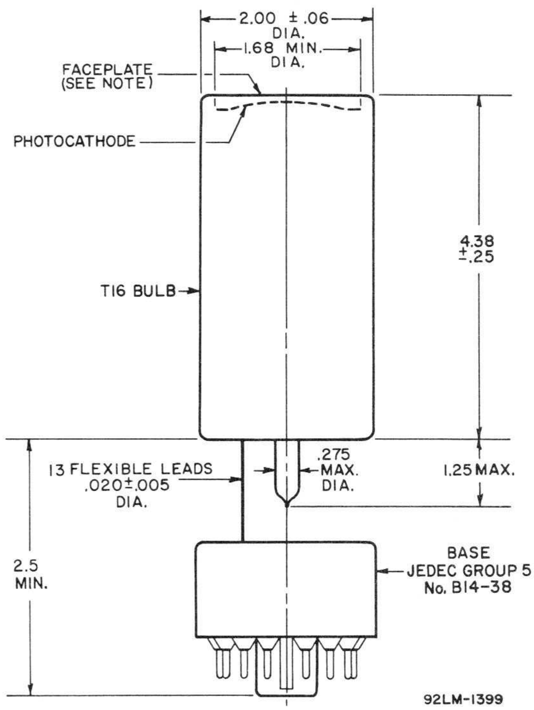
BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF RADIATION: INTO END OF BULB

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: Dynode No.10
Pin 11: Anode
Pin 12: No Connection
Pin 13: Focusing Electrode
Pin 14: Photocathode

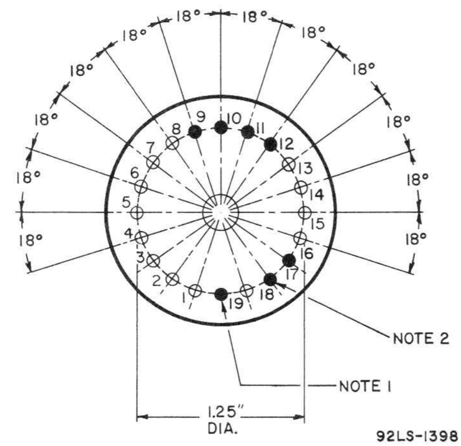
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

Note: Within 1.68" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

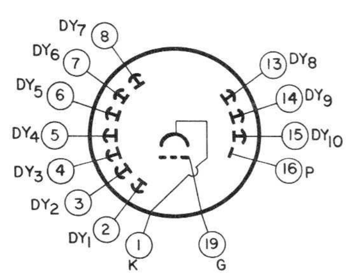
BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off near glass button for indexing.

Note 2: Leads 9, 10, 11, 12, 17, and 18 are cut off near glass button.

TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



DIRECTION OF LIGHT: INTO END OF BULB

92LS-1397

Lead 1: Photocathode
Lead 2: Dynode No.1
Lead 3: Dynode No.2
Lead 4: Dynode No.3
Lead 5: Dynode No.4
Lead 6: Dynode No.5
Lead 7: Dynode No.6
Lead 8: Dynode No.7
Lead 13: Dynode No.8
Lead 14: Dynode No.9
Lead 15: Dynode No.10
Lead 16: Anode
Lead 19: Focusing Electrode

RCA-2063

PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
2.06" Max. Diameter
S-11 Spectral Response
Venetian-Blind Dynode Structure

This bulletin is to be used in conjunction with the bulletin for RCA-8053.

RCA-2063 is a 2"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response and employing a venetian-blind dynode structure. It is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2063 in a given system.

The 2063 is electrically similar to type 8053 except for the following performance characteristics and that the anode luminous sensitivity and equivalent noise input ratings shown on the attached bulletin do not apply for type 2063.

Performance Characteristics:

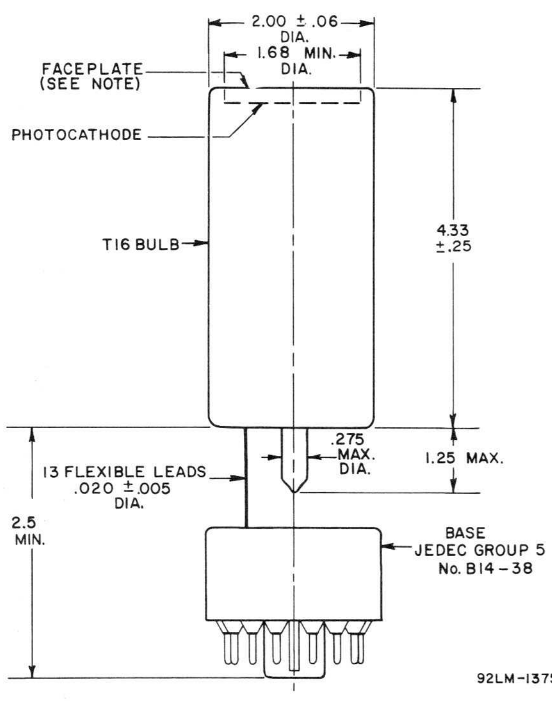
Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode-No.1 potential (referred to cathode) which will provide maximum anode current.

Maximum Anode Dark Current[a]	0.05	μA
Minimum Pulse Height[b]	0.13	volt

[a]Measured under the following conditions: Light incident on the photocathode 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 light flux incident on the filter is 10 microlumens. The supply voltage is adjusted to obtain an anode current of 9 μA. Dark current is measured with the light source removed.

[b]Pulse height is defined as the amplitude of the anode pulse voltage (referred to anode) measured across a 100 ± 5% kilohm resistor and a total capacitance of 92 ± 3% pF in parallel. An anode-to-cathode voltage of 1130 volts is applied across a voltage-divider network having a 1.5 ± 5% megohm resistor between cathode and dynode No.1, 450 ± 5% kilohm resistors between each succeeding stage including dynode No.10 to anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode No.1 potential (referred to cathode) which will provide maximum anode current. The 662 KeV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 2" x 2" thallium-activated sodium-iodide scintillator [NaI(T1)] type 8D8, or equivalent are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97th Street, Cleveland 6, Ohio. The Cs^{137} is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 2063 by a coupling fluid such as Dow Corning Corp., Type DC200 (Viscosity of 100 centipoise) manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

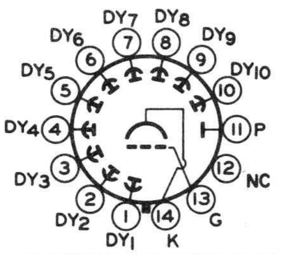
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

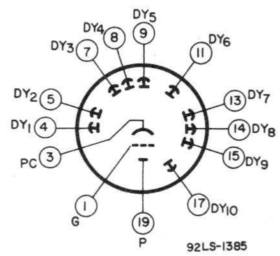
Note: Within 1.68" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

BASING DIAGRAM
Bottom View
(With Base Attached)



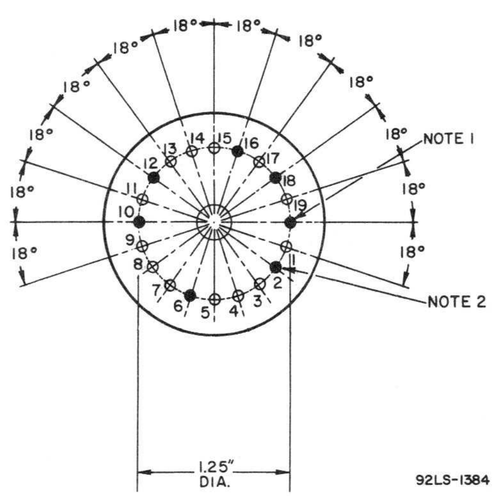
**DIRECTION OF RADIATION:
INTO END OF BULB**

TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



Pin 1: Dynode No.1	Pin 8: Dynode No.8	Lead 1: Focusing Electrode	Lead 11: Dynode No.6
Pin 2: Dynode No.2	Pin 9: Dynode No.9	Lead 3: Photocathode	Lead 13: Dynode No.7
Pin 3: Dynode No.3	Pin 10: Dynode No.10	Lead 4: Dynode No.1	Lead 14: Dynode No.8
Pin 4: Dynode No.4	Pin 11: Anode	Lead 5: Dynode No.2	Lead 15: Dynode No.9
Pin 5: Dynode No.5	Pin 12: No Connection	Lead 7: Dynode No.3	Lead 17: Dynode No.10
Pin 6: Dynode No.6	Pin 13: Focusing Electrode	Lead 8: Dynode No.4	Lead 19: Anode
Pin 7: Dynode No.7	Pin 14: Photocathode	Lead 9: Dynode No.5	

BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off close to glass button for indexing.

Note 2: Leads 2, 6, 10, 12, 16, and 18 are cut off close to glass button.

RCA-2064

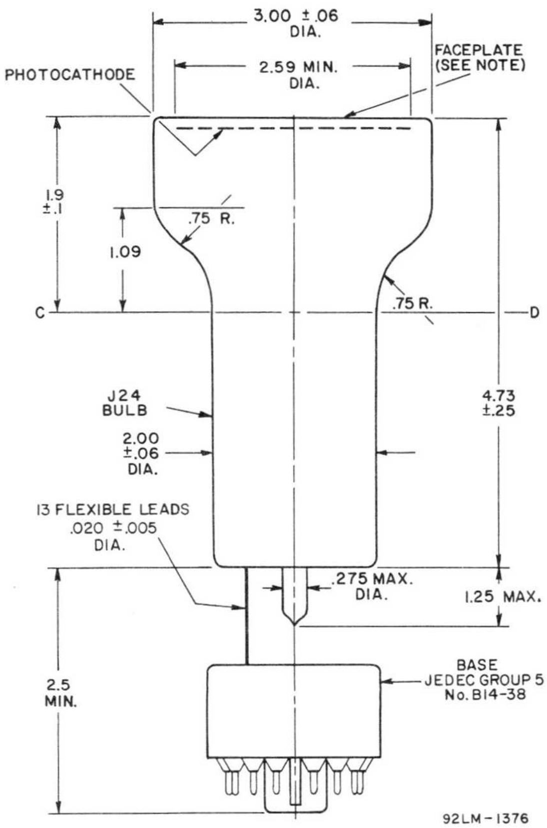
PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
3.06" Max. Diameter
S-11 Spectral Response
Venetian-Blind Dynode Structure

This bulletin is to be used in conjunction with the bulletin for RCA-8054.

RCA-2064 is a 3"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response and employing a venetian-blind dynode structure. It is identical to RCA-8054 in all respects except that it is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2064 in a given system.

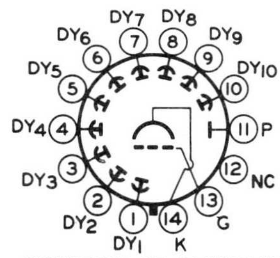
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

Note: Within 2.59" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

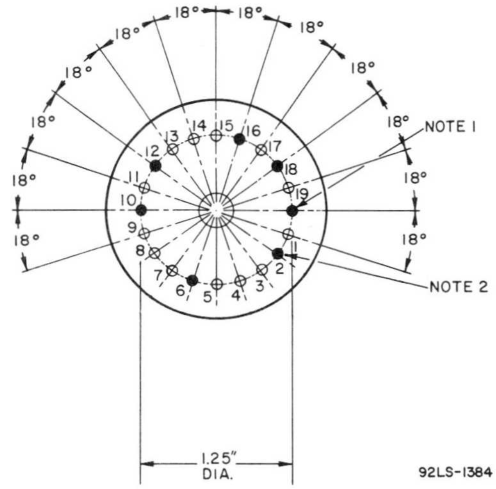
BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF RADIATION: INTO END OF BULB

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: Dynode No.10
Pin 11: Anode
Pin 12: No Connection
Pin 13: Focusing Electrode
Pin 14: Photocathode

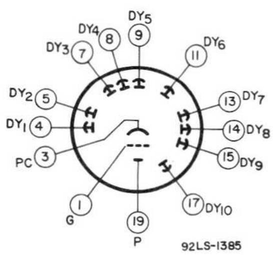
BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off close to glass button for indexing.

Note 2: Leads 2, 6, 10, 12, 16, and 18 are cut off close to glass button.

TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



Lead 1: Focusing Electrode
Lead 3: Photocathode
Lead 4: Dynode No.1
Lead 5: Dynode No.2
Lead 7: Dynode No.3
Lead 8: Dynode No.4
Lead 9: Dynode No.5
Lead 11: Dynode No.6
Lead 13: Dynode No.7
Lead 14: Dynode No.8
Lead 15: Dynode No.9
Lead 17: Dynode No.10
Lead 19: Anode

RCA-2064B

PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
3.06" Max. Diameter
S-11 Spectral Response
Venetian-Blind Dynode Structure

This bulletin is to be used in conjunction with the bulletin for RCA-8054.

RCA-2064B is a 3"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response and employing a venetian-blind dynode structure. It is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2064B in a given system.

The 2064B is electrically similar to type 8054 except for the following performance characteristics and that the anode luminous sensitivity and equivalent noise input ratings shown on the attached bulletin do not apply for type 2064B.

Performance Characteristics:

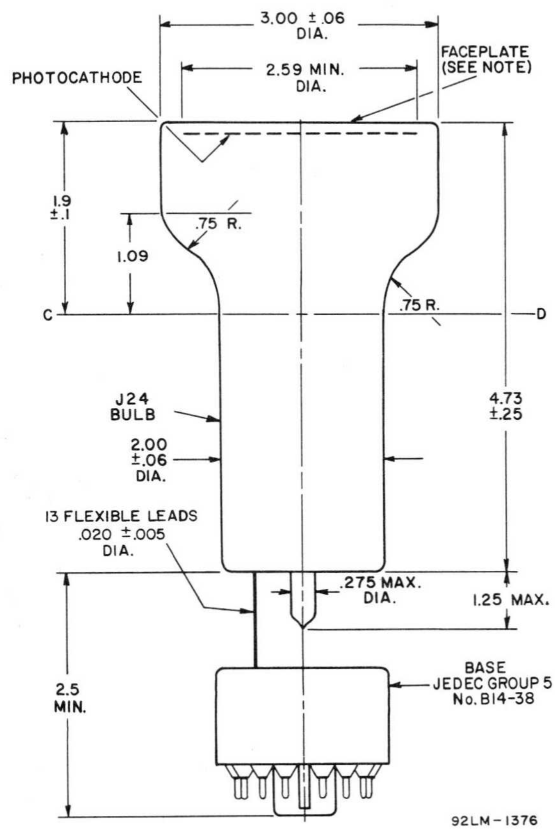
Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode-No.1 potential (referred to cathode) which will provide maximum anode current.

Maximum Anode Dark Current[a]	0.05	µA
Minimum Pulse Height[b]	0.18	volt

[a]Measured under the following conditions: Light incident on the photocathode 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 light flux incident on the filter is 10 microlumens. The supply voltage is adjusted to obtain an anode current of 9 µA. Dark current is measured with the light source removed.

[b]Pulse height is defined as the amplitude of the anode pulse voltage (referred to anode) measured across a 100 ± 5% kilohm resistor and a total capacitance of 92 ± 3% pF in parallel. An anode-to-cathode voltage of 1130 volts is applied across a voltage-divider network having a 1.5 ± 5% megohm resistor between cathode and dynode No.1, 450 ± 5% kilohm resistors between each succeeding stage including dynode No.10 to anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode No.1 potential (referred to cathode) which will provide maximum anode current. The 662 KeV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 3" x 3" thallium-activated sodium-iodide scintillator [NaI(Tl)] type 12A12, or equivalent are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97th Street, Cleveland 6, Ohio. The Cs^{137} is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 2064B by a coupling fluid such as Dow Corning Corp., Type DC200 (Viscosity of 100 centipoise) manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

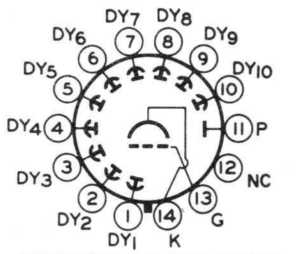
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

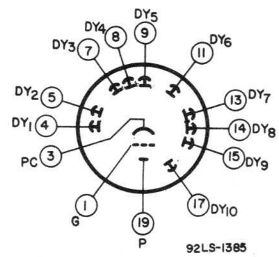
Note: Within 2.59" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF RADIATION:
INTO END OF BULB

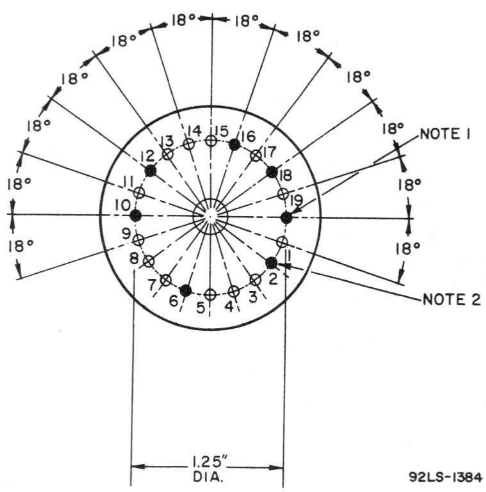
TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



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: Dynode No.10
Pin 11: Anode
Pin 12: No Connection
Pin 13: Focusing Electrode
Pin 14: Photocathode

Lead 1: Focusing Electrode
Lead 3: Photocathode
Lead 4: Dynode No.1
Lead 5: Dynode No.2
Lead 7: Dynode No.3
Lead 8: Dynode No.4
Lead 9: Dynode No.5
Lead 11: Dynode No.6
Lead 13: Dynode No.7
Lead 14: Dynode No.8
Lead 15: Dynode No.9
Lead 17: Dynode No.10
Lead 19: Anode

BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off close to glass button for indexing.

Note 2: Leads 2, 6, 10, 12, 16, and 18 are cut off close to glass button.

RCA-2065

PHOTOMULTIPLIER TUBE

10-Stage, Head-On Type
5.31" Max. Diameter
S-11 Spectral Response
Venetian-Blind Dynode Structure

This bulletin is to be used in conjunction with the bulletin for RCA-8055.

RCA-2065 is a 5"-diameter, 10-stage, head-on type of photomultiplier tube having S-11 spectral response and employing a venetian-blind dynode structure. It is supplied with a medium-shell diheptal base attached to flexible leads to facilitate testing. After testing, the attached base should be removed prior to installing the 2065 in a given system.

The 2065 is electrically similar to type 8055 except for the following performance characteristics and that the anode luminous sensitivity and equivalent noise input ratings shown on the attached bulletin do not apply for type 2065.

Performance Characteristics:

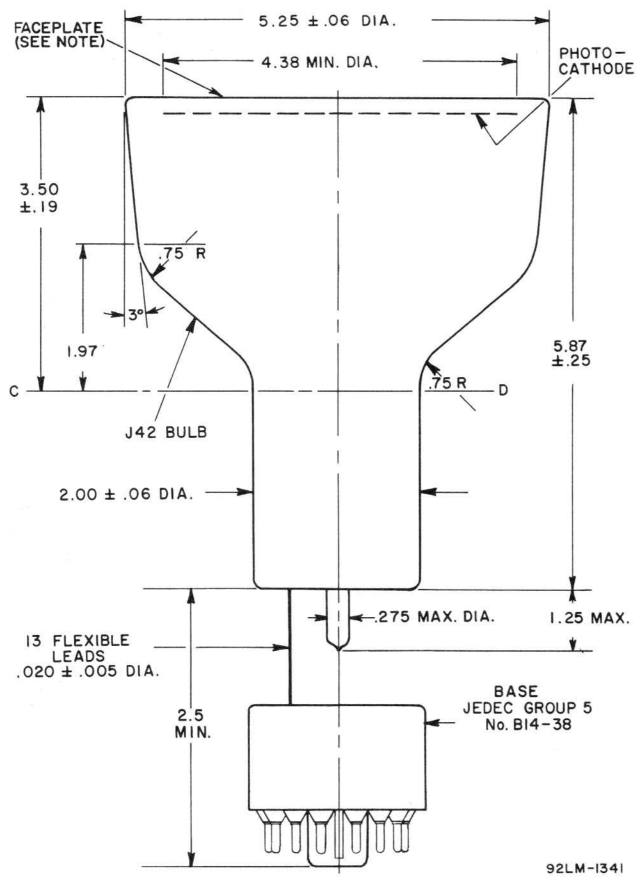
Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode-No.1 potential (referred to cathode) which will provide maximum anode current.

Maximum Anode Dark Current[a]	0.05	µA
Minimum Pulse Height[b]	0.13	volt

[a]Measured under the following conditions: Light incident on the photocathode 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 light flux incident on the filter is 10 microlumens. The supply voltage is adjusted to obtain an anode current of 9 µA. Dark current is measured with the light source removed.

[b]Pulse height is defined as the amplitude of the anode pulse voltage (referred to anode) measured across a 100 ± 5% kilohm resistor and a total capacitance of 92 ± 3% pF in parallel. An anode-to-cathode voltage of 1130 volts is applied across a voltage-divider network having a 1.5 ± 5% megohm resistor between cathode and dynode No.1, 450 ± 5% kilohm resistors between each succeeding stage including dynode No.10 to anode. The focusing electrode is adjusted to that value between 50% and 100% of dynode No.1 potential (referred to cathode) which will provide maximum anode current. The 662 KeV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 3" x 3" thallium-activated sodium-iodide scintillator [NaI(Tl)] type 12A12, or equivalent are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97th Street, Cleveland 6, Ohio. The Cs^{137} is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 2065 by a coupling fluid such as Dow Corning Corp., Type DC200 (Viscosity of 100 centipoise) manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

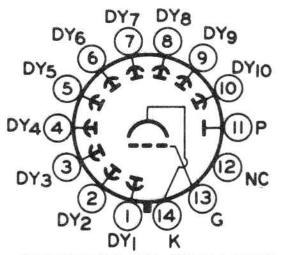
DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

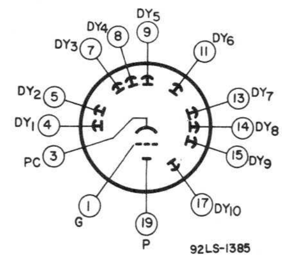
Note: Within 4.38" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

BASING DIAGRAM
Bottom View
(With Base Attached)



DIRECTION OF RADIATION: INTO END OF BULB

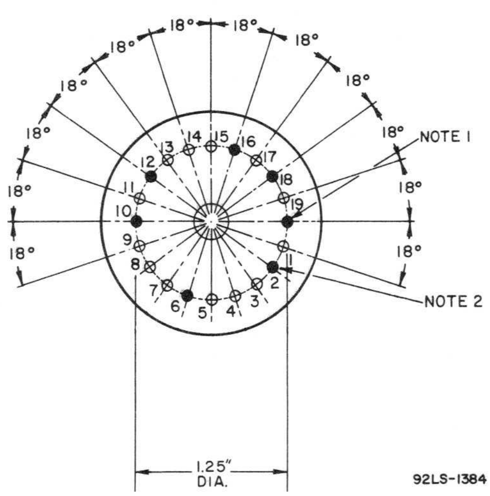
TERMINAL CONNECTIONS
Bottom View
(With Base Removed)



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:	Dynode No.10
Pin 11:	Anode
Pin 12:	No Connection
Pin 13:	Focusing Electrode
Pin 14:	Photocathode

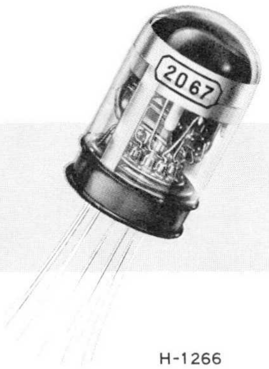
Lead 1:	Focusing Electrode
Lead 3:	Photocathode
Lead 4:	Dynode No.1
Lead 5:	Dynode No.2
Lead 7:	Dynode No.3
Lead 8:	Dynode No.4
Lead 9:	Dynode No.5
Lead 11:	Dynode No.6
Lead 13:	Dynode No.7
Lead 14:	Dynode No.8
Lead 15:	Dynode No.9
Lead 17:	Dynode No.10
Lead 19:	Anode

BASE ARRANGEMENT
Bottom View



Note 1: Lead is cut off close to glass button for indexing.

Note 2: Leads 2, 6, 10, 12, 16, and 18 are cut off close to glass button.



H-1266

RCA-2067

Photomultiplier Tube

STURDY, 10-STAGE, HEAD-ON TYPE
S-11 RESPONSE
1.56" MAX. DIAMETER, 2.80" MAX. LENGTH
(Excluding Semiflexible Leads)

RCA-2067 is a very sturdy head-on photomultiplier tube intended for use in the detection and measurement of nuclear radiation and in other applications involving low-level light sources. It has a hemispherical face-plate to enhance collection of incident radiation over a solid angle of greater than 2π steradians. The 2067 is designed especially for use in rocket, missile, and similar applications of severe environmental conditions.

In addition to an extremely sturdy structure, the 2067 utilizes a special photocathode connection which assures continuous contact with the cathode when the tube is subjected to rough usage.

TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

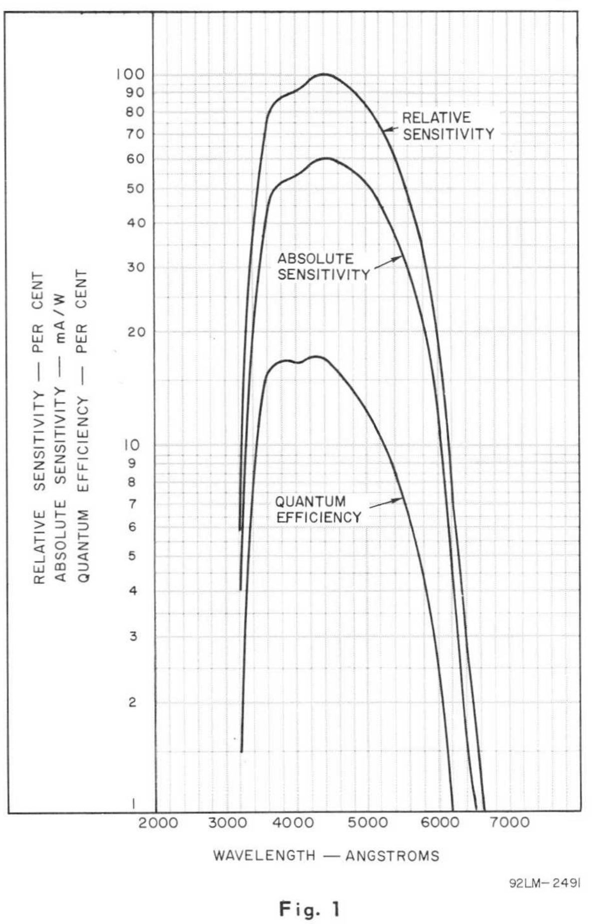


Fig. 1

Other design features include a semitransparent cathode on the inner surface of the face end of the bulb having a minimum projected diameter of 1.24 inches, ten electrostatically-focused multiplying (dynode) stages, and semiflexible leads that may be soldered directly into the associated circuit.

The spectral response of the 2067 covers the range from about 3000 to 6500 angstroms, as shown in *Fig.1*. Maximum response occurs at approximately 4400 angstroms. The 2067, therefore, has high sensitivity in the blue and less sensitivity in the red region of the visible spectrum.

DATA

General:

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 Å
Cathode, Semitransparent	Cesium-Antimony
Shape	Hemispherical, Circular
Window	Lime Glass, Corning No.0080[a] or equivalent
Minimum projected area	1.2 sq. in (774 sq. mm)
Minimum projected diameter	1.24 in (6.1 mm)
Index of refraction at 4360 Å	1.523
Dynode-Surface Material	Cesium-Antimony
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	4 pF
Anode to all other electrodes	7 pF
Maximum Overall Length (Excluding semiflexible leads)	2.80 in (71.1 mm)
Maximum Diameter	1.56 in (39.6 mm)
Bulb	T-12
Lead Connections	See *Dimensional Outline*
Temporary Base	Small-Shell Duodecal, JEDEC B12-43
Magnetic Shield	*See Note* b
Operating Position	Any
Weight (Approx.):	
With temporary base	2.6 oz (73.7 g)
Without temporary base	1.8 oz (51 g)

Maximum Ratings, *Absolute-Maximum Values:*[c]

DC Supply Voltage Between Anode and Cathode	1250 max.	V
DC Supply Voltage Between Anode and Dynode No.10	250 max.	V
DC Supply Voltage Between Consecutive Dynodes	200 max.	V
DC Supply Voltage Between Dynode No.1 and Cathode	300 max.	V
Average Anode Current[d]	0.75 max.	mA
Ambient Temperature	75 max.	°C

Characteristics Range Values:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1000 volts dc (Except as noted)

	Min.	*Typical*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	1.6×10^{4}	–	A/W
Cathode radiant, at 4400 angstroms	–	0.06	–	A/W
Luminous, at 0 Hz[e]	5	20	300	A/lm
Cathode luminous:				
With tungsten light source[f]	3.7×10^{-5}	7.4×10^{-5}	–	A/lm
With blue light source[g]	3.6×10^{-8}	6.9×10^{-8}	–	A

	Min.	*Typical*	*Max.*	
Quantum Efficiency at 4300 Å		17		%
Current Amplification	–	2.7×10^{5}	–	
Anode Dark Current[h,i]	–	2.6×10^{-9}	4×10^{-8}	A
Equivalent Anode-Dark-Current Input	–	1.3×10^{-10}[k]	2×10^{-9}[k]	lm
	–	1.6×10^{-13}[m]	2.5×10^{-12}[m]	W
Equivalent Noise Input[n,p]	–	2.6×10^{-12}	1.9×10^{-11}	lm
	–	3.2×10^{-15}[m]	2.4×10^{-14}[m]	W

NOTES

[a] Manufactured by Corning Glass Works, Corning, N.Y. 14830.

[b] Magnetic shielding material in the form of foil or tape (as available from the Magnetic Shield Division, Perfection Mica Co., 1322 N. Elston Ave., Chicago, Ill. 60622, or equivalent) may be used.

[c] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environment conditions, and variations in device characteristics.

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

[e] 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. A light input of 1 microlumen is used.

[f] 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 is applied between cathode and all other electrodes connected together as anode.

[g] Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning C.S. No. 5-58 Glass Code No.5113 polished to 1/2 stock thickness—Manufactured by the Corning Glass Works, Corning, New York) from a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2870° K. The value of light flux incident on the filter is 0.01 lumen, and 200 volts is applied between cathode and all other electrodes connected together as anode.

[h] At a tube temperature of 22° C.

[i] The light flux incident on the cathode is 1 microlumen. The supply voltage (E) is adjusted to obtain a luminous sensitivity of 20 A/lm. Dark current is measured with no light incident on the tube.

[k] With supply voltage (E) adjusted to give an equivalent luminous sensitivity of 20 A/lm.

[m] At 4400 angstroms. This value is calculated from the EADCI value in lumens using a conversion factor of 804 lumens per watt.

[n] For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

[P] Under the following conditions: Supply voltage (E) is 1000 volts, 22° C tube temperature, external shield connected to cathode, bandwidth 1 cycle per second, tungsten-light source at 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.

OPERATING CONSIDERATIONS

Mounting:

The 2067 is supplied with a small-shell duodecal base attached to the semiflexible leads to facilitate testing. The attached base should be removed prior to installing the 2067 in a given system.

The *leads are semiflexible* but can be broken. Excessive bending of the leads, especially in the region close to the glass button, is to be avoided.

The *semiflexible leads* of the 2067 may be soldered into the associated circuit. When leads of reduced length are soldered, care must be taken to conduct excessive heat away from the lead seals. Otherwise, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.

Support for the tube may be provided by any suitable arrangement that maintains the external surface of the glass bulb, especially that region near the photocathode, at or near photocathode potential. Should the potential of the glass bulb differ appreciably from photocathode potential, signal-to-noise ratio may decrease because of an increase in dark current and noise output caused by the voltage gradient developed across the bulb wall. The metal flange should never be used for mechanical clamping purposes because of the possibility of breaking the glass-to-metal seals.

Precautions should also be taken to prevent an electrical conductor from contacting the cathode flange unless the conductor is to be maintained at cathode potential.

Shielding:

Electrostatic and magnetic shielding of the 2067 is ordinarily required. When a shield is used, it must be connected to the cathode terminal. The application of high voltage, with respect to cathode, to insulating or other materials supporting or shielding the 2067 at the photocathode end of the tube should not be permitted unless such materials are chosen to limit leakage current to the tube envelope to 1 x 10^{-12} ampere or less.

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

Electrical:

The high voltage at which the 2067 is operated is very dangerous. Before any part of the circuit is touched, the power supply switch should be turned off and both terminals of any capacitors grounded.

The *operating stability* of the 2067 is dependent on the magnitude of the anode current and its duration. When the 2067 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 on the severity of the operating conditions. After a period of idleness, the 2067 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 1 milliampere is recommended when stability of operation is important. When maximum stability is required, the average anode current should not exceed 10 microamperes.

For optimum tube performance it is also recommended that the 2067 be operated at or below room temperature.

TYPICAL ANODE CHARACTERISTICS

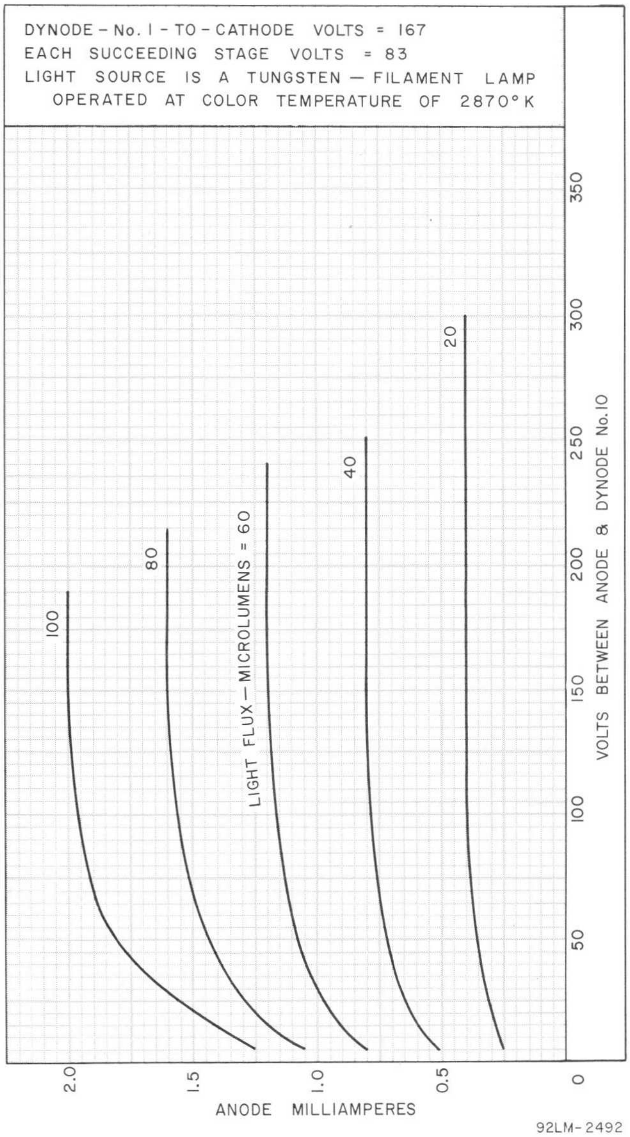


Fig. 2

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

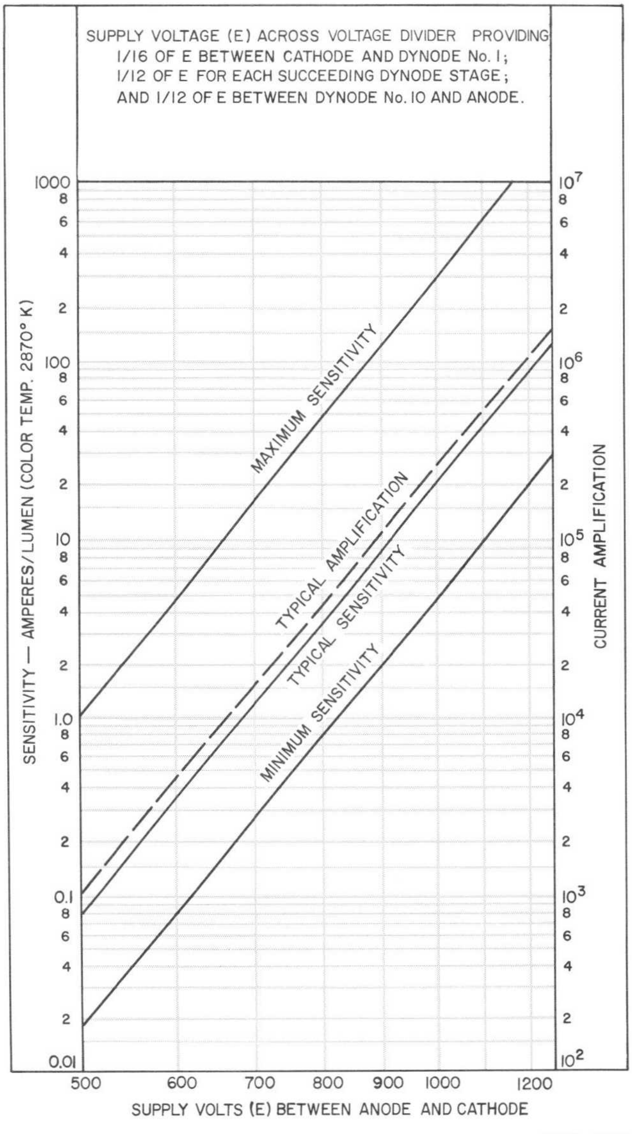
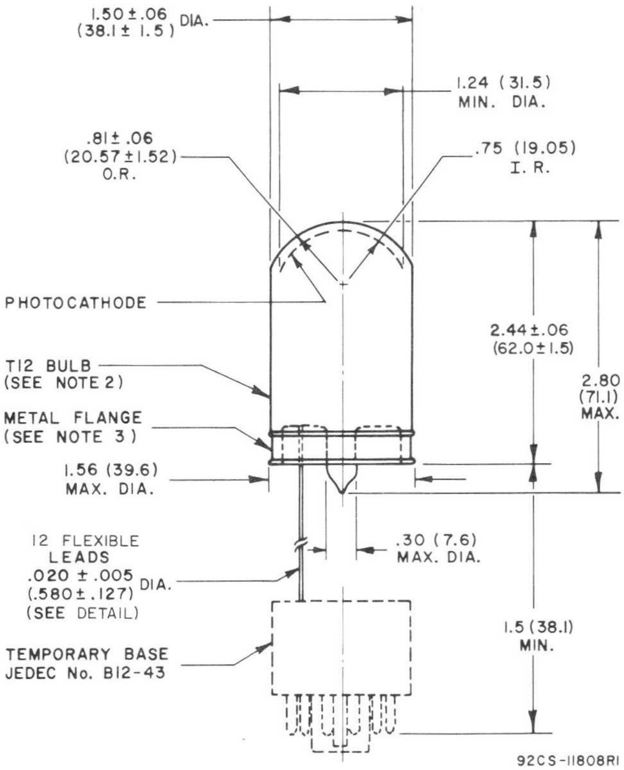


Fig. 3

DIMENSIONAL OUTLINE

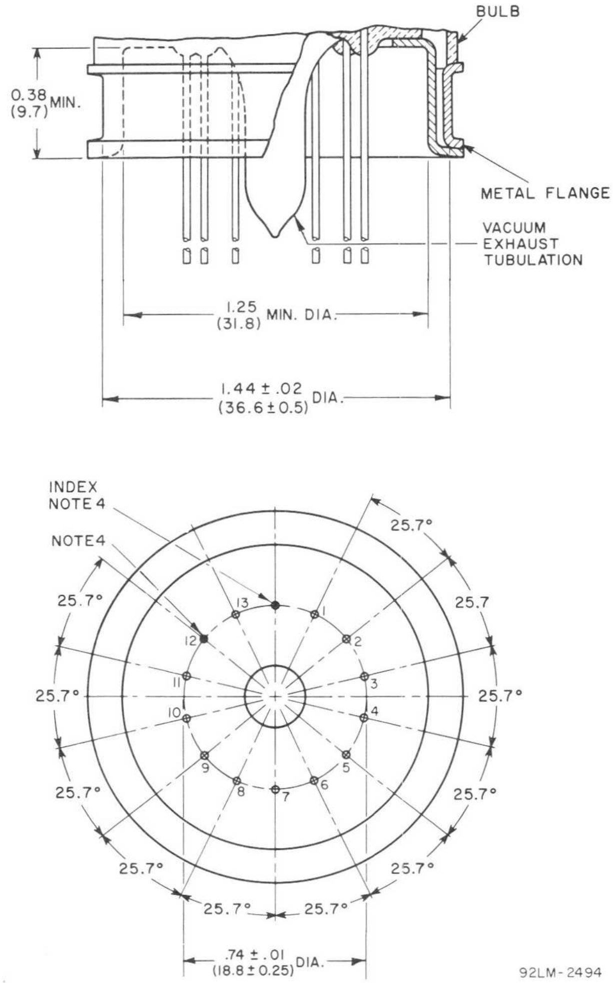


Note 1: Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

Note 2: ℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the metal flange.

Note 3: The metal flange should never be employed for mechanical mounting purposes.

Detail of Terminal Lead Arrangement

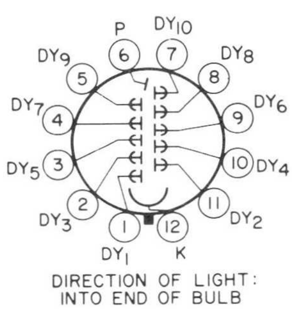


Note 4: Lead No.12 and 14 are cut off within 0.04 inch (1.02 mm) of the glass button.

BASING DIAGRAM
With Temporary Base, JEDEC B12-43

Bottom View

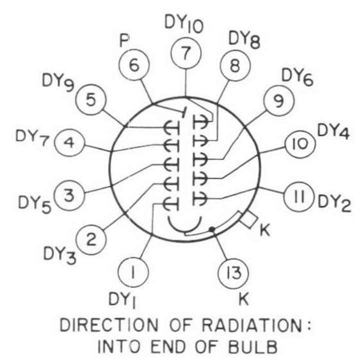
Pin 1: Dynode No.1
Pin 2: Dynode No.3
Pin 3: Dynode No.5
Pin 4: Dynode No.7
Pin 5: Dynode No.9
Pin 6: Anode
Pin 7: Dynode No.10
Pin 8: Dynode No.8
Pin 9: Dynode No.6
Pin 10: Dynode No.4
Pin 11: Dynode No.2
Pin 12 and Metal Flange: Photocathode



LEAD TERMINAL CONNECTIONS

Bottom View

Lead 1: Dynode No.1
Lead 2: Dynode No.3
Lead 3: Dynode No.5
Lead 4: Dynode No.7
Lead 5: Dynode No.9
Lead 6: Anode
Lead 7: Dynode No.10
Lead 8: Dynode No.8
Lead 9: Dynode No.6
Lead 10: Dynode No.4
Lead 11: Dynode No.2
Lead 13 and Metal Flange: Photocathode



RCA

New Product Announcement

Electronic Components
Harrison, NJ 07029

RCA

International Licensing
Licensee Services

May 1, 1970

DR2100 SERIES NUMITRONS

Intended for equipment which requires more compact digital display devices, the new 0.5-inch DR2100 Series Numitrons have all the desirable features of the original DR2000 Series.

Numitrons provide a wide-spectrum, high-brightness display which permits unlimited filter selection. Their single plane, rugged construction results in a highly reliable device which displays high contrast numerals free of clutter.

Numitrons are fully compatible with IC decoder/drivers such as the RCA CD2500E. Equipment design is further simplified because Numitrons may be soldered directly into PC-boards or may be socket mounted with commercially available sockets.

A technical bulletin for the DR2000 Series and DR2100 Series Numitrons is enclosed.

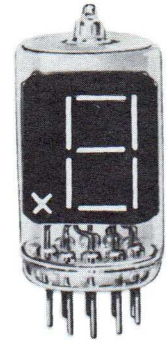
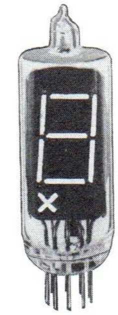
RCA
Numitron

Digital Display Devices
Segmented Incandescent Types

DR2000 DR2010 DR2020 DR2030 DR2100 DR2110 DR2120 DR2130

Features

- high brightness -- fully adjustable
- low voltage operation
- high contrast -- segmented digits viewed against a dark background
- compatible with IC Decoder/Drivers such as the RCA CD2500E family
- high reliability -- rugged construction
- wide-spectrum light emission permits unlimited filter selection
- wide viewing angle
- void of "clutter"
- Solderable base pins permits direct PC board mounting
- DR2000 series fits popular low-cost 9-pin miniature socket
- DR2100 series fits popular TO-5 style, 10-pin socket

DR2000 *DR2100*
0 through 9
DR2010 *DR2110*
0 through 9 with decimal point

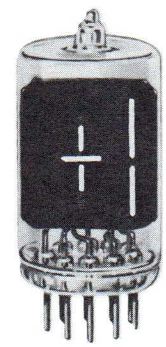
Description

RCA Numitron types DR2000 series and DR2100▲ series are digital display devices which provide a sharp, high-brightness numeric* display. These low-voltage, incandescent-type devices have wide-spectrum light emission which permits the use of filters to obtain a display of any desired color. Intended for use in equipment which requires a numeric display output, these devices are fully compatible with IC decoder/drivers and may be operated in either a direct or multiplex mode.

The RCA Numitron devices utilize a rugged, single-plane unit construction which results in a highly reliable device with very long life expectancy. The "up-front" display surface permits a wide viewing angle with a display that is free of "clutter" and residual images. Brightness is completely adjustable, with simple voltage controls, from zero output to a level that is easily viewable under very high ambient-light conditions. The devices are free of induced or radiated interference. The 9-pin, circular basing arrangement facilitates the design of PC board layout.

The DR2000, DR2010, DR2020, and DR2030 Numitron devices fit into a standard 9-pin miniature electron tube socket. However, for PC board applications where mounting space is limited, a commercial PC board socket which permits 0.8-inch center-to-center mounting is available. Solderable base pins provide direct PC board mounting if desired.

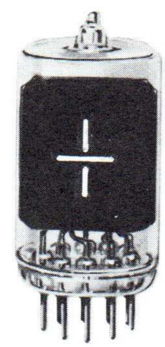
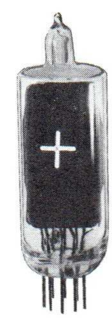
The DR2100, DR2110, DR2120, and DR2130 Numitron devices may be mounted on 0.5-inch centers directly on PC boards or, if required, a standard TO-5 style, 10-pin socket may be used. For application information on RCA Numitrons see RCA Application Note AN-4277 "Description and Application of RCA Numitrons".




DR2020 *DR2120*
Plus-Minus sign and numeral 1

Mechanical

	DR2000 Series	DR2100 Series
Mounting Position	Any	Any
Maximum Overall Length	1.875 in.	1.660 in.
Maximum Seated Length	1.625 in.	1.450 in.
Maximum Diameter	0.785 in.	0.485 in.
Base	9-pin miniature	9-pin, 0.230 in. pin circle

DR2030 *DR2130*
Plus-Minus sign

▲ DR2100 series formerly RCA Dev. Nos. DTF122, DTF123, DTF124, and DTF125, respectively.

* Individual segments may be addressed to provide symbol or alphabetic output such as the letters A, C, E, F, H, J, L, P, & U.

RCA Electronic Components

Printed in U.S.A./4-70
Supersedes issue dated 3-70

Characteristics

	DR2000 Series	DR2100 DR2100V1 Series
Electrical DC segment voltage = 4.5 V unless otherwise specified		
Recommended dc Segment Voltage Range	3.5 to 5.0 V	3.5 to 5.0 V
Segment Current	24 mA	24 mA
Life Expectancy	100,000 h min.	100,000 h min.
Visual DC segment voltage = 4.5 V		
Viewing Angle (included angle)	140^{0}	120^{0}
Segment Luminance	7000 fL typ.	7000 fL typ.
Response Times:		
ascent (to visibility)	15 ms typ.	15 ms typ.
descent (to 50% of luminance)	<20 ms	<20 ms
Maximum Segment Deflection From a Straight Line	0.005 in.	0.005 in.

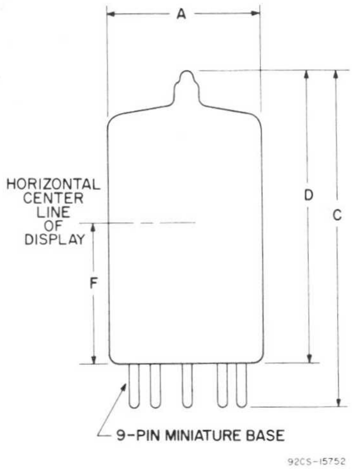
MECHANICAL SPECIFICATIONS for DR2000 Series, DR2100 Series, and DR2100V1 Series Numitrons

TEST	CONDITIONS	DC Segment Voltage V	MIL-STD	METHOD
SHOCK				
a)	100g, 1 ms, Half-Sine Wave	4.5	1311 MIL-E-1F	1041 4.3.3
b)	50g, 11 ms, Half-Sine Wave	Non-Operating	1311	1042A
VIBRATION				
a)	Variable Frequency: 10 to 44 Hz, 0.1-inch DA, and 44 to 200 Hz, 10g	4.5		
b)	Variable Frequency: 200 to 600 Hz, 1g	4.5		
c)	Variable Frequency: 600 to 2000 Hz, 10g	4.5		
d)	Variable Frequency: 10 to 50 to 10 Hz, 0.08-inch DA, 10g maximum	4.5	1311	1031A
e)	Fatigue: 25 Hz, 2.5g, 96 hr	4.5	1311	1031A

RCA Numitron devices will meet the Radio Technical Commission for Aeronautics (RTCA), Document No. DO-138 Dated June 27, 1968. Specifications for operational and crash safety shock tests; standard environmental vibration for instrument panel location in all types of aircraft.

DIMENSIONAL OUTLINE

DR2000 Series

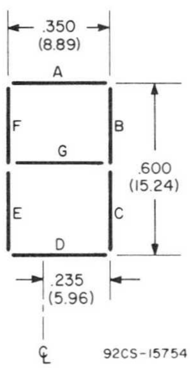


DIMENSION	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.
A		0.785		19.93
C		1.875		47.62
D		1.625		41.27
F	0.700	0.730	17.78	18.54
MILLIMETER DIMENSION DERIVED FROM INCH DIMENSION				

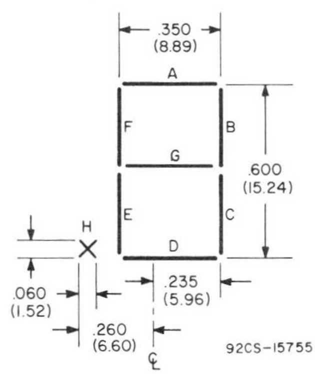
PC board socket for 0.8-inch center-to-center mounting:
Methode Electronics, Inc. PN-8610 or equivalent.

SEGMENT DIMENSIONS AND ASSIGNMENT

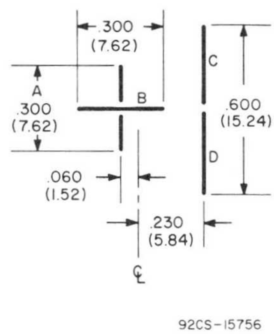
DR2000



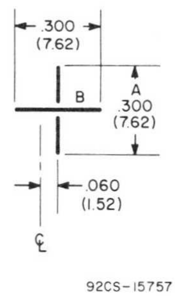
DR2010



DR2020



DR2030



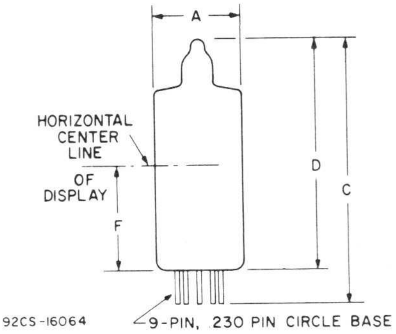
℄ = center line of device with pin No. 3 toward viewer.

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

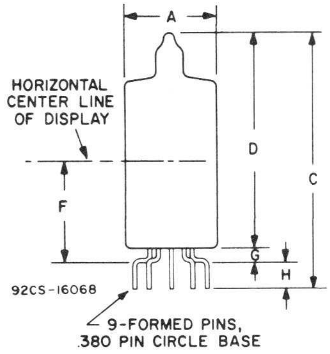
RCA TYPE	Segment Assignment — Pin Designations 1	2	3	4	5	6	7	8	9
DR2000	DO NOT USE	COMMON	E	D	C	G	A	B	F
DR2010	H		E	D	C	G	A	B	F
DR2020	DO NOT USE		DO NOT USE			D	B	C	A
DR2030	DO NOT USE		DO NOT USE			B	DO NOT USE	A	DO NOT USE

DIMENSIONAL OUTLINE

DR2100 Series



DR2100V1 Series



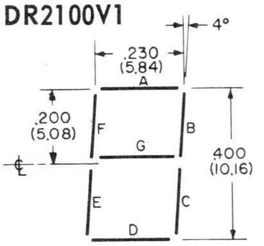
DIMENSION	DR2100 Series				DR2100V1 Series			
	INCHES		MILLIMETERS		INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
A		0.485		12.32		0.485		12.32
C		1.660		42.16		1.705		43.30
D		1.450		36.83		1.450		36.83
F	0.625	0.655	16.51	17.27	0.685	0.745	17.39	18.92
G					0.060	0.090	1.52	2.28
H					0.135	0.165	3.43	4.19
MILLIMETER DIMENSION DERIVED FROM INCH DIMENSION								

The table below lists some commercially available sockets for the DR2100 series Numitron.

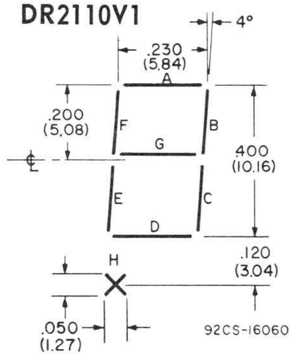
10-Lead TO-5 Style	Augat, Inc.	8058-1G22	Miniature, Teflon* for chassis mounting
		8058-2HG1	Miniature, Teflon, for printed-circuit boards
	Barnes Corp.	MG-1002	Miniature, Teflon, press-fit type
		MGR-102	Miniature, Teflon, for printed-circuit boards
		MF-02-10	For chassis mounting, chamfered-lead entrance
		MF-03-10	For printed-circuit boards, chamfered-lead entrance
	Cinch Mfg. Co.	133-99-92-054	Miniature, diallyl phthalate, for printed-circuit boards
		133-99-92-065	Miniature spread lead type, diallyl phthalate, for printed-circuit boards
	Sealectro Corp.	Series 60#	Press-fit type, Teflon

SEGMENT DIMENSIONS AND ASSIGNMENT

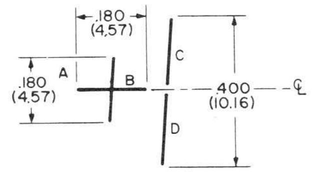
DR2100 / DR2100V1



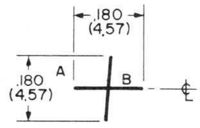
DR2110 / DR2110V1



DR2120 / DR2120V1



DR2130 / DR2130V1



℄ = center line of display (dimension F above). Pin No.3 toward viewer.

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

<table>
<tr><th rowspan="3">RCA TYPE</th><th colspan="9">Segment Assignment</th></tr>
<tr><th colspan="9">Pin Designations</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr>
<tr><td>DR2100</td><td>DO NOT USE</td><td rowspan="4">COMMON</td><td>E</td><td>D</td><td>C</td><td>G</td><td>A</td><td>B</td><td>F</td></tr>
<tr><td>DR2110</td><td>H</td><td>E</td><td>D</td><td>C</td><td>G</td><td>A</td><td>B</td><td>F</td></tr>
<tr><td>DR2120</td><td>DO NOT USE</td><td colspan="3">DO NOT USE</td><td>D</td><td>B</td><td>C</td><td>A</td></tr>
<tr><td>DR2130</td><td>DO NOT USE</td><td colspan="3">DO NOT USE</td><td>DO NOT USE</td><td>B</td><td>DO NOT USE</td><td>A</td></tr>
</table>

* Registered Trade Mark, E. I. DuPont De Nemours and Co.
\# Registered Trade Mark, Sealectro Corporation

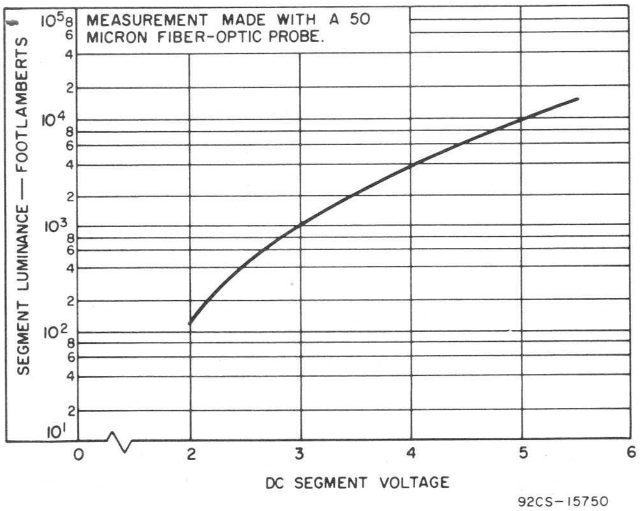


Fig.1 - Segment Luminance vs Segment Voltage.

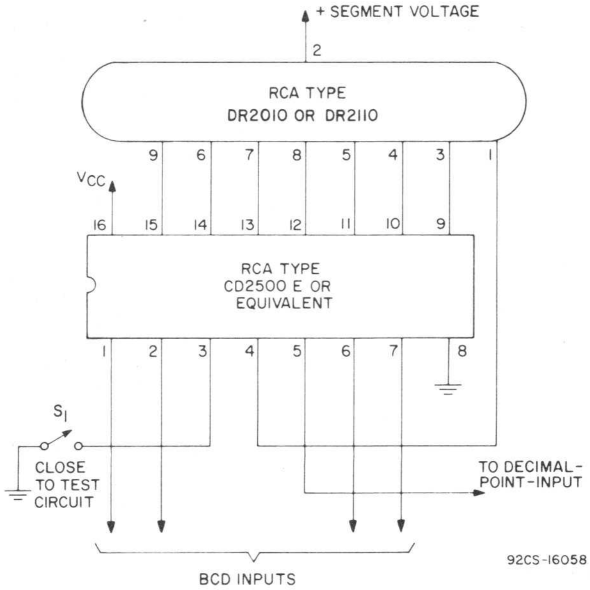


Fig.4 - Basic Interconnection Circuit of Numitron Display Device and Decoder-Driver.

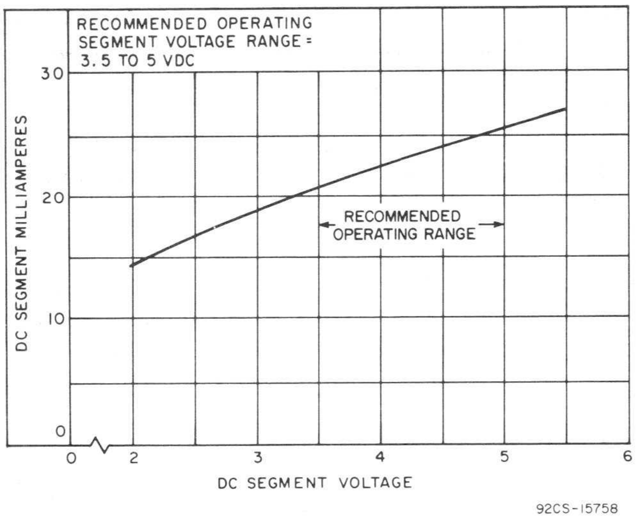
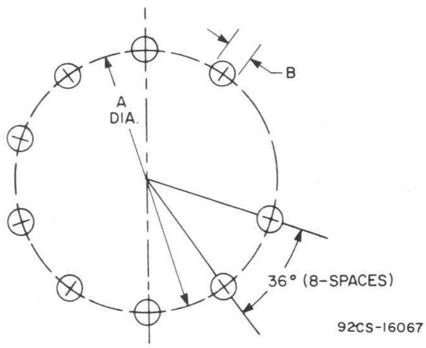


Fig.2 - Segment Current vs Segment Voltage.



NUMITRON Series	DIMENSION		
	A	B	
	Nominal	Min.	Max.
DR2000	0.468	0.038	0.042
DR2100	0.230	0.018	0.022
DR2100V1	0.380	0.018	0.022
DIMENSIONS IN INCHES			

Bottom View

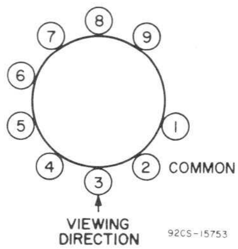


Fig.5 - Base Diagram and Pin Circle Dimensions for DR2000, DR2100, and DR2100V1 Series Digital Display Devices.

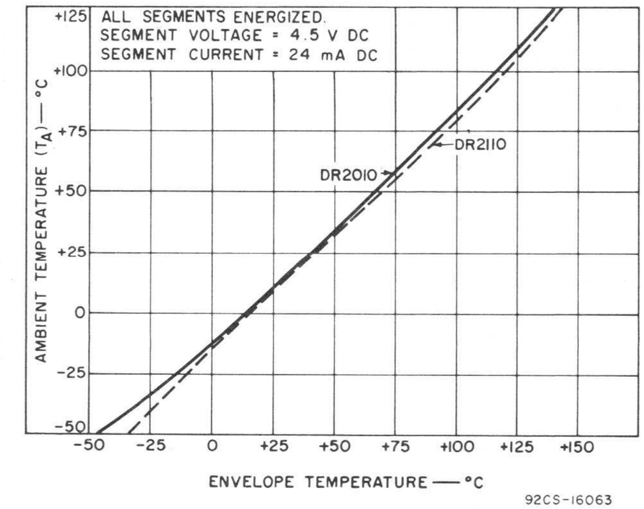


Fig.3 - Ambient Temperature vs Envelope Temperature.

OPERATING CONSIDERATIONS

Character Generation

The following chart gives the pin connections for forming the various decimal-character displays for each device. Pin No.2 is the common connection for all segments in each device. For example, to form a numeral one using type DR2000, connect the segment voltage between pin No.2 (common) and pin Nos.5 and 8.

Display	Device Pin Designation Pin No. 2 Common For All Types				
	DR2000 DR2100	DR2010 DR2110	DR2020 DR2120	DR2030	DR2130
0	3,4,5,7,8,9	3,4,5,7,8,9			
1	5, 8	5,8	6,8		
2	3,4,6,7,8	3,4,6,7,8			
3	4,5,6,7,8	4,5,6,7,8			
4	5,6,8,9	5,6,8,9			
5	4,5,6,7,9	4,5,6,7,9			
6	3,4,5,6,7,9	3,4,5,6,7,9			
7	5,7,8	5,7,8			
8	3,4,5,6,7,8,9	3,4,5,6,7,8,9			
9	4,5,6,7,8,9	4,5,6,7,8,9			
÷			7,9	6,8	7,9
−			7	6	7
.		1			

Integrated Circuit Decoder/Driver

The Numitron series devices are compatible with the RCA Integrated Circuit Decoder/Driver types CD2500E and CD2501E. The integrated circuit decoder/driver accepts four inputs in BCD (8-4-2-1 code) and decodes them into outputs representing a decimal number from 0 to 9 on a 7-segment display. For basic interconnection of decoder/driver and the Numitron display devices see Fig.4. For data on CD2500E and CD2501E integrated circuit types see File No. 392.

Mounting Arrangements

The Numitron devices are designed for mounting in either commercially available sockets or directly on printed circuit boards. The DR2000 series devices fit into a standard 9-pin miniture electron tube socket. A commercial PC board socket which permits 0.8-inch center-to-center mounting is available.■ The DR2100 series Numitron devices are available in two electrically identical versions: DR2100 series with straight leads and the DR2100V1 series with formed leads. The DR2100 series may be mounted on 0.5-inch centers directly on PC boards or, if required a standard TO-5 style, 10-pin socket may be used. See table on page 4 which lists some commercially available sockets for the DR2100 series devices. The DR2100V1 series devices facilitate direct PC board mounting techniques and maintain a mounting distance between devices of 0.5-inch center-to-center, including space for an inter-unit shield.

Figure 5 shows the base diagram and pin-circle dimensions for the DR2000, DR2100, and DR2100V1 series Numitron devices.

Power Supply Requirements

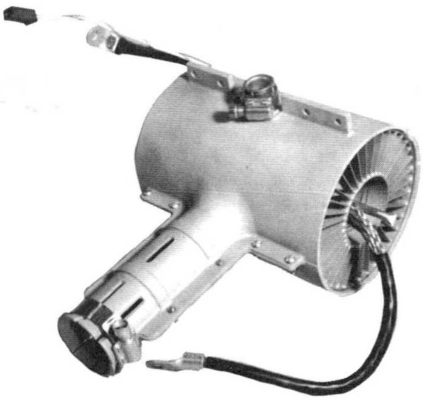
The Numitron Series devices do not require critical voltage regulation over the useable operating range of 3.5 to 5.0 Vdc. As in the case with any incandescent type device, dc voltage operation above the recommended value may result in reduced life expectancy. For multiplex operation, segment voltage above 5.0 volts may be used provided that the appropriate duty factor is observed.

Display

Because these Numitron devices have a wide-band light spectrum emission, an unlimited choice of filters can be used to produce any desired color display. If a broader stroke is desired, it can be obtained with an etched glass such as "Trusite"*. When a larger size display is needed, a Fresnel lens may be used in front of the display.

* Trademark "Trusite "- Dearborn Glass Co., Chicago, Illinois.

■ Methode Electronics, Inc. part No. PN-8610.



900 W – 915 MHz RF Power
High Mismatch Tolerance
Low Voltage Operation
Low Impedance Gridded Tube

RCA-FE2100
TUBE-CAVITY

The RCA FE2100 is an integral, tube-cavity assembly designed especially for use in food processing and home cooking. With the simple application of filament and anode voltages it will deliver approximately 900 watts of RF power at 915 MHz.

The FE2100 is highly tolerant of mismatches and can operate into an empty oven or even into one using metal containers for the food to be processed.

The triode approach allows lightweight accessories, including a 600 volt doubler, power supply operating from the standard 236 volt line.

GENERAL DATA

Electrical:

Filament:		
Current ac (typical)	180	A
(maximum)	200	A
Voltage (@ 180 A ac)	0.7	V
Maximum Heating Time	20	s
Anode:		
Voltage dc (typical)	600	V
(maximum)	700	V
Current (@ 600 V dc)	4.0	A
(maximum)	5.0	A
Load:		
Nominal Impedance	50	Ω
Output Power (into matched load):		
Typical @ 600 V dc	900	W
Typical @ 450 V dc	450	W

Mechanical:

Operating Position	Any
Maximum Length	(177.8 mm) 7.00 in
Maximum Width	(301.2 mm) 11.86 in
Cavity Diameter	(127.0 mm) 5.00 in
Output Circuit:	
Mates with 50 Ω line.	
50 Ω line diameter	(41.3 mm) 1-5/8 in
Weight	(3.8 kg) 8.5 lb
Cooling Requirements:	
Air Flow (61 liters/s)	130 cu ft/min
Pressure Drop (Approx.) (inches H_2O)	(12.7 mm) 0.50 in

OPERATING CONSIDERATIONS

The tube/cavity unit requires only the connections to the proper air flow and the prescribed voltages to deliver useful power. With a matched load the power transferred will approach 950 watts of useful power. Sactisfactory operation can be obtained into mismatched loads.

This tube-cavity assembly has been used satisfactorily in systems similar to that shown in block diagram form.

For further information on the operation of this assembly, contact RCA, Power Tube Application Engineering, Lancaster, Pennsylvania.

RADIO CORPORATION OF AMERICA
Electronic Components and Devices Harrison, N. J.
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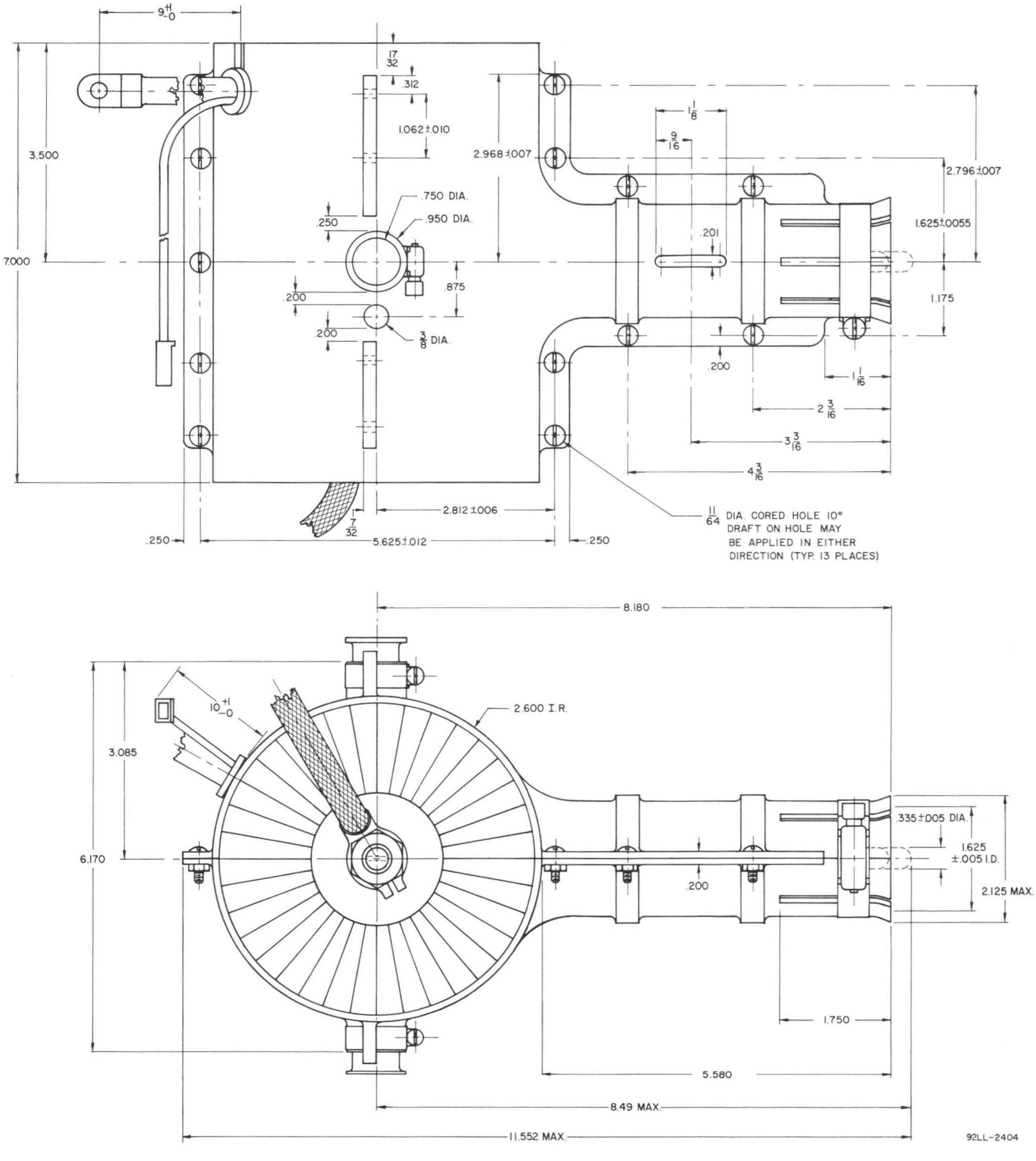
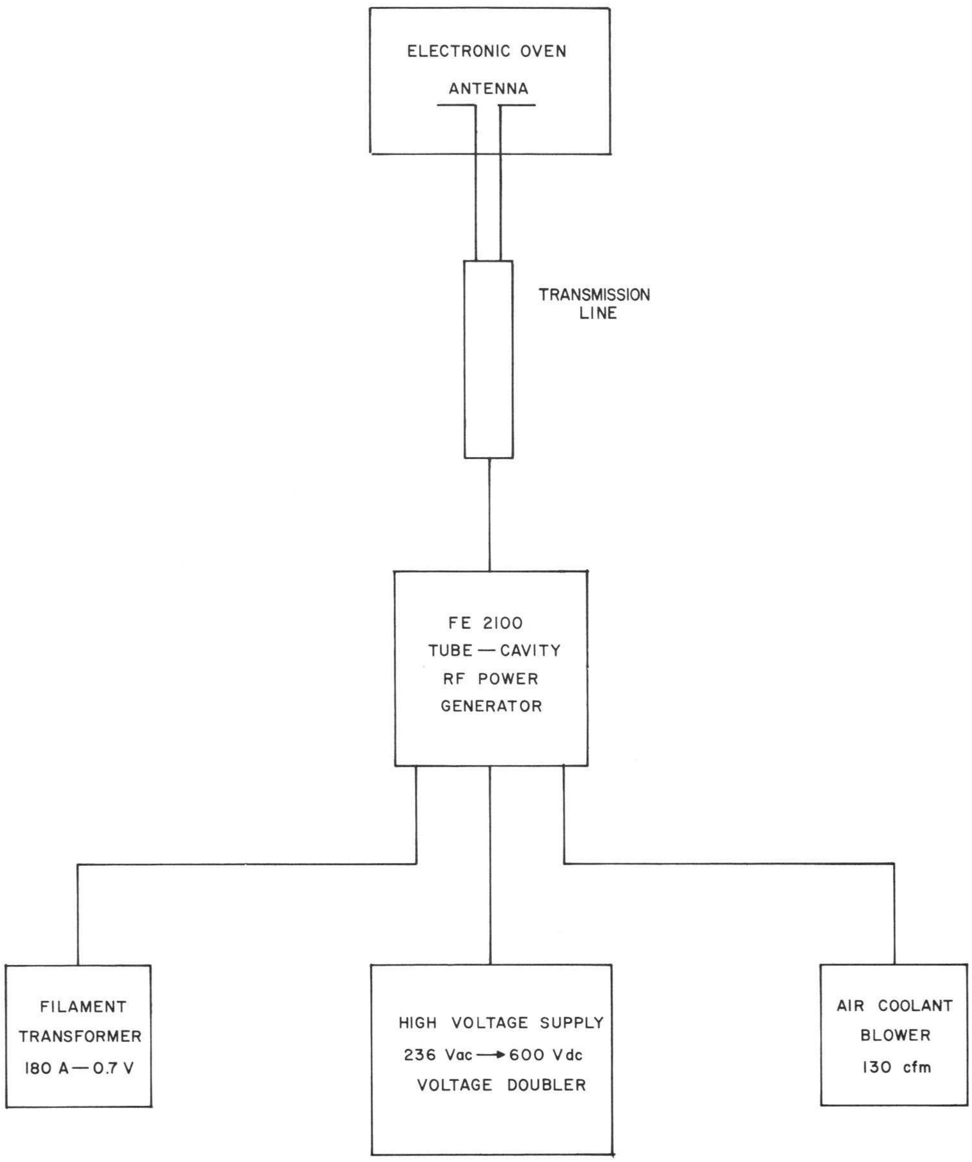
Marca(s) Registrada(s)
12-67
Printed in U.S.A.

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

ELECTRONIC OVEN SYSTEM
RCA FE2101



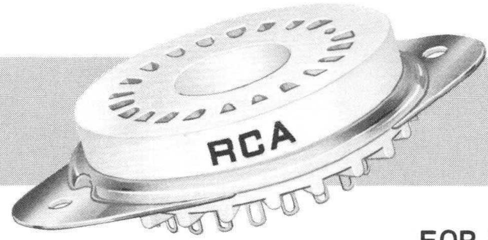
92LM-2405

RCA

RCA-DP2118

RCA

TUBE SOCKET

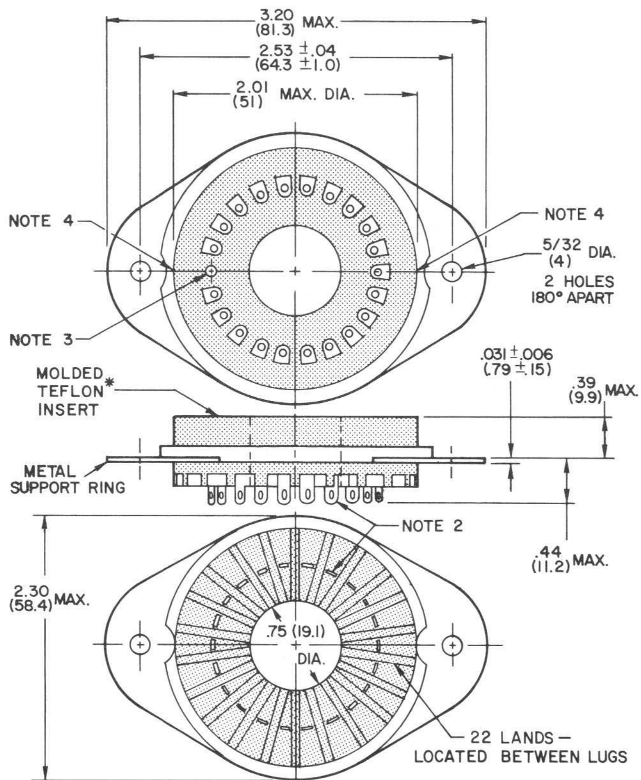


H-1574

FOR USE WITH PHOTOMULTIPLIER TUBES SUCH AS RCA-8575 AND RCA-4522

RCA-DP2118 is a high-quality, low-leakage 21-contact Teflon* socket. Dimensions and associated information for this socket are shown below.

DIMENSIONAL OUTLINE



92LS-1508R1

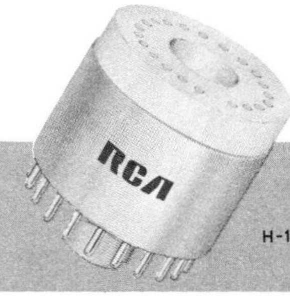
NOTE 1: Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

NOTE 2: Socket has 21 gold-plated contacts.

NOTE 3: Contact omitted for indexing. Teflon insert may have indentation of up to 1/8" diameter x 3/16" deep (3.2 mm diameter x 4.8 mm deep).

NOTE 4: Teflon insert may be notched at this point. Notch may be up to 1/16" (1.6 mm) deep.

*Registered trademark of DuPont de Nemours, Inc., Wilmington, Del.



H-1572R1

RCA-AJ2132

Adapter

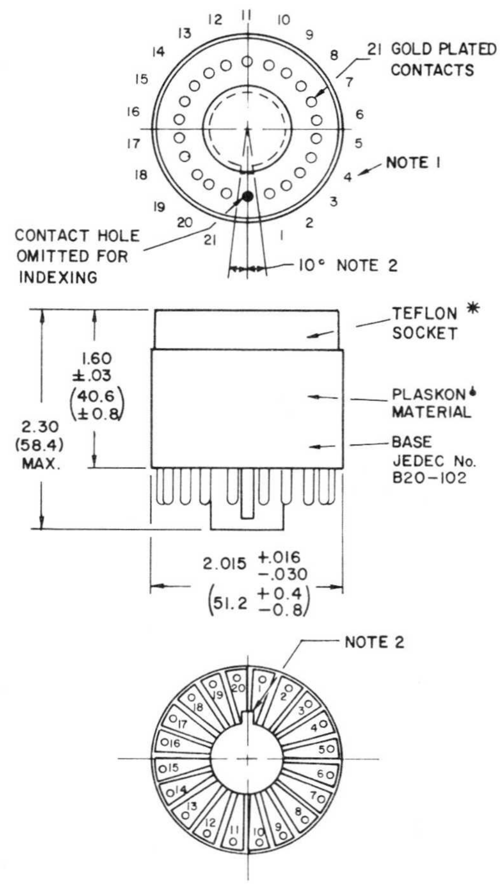
For Use With RCA Photomultiplier Tube Type 8575 to Replace Tube Types 56AVP, 6810A or 7264

The excellent performance characteristics of the RCA photomultiplier tube type 8575, a 12-stage head-on type employing the highly efficient bialkali photocathode, are obtainable in existing low-level-radiation detection and measurement systems now employing tube types 56AVP, 6810A, or 7264. RCA adapter type AJ2132 allows replacement of these 14-stage tubes with only minor required changes in the present voltage-divider network and, in most equipment, no required rearrangement of parts. Use of this adapter with the 8575 is not recommended for applications where the ultimate in speed of response is required and especially for those applications where a high peak current capability is necessary.

The AJ2132 has integral capacitors connected across its internal leads for dynodes No.10 and No.11 and for dynodes No.11 and No.12 to minimize the effects of increased lead inductance.

The internal connections of the AJ2132 and the required changes in existing voltage-divider networks are indicated in *Fig.1* for type 56AVP, and in *Fig.2* for types 6810A or 7264.

Dimensional Outline



92LS—1515R2

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

Note 1: The contact numbers shown on this top view do not appear on the socket body. They are shown here for the convenience of the user.

Note 2: Alignment between JEDEC B20-102 base key and index of teflon socket will not exceed ±10°.

*TEFLON is a registered trademark of the DuPont de Nemours, E.I. & Co., Inc., Wilmington, Del.

♦PLASKON is a registered trademark of the Allied Chemical Corporation, New York.

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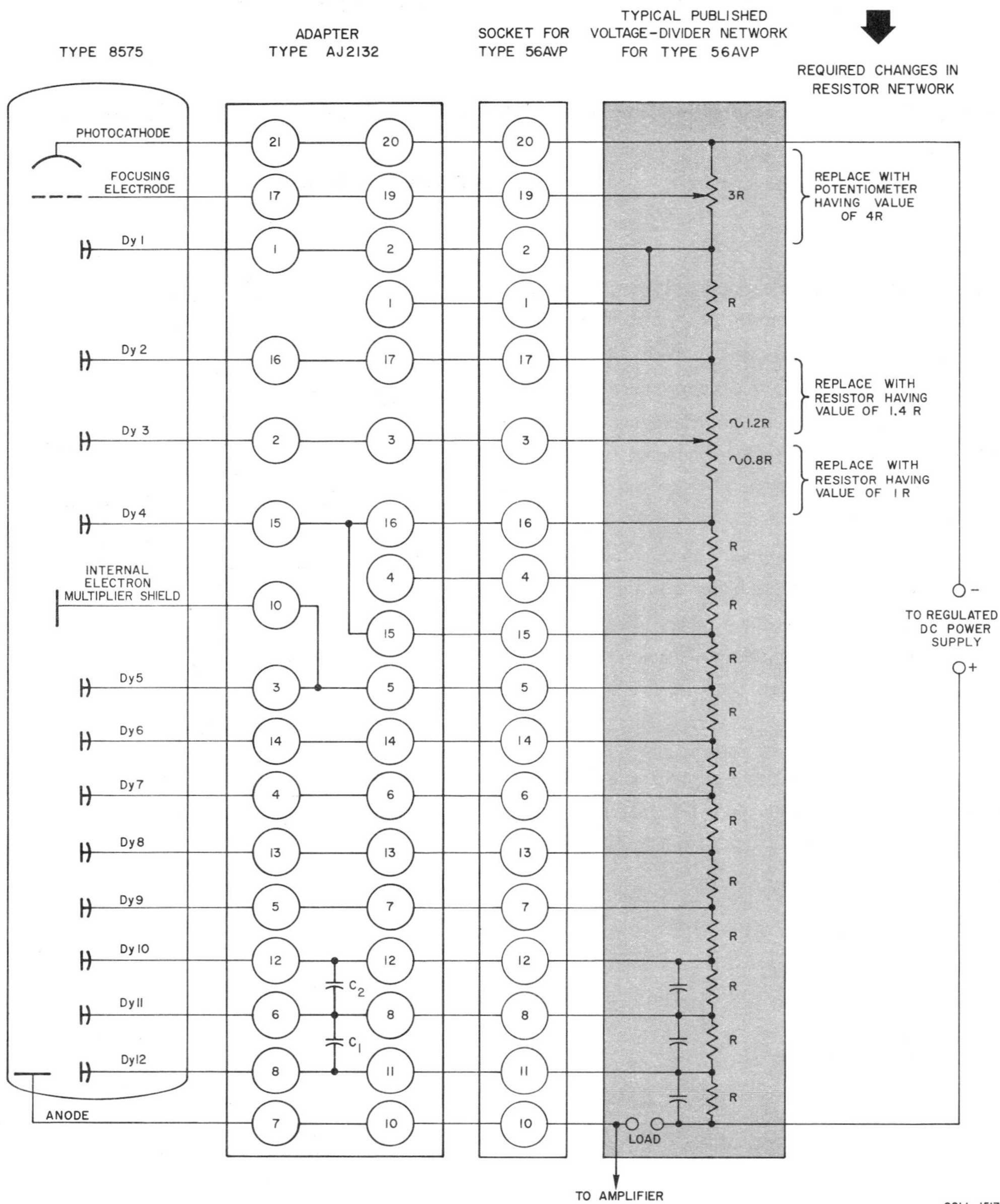
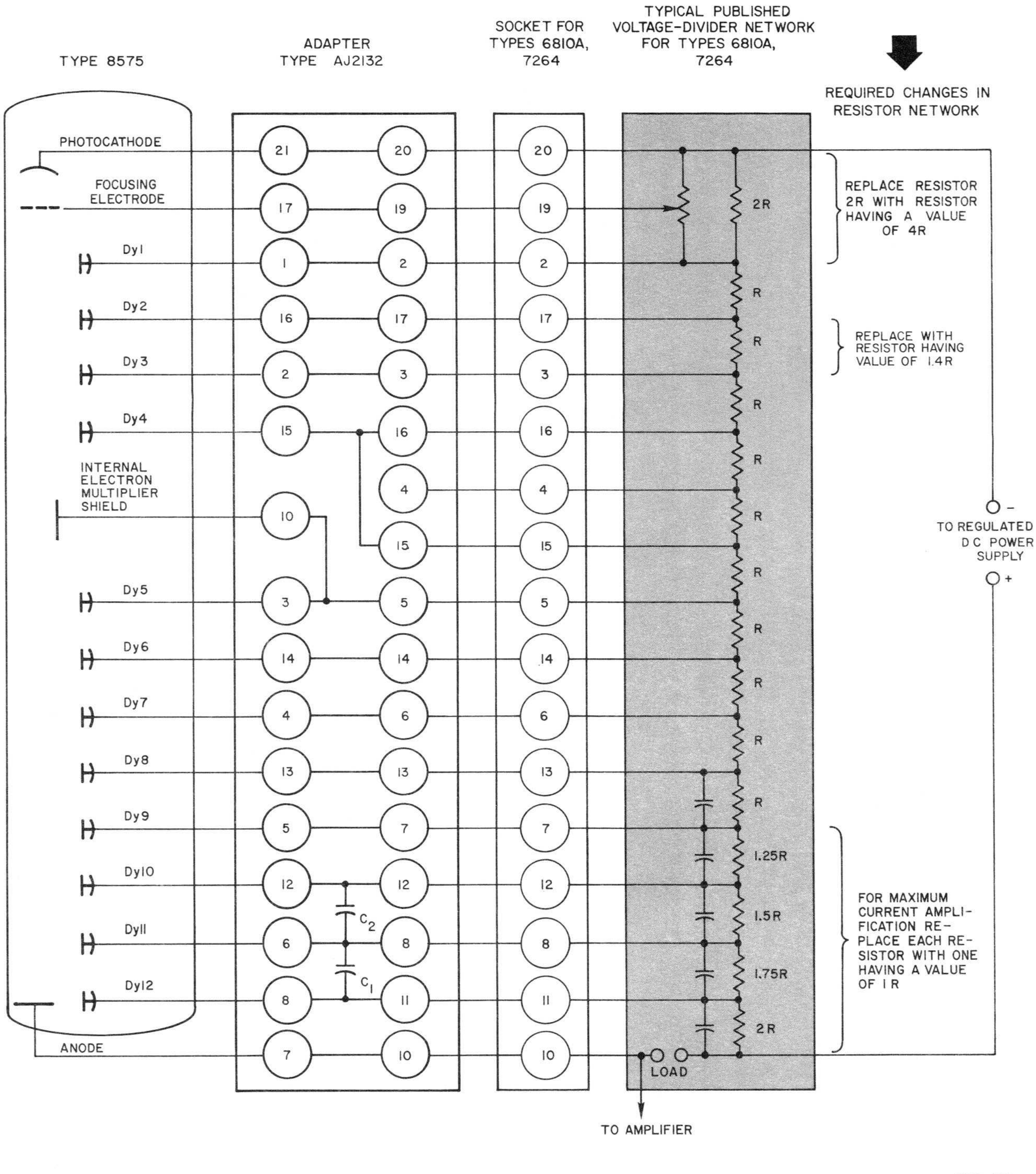
Schematic Diagram Showing Required Resistor Changes When Replacing Type 56AVP



C_1, C_2: 500 pF ± 20%, ceramic capacitors, 1 kV (dc working volts)

Fig. 1

Schematic Diagram Showing Required Resistor Changes When Replacing Types 6810A or 7264

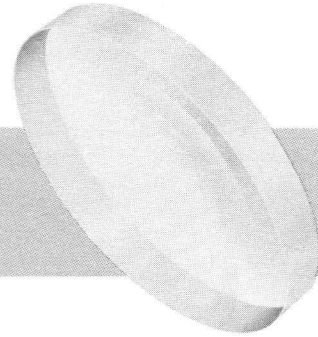


C_1, C_2: 500 pF ± 20%, ceramic capacitors, 1 kV (dc working volts)

Fig. 2

RCA-AJ2142

Faceplate Adapter

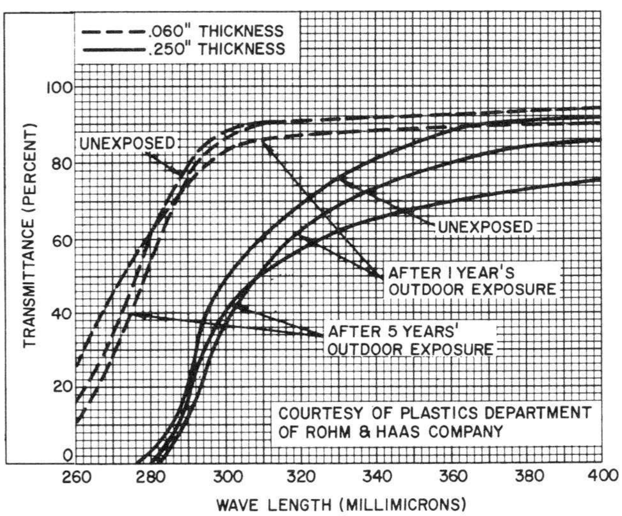


H-1557

For Use With RCA-4522 Photomultiplier Tube

RCA-AJ2142, an acrylic plastic faceplate adapter (or light pipe) made from Plexiglass● II UVT, or equivalent, provides efficient optical coupling between the curved faceplate of the RCA-4522 photomultiplier tube and flat surfaces.

Typical Transmission Characteristics Ultra-Violet Transmitting Plexiglass II■



92LS-2450

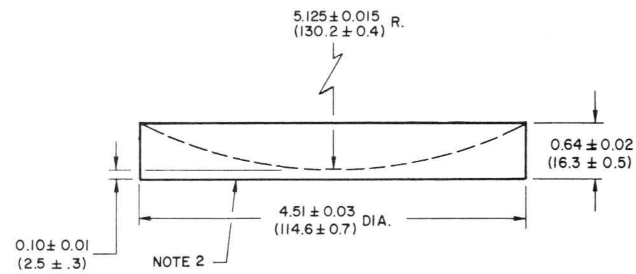
Fig. 1

● Registered trademark of Rohm and Haas Co.

■ Manufactured by Rohm and Haas Co., Plastics Dept., Washington Square, Philadelphia 5, Pa.

* Manufactured by Dow Corning Corp., Midland, Michigan.

Dimensional Outline



92LS-2451R1

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

Note 2: Flatness: within 0.010 inch (0.3 mm) from peak to valley.

Mounting

For best efficiency, it is recommended that an optical coupling compound, such as Dow-Corning* 20-057, or equivalent, be used between the 4522 and the curved face of the AJ2142 and between any large-area flat surface adjoining the flat face of the AJ2142; for example, large-diameter flat-surface scintillators. The thickness of these compound layers should be as thin as possible, and care should be taken so that voids, foreign particles, and air bubbles are not present.

Caution

Avoid dropping or scratching the adapter. Also avoid any air bubbles or foreign particles in the fluid.

RCA Electronic Components

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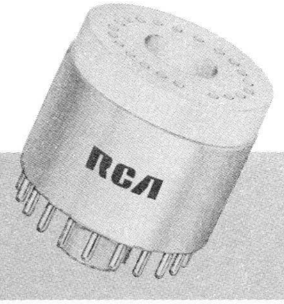


H-1572R1

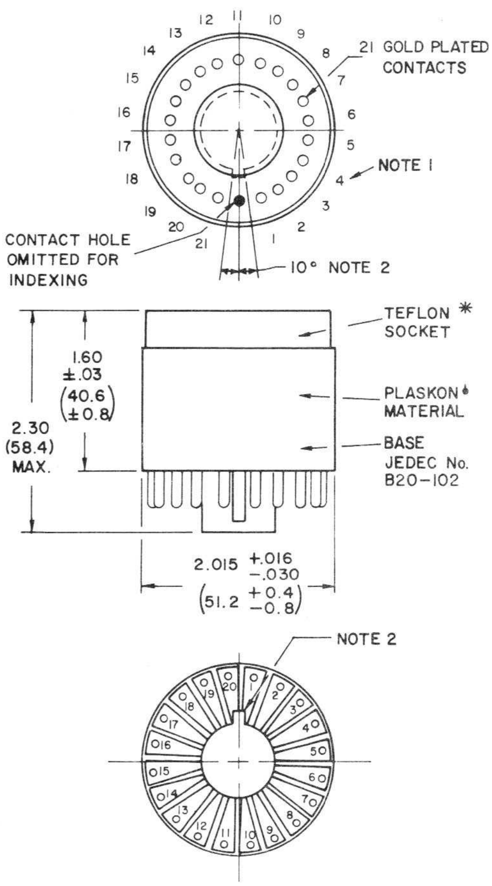
RCA-AJ2143

Socket Adapter

For Use With RCA-4522 Photomultiplier Tube To Replace Tube Type 58AVP

RCA-AJ2143 is a socket adapter which permits the replacement of the photomultiplier tube type 58AVP by the RCA photomultiplier tube type 4522. Dimensions and associated information for this adapter are shown below. The changes required in the existing voltage divider network are indicated in *Fig.1*.

Dimensional Outline



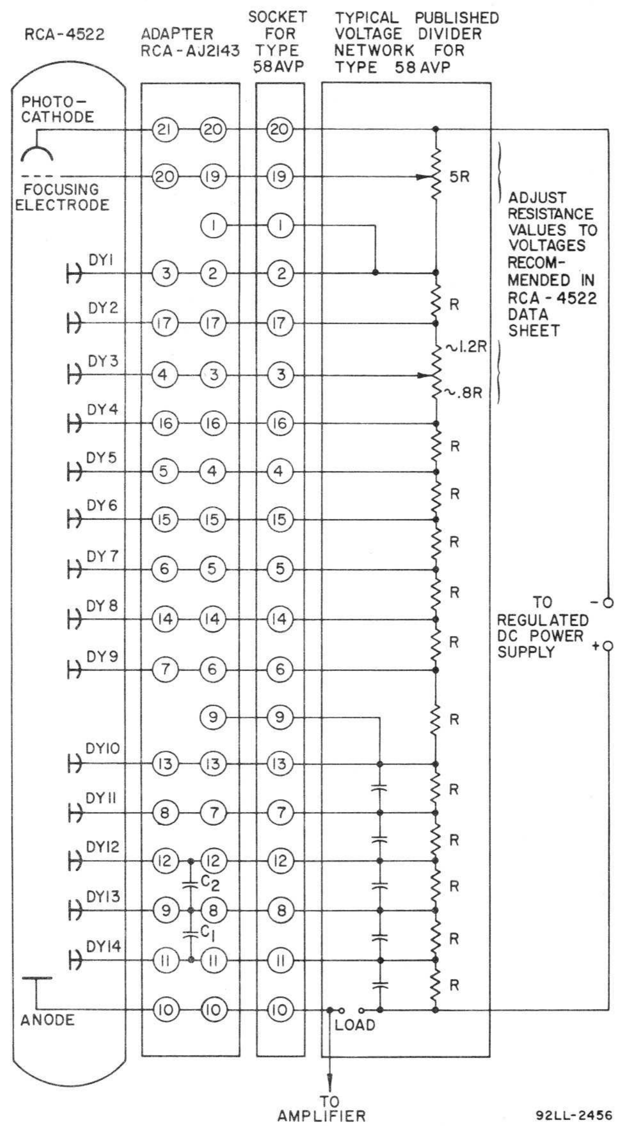
92LS—1515R2

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

Note 1: The contact numbers shown on this top view do not appear on the socket body. They are shown here for the convenience of the user.

Note 2: Alignment between JEDEC B20-102 base key and index of teflon socket will not exceed ±10°.

Schematic Diagram of Connection Changes When Replacing Type 58AVP



92LL-2456

C_1, C_2: 500 pF ± 20%, ceramic capacitors, 1 kV (dc working volts)

Fig. 1

*TEFLON is a registered trademark of DuPont de Nemours, E.I. & Co., Wilmington, Del.

♦PLASKON is a registered trademark of the Allied Chemical Corporation, New York, New York.

RCA Electronic Components

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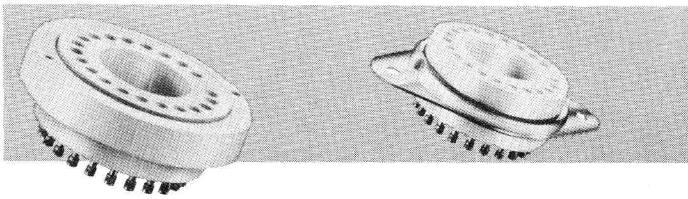
RCA | Electronic Components | Harrison, N.J. 07029

Tube Sockets



L-417 L-418

For Use With RCA Photomultiplier Tubes Such as 4522 and 8575.

RCA-AJ2144 and AJ2145* are high-quality 21-contact Teflon■ sockets intended for use with the 21-pin base of RCA photomultiplier tubes such as the 4522 and the 8575.

The AJ2145 is designed specifically for chassis mounting and is supplied with a permanently attached metal flange.

The AJ2144 is designed for use in any desired mounting arrangement. It is supplied with an unattached Teflon clamp 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. An advantage of the AJ2144 in chassis-mounting systems is that use of the clamp ring allows initial freedom in the rotation of the socket body to any desired angular position on the chassis before the socket is clamped.

The center hole of the socket body of the AJ2144 can also be tapped for NF 1"-14 thread or 3/4"-14 pipe thread for mounting on a threaded insulating tube for probe-type mounting systems.

The contacts of both sockets are supplied uninserted. Circuit-element to socket-contact connection by soldering, welding, or crimping♦ can therefore be made prior to contact insertion in the socket body. The contacts should be inserted into the bottom of the socket body, as shown in *Fig.1*. **Once the contacts are inserted, it is not recommended that they be removed because of possibility of permanent damage to the socket body.**

*This socket replaces RCA-DP2118.

■Registered trademark of DuPont de Nemours, Inc., Wilmington, Del.

♦A suitable crimping tool is available from AMP, Inc., Harrisburg, Pa., as Part No.45099.

Contact Insertion Method For Both Sockets

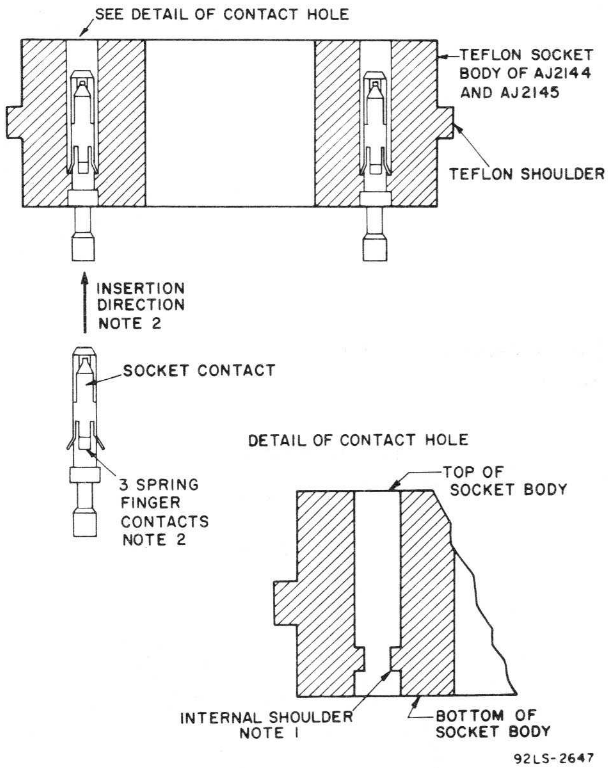


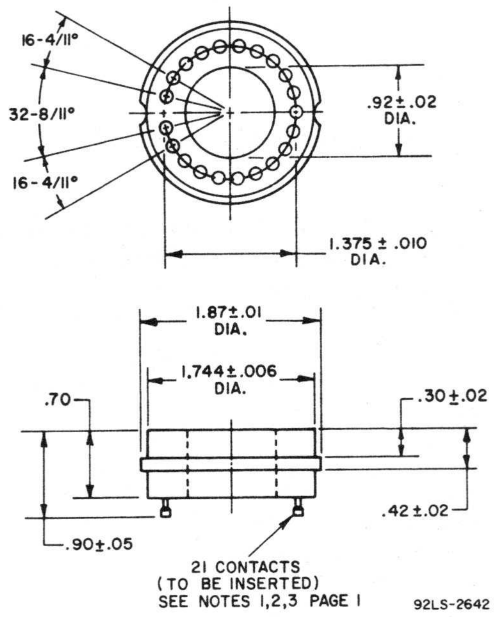
Fig. 1

Note 1: The contacts should be inserted into the bottom of the socket body. The bottom can be identified by locating the internal shoulder visually, by using the contact as a probe, or by using the shank end of a 1/8" drill as a probe.

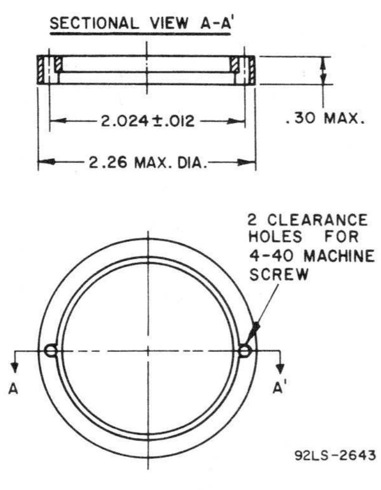
Note 2: The contact should be inserted to the indicated depth. Each socket contact has 3 spring fingers which hold the contact in position after insertion. A slight pull in a direction opposite that of insertion will assure the spring fingers have opened and have anchored the contact in position.

Note 3: It is recommended that all 21 contacts be inserted.

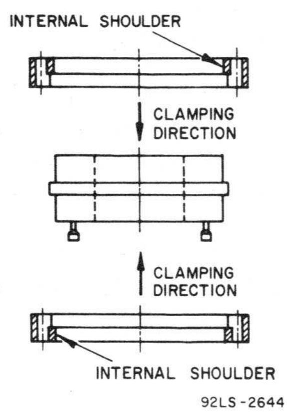
Dimensional Outline
AJ2144
Teflon Socket Body



Teflon Mounting Clamp
(Note)



Note: The clamp ring fits to either the top or bottom of the socket body. The drawing below shows the proper fitting of the internal shoulder of the clamp ring to the external shoulder of the socket body.

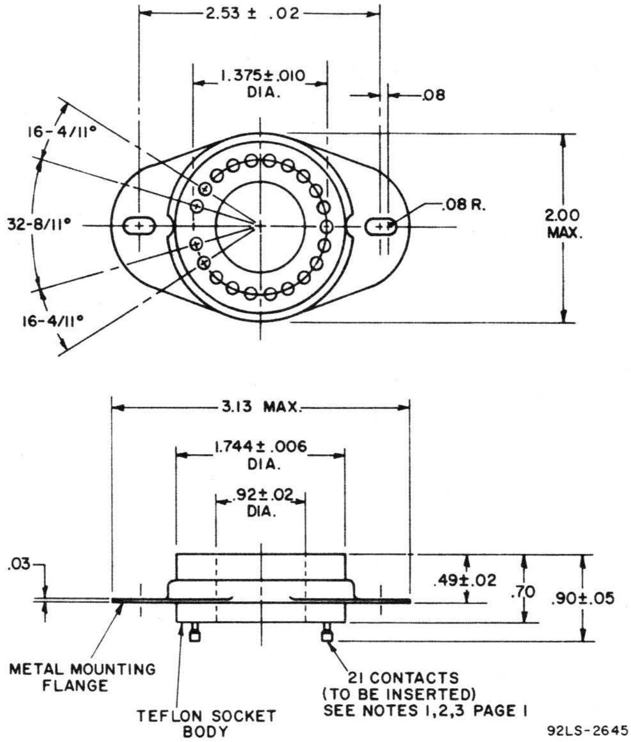


Dimensions are in inches unless otherwise stated. Dimensions tabulated below are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

Inch Dimension Equivalents in Millimeters

Inch	mm	Inch	mm	Inch	mm	Inch	mm
.006	.15	.05	1.27	.90	22.86	1.87	47.5
.010	.25	.30	7.62	.92	23.37	2.024	51.41
.012	.30	.42	10.66	1.375	34.92	2.26	57.4
.02	.51	.70	17.78	1.744	44.30		

Dimensional Outline
AJ2145



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

Inch Dimension Equivalents in Millimeters

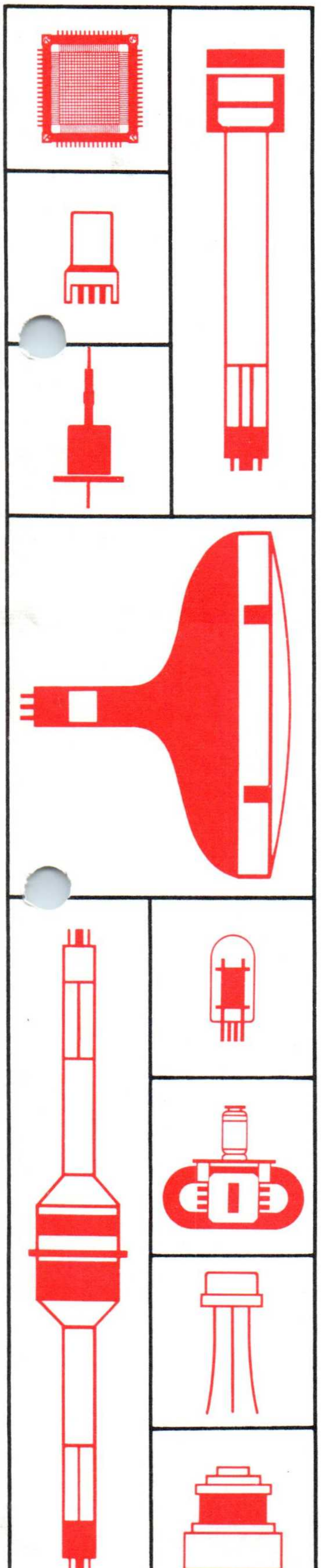
Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
.006	.15	.03	.76	.49	12.45	.92	23.37	2.00	50.8
.010	.25	.05	1.27	.70	17.78	1.375	34.92	2.53	64.26
.02	.51	.08	2.03	.90	22.86	1.744	44.30	3.13	79.50

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



NEW RCA 1"-DIA., ½"-DIA., AND ¼"-DIA. CADMIUM-SULFIDE PHOTOCONDUCTIVE CELLS

SQ2523 SQ2525 SQ2527 SQ2529
SQ2524 SQ2526 SQ2528

SQ2531 THROUGH SQ2531V6
SQ2532 THROUGH SQ2532V4
SQ2533 THROUGH SQ2533V7

➔ It's *YOUR* choice —

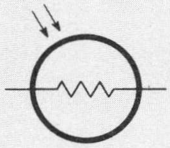
- Choose Either a Transistor-Glass Package, an All-Glass Envelope, or a Plastic-Filled Metal Case
- Choose Your Resistance Level @ 2 Footcandles Illumination
- Choose Your Photocell Package Diameter
- Choose An RCA PHOTOCELL from this New Line of Solid-State Photosensitive Devices

Approx. Resistance (ohms) @ 2 fc	TO-5 1/4"-Dia. Glass-Metal Case	TO-5 1/4"-Dia. Plastic-Filled Case	TO-8 1/2"-Dia. Glass-Metal Case	TO-8 1/2"-Dia. Plastic-Filled Case	1"-Dia. Glass-Metal Plastic-Filled Case	1/4"-Dia. All-Glass Envelope	1/2"-Dia. All-Glass Envelope
800,000	SQ2529	SQ2531	-	-	-	SQ2528	-
150,000	-	SQ2531V1	SQ2525	-	SQ2533	-	-
60,000	-	SQ2531V2	-	-	-	-	-
30,000	-	-	-	-	SQ2533V1	-	-
20,000	-	SQ2531V3	-	-	-	-	-
18,000	-	-	-	-	SQ2533V2	-	-
15,000	-	-	-	SQ2532	-	-	-
10,000	-	SQ2531V4	-	-	SQ2533V3	-	-
8,000	-	-	-	SQ2532V1	SQ2533V4	-	-
5,500	-	-	-	-	SQ2533V5	-	-
4,000	-	-	-	-	SQ2533V6	-	-
3,900	-	SQ2531V5	SQ2526	SQ2532V2	-	-	SQ2523
2,000	-	SQ2531V6	SQ2527	SQ2532V3	SQ2533V7	-	SQ2524
700	-	-	-	SQ2532V4	-	-	-

November 13, 1964

RCA PHOTOCONDUCTIVE CELLS

CADMIUM-SULFIDE, HEAD-ON TYPES S-15 SPECTRAL RESPONSE



Solid-State Photosensitive Devices

Photoconductive cells are also known as light dependent resistors or photoresistors

RCA cadmium-sulfide photoconductive cells are designed for use in a variety of light-operated control applications. Cells are available in three basic package designs.

Glass-Metal and **All-Glass Types** are hermetically sealed and may be subjected continuously to environmental conditions of high humidity and high temperature without adversely affecting cell performance.

Plastic-Filled Types, on the other hand, are low-cost types designed for operation where conditions of high humidity and temperature are not prolonged.

Spectral response for these cells covers the approximate range from 3300 to 7400 angstroms as shown in Fig.1. Maximum response occurs at about 5800 angstroms. Highest sensitivity is therefore obtained from yellow-red light. The photosensitive cadmium-sulfide is located between metallic electrodes.

S-15 SPECTRAL RESPONSE

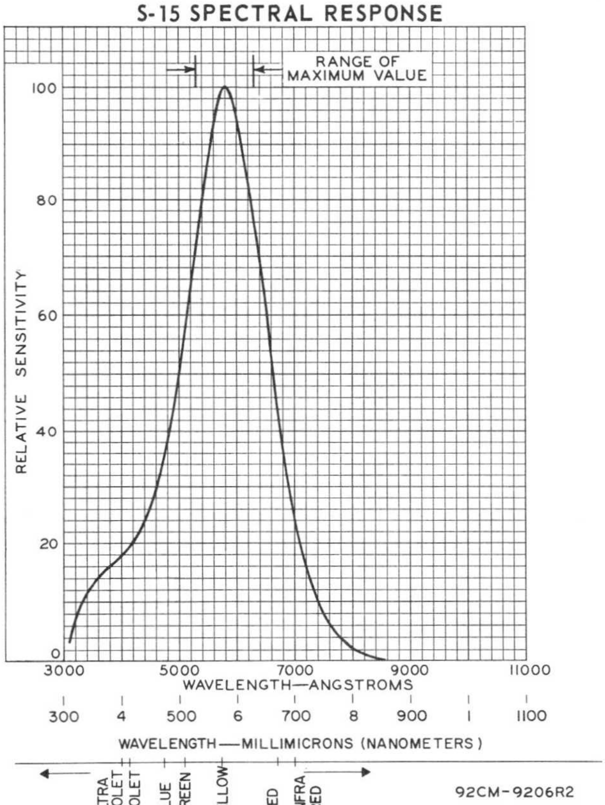


Fig.1

Rise time for cell photocurrent to reach a steady value after excitation is applied is a function of illumination as shown in Fig.2.

TYPICAL RISE CHARACTERISTICS

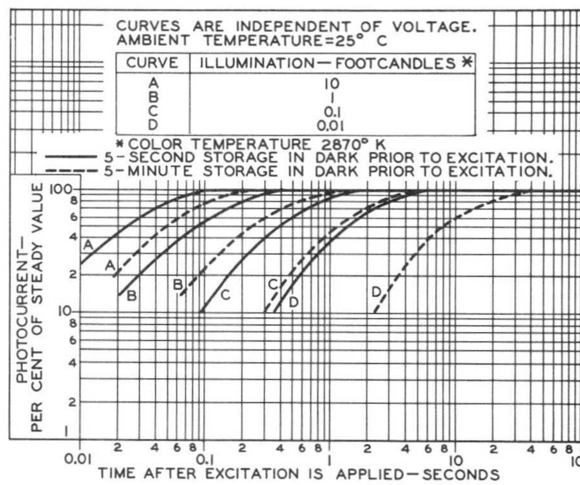


Fig.2

Photocurrent decay after removal of excitation is a function of time and illumination as shown in Fig.3.

TYPICAL DECAY CHARACTERISTICS OF CADMIUM-SULFIDE CELL

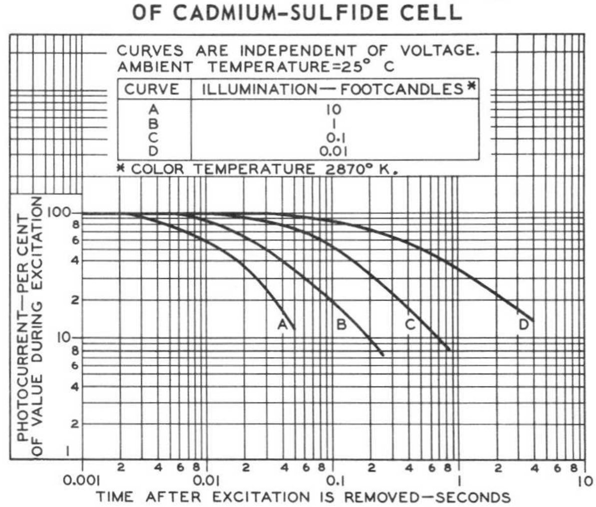
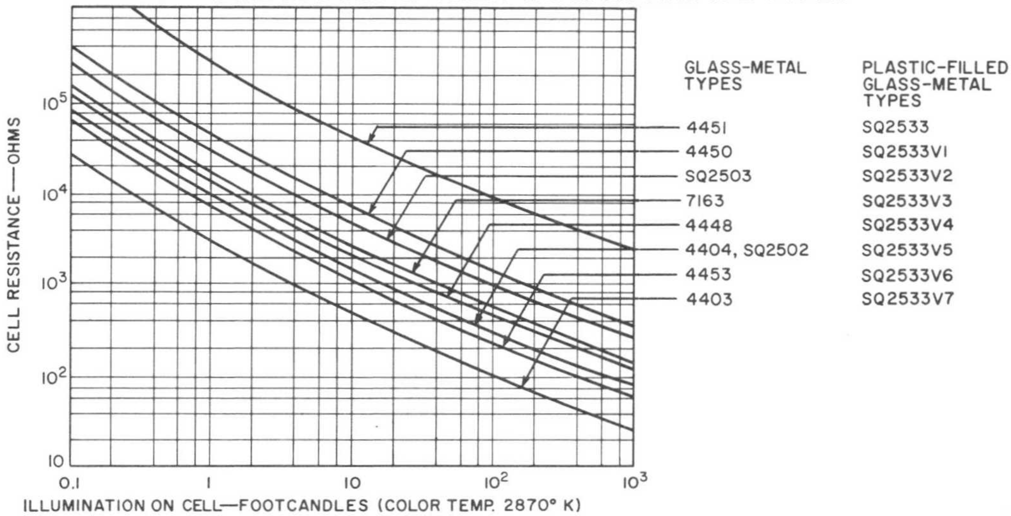


Fig.3

RADIO CORPORATION OF AMERICA
Electronic Components and Devices Harrison, N. J.

CSS-801 11-64
Printed in U.S.A.

1"-DIAMETER BROAD-AREA CADMIUM-SULFIDE TYPES



92CS-11973

RCA TYPES			MAXIMUM RATINGS				CHARACTERISTICS AT 25°C				
Glass-Metal Types[a]	Plastic-Filled Glass-Metal Types[b]	Spectral Response	Voltage Between Terminals DC or Peak AC volts	Power Dissipation[c] watt: Continuous Service	Power Dissipation[c] watt: Demand Service[d]	Photo-current ma	Voltage Between Terminals ac volts	Illumination[e] foot-candles	Photocurrent[f] ma: Min.	Photocurrent[f] ma: Max.	Max. Decay Current[g] μa
4451	SQ2533	S-15	600	0.75	1.0	50	50	35	2	3.5	40
4450	SQ2533V1	S-15	600	0.75	1.0	50	50	35	2	3.5	40
SQ2503	SQ2533V2	S-15	600	0.75	1.0	50	50	1	0.8	1.7	40
7163	SQ2533V3	S-15	600	0.75	1.0	50	50	1	1	3	40
4448	SQ2533V4	S-15	600	0.75	1.0	50	50	1	1.5	4	40
4404 SQ2502[h]	SQ2533V5	S-15	600	0.75	1.0	50	50	1	2.5	5	40
4453	SQ2533V6	S-15	600	0.75	1.0	50	50	1	3	7	40
4403	SQ2533V7	S-15	250	0.75	1.0	50	50	1	8	16	78

[a] The maximum ambient operating temperature range for these cells is -75° C to +75° C.

[b] The maximum ambient operating temperature range for these cells is -40° C to +75° C.

[c] With sensitive surface of cell fully illuminated. These dissipation ratings apply up to a temperature of +40° C from which point the cells are derated linearly to 0 watts at +75° C.

[d] The demand rating is a dissipation rating to which the cell may be exposed in outdoor applications. The rating may be utilized twice every 24 hours for a period of 20 minutes each time provided the interval between demand periods is not less than 4 hours.

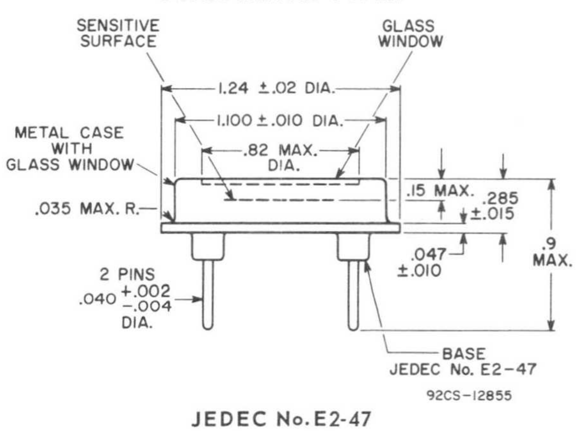
[e] For conditions where light flux from a tungsten-filament lamp operated at 2870° K is transmitted through a filter (Corning C.S. No.1-62 which has an effective transmission of luminous flux of 13.3%) onto the sensitive surface. The value of illumination incident on the sensitive surface is 7.5 footcandles measured before positioning the filter between the lamp and the cell. The sensitive surface of the cell is fully illuminated.

[f] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

[g] Measured 10 seconds after removal of incident-illumination level.

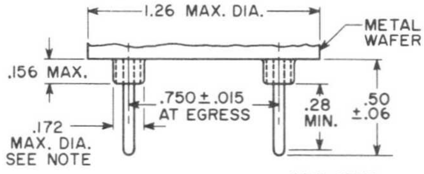
[h] Type SQ2502 is not recommended for new equipment design. It is identical with type 4404 except it is supplied with attached Intermediate-Shell Octal 5-pin base (JEDEC No.B5-10).

GLASS-METAL TYPES



92CS-12855

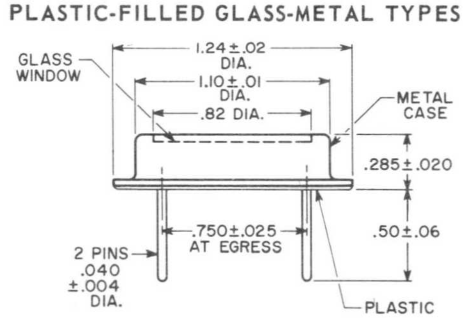
JEDEC No. E2-47



92CS-12856

Note: For socket design, provide clearance hole having minimum diameter of 0.188".

PLASTIC-FILLED GLASS-METAL TYPES

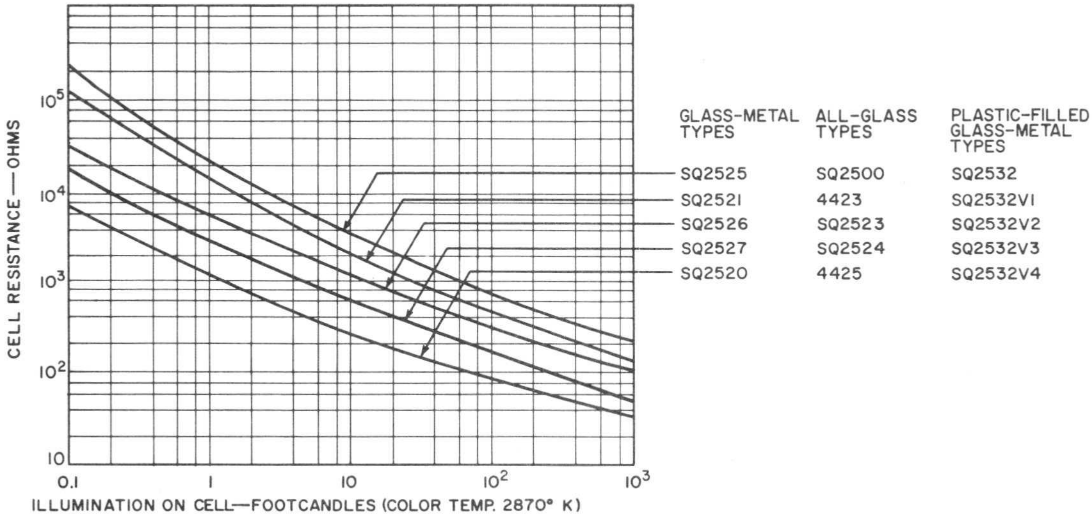


92CS-12857

Dimensions in Inches

RCA PHOTOCONDUCTIVE CELLS

1/2"-DIAMETER BROAD-AREA CADMIUM-SULFIDE TYPES



92CS-11974

RCA TYPES			Spectral Response	MAXIMUM RATINGS			CHARACTERISTICS AT 25°C				
Glass-Metal Types[a]	All-Glass Types[a]	Plastic-Filled Glass-Metal Types[b]		Voltage Between Terminals DC or Peak AC volts	Power Dissipation[c] watt	Photocurrent ma	Voltage Between Terminals volts	Illumination[d] foot-candles	Photocurrent[e] ma Min.	Photocurrent[e] ma Max.	Max. Decay Current[f] μa
SQ2525	SQ2500	SQ2532	S-15	250	0.2	20	12 (dc)	1	0.24	0.8	6
SQ2521	4423	SQ2532V1	S-15	250	0.2	20	50 (ac)	1[g]	1.5[h]	4[h]	40
SQ2526	SQ2523	SQ2532V2	S-15	110	0.2	50	12 (dc)	1	1	3	80
SQ2527	SQ2524	SQ2532V3	S-15	110	0.2	50	12 (dc)	1	2	6	80
SQ2520	4425	SQ2532V4	S-15	110	0.2	50	12 (dc)	1	3.6	14.5	80

[a] The maximum ambient operating temperature range for these cells is -75° C to +60° C.

[b] The maximum ambient operating temperature range for these cells is -40° C to +60° C.

[c] In continuous service with sensitive surface of cell fully illuminated. The power dissipation rating applies up to the maximum rated ambient operating temperature.

[d] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

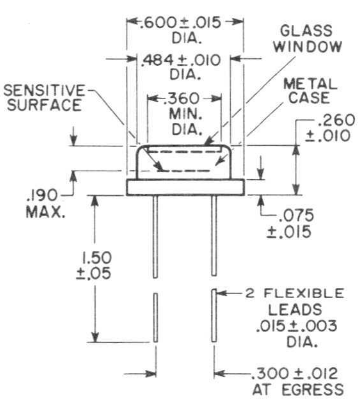
[e] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 50 to 100 foot-candle illumination (white fluorescent light).

[f] Measured 10 seconds after removal of incident-illumination level.

[g] For conditions where light flux from a tungsten-filament lamp operated at 2870° K is transmitted through a filter (Corning C.S. No.1-62 which has an effective transmission of luminous flux of 13.3%) onto the sensitive surface. The value of illumination incident on the sensitive surface is 7.5 footcandles measured before positioning the filter between the lamp and the cell. The sensitive surface of the cell is fully illuminated.

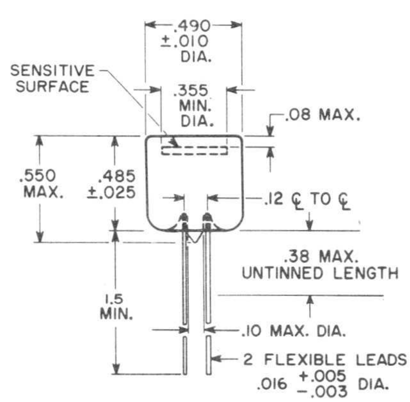
[h] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

GLASS-METAL TYPES
MODIFIED TO-8 CASE



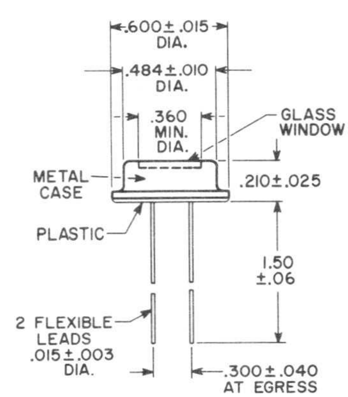
92CS-12862

ALL-GLASS TYPES



92CS-12864

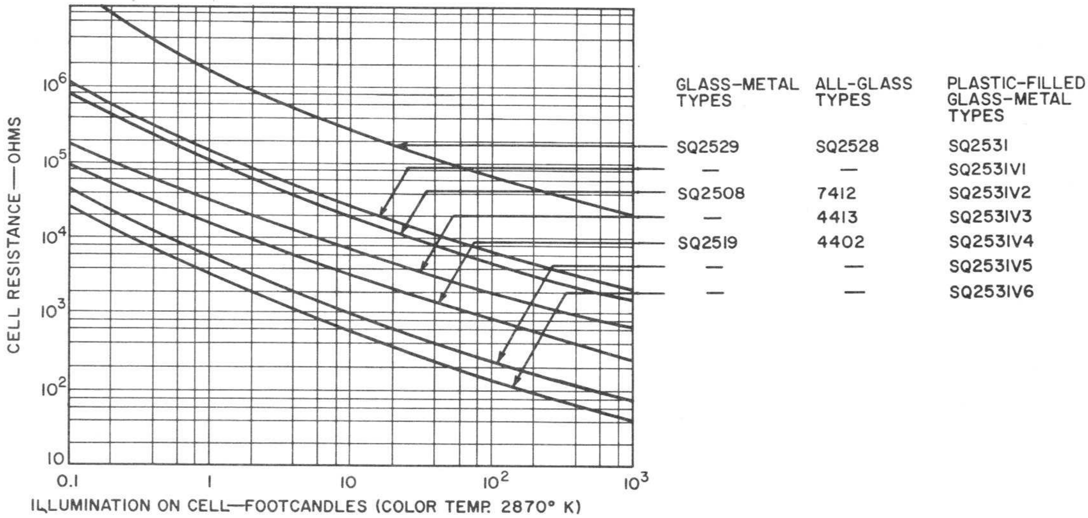
PLASTIC-FILLED
GLASS-METAL TYPES



92CS-12863

Dimensions in Inches

1/4"-DIAMETER BROAD-AREA CADMIUM-SULFIDE TYPES



RCA TYPES				MAXIMUM RATINGS			CHARACTERISTICS AT 25°C				
Glass-Metal-Types[a]	All-Glass Types[a]	Plastic-Filled Glass-Metal Types[b]	Spectral Response	Voltage Between Terminals DC or Peak AC volts	Power Dissipation[c] watt	Photocurrent ma	Voltage Between Terminals dc volts	Illumination[d] foot-candles	Photocurrent[e] ma Min.	Photocurrent[e] ma Max.	Max. Decay Current[f] µa
SQ2529	SQ2528	SQ2531	S-15	300	0.05	5	12	1	0.004	0.012	0.1
-	-	SQ2531V1	S-15	200	0.05	5	12	1	0.04	0.12	1
SQ2508	7412	SQ2531V2	S-15	200	0.05	5	12	1	0.065	0.275	1
-	4413	SQ2531V3	S-15	110	0.05	5	12	10	1.4	2.75	12
SQ2519	4402	SQ2531V4	S-15	300	0.05	5	12	10	1.6[g]	-	12
-	-	SQ2531V5	S-15	110	0.05	7	12	1	1	3	15
-	-	SQ2531V6	S-15	110	0.05	7	12	1	1.6	4.8	15

[a] The maximum ambient operating temperature range for these cells is -75° C to +60° C.

[b] The maximum ambient operating temperature range for these cells is -40° C to +60° C.

[c] In continuous service with sensitive surface of cell fully illuminated. The dissipation rating applies up to the maximum ambient operating temperature.

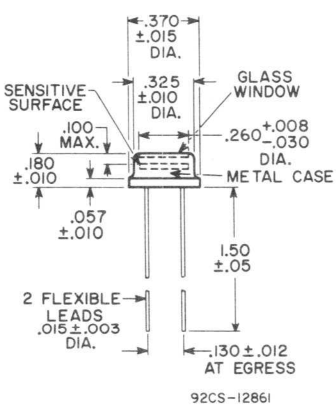
[d] For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

[e] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 500 footcandle illumination (white fluorescent light).

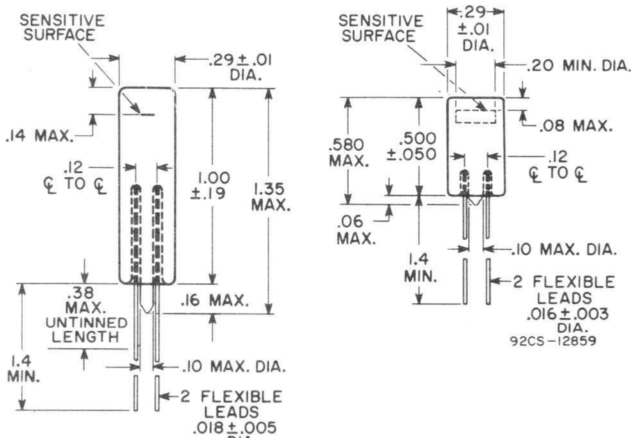
[f] Measured 10 seconds after removal of incident-illumination level.

[g] This characteristic is determined after the cell has been exposed for a period of 16 to 24 hours to 50 to 100 footcandle illumination (white fluorescent light).

GLASS-METAL TYPES MODIFIED TO-5 CASE

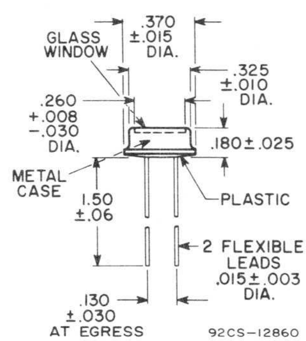


ALL-GLASS TYPES



7412 only

PLASTIC-FILLED GLASS-METAL TYPES



Dimensions in Inches

Cell response to pulsed light is shown in Fig.4.

RESPONSE CHARACTERISTICS OF CADMIUM SULFIDE CELL TO PULSED LIGHT

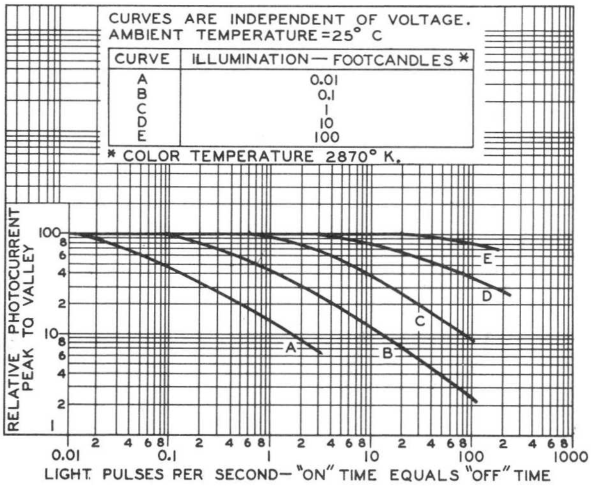


Fig.4

The effect of ambient temperature on cell sensitivity is shown in Fig.5.

The angle of view of the cell may be narrowed by use of a hood of the desired length placed in front of the sensitive surface.

If the source of radiation is some distance from the cell, the use of a light-collecting lens system may be desirable to utilize more effectively the available radiation. However, when such a system is used the radiation should not be focused onto such a small area that localized overheating of the sensitive surface may result with consequent adverse effects on its characteristics. Exposure of these cells to radiation (even without voltage applied) so intense as to cause excessive heating of the cells may permanently damage them.

For a given illumination, the output current will have its highest value when the incident illumination is normal (angle of incidence is 0^{o}) to the face of the cell. For greater angles of incidence, the output current decreases. The decrease depends upon several factors including the angle of incidence of the illumination, the amount of illumination, and the area of sensitive surface illuminated.

TYPICAL CHARACTERISTICS

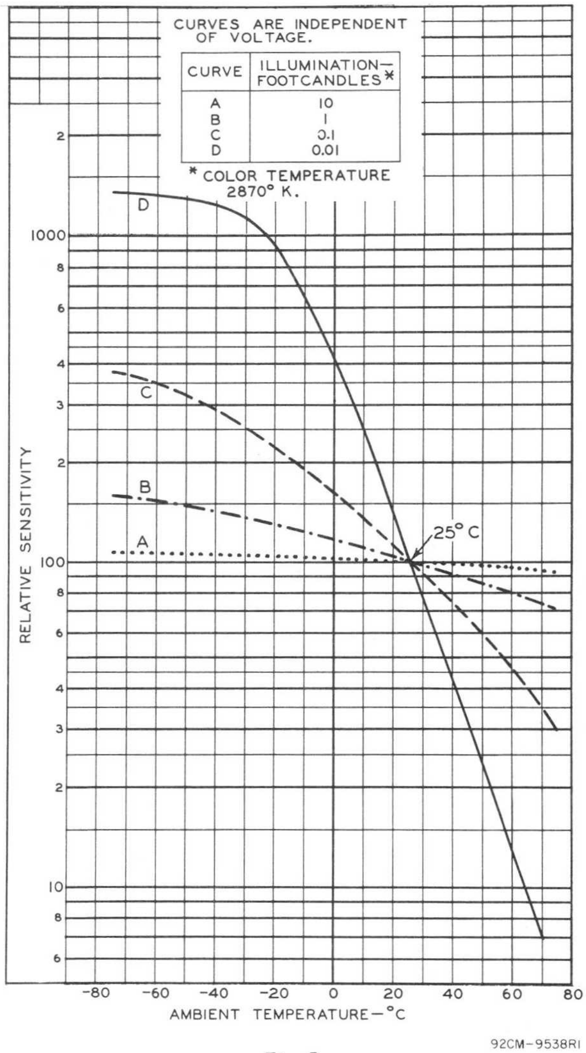


Fig.5

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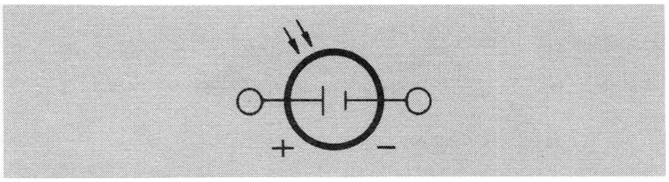
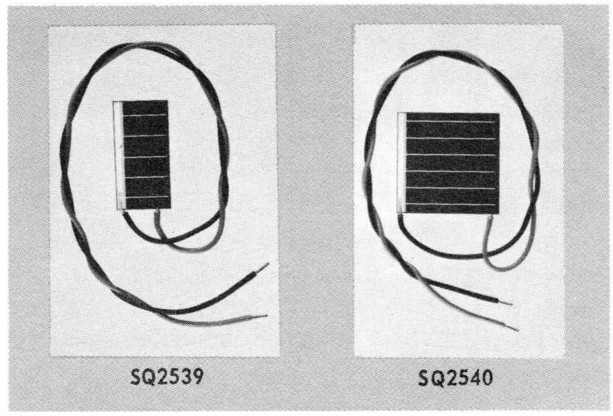
RCA PHOTOCONDUCTIVE CELLS

CADMIUM-SULFIDE, HEAD-ON TYPES
S-15 SPECTRAL RESPONSE

RCA PHOTOVOLTAIC CELLS

SILICON
N-on-P
Diffused-Junction
Types
SQ2539, SQ2539V1
SQ2540, SQ2540V1





RCA-SQ2539, SQ2539V1, SQ2540, and SQ2540V1 are small, flat, silicon N-on-P type photovoltaic cells. The SQ2539 and SQ2540 are electrically identical with types SQ2539V1 and SQ2540V1, respectively, except they are supplied with attached semiflexible leads.

The SQ2539 and SQ2539V1 are 1 cm x 2 cm in size while the SQ2540 and SQ2540V1 are 2 cm x 2 cm in size.

These cells are intended for light-measurement, light-detection, and light-operated control applications. Because they are photovoltaic, they require no external power supply.

The spectral response for these cells, at the 10-percent points, covers the approximate range from 3750 angstroms to 10,800 angstroms. Maximum response occurs at about 8600 ± 750 angstroms. Both relative spectral response and quantum yield are shown in Fig.1.

TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

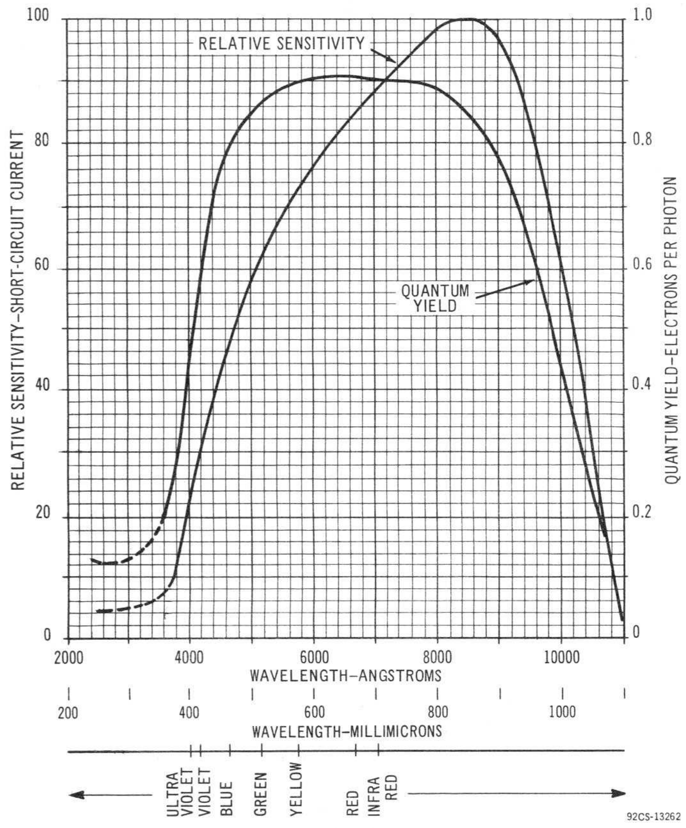


Fig.1

GENERAL

A silicon photovoltaic cell is a photosensitive solid-state device which generates a voltage when its sensitive surface is irradiated. RCA photovoltaic cells are of the silicon N-on-P diffused-junction type. The silicon base material is made P-type by the addition of an impurity such as boron. The photosensitive surface is made N-type by the diffusion of a thin layer of a material such as phosphorus. A potential barrier exists at the point within the cell where the N-type material changes to P-type, i.e., at the junction between the N and P materials. When the cell is irradiated, electron-hole pairs are produced within the cell. Holes are defined as the absence of electrons and behave as mobile positive charges. The electrons and holes are separated by the potential barrier because of the repelling effect of the electrical charges within the cell which in turn produce a voltage across the terminals of the cell. If a load is connected across the cell terminals, the generated voltage causes electrons to flow in the external circuit. The flow is such that the electrons emerge from the N-contact and flow through the load to the P-contact.

The electrode configuration on the active photosensitive surface of the cell is designed to reduce series electrical resistance while permitting almost all incident energy to enter the junction region. The output signal from the cell is also increased by coating its surface with a non-reflecting layer of silicon monoxide.

The silicon cell is highly efficient in converting radiant power into electrical power. Quantum yield of a typical silicon photovoltaic cell is shown in Fig.1.

OPERATING CONSIDERATIONS

Contact to the terminals of the SQ2539V1 and SQ2540V1 may be made by pressure contacts or flexible springs. The front surfaces and the edges of the cells should never be handled with bare hands. Such handling can damage the junction of the cell. However, if a cell has been so handled, or dust accumulates on its surface, it may be cleaned by using a swab or tissue dipped in common solvents such as acetone, methanol, or hot water, and then subjected to a stream of dry air.

For a given light flux, electrical power output will have its highest value when the incident flux is normal (angle of incidence is 0°) to the face of the cell. For greater angles of incidence, electrical power output decreases.

Typical photocurrent-voltage relationships for the SQ2539, SQ2539V1, and for the SQ2540 and SQ2540V1 are shown in Figs.2 and 3, respectively.

Typical curves showing photocurrent and voltage as functions of ambient temperature are shown in Fig.4.

A *typical decay characteristic* for silicon photovoltaic cells is shown in Fig.5. The light pulse employed is from a spark gap in air. The value of the load resistor is chosen so that the RC time constant of the cell junction capacitance and the load resistance is negligible compared with the time constant of the cell. Typical cell capacitance for these devices is approximately 0.03 μF/cm^2.

DATA

General:

Spectral Response	See Fig.1
Wavelength of Maximum Response	8600 ± 750 angstroms
Ambient Operating Temperature Range	-100° to $+125^{\circ}$ C
Terminals	See *Dimensional Outlines*
Operating Position	Any
Weight:	
SQ2539V1	0.25 gram
SQ2539	0.60 gram
SQ2540V1	0.5 gram
SQ2540	0.85 gram

Characteristics:

At an ambient temperature of 27° C

	SQ2539, SQ2539V1			SQ2540, SQ2540V1			
	Min.	*Typ.*	*Max.*	*Min.*	*Typ.*	*Max.*	
Sensitivity:[a]							
Radiant, at 8600 Angstroms	-	0.58	-	-	0.58	-	A/W
Luminous[b]	-	7.13	-	-	7.13	-	mA/lm
Short-Circuit Current[a]	-	14.5	-	-	29	-	μA/fc
Output Voltage[b]	0.175[c]	0.250[c]	-	0.200[d]	0.275[d]	-	V

[a] Short circuit current.

[b] For conditions where the light flux is from a tungsten-filament lamp operated at a color temperature of 2870° K. The sensitive surface of the cell is fully illuminated. The illumination on the cell is 100 footcandles.

[c] The load resistance is 220 ohms.

[d] The load resistance is 100 ohms.

TYPICAL PHOTOCURRENT-VOLTAGE RELATIONSHIP FOR TYPES SQ2539 AND SQ2539V1

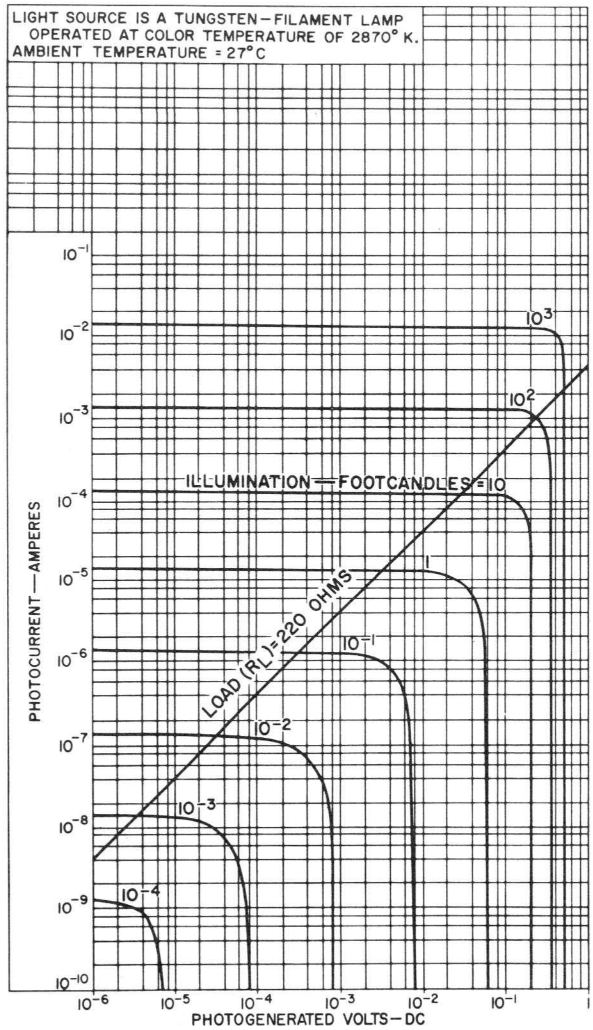


Fig.2

TYPICAL PHOTOCURRENT-VOLTAGE RELATIONSHIP FOR TYPES SQ2540 AND SQ2540V1

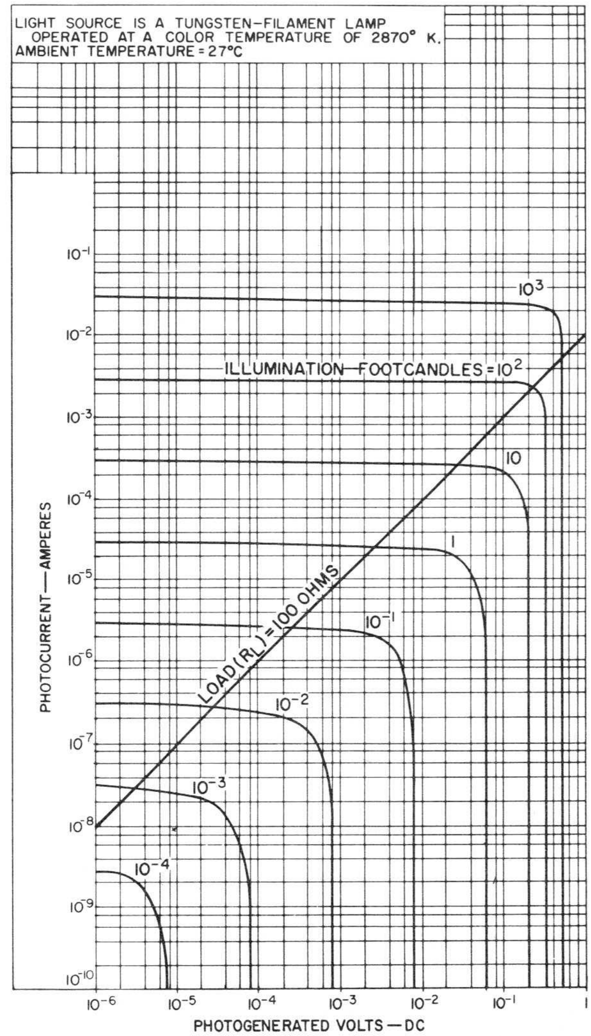


Fig.3

TYPICAL PHOTOCURRENT-VOLTAGE RELATIONSHIPS AS A FUNCTION OF AMBIENT TEMPERATURE

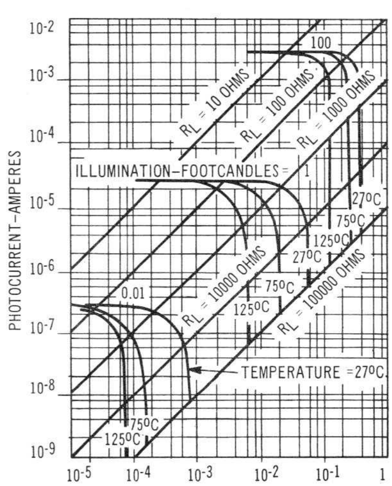


Fig.4

TYPICAL DECAY CHARACTERISTIC

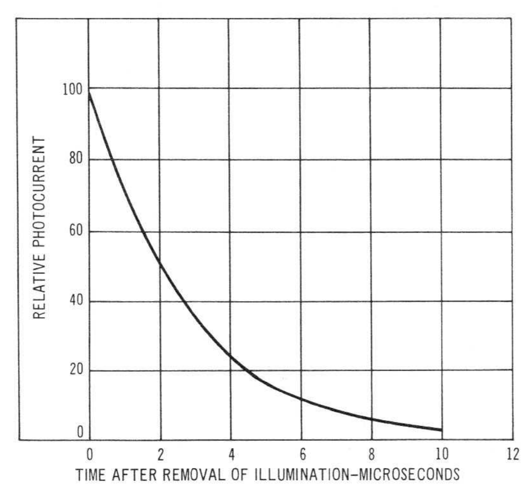
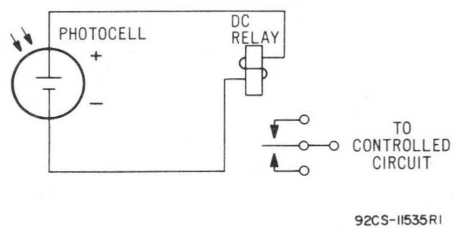


Fig.5

TYPICAL APPLICATIONS AND CIRCUIT DIAGRAMS

CONTROL CIRCUIT REQUIRING NO EXTERNAL POWER SUPPLY

A control circuit which requires no external power supply is shown in Fig.6. When illuminated, the cell converts incident light into electrical power to activate the relay. Light levels as low as about 25 footcandles incident on the surface of the cell operate the relay. The center contact of the specified relay is in a "floating" neutral position. The relay contact which closes is dependent on the connection polarity of the relay terminals to the photovoltaic cell.



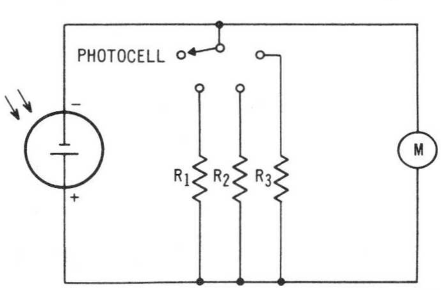
RCA PHOTOVOLTAIC CELL: TYPE SQ2540

DC RELAY: Barber-Colman, Type AYLZ 7306-100, or equivalent. Pull-in voltage 0.155 volt; pull-in current 280 microamperes.

Fig.6

LIGHT-INTENSITY METER

Short-circuit current is linear with respect to illumination incident on the sensitive surface of the photovoltaic cell. A low-impedance current meter may therefore be placed across the cell permitting light intensity to be measured, as shown in Fig.7. If the light source is a tungsten-filament lamp operated at a color temperature of 2870° K, the calibration of this meter is approximately 29 microamperes per footcandle. This circuit has been used in industrial applications such as the measurement of the density of thin evaporated films.



RCA PHOTOCELL: TYPE SQ2540

R_1: 22 ohms. Current for full scale deflection is 5.0 mA.

R_2: 2 ohms. Current for full scale deflection is 50 mA.

R_3: 0.39 ohm. Current for full scale deflection is 250 mA.

M: Simpson, Type 1212 DC microammeter, 0-500 μA 200 ohms resistance, or equivalent.

Fig.7

LOW-VOLTAGE SOURCE

The photocell may be considered a low-voltage current-limited power supply when it is illuminated. The V-I curves shown in Fig.3 have been redrawn on a linear scale and are shown in Fig.8. These curves are characteristic of current-limited power supplies. The magnitude of the voltage that is generated is a function of the illumination on the cell. A typical low-voltage-source circuit is shown in Fig.9.

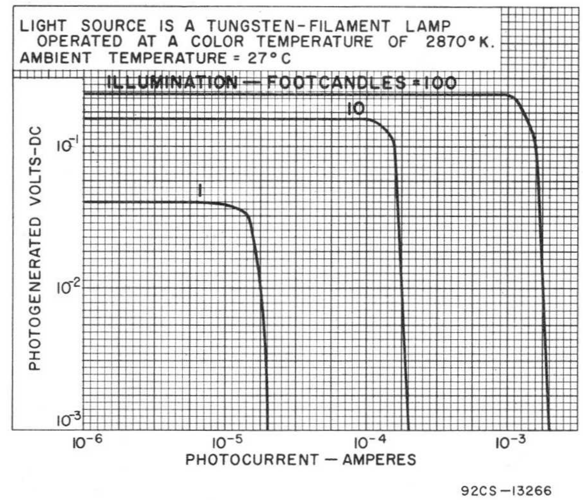
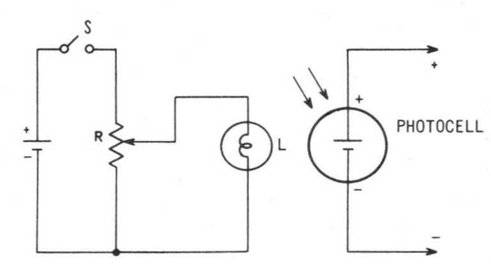


Fig.8



RCA PHOTOCELL: TYPE SQ2540

BATTERY: 6-volt battery, RCA-VS040S

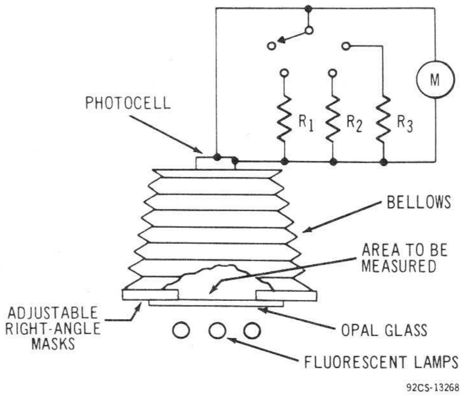
L: General Electric Lamp, Type GE-51, 6-volt, 0.22 ampere

R: 200-ohm potentiometer

S: On-off switch

Fig.9

The light intensity meter of Fig.7 may be used with a bellows to measure unknown pattern areas as shown in Fig.10. To measure area, the right-angle masks should be adjusted to define the field of interest. The meter is then calibrated by inserting a standard pattern of known area. An unknown pattern may then be substituted and the current indicated by the meter will be directly proportional to area.



RCA PHOTOCELL: TYPE SQ2540

R_1: 22 ohms. Current for full scale deflection is 5.0 mA.

R_2: 2 ohms. Current for full scale deflection is 50 mA.

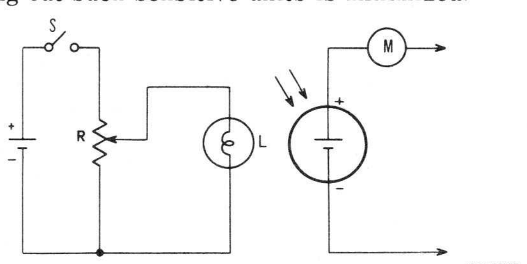
R_3: 0.39 ohm. Current for full scale deflection is 250 mA.

M: Simpson, Type 1212 DC microammeter, 0-500 μA 200 ohms resistance, or equivalent.

Fig.10

CONTINUITY CHECKER OR OHMMETER

The circuit shown in Fig.11 is especially useful as a continuity checker for such highly sensitive units as meter movements, low-current fuses, or semiconductor diodes. Because current output is limited, the danger of burning out such sensitive units is minimized.



RCA PHOTOCELL: TYPE SQ2540

BATTERY: 6-volt battery, RCA-VS040S

L: General Electric Lamp, Type GE-51, 6-volt, 0.22 ampere

M: Simpson, Type 1212 DC microammeter, 0-500 μA, 200 ohms resistance, or equivalent

R: 200-ohm potentiometer

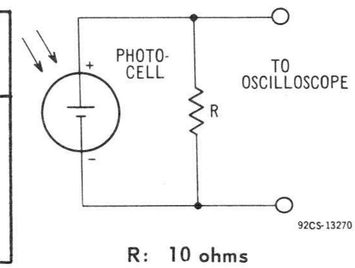
S: On-off switch

Fig.11

LASER-BEAM DETECTION AND MONITORING SYSTEM

Photovoltaic cells are highly useful in laser-beam detection and monitor service because they have relatively fast time response, high quantum yield, and are inexpensive. The large sensitive area of the cells permit the monitoring of the laser beam over its entire diameter without prefocusing. A typical laser-beam monitor circuit is shown in Fig.12. The load resistor employed in this circuit is chosen so that the RC time-constant of the resistor and the junction capacity of the cell is low with respect to the response time of the silicon. The response time of the cell (1/e) is approximately 3 microseconds. Where it is desired to demodulate a laser beam at higher speeds, photocells with lower junction capacitance and higher speed of response can be fabricated.

Laser Material	Wavelength of Emission–Angstroms
$Al_2O_3:Cr^{3+}$ (ruby)	6943
$CaF_2:Sm^{2+}$	7082
$CaF_2:Nd^{3+}$	10460
Ga As	8400

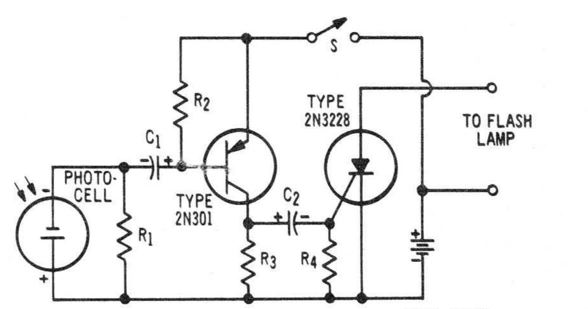


R: 10 ohms

Fig.12

PHOTOGRAPHIC-FLASH SLAVE UNIT

A photographic flash unit is shown in Fig.13. The photocell is capacitively coupled to the transistor so that stray but steady ambient illumination will not cause the unit to fire. In this simple circuit, the light-pulse from the main flash lamp or electronic flash unit is converted into an electrical pulse which is amplified and fires the silicon controlled-rectifier. The current flowing through the controlled rectifier, in turn, fires the flash lamp. The switch (S) should be closed before inserting the flash lamp in the circuit to prevent premature flashing due to switching transients.



RCA PHOTOCELL: TYPE SQ2540

BATTERY: 6-volt battery

C_1: 100 μF, electrolytic, 6 volts

C_2: 15 μF, electrolytic, 6 volts

R_1: 100 ohms, 1/2 watt

R_2: 1000 ohms, 1/2 watt

R_3: 68 ohms, 1/2 watt

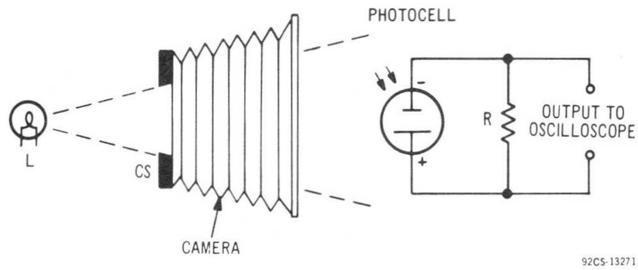
R_4: 1000 ohms, 1/2 watt

S: On-off switch

Fig.13

CAMERA SHUTTER-SPEED MEASUREMENT UNIT

A typical circuit for measuring the shutter speed of a camera is shown in Fig.14. When the shutter in this system is opened, light passes through the opening and falls on the photovoltaic cell. An electrical pulse is generated by the cell. By observing the time duration of the pulse on a calibrated oscilloscope, the shutter speed of the camera may be determined.



RCA PHOTOCELL: TYPE SQ2539
L: Lamp
CS: Camera Shutter
R: 470 ohms, 1/2 watt

Fig.14

SOLAR CELLS FOR ENERGY CONVERSION IN SPACE APPLICATIONS

SOLAR IRRADIANCE AS A FUNCTION OF WAVELENGTH

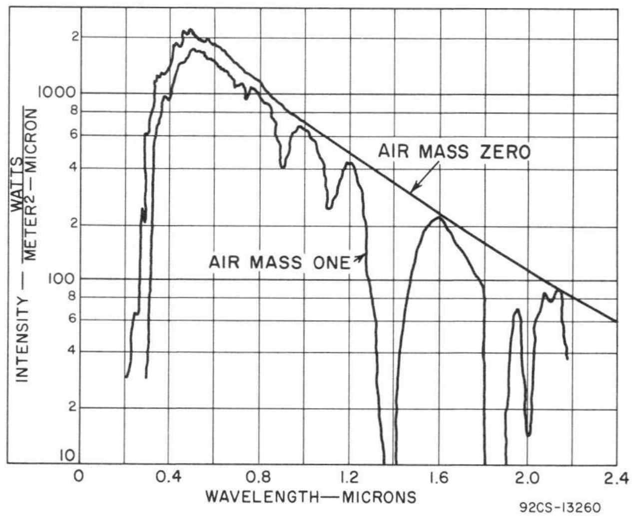


Fig.15

Silicon photovoltaic cells are extremely useful in converting radiant energy from the sun into electrical energy. Solar irradiance curves as a function of wavelength at both air mass zero (outside of the earth's atmosphere) and also at air mass one (at sea level with the sun directly overhead) are shown in Fig.15. The curve for air mass zero is frequently called the Johnson Curve. The total energy output of the sun is obtained by integration of the area under this curve. A commonly accepted value of the solar constant at mean earth distance is 139.6 mW/cm^2. A typical energy-conversion-efficiency value is 10.8 per cent. The generally accepted value of solar radiation reaching the earth is 100 mW/cm^2. This value is also subject to weather conditions, the altitude of the observer, the angle of the sun, and the season of the year.

For energy conversion applications in both space and ground-level systems, it is generally necessary to connect photovoltaic cells in various series-parallel configurations to obtain required power at desired voltage and current levels.

Inquiries on silicon photovoltaic cells for energy conversion applications should be directed to:

Solar Cell Products
Direct Energy Conversion Department
Radio Corporation of America (18-3)
Harrison, New Jersey 07029

For non-energy conversion applications, additional information may be obtained from the Sales Offices listed on the back cover of this bulletin.

NUCLEAR PARTICLE DETECTORS

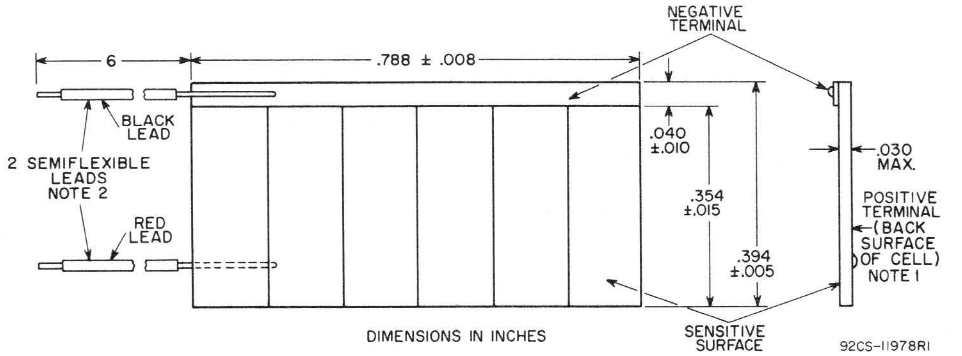
Silicon junction diodes have also been designed as small, rugged, "solid-state ionization chambers" capable of direct detection of alpha and beta particles; protons; fission fragments; heavy ions; gamma rays; and with the use of a conversion cap, neutrons.

Information on these devices is contained in a brochure which may be obtained by writing to:

Radio Corporation of America
Phototube Marketing
Lancaster, Pennsylvania

DIMENSIONAL OUTLINES

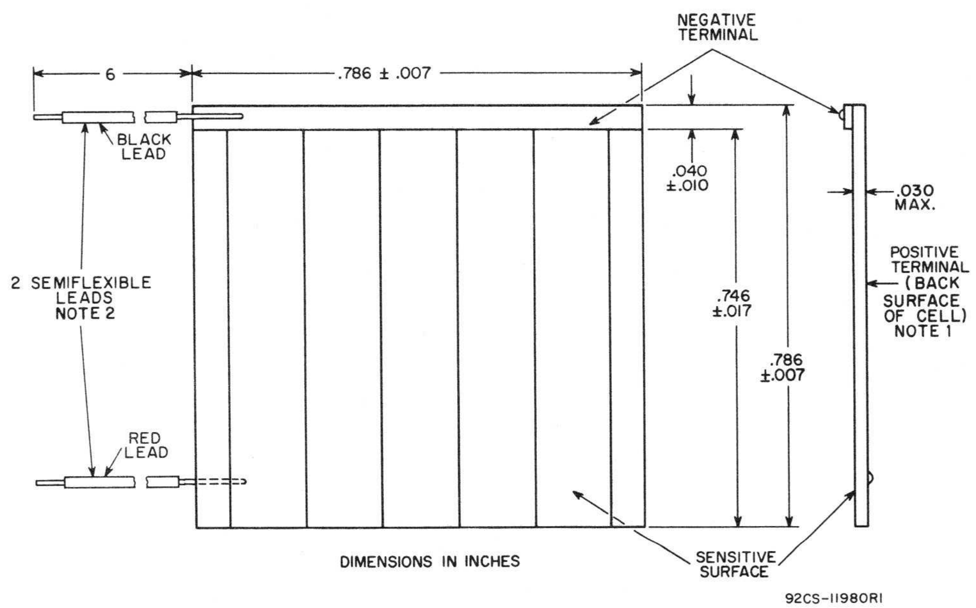
FOR TYPES SQ2539, SQ2539V1



Note 1: Entire back surface of cell serves as the positive terminal.

Note 2: For type SQ2539 only. Insulated, stranded No.32 AWG wire. Type SQ2539V1 is furnished without leads.

FOR TYPES SQ2540, SQ2540V1



Note 1: Entire back surface of cell serves as the positive terminal.

Note 2: For type SQ2540 only. Insulated, stranded No.32 AWG wire. Type SQ2540V1 is furnished without leads.

RCA PHOTOVOLTAIC CELLS

SILICON, N-on-P TYPES

FIELD OFFICES

Newark	32 Green St., Newark, N.J. 07102	(201) 485-3900
Washington	1725 K St., N.W., Washington, D.C. 20006	(202) 337-8500
Dayton	224 N. Wilkinson St., Dayton, Ohio 45402	(513) 461-5420
Hollywood	6363 Sunset Blvd., Hollywood, Calif. 90028	(213) 461-9171
Detroit	714 New Center Building, Detroit, Mich. 48202	(313) 875-5600
Des Plaines	446 E. Howard Ave., Des Plaines, Illinois 60018	(312) 827-0033
Dallas	210-C Court Terrace, Exchange Park North, Dallas, Texas 75235	(214) 351-5361
Los Altos	4546 El Camino Real, Los Altos, Calif. 94022	(415) 948-8996
Needham	64 A Street, Needham Heights, Mass. 02194	(617) 444-7200

INTERNATIONAL SALES

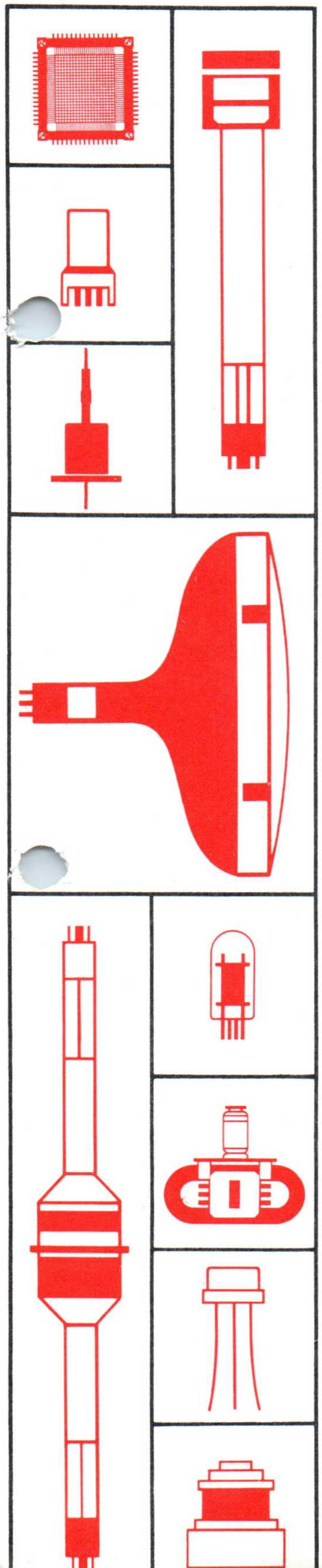
Clark	Central & Terminal Aves., Clark, N.J. 07066 Cable: RADIOINTER	(201) 382-1000
Geneva	118 Rue du Rhone, Geneva, Switzerland Cable: RADIOCORP	35 75 00 to 09
Montreal	1001 Lenoir Street, Montreal 30, Quebec Cable: VICTORADIO	(514) 933-7551
Hong Kong	1641 Union House, Connaught Road C, Hong Kong Cable: RADIOINTER	239529, 239522

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-4028A
RCA-4055

NEW PENCIL TUBES

RCA-4028A and 4055 are high-mu, ceramic-metal pencil triodes designed for plate-pulsed operation. These new pencil tubes feature a sturdy coaxial-electrode structure, small size, fast warmup, and high heat dissipation capability. The 4028A and 4055 are ideally suited as oscillators and amplifiers in DME, airborne transponders and transceivers.

4028A

- Maximum Frequency — 4 Gc
- Amplification Factor — 70
- Maximum Peak Voltage — 2000 volts
- Peak Power Output — 1000 watts
- Weight — 0.3 oz.
- Length — 1.567"

4055

- Maximum Frequency — 4 Gc
- Amplification Factor — 70
- Maximum Peak Voltage — 3500 volts
- Peak Power Output — 1300 watts
- Weight — 0.4 oz.
- Length —1.77"

ADDITIONAL INFORMATION: Data sheets giving detailed technical information on the 4028A and 4055 are attached for your convenience.

March 15, 1965

RCA-4028A

PENCIL TUBE

Sturdy Coaxial-
Electrode Structure
Fast Warmup Time

CERAMIC-METAL, HIGH-MU TRIODE
For Use at Frequencies up to 4 Gc

1.567" Length
.552" Diameter
at Grid Flange

RCA-4028A is a high-mu, ceramic-metal pencil triode designed for use in plate-pulsed operation as a power amplifier, oscillator, and frequency multiplier in compact mobile and aircraft equipment at altitudes up to 25,000 feet without pressurization. The 4028A can be operated at frequencies up to 4 Gc and above.

Actual Size

In a typical plate-pulsed oscillator circuit operating at a frequency of 3.3 Gc, the 4028A can deliver a useful peak power output of 1 kilowatt. In a typical cathode-drive amplifier circuit operating at 550 Mc, the 4028A can deliver a useful power output of 6 watts.

Pencil-tube design incorporating ceramic-metal construction permits a smaller, more sturdy tube, improved processing, and higher operating temperature. Furthermore, evidence indicates that ceramic-metal construction has greater endurance to nuclear radiation than glass-metal construction.

Featured in the design of the 4028A is a sturdy, double-ended, coaxial-electrode structure in which the plate cylinder extends outward from one side of the grid flange and the cathode cylinder extends outward from the other side. The relatively large area of the plate cylinder allows fast heat dissipation—a significant advantage in compact equipment. Electrode surfaces are silver plated and are separated from each other by ceramic bushings. The design of the 4028A provides low lead inductance, very short transit time, and excellent thermal stability.

The pencil-type structure of the 4028A permits rf isolation of the load circuit from the input circuit and thus makes this type particularly useful in cathode-drive circuits. These may be of the coaxial-cylinder cavity type, the parallel-line type, or the lumped-circuit type.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	0.300	amp
Cathode Warmup Time (Average) to reach 80% of operating plate current:		
For conditions: dc plate supply volts = 80, grid volts = 0, cathode resistor = 0 ohms, load resistor = 10 ohms, heater volts = 6.3	10	sec
Amplification Factor	70	
Transconductance, for dc plate current of 14 milliamperes, dc plate voltage of 125 volts, and cathode resistor of 50 ohms.	22500	μmhos
Direct Interelectrode Capacitances:		
Grid to plate	2.0	pf
Grid to cathode and heater	5.8	pf
Plate to cathode and heater.	0.08 max.	pf

Mechanical:

Operating Position	Any
Dimensions and Terminal Connections.	See *Dimensional Outline*
Weight (Approx.).	0.3 ounce
Sockets:	
Heater-Terminals Connector	Grayhill[a] No.22-5, or equivalent
Socket for operation up to about 550 Mc (Including heater-terminals connector)	Jettron[b] No.CD7010, or equivalent
Cavities (Including heater-terminals connector)	J-V-M[c] No.D-7980 Series, Resdel[d] No.10 Series, AML, Inc,[e] MCL, Inc,[f] or equivalent

CUTAWAY VIEW OF CERAMIC-METAL PENCIL TUBE

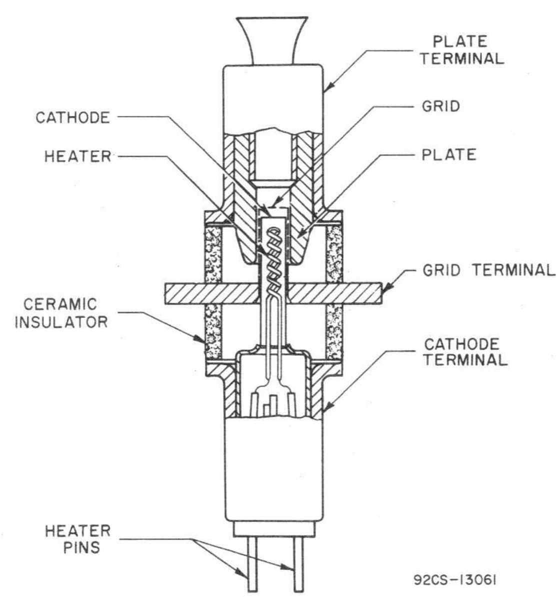


PLATE-PULSED SERVICE – Class C

Maximum Ratings, *Absolute-Maximum Values*[g] *up to 4 Gc:*

For a maximum "ON" time[h] *of 5 microseconds in any 5000-microsecond interval.*

Peak Positive-Pulse Plate-Supply Voltage	2000 max.	volts
Peak Plate Current from Pulse Supply	3.0 max.	amp
DC Plate Current	3.0 max.	ma
DC Grid Current	1.5 max.	ma
Pulse Duration	1.5 max.	μsec
Duty Factor	0.001 max.	
Plate-Seal Temperature[i]	225 max.	^{o}C

Typical Operation as Oscillator with Rectangular Wave Shape in Cathode-Drive Circuit at 3.3 Gc:

With duty factor[k] *of 0.001 and pulse duration of 1 microsecond*

Peak Positive-Pulse Plate-Supply Voltage	1750	volts
DC Plate Current	2.5	ma
DC Grid Current	1.0	ma
Grid Resistor	50	ohms
Useful Power Output at Peak of Pulse (Approx.)	1000	watts

Typical Operation as Frequency Doubler to 1 Gc with Rectangular Wave Shape in Cathode-Drive Circuit:

Peak Positive-Pulse Plate-Supply Voltage	1200	volts
DC Plate Current	0.4	ma
DC Grid Current	0.2	ma
Grid Resistor	2000	ohms
Driver Power Output (Approx.)	50	watts
Useful Power Output (Approx.)	100	watts

RF POWER AMPLIFIER & OSC. – Class C Telegraphy[m]
RF POWER AMPLIFIER – Class C FM Telephony

Maximum CCS[n] Ratings, *Absolute-Maximum Values*[g] *up to 4 Gc:*

DC Plate Voltage	300 max.	volts
DC Grid Voltage	-50 max.	volts
DC Plate Current	35 max.	ma
DC Cathode Current	45 max.	ma
DC Grid Current	15 max.	ma
Plate-Seal Temperature[i]	225 max.	^{o}C
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	50 max.	volts
Heater positive with respect to cathode	50 max.	volts

Typical Operation as RF Power Amplifier in Cathode-Drive Circuit at 550 Mc:

DC Plate Voltage	250	300	volts
DC Grid Voltage	-6.5	-9	volts
Grid Resistor	500	700	ohms
DC Plate Current	31	35	ma
DC Grid Current	13	13	ma
Driver Power Output (Approx.)	0.2	0.2	watt
Useful Power Output (Approx.)	4.8	6	watts

Maximum Circuit Value:

Grid-Circuit Resistance	0.25 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.270	0.330	amp
Direct Interelectrode Capacitances:				
Grid to plate	-	1.7	2.4	pf
Grid to cathode	-	5.0	6.5	pf
Plate to cathode	-	-	0.08	pf
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,2	-	30	μa
Heater positive with respect to cathode	1,3	-	30	μa
Reverse Grid Current	1,4	-	0.3	μa
Transconductance	1,5	18000	27000	μmhos
Plate Current (1)	1,5	13	25	ma

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With 60 volts dc between heater and cathode, heater negative with respect to cathode.

Note 3: With 60 volts dc between heater and cathode, heater positive with respect to cathode.

Note 4: With dc plate voltage of 200 volts, dc grid voltage of -2 volts, grid resistor of 0.5 megohm.

Note 5: With dc plate-supply voltage of 125 volts, cathode resistor of 50 ohms, and cathode bypass capacitor of 1000 μf.

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[a] Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill.

[b] Jettron Products, Inc., 56 Route 10, Hanover, N.J.

[c] Fidelitone Microwave, Inc., JVM Division, 6415 N. Ravenswood Ave., Chicago, Ill. Indicated No. applies to a series of cavities covering the range from 220 to 3500 Mc.

[d] Resdal Engineering Corp., 330 South Fair Oaks Ave., Pasadena, Calif. This series of cavities covers the range from 215 to 2325 Mc.

[e] Applied Microwave Laboratory, Inc., 106 Albion St., Wakefield, Mass.

[f] Microwave Cavity Laboratory, Inc., 10 Beach Ave., LaGrange, Ill.

[g] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[h] *"ON"* time is defined as the sum of the duration of all individual pulses which occur during the indicated interval. *Pulse duration* is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak power value. The *peak value* is defined

as the maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse.

i In applications where the plate dissipation exceeds 2.5 watts, it is important that a large area of contact be provided between the plate cylinder and the terminal to provide adequate heat conduction.

k Duty factor is the product of pulse duration and repetition rate. For variable pulse durations and pulse repetition rates, the duty factor is defined as the ratio of time "ON" to total elapsed time in any 5000-microsecond interval.

m Key-down conditions per tube without amplitude modulation. Modulation essentially negative may be used if the positive peak of the audio frequency envelope does not exceed 115 per cent of the carrier conditions.

n Continuous Commercial Service.

OPERATING CONSIDERATIONS

Connections to the cathode cylinder, grid flange, and plate cylinder should be made by flexible spring contacts. The connectors should make firm, large-surface contact, yet must be sufficiently flexible to insure that no part of the tube is subjected to excessive strain.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum rated values shown in the tabulated data.

The *temperature of the plate seal* should not exceed 225° C (at the hottest point). The temperature may be measured with a temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd St., New York 11, N.Y. in the form of liquid or stick.

AVERAGE CHARACTERISTICS OF TYPE 4028A IN CATHODE-DRIVE SERVICE

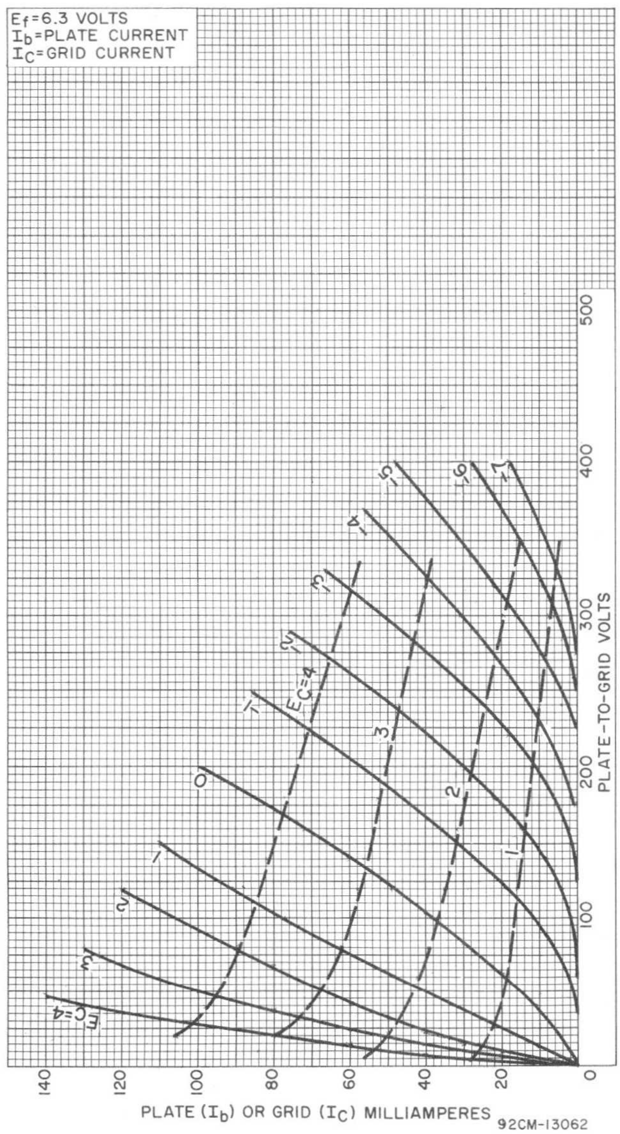


Fig.1

AVERAGE CONSTANT-CURRENT CHARACTERISTICS OF TYPE 4028A IN CATHODE-DRIVE SERVICE

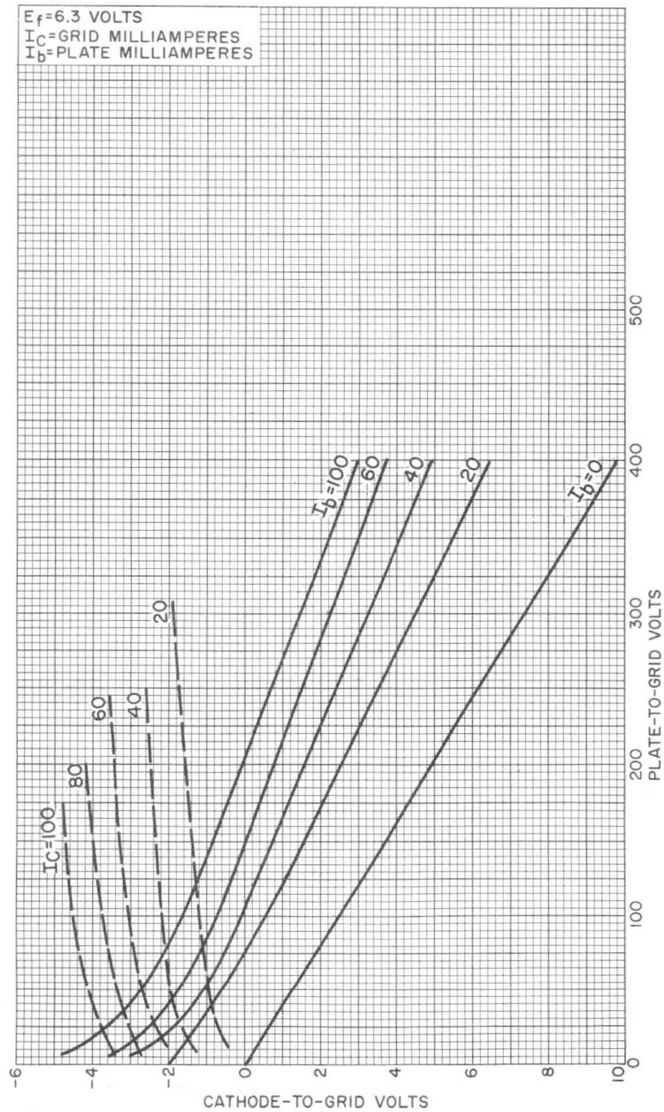


Fig.2

REFERENCES

Bogaenko, S. and Jonk, O., *"A Quick-Heating Rugged UHF Ceramic Pencil Triode for Missiles and Satellites"* IRE MIL-E-CON CONVENTION RECORD, June 1961.

DeBacker, L.P.A., *"Tube Noise Factor Chart"*. ELECTRONICS, July 18, 1958.

DeBacker, L.P.A., and Thompson, J.J., *"A New, Reliable Low-Noise, Ceramic Pencil Tube for Use as a UHF Triode"*. PROCEEDINGS OF THE NATIONAL AERONAUTICAL ELECTRONICS CONFERENCE, 1959.

Harris, W.A., *"Corrections to the Theory of the Grounded-Grid Triode"*. I.R.E. CONVENTION RECORD, 1955.

Harris, W.A., *"Measurement and Analysis of Triode Noise"*. TRANSACTIONS OF THE I.R.E. Professional Group on Electron Devices, Vol. ED-1, December 1954.

Harris, W.A., *"Some Notes on Noise Theory and Its Application to Input Circuit Design"*. RCA REVIEW, September, 1948.

Harris, W.A., and Thompson, J.J., *"The Use of Concentric-Line Transformers in UHF Measurements"*. I.R.E. TRANSACTIONS ON INSTRUMENTATION PGI-4.

Rose, G.M., Power, D.W., and Harris, W.A., *"Pencil-Type UHF Triodes"*, RCA REVIEW, Vol. 10, No. 3, September, 1949.

Spitzer, E.E., *"Grounded-Grid Power Amplifiers"*, ELECTRONICS, Vol. 19, No. 4, April 1946.

Booklet 1CE-219—RCA Pencil Tubes.

TYPICAL OSCILLATOR POWER OUTPUT OF TYPE 4028A AS A FUNCTION OF VARIATIONS IN HEATER VOLTAGE

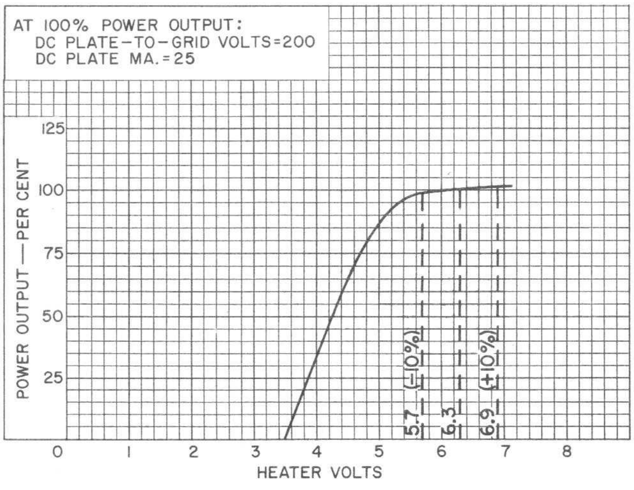


Fig.3

PLATE-SEAL TEMPERATURE OF TYPE 4028A AS A FUNCTION OF AMBIENT TEMPERATURE WITH LUMPED-CONSTANT CIRCUIT

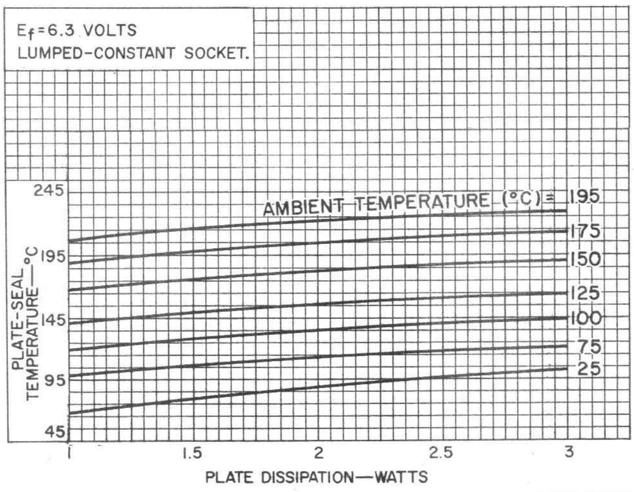


Fig.4

TYPICAL CATHODE-DRIVE POWER AMPLIFIER CIRCUIT FOR TYPE 4028A

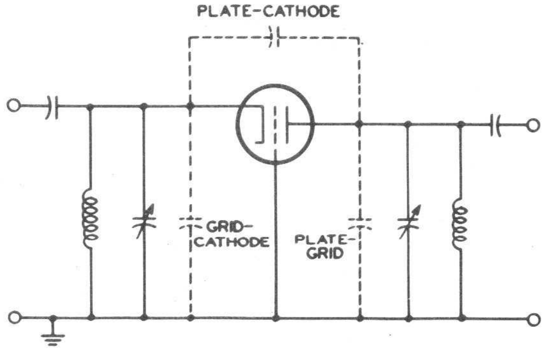
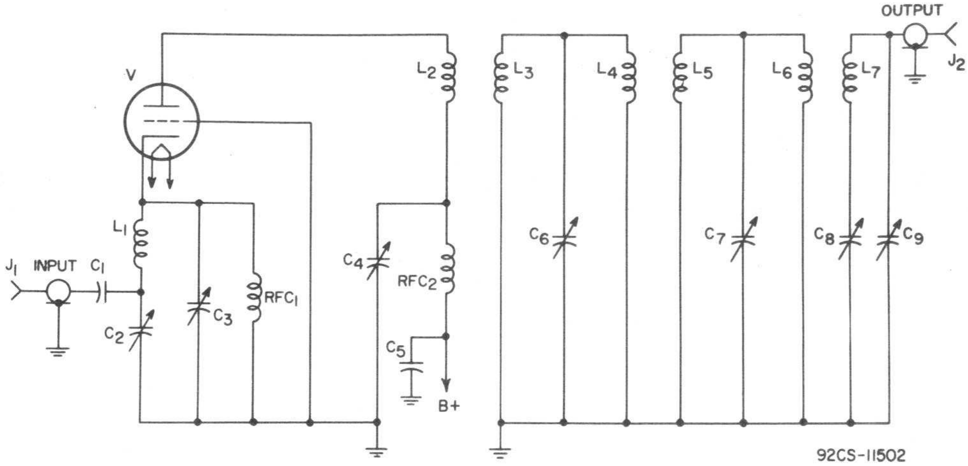


Fig.5

TYPICAL BROADBAND AMPLIFIER CIRCUIT FOR TYPE 4028A



C_1: 100 to 500 pf.

C_2, C_3, C_4, C_6, C_7, C_8, C_9: 0.8-8.5 pf
Glass Dielectric Trimmers – JFD VC 20G or equivalent.

C_5: 500 pf.

J_1, J_2: BNC Connectors.

L_1, L_2, L_3, L_4, L_5, L_6, L_7:
For Frequency Range of:
200-500 Mc -- Two Turns, 1/2" Dia., Spaced 3/8", Silver-Plated #14 Wire.
500-1000 Mc -- One Turn, 1/2" Dia., Silver-Plated #14 Wire.

RFC_1, RFC_2: Ohmite Z-450 RF Chokes, or equivalent.

V: RCA-4028A

Fig.6

TYPE 4028A IN FREQUENCY-MULTIPLIER CAVITY USING RECTANGULAR COAXIAL-LINE OUTPUT AND DIRECT CATHODE DRIVE

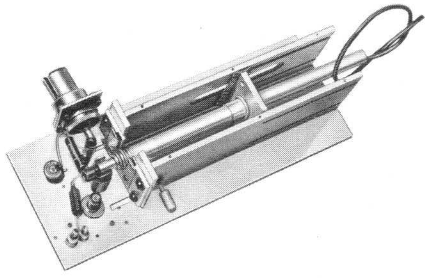
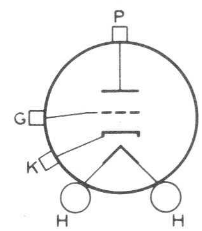


Fig.7

TERMINAL CONNECTIONS



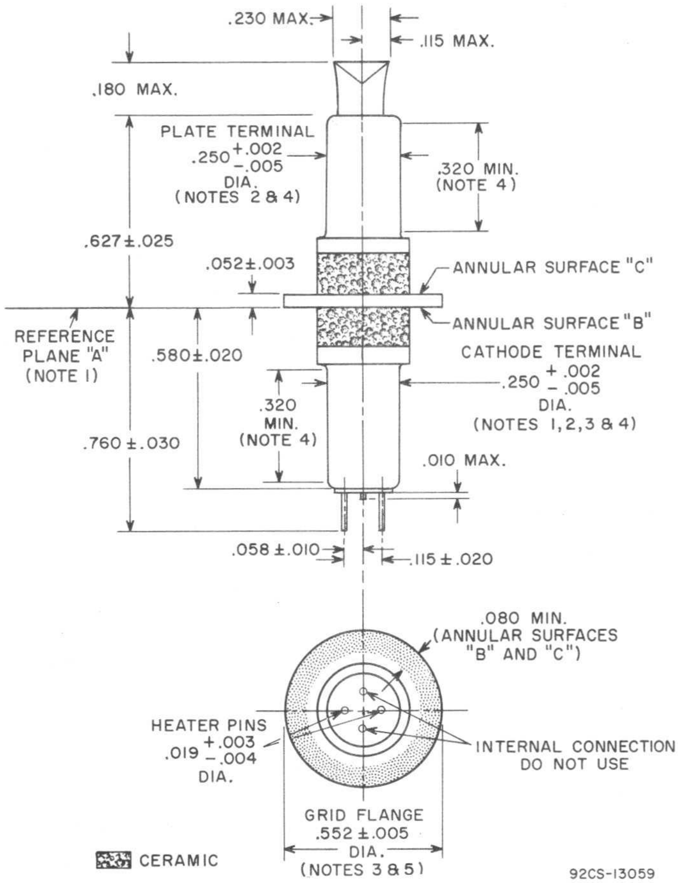
H: HEATER PIN

K: CATHODE CYLINDER (Adjacent to Heater Pins)

G: GRID FLANGE

P: PLATE CYLINDER (Adjacent to pinch-off)

DIMENSIONAL OUTLINE



Dimensions in Inches

REFERENCE PLANE "A" IS DEFINED AS THAT PLANE AGAINST WHICH ANNULAR SURFACE "B" OF THE GRID FLANGE ABUTS.

ANNULAR SURFACE "B" IS ON THE SIDE OF THE GRID FLANGE TOWARD THE CATHODE CYLINDER.

ANNULAR SURFACE "C" IS ON THE SIDE OF THE GRID FLANGE TOWARD THE PLATE CYLINDER.

NOTE 1: WITH ANNULAR SURFACE "B" RESTING ON REFERENCE PLANE "A". THE AXIS OF THE CATHODE CYLINDER WILL BE WITHIN 2° OF A LINE PERPENDICULAR TO REFERENCE PLANE "A".

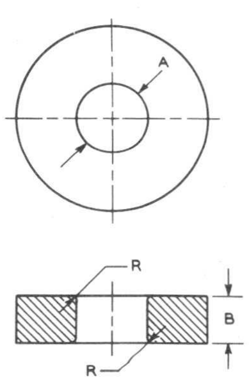
NOTE 2: THE AXES OF THE PLATE CYLINDER AND CATHODE CYLINDER WILL COINCIDE WITHIN 0.010".

NOTE 3: THE AXES OF THE CATHODE CYLINDER AND GRID FLANGE WILL COINCIDE WITHIN 0.005".

NOTE 4: THE DIAMETER ALONG THE 0.320" MINIMUM LENGTH IS MEASURED WITH "GO" AND "NO-GO" RING GAUGES G1-1 AND G1-2, RESPECTIVELY.

NOTE 5: THIS DIAMETER IS MEASURED WITH "GO" AND "NO-GO" GAUGES G3-1 AND G3-2, RESPECTIVELY.

GAUGES



92CS-10370

Gauge	Type	Dimension		
		Diameter A	Thickness B	Radius R
G_1-1	Go	$0.25200'' {}^{+0.00000''}_{-0.00007''}$	$0.320'' {}^{+0.001''}_{-0.000''}$	0.003" MAX.
G_1-2	No-Go	$0.24500'' {}^{+0.00007''}_{-0.00000''}$	–	–
G_3-1	Go	$0.55700'' {}^{+0.00000''}_{-0.00007''}$	–	–
G_3-2	No-Go	$0.54700'' {}^{+0.00007''}_{-0.00000''}$	–	–

Long Life
Low Heater Power
High Efficiency

Applications:
- **Local Oscillator**
- **RF Power Amplifier**
- **Frequency Multiplier**

RCA-4037A

PENCIL TUBE

OCTAL-BASED, TRIODE

Replaces 2C40A in *Most* Applications.

RCA-4037A is a high-mu, octal-based pencil triode intended for use in cathode-drive or grid-drive service as a cw local oscillator up to 3500 Mc or an rf power amplifier or mixer tube up to 1500 Mc. The 4037A may be used in receivers and transmitters operating at altitudes up to 25,000 feet without pressurization.

Type 4037A features the coaxial pencil-type structure with an octal base and a large cathode cylinder which makes this tube serviceable in cavities and equipment designed for lighthouse-type tubes. Pencil-tube construction provides many desirable performance advantages over lighthouse types, namely:

- About three times the cathode area per watt of heater power.
- One-third the cathode warmup time—10 seconds maximum to reach 90 percent of typical oscillator power output or 15 seconds maximum to reach 90 percent of operating dc plate current.
- Output power and frequency remain essentially constant over 10 percent heater-voltage fluctuations.
- Cantilever arrangement of coaxial electrodes provides low interelectrode leakage, adds to efficiency, and increases reliability.

In addition, the 4037A possesses extremely long life, and excellent stability with variations in plate-supply voltages and ambient temperature fluctuations.

Mechanically, the 4037A differs from the comparable lighthouse type primarily in the plate-cylinder length. In most applications this dimensional difference presents no problem, and the 4037A can be substituted directly. Electrically, the 4037A is interchangeable with the comparable lighthouse type providing the maximum plate voltage rating of the 4037A is not exceeded. A slight re-tuning of the cavity may be required in some cases to compensate for the minor differences in the interelectrode capacitances between the two types.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ± 10%		volts
Current at 6.3 volts	0.145		amp
Cathode Warmup Time:			
To reach 90 percent of typical oscillator power output	10	max.	sec
To reach 90 percent of operating dc plate current	15	max.	sec
Amplification Factor	30		
Transconductance, for dc plate current of 18 milliamperes and dc plate voltage of 250 volts	5500		μmhos
Direct Interelectrode Capacitances (Approx.):			
Grid to plate	1.1		$\mu\mu$f
Grid to cathode	1.8		$\mu\mu$f
Plate to cathode	0.05	max.	$\mu\mu$f
Cathode to rf cathode terminal	100		$\mu\mu$f

Mechanical:

Operating Position	Any
Dimensions and Terminal Connections	See *Dimensional Outline*
Base	Small H-Wafer Octal 6-Pin (JEDEC Group 1, No.B6-108)
Plate Seal Temperature	175 max. °C

RF AMPLIFIER — Class A$_1$

Maximum CCS[a] Ratings, *Absolute-Maximum Values*[b] *up to 2000 Mc:*

For Altitudes up to 25000 ft.

DC PLATE VOLTAGE	300	max.	volts
DC GRID VOLTAGE	-100	max.	volts
DC PLATE CURRENT	25	max.	ma
PLATE DISSIPATION[c]	6.25	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	90	max.	volts
Heater positive with respect to cathode	90	max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance	0.5	max.	megohm

RADIO CORPORATION OF AMERICA
Electronic Components and Devices Harrison, N. J.

4037A 1-65
Printed in U.S.A.

RF POWER AMPLIFIER AND OSCILLATOR — Class C Telegraphy

Key-down conditions per tube without amplitude modulation[d]

Maximum CCS[a] Ratings, *Absolute-Maximum Values*[b] *up to 2000 Mc:*

For Altitudes up to 25000 ft.

DC PLATE VOLTAGE	360 max.	volts
DC GRID VOLTAGE	-100 max.	volts
DC PLATE CURRENT	25 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	9 max.	watts
PLATE DISSIPATION[c]	6.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Typical CCS Operation as Oscillator in Cathode-Drive Circuit:

	At 500 Mc	At 2000 Mc	At 3000 Mc	
DC Plate-to-Grid Voltage	262	252	252	volts
DC Cathode-to-Grid Voltage[e]	12	2	2	volts
DC Plate Current	23	23	25	ma
DC Grid Current (Approx.)	6	3	4	ma
Useful Power Output (Approx.)	3	0.45	0.1	watts

Typical CCS Operation as RF Power Amplifier in Cathode-Drive Circuit at 500 Mc:

DC Plate-to-Grid Voltage	326	volts
DC Cathode-to-Grid Voltage[e]	51	volts
DC Plate Current	23	ma
DC Grid Current (Approx.)	7	ma
Driver Power Output (Approx.)	2	watts
Useful Power Output (Approx.)	5	watts

Maximum Circuit Values:

Grid-Circuit Resistance	0.1 max.	megohm

PLATE-MODULATED RF POWER AMPLIFIER — Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS[a] Ratings, *Absolute-Maximum Values*[b] *up to 2000 Mc:*

For Altitudes up to 25000 ft.

DC PLATE VOLTAGE	275 max.	volts
DC GRID VOLTAGE	-100 max.	volts
DC PLATE CURRENT	22 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	6 max.	watts
PLATE DISSIPATION[c]	4.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance	0.1 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Heater Current	1	0.130	0.160	amp
Direct Interelectrode Capacitances:				
Grid to plate	-	0.8	1.3	μμf
Grid to cathode	-	1.5	2.1	μμf
Plate to cathode	-	-	0.05	μμf
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,2	-	50	μa
Heater positive with respect to cathode	1,3	-	50	μa
Reverse Grid Current	1,4	-	1	μa
Amplification Factor	1,5	22	38	
Transconductance	1,5	4000	7000	μmhos
Plate Current (1)	1,5	13.5	24.5	ma
Plate Current (2)	1,6	-	55	μa
Power Output	1,7	0.15		watt

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With 100 volts dc between heater and cathode, heater negative with respect to cathode.

Note 3: With 100 volts dc between heater and cathode, heater positive with respect to cathode.

Note 4: With dc plate voltage of 250 volts, dc grid voltage of -2.5 volts, grid resistor of 0.5 megohm.

Note 5: With dc plate-supply voltage of 250 volts, cathode resistor of 200 ohms, and cathode bypass capacitor of 1000 μf.

Note 6: With dc plate voltage of 250 volts and dc grid voltage of -25 volts.

Note 7: With dc plate voltage of 250 volts, grid resistor adjusted to give a dc plate current of 25 milliamperes in a cavity-type oscillator operating at 1800 ± 25 Mc.

[a] Continuous Commercial Service.

[b] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[c] In applications where the plate dissipation exceeds 2.5 watts, it is important that a large area of contact be provided between the plate cylinder and the terminal to provide adequate heat conduction.

[d] Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

[e] Obtained from grid resistor.

SPECIAL TESTS AND PERFORMANCE DATA

Low-Pressure Voltage Breakdown Test:

This test (similar to MIL-E-1D, par. 4.9.12.1) is periodically performed on a sample lot of tubes. Tubes are tested in a chamber at an air pressure equivalent to an altitude of 25,000 feet. Breakdown will not occur when a 60-cycle rms voltage of 500 volts is applied between the plate cylinder and grid flange.

Low-Frequency Vibration Performance:

This test (similar to MIL-E-1D, par. 4.9.19.1) is performed on a sample lot of tubes from each production run under the following conditions:

Heater voltage of 6.3 volts, dc plate-supply voltage of 250 volts, grid voltage of -2.5 volts, and plate load resistor of 10,000 ohms. The tubes are vibrated in a plane perpendicular to the tube axis at 25 cycles per second at an acceleration of 2.5 g. The rms output voltage across the plate load resistor as a result of vibration of the tube will not exceed 100 millivolts.

High-Frequency Vibration Performance:

This test (similar to MIL-E-1D, par. 4.9.19.2) is performed on a sample lot of tubes from each production run. The tube is vibrated perpendicular to its axis, with no voltages applied to the tube. Vibration frequency is 40-60 cps and acceleration is 10 g. At the end of this test, tubes will not show temporary or permanent shorts or open circuits and will meet the following limits:

Heater-Cathode Leakage Current. . . . 50 max. µa

For conditions shown under *Characteristics Range Values Notes 1,2 and 1,3.*

Low-Frequency Vibration (rms) . . . . 100 max. mv

For conditions shown above under *Low-Frequency Vibration Performance.*

Transconductance. . . . . 3900 min. µmhos

For conditions shown under *Characteristics Range Values Notes 1,5.*

Shorts and Continuity Test:

This test (similar to MIL-E-1D, par. 4.7.3) is performed on all tubes from each production run. Voltage applied between adjacent elements of the tube under test will be between 20 and 70 volts dc or peak ac. Plate and cathode terminals are tied together and connected to the grid terminal through the shorts test equipment. Tubes are tapped with a rubber tapper three times in each of three mutually perpendicular directions. If a short indication is obtained, the tapping cycle is repeated two times for verification. Acceptance criteria is based on the "Resistance vs. Time Duration" curve shown in par. 4.7.7 of MIL-1-D, Amendment 5.

Glass Seal Fracture Tests:

Fracture tests are performed on sample lots of subassemblies during manufacture.

1. Tubes (prior to final assembly) are placed on supports spaced 15/16" ± 1/64" apart with the grid flange centered between these supports. Tubes will withstand gradual application, perpendicular to the tube axis, of a force of 30 pounds upon the grid flange without causing fracture of the glass insulation.

2. Tubes (prior to final assembly) are held by clamping to the cathode cylinder. Tubes will withstand gradual application of a torque of 12.5 inch-pounds upon the plate terminal without causing fracture of the glass insulation.

Dynamic Life Performance:

This test (similar to MIL-E-1D, par. 4.11.3.2) is performed on a sample lot of tubes from each production run to insure high quality of rf performance. Each tube is life-tested in a cavity-type oscillator at 500 ± 15 Mc under the following conditions:

Heater voltage of 6.3 volts, plate-supply voltage of 300 volts, cathode resistor is adjusted to give a dc plate current of 25 ma and value is recorded, heater positive with respect to cathode by 100 volts, and plate-seal temperature of 175° C min.

At the end of 500 hours, the tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to meet the following limit.

Power Output. . . . . 0.2 min. watt

For conditions shown under *Characteristics Range Values Notes 1,7.*

OPERATING CONSIDERATIONS

Mechanical:

The *maximum plate-seal temperature* of 175° C is a tube rating and is to be observed in the same manner as other ratings. The temperature of the plate seal should be measured on the plate seal. The temperature may be measured with temperature-sensitive paint, such as *Tempilaq*. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y., in the form of a liquid or stick.

The *mounting* for the 4037A in cavity-type circuits should support the tube by the cathode cylinder which should make firm contact to the cavity surface. Connections to the grid flange and plate cylinder must be made by contacts with flexible leads to allow for variations in tube dimensions and eccentricities of the tube structure. In addition the plate connector should make firm, large-surface contact and be capable of conducting heat so that the plate-seal temperature will not exceed 175° C under any operating conditions. Contact should not be made to the 0.230" cap at the plate-terminal end of the tube as indicated on the *Dimensional Outline.*

Electrical:

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

In *class A_1 amplifier service,* grid-bias voltage should be obtained from a cathode resistor.

In *class C rf telegraphy service,* the 4037A may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 4037A is operated at a plate voltage of 300 volts, a fixed bias of at least -2 volts should be used.

In *plate-modulated class C rf power amplifier service,* the 4037A should be supplied with bias from a grid resistor, from a suitable combination of grid resistor and fixed supply, or from a suitable combination of grid resistor and cathode resistor. The cathode resistor should be bypassed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from the calculated values.

In *cathode-drive plate-modulated class C telephony service,* the 4037A can be modulated 100 percent if the rf driver stage is also modulated 100 percent simultaneously. Care should be taken to insure that the driver-modulation and the amplifier-modulation voltages are exactly in phase. In such service, the 4037A requires increased driving power, but increased power output is obtained.

In *cathode-drive circuits,* the driving voltage and the developed rf plate voltage act in series to supply the load circuit. Furthermore, the driving power required is greatly increased over that needed for grid-drive circuits. However, this increase in power is not lost, because it is transferred to the plate circuit and appears there as tube output.

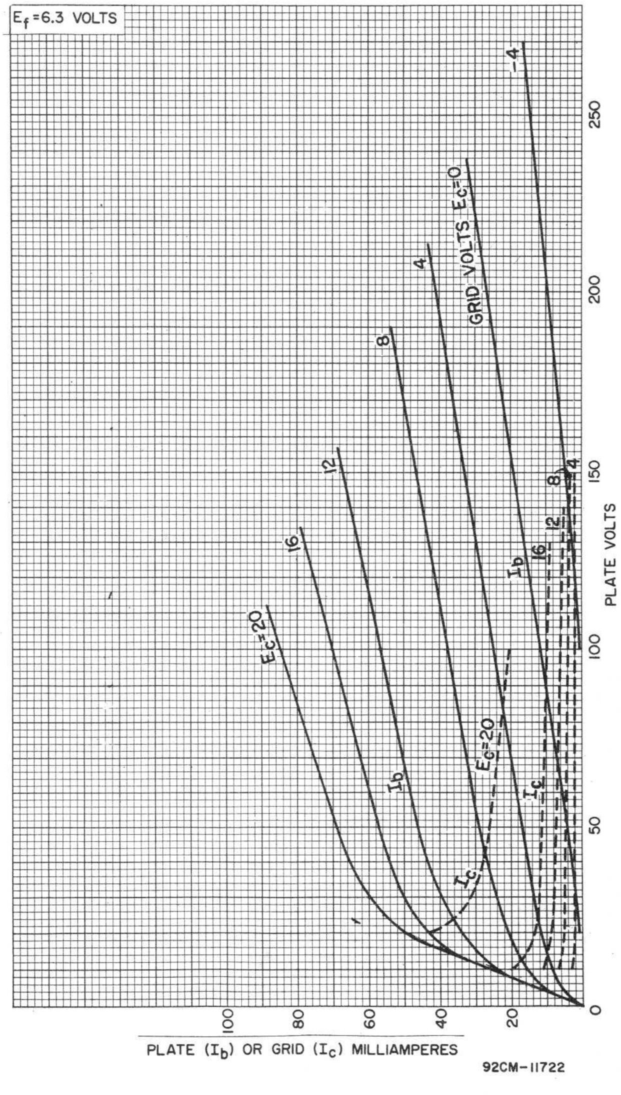
Another distinction between cathode-drive and grid-drive circuits is that in a grid-drive circuit where a surplus of grid driving power is always available, the power output is only moderately affected by variations in tube characteristics and operating conditions with the result that the power output is fairly independent of such variations. In a cathode-drive circuit, however, because part of the driving power is transferred to the output circuit, the power output continues to increase with increased driving power to the point that the tube may be seriously overloaded. This difference in the operating nature of the two circuits is especially important when several tubes are operated in cascade.

In the grid-drive circuit, the output from the final stage is affected to only a minor degree by variations in tube characteristics and operating conditions, whereas in a cathode-drive circuit, the effects of either high or low efficiency are cumulative and can produce wide differences in power output. It is important, therefore, in the design of cathode-drive circuits that due allowances are made for the normal variations which can be expected from individual tubes.

For example, it is not good design practice to base the expected performance of cascaded cathode-drive stages on a few high performance tubes. If this practice were to be followed, a substantial percentage of tubes would either not give the anticipated performance or would be disastrously overloaded.

In tuning a cathode-drive rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

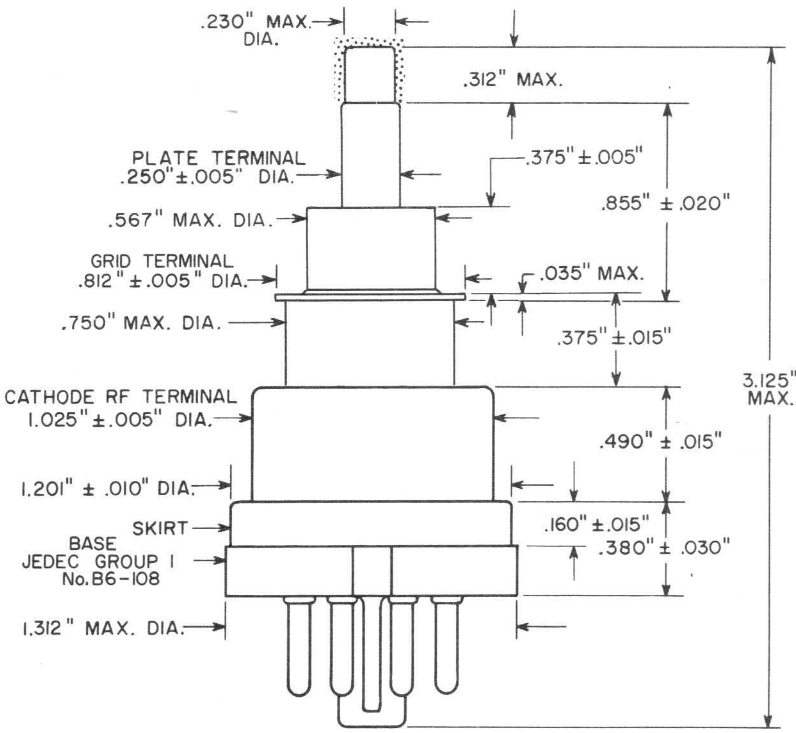
Push-pull or parallel circuit arrangements may be used when more radio-frequency power is required than can be obtained from a single tube. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single



Average Characteristics of Type 4037A.

tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. When two or more tubes are used in the circuit, precautions should be taken to balance the plate currents.

DIMENSIONAL OUTLINE



STIPPLED REGION (NOTE 1)

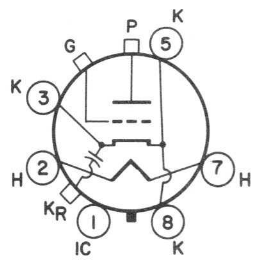
92CM-11472R2

NOTE 1: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE AREAS.

BASING DIAGRAM

Bottom View

PIN 1: IC — Do Not Use
PIN 2: HEATER
PIN 3: CATHODE
PIN 5: CATHODE
PIN 7: HEATER
PIN 8: CATHODE



KR: CATHODE RF TERMINAL (Cylinder adjacent to base)

G: GRID (Flange between insulator sections)

P: PLATE (Cylinder adjacent to upper insulator section)

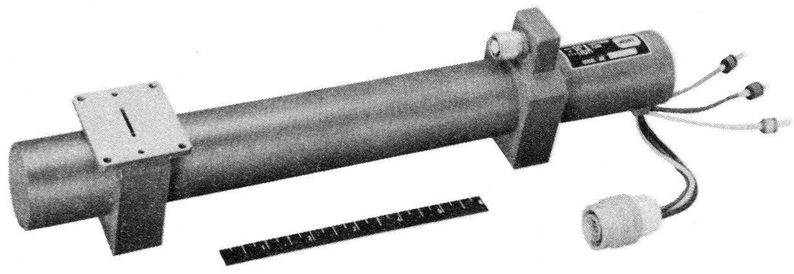
RCA

RCA-4041
Traveling-Wave Tube

1.0 Watt Min. Power Output
34 dB Gain

Frequency Range
8 to 12 GHz

Integral Periodic-Permanent-Magnet Type



H-1577

RCA-4041 is an intermediate-power, X-band traveling-wave amplifier tube. It is a helix-transmission-line type and incorporates periodic-permanent-magnet focusing.

The 4041 can provide a typical saturated power output of 1.5 watts and a typical small-signal gain of 37 dB across the 8 to 12 GHz frequency range.

Design features of the 4041 include built-in periodic permanent magnets to focus the electron beam and a ruggedized construction.

Variants of the basic tube design can be developed to meet special requirements.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (ac or dc)	6.3 ± 5%	V
Current at 6.3 volts	0.7	A
Starting Current	Must never exceed 4 amperes, even momentarily	
Minimum Cathode Heating Time	3	minutes
Frequency Range	8 to 12	GHz
Cold Insertion Loss	60	dB
Input VSWR	2.5:1 max.	
Output VSWR	2.0:1 max.	
Gain, Small Signal (at 0.1 W output) 8.0 to 12 GHz	34 min.	dB

Mechanical:

Operating Position	Any	
Maximum Dimensions:		
Overall Length	15 max.	in
Height	3.25 max.	in
Width	2.20 max.	in
Shell Diameter	1.75	in
Connectors:		
RF Input	Type TNC Plug	
RF Output	Special Flange Coupling	
Terminal Leads	See *Dimensional Outline*	
Weight (Approx.)	6.0	lb

RF POWER AMPLIFIER

Maximum Ratings, *Absolute-Maximum Values:*[a]

DC Collector Voltage	3000 max.	V
DC Helix Voltage	2950 max.	V
DC Grid-No.2 Voltage	2000 max.	V
DC Collector Current	15 max.	mA
DC Helix Current	2.5 max.	mA
DC Grid-No.2 Current	0.1 max.	mA
RF Power Input	1 max.	mW

Typical Operation at 10 GHz:

DC Collector Voltage	3000	V
DC Helix Voltage	2800	V
DC Grid-No.2 Voltage	1800	V
DC Collector Current	12	mA
DC Helix Current	0.5	mA
DC Grid-No.2 Current	0	mA
Input VSWR	2.0:1	
Output VSWR	1.5:1	
RF Power Input	1 to 10	mW
Saturated Power Output	1.5	W

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.5	1.1	A
DC Collector Voltage	2,3	2600	3000	V
DC Helix Voltage	2,3	2600	2950	V
DC Grid-No.2 Voltage	3	1600	2000	V
DC Collector Current	3	8	15	mA
DC Helix Current	3	0.1	2.5	mA
DC Grid-No.2 Current	–	0	0.1	mA

Note 1: With heater voltage of 6.3 volts.

Note 2: Normally the tube is operated with the helix voltage equal to the collector voltage.

Note 3: Specific operating value is supplied with each tube.

[a] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

OPERATING CONSIDERATIONS

The magnetic field required to focus the electron beam in the 4041 is supplied by integral periodic permanent magnets. Although the periodic-magnet structure is difficult to demagnetize, and has little stray field, care should be taken to prevent the presence of any appreciable external transverse magnetic field which might cause defocusing of the electron beam within the tube. Magnetic material should be kept at least eight inches away from the tube.

Impedance match between the 4041 rf power output and the load should have a voltage standing wave ratio (VSWR) no greater than 4:1. With VSWR's in excess of 4:1, oscillations may occur causing permanent damage to the tube. Tubes should not be operated without a termination.

Conduction cooling on the tube is necessary whenever collector current is flowing. Failure to observe this precaution may result in permanent damage to the tube.

The power supply should incorporate a helix-current overload protective device to prevent damage to the tube in the event of loss of collector voltage. Such a condition would cause the entire electron beam current to flow to the helix and thereby overheat that electrode. If it is desired to remove all voltages by a single control, the time-constant values of the power supply should be chosen so that the grid No.2 voltage decays faster than all other voltages (except the heater voltage).

Mounting. The 4041 may be mounted in any position by means of clamps around the specified areas shown on the *Dimensional Outline.*

Electrical connections are made to the 4041 by means of the six leads. These color-coded, flexible, insulated leads are identified on the *Dimensional Outline.* The rf input is made to a type TNC male plug on the tube, the rf output is by means of a flange coupling and a transition piece (see *Dimensional Outline*). The collector is connected to the capsule and is normally grounded.

The rated values for collector voltage, helix voltage, and grid-No.2 voltage are high enough to be dangerous to the user. Care should be taken during adjustment of circuits, especially when exposed circuit parts are at a high dc potential.

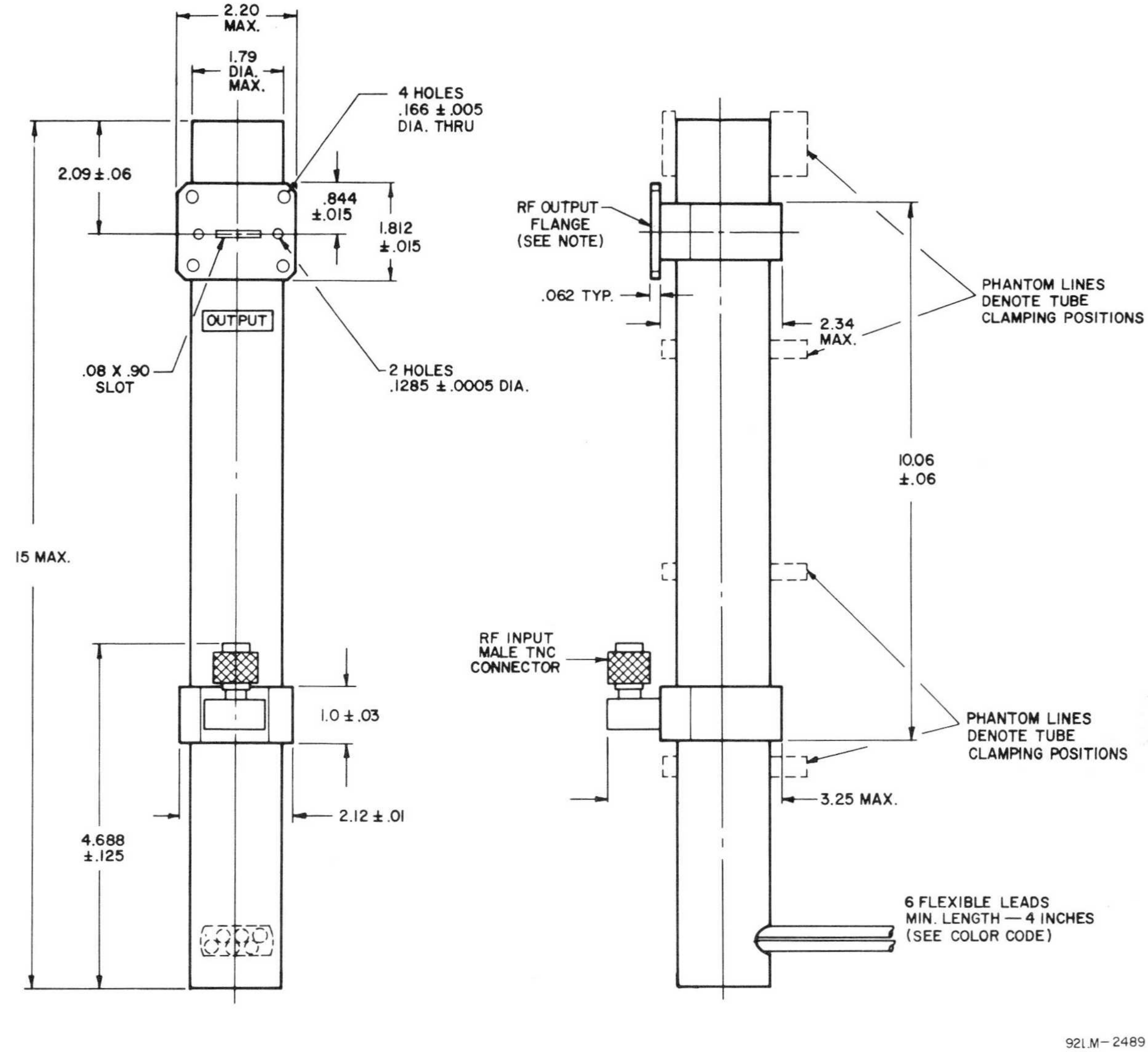
Starting Procedure

Voltages should be applied to the 4041 in the following sequence: Apply the rated heater voltage and allow tube to warm-up for 3 minutes minimum. Then apply the collector voltage as specified on the tube label. Next, apply the helix voltage as specified on the tube label. Finally, increase the grid-No.2 voltage in a few milliseconds to obtain the collector current specified on the tube label. The three power supplies can be controlled by one switch provided there is a sufficient delay in application of the grid-No.2 voltage to allow the collector and helix voltages to stabilize first.

Turn-Off Procedure

To turn off the tube, remove the electrode voltages in the following sequence: First reduce the grid-No.2 voltage, then remove the helix voltage, collector voltage, and heater voltage in that order. The three power supplies can be controlled by one switch provided the grid-No.2 voltage decays faster than the collector and helix voltages.

DIMENSIONAL OUTLINE



COLOR CODE

Yellow: Heater-Cathode
Brown: Heater
Green: Grid No. 1
Black: Collector (Ground)
Orange: Helix
Blue: Grid No. 2 (Anode)

Note: RF output flange requires use of a transition piece (Waveline Type 60083, or equivalent) if matching to standard waveguide flange.

DIMENSIONS IN INCHES

RCA | Electronic Components | Harrison, N.J. 07029

TYPE

4055

(Formerly A15499)

MICROWAVE DEVICES

HIGH-MU CERAMIC-METAL

PENCIL TRIODE

INITIAL DATA

APPLICATIONS

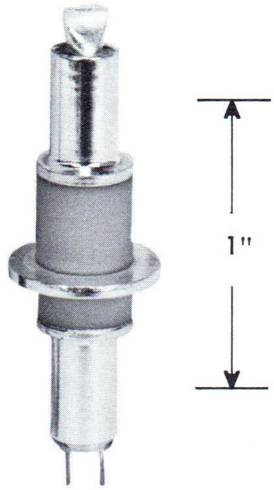
TO 4000 Mc

Oscillator (Plate-or Grid-Pulsed)

Amplifier (Grid-or Cathode-Pulsed)

OVER 1000 Mc

Frequency Multiplier



FEATURES*

Smaller

Improved Processing

Greater Endurance To Nuclear Radiation

Higher Operating Temperature

Sturdier

Excellent Thermal Stability

Fast Warmup   Fast Heat Dissipation

*As compared to similarly rated glass-metal tube.

For further information or application assistance on this or other RCA microwave devices please contact your field representative at the RCA District Office nearest you (See list on back page) or Manager, Marketing, Microwave Tube Operations Department.

GENERAL DATA

ELECTRICAL:

Heater volts	6.3 ± 10%
Heater amperes	0.295
Direct interelectrode capacitances:	
Grid to plate	1.9 pf
Grid to cathode	5.5 pf
Plate to cathode	0.07 max. pf
Amplification factor	70
Transconductance	35000 µmhos

MECHANICAL:

Mounting position	Any
Plate-seal temperature	225°C max.
Altitude (without pressurization 3500 volts dc applied between plate cylinder and grid flange)	25000 ft
Weight	0.4 oz.

PLATE-PULSED SERVICE—CLASS C

Maximum Ratings (absolute values)*

Peak positive plate-supply volts	3500
Peak plate amperes from pulse supply	3.0
DC plate milliamperes	40
DC grid milliamperes	15
Plate dissipation	10 watts
Pulse duration	5.0 µsec
Duty factor	0.01
Total pulse duration for any 5000 µsec interval	50 µsec

Typical Operation as a Plate-Pulsed Oscillator at 3300 Mc.

Heater volts	6.0
Peak positive plate supply volts	1750
DC plate milliamperes	3.0
DC grid milliamperes	1.4
Grid resistor	2000 ohms
Pulse duration	1.0 µsec
Pulse repetition frequency	1000 pps
Duty factor	0.001
Useful power output at peak of pulse	1300 watts

GRID-OR-CATHODE—PULSED SERVICE CLASS C

Maximum Ratings (absolute values)*

Plate supply volts	2000
Grid bias volts	-100 (min)
Peak plate amperes	3.0
Peak grid amperes	1.5
Pulse width	5.0 µsec
Duty factor	0.01
Plate dissipation**	10.0 watts

* The absolute maximum ratings shown are individual ratings and apply only to single characteristics. Care must be exercised so as not to exceed individual ratings or approach maximum ratings on all parameters simultaneously.

** When used in a heat sink that will limit the plate-seal temperature to 225°C.

Typical Operation as a Grid-Pulsed Amplifier at 1090 Mc.

Plate supply volts.	1000
Bias volts.	-30
Peak driver power	50 watts
Peak power output	600 watts
Pulse duration.	0.5 μsec
Pulse repetition rate	2000 pps
Peak plate amperes.	1.5

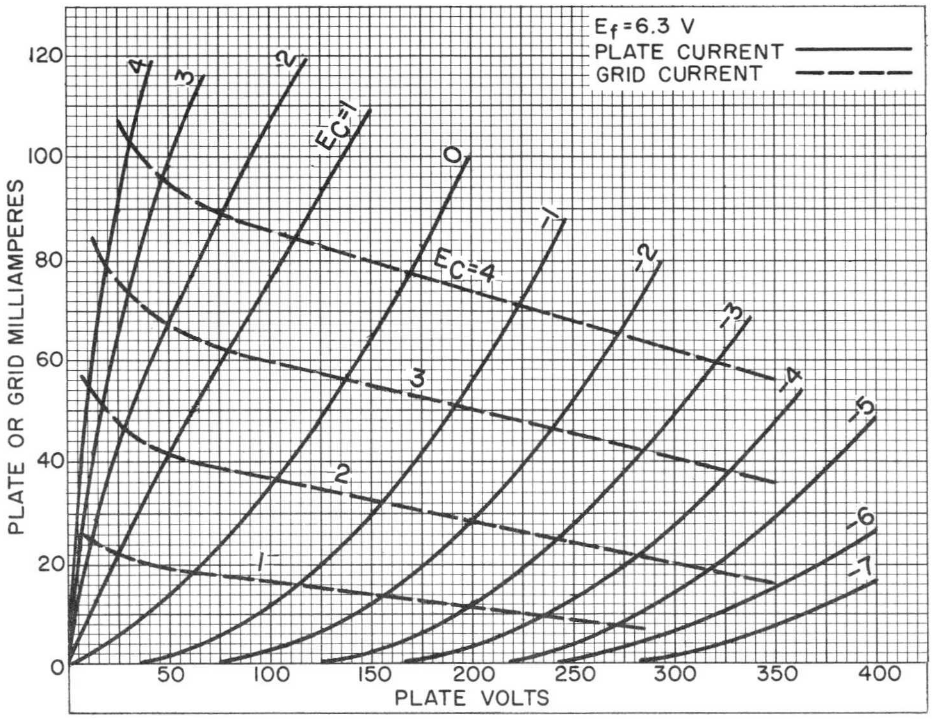


Fig. 1 - Average Plate and Grid Characterestics.

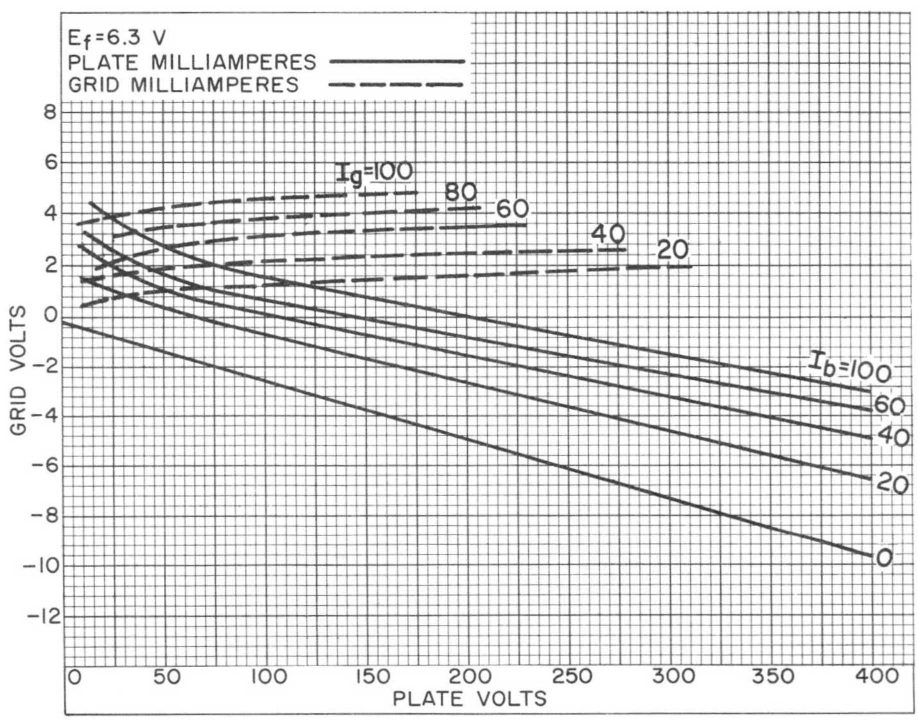


Fig. 2 - Constant-Current Curves

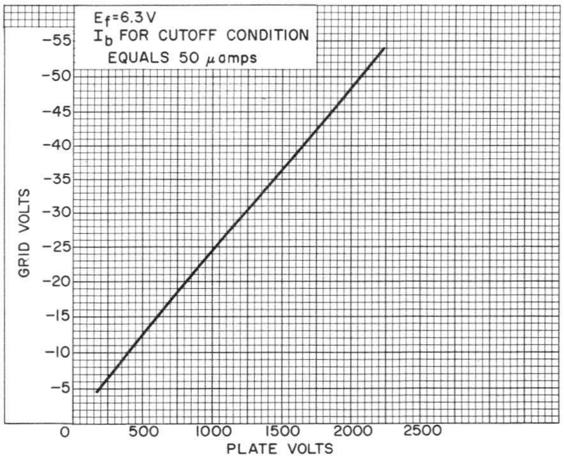
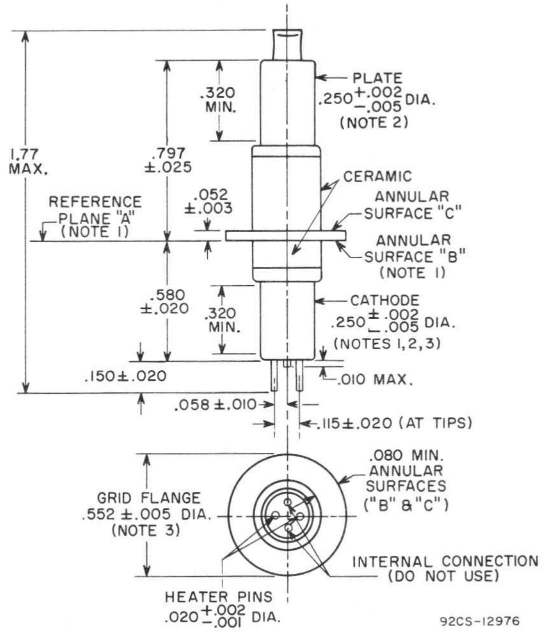


Fig. 3 - Plate-Current Cutoff Characteristic.

DIMENSIONAL OUTLINE



Reference Plane "A" is defined as that plane against which annular surface "B" of the grid flange abuts.

Annular Surface "B" is on the side of the grid flange toward the cathode cylinder.

Annular Surface "C" is on the side of the grid flange toward the plate cylinder.

Note 1: With annular surface "B" resting on reference plane "A", the axis of the cathode cylinder will be within 2° of a line perpendicular to reference plane "A".

Note 2: The axes of the plate cylinder and cathode cylinder will coincide within 0.010 inch.

Note 3: The axes of the cathode cylinder and grid flange will coincide within 0.010 inch.

For further information or application assistance, please contact your field representative at the RCA District Office nearest you or Manager, Marketing, Microwave Tube Operations Department.

32 Green Street
Newark, N.J 07102
201 485-3900

1725 K Street, N.W.
Washington, D.C. 20006
202 Fe 7-8500

446 East Howard Avenue
Des Plaines, Illinois 60018
312 827-0033

7901 Carpenter Freeway
Dallas, Texas 75247
214 Me 1-3050

714 New Center Bldg.
Detroit, Mich. 48202
313 875-5600

6363 Sunset Blvd.
Hollywood, Calif 90028
213 461-9171

Suite P
4546 El Camino Real
Los Altos, Calif 94022
415 948-8996

RCA Victor Limited
1001 Lenoir Street
Montreal PQ Canada
514 WE 3-7551

Product Marketing
RCA Electronic Components and Devices
Microwave Tube Operations Department
1000 South 2nd Street
Harrison, N.J.
201 485-3900

RCA International Division
118 Rue du Rhone
Geneva, Switzerland
022 35-75-00 to 09

MICROWAVE DEVICES

PENCIL TRIODE

MEDIUM-MU GLASS-METAL

TYPE 4058

INITIAL DATA

RCA-4058 is a uhf triode utilizing coaxial pencil-type structure and having an amplification factor of 40. It is intended particularly for use as a plate-pulsed or grid-pulsed oscillator and amplifier at frequencies up to 4000 Mc/s and at altitudes up to 30,000 feet without pressurization. The 4058 may also be used as an rf power amplifier, cw oscillator, or frequency multiplier up to 1700 Mc/s and at altitudes up to 60,000 feet without pressurization. Its structure makes it especially suitable in cathode-drive service. In such applications, the grid is employed to provice rf isolation within the tube between the load circuit and the input circuit. The 4058 can be operated with full ratings at frequencies up to 4000 Mc/s in pulse service and 2000 Mc/s in cw service.

Actual Size

Featured in the 4058 is a construction which not only meets requirements as to minimum transit time, low lead inductance, and low interelectrode capacitances, but also provides other desirable design features such as sturdiness, small size, light weight, low heater power, fast warmup time, good thermal stability, and convenience of use in equipment design.

The coaxial-electrode structure is of the double-ended metal-glass type in which the plate cylinder and cathode cylinder extend outward from each side of the grid flange. The latter is particularly effective in permitting isolation between the load circuit and the input circuit in cathode-drive service. In addition, the disk-seal type of electrode termination, inherent in the design of pencil tubes, permits the utilization of closed-cavity resonators which minimize power loss through radiation, besides giving much lower inductance values and higher resonant frequencies than are obtainable with wire leads. Although designed for use in circuits of the coaxial-cylinder type, the 4058 is also suitable for use in circuits of the line type and lumped-circuit type.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC):		
Under transmitting conditions	6.0 ± 10%	volts
Under standby conditions	6.3 max.	volts
Current at 6.0 volts	0.300	amp
Amplification Factor	40	
Transconductance, for dc plate current of 22 milliamperes and dc plate voltage of 200 volts	7300	μmhos
Direct Interelectrode Capacitances (Approx.):		
Grid to plate	1.8	pF
Grid to cathode	3.2	pF
Plate to cathode	0.07 max.	pF

Mechanical:

Operating Position		Any
Dimensions and Terminal Connections	See *Dimensional Outline*	
Plate Seal Temperature	175 max.	°C
Weight (Approx.)	0.4	oz
Sockets:		
Heater terminals connector	Grayhill No.22-3[a]	

For further information or application assistance on this device, contact your RCA Field Representative or write Microwave Marketing, RCA, Harrison, N.J.

PLATE-PULSED OSCILLATOR[b] – Class C

Maximum CCS[c] Ratings, *Absolute-Maximum Values*[d] *up to 4000 Mc/s:*

For a maximum "ON" time[e] of 5 microseconds in any 500-microsecond interval.

For Altitudes up to 30,000 ft.

Peak Positive-Pulse Plate-Supply Voltage[f]	2000 max.	volts
Peak Grid-Bias Voltage		
Negative Pulse	150 max.	volts
Positive Pulse	25 max.	volts
Peak Plate Current from Pulse Supply	3 max.	amp
Peak Rectified Grid Current	1.5 max.	amp
DC Plate Current	0.03 max.	amp
DC Grid Current	0.013 max.	amp
Plate Dissipation[g]	7 max.	watts
Pulse Duration	5 max.	µsec

Typical Operation with Rectangular Wave Shape in Cathode-Drive Circuit at 3300 Mc/s:

With duty factor[h] of 0.01 and pulse duration of 1 microsecond

Peak Positive-Pulse Plate-Supply Voltage[f]	1750	volts
Peak Negative-Pulse Grid-Bias Voltage	110	volts
From grid resistor of	100	ohms
Peak Plate Current from Pulse Supply	3.0	amp
Peak Rectified Grid Current	1.1	amp
DC Plate Current	0.03	amp
DC Grid Current	0.011	amp
Useful Power Output at Peak of Pulse[i] (Approx.)	800	watts

RF POWER AMPLIFIER AND OSCILLATOR – Class C Telegraphy

Key-down conditions per tube without amplitude modulation[k]

Maximum Ratings, *Absolute-Maximum Values:*[d]

For Altitudes up to 60,000 ft.

	CCS[c]	*ICAS*[m]	
DC Plate Voltage	330 max.	400 max.	volts
DC Grid Voltage	–100 max.	–100 max.	volts
DC Plate Current	40 max.	55 max.	mA
DC Grid Current	25 max.	25 max.	mA
DC Cathode Current	55 max.	70 max.	mA
Plate Input	13.2 max.	22 max.	watts
Plate Dissipation	8 max.	13 max.	watts
Peak Heater-Cathode Voltage:			
Heater negative with respect to cathode	50 max.	50 max.	volts
Heater positive with respect to cathode	50 max.	50 max.	volts

Typical Operation as Oscillator in Cathode-Drive Circuit at 500 Mc/s:

	CCS[c]	*ICAS*[m]	
DC Plate-to-Grid Voltage	325	380	volts
DC Cathode-to-Grid Voltage[h]	25	30	volts
DC Plate Current	35	35	mA
DC Grid Current (Approx.)	11	13	mA
Useful Power Output (Approx.)	5[p]	6[p]	watts

Typical Operation as Oscillator in Cathode-Drive Circuit at 1700 Mc/s:

	CCS[c]	
DC Plate-to-Grid Voltage	263	volts
DC Cathode-to-Grid Voltage[h]	13	volts
DC Plate Current	40	mA
DC Grid Current (Approx.)	13	mA
Useful Power Output (Approx.)	1.0[p]	watts

Typical Operation as RF Power Amplifier in Cathode-Drive Circuit at 500 Mc/s:

	CCS[c]	*ICAS*[m]	
DC Plate-to-Grid Voltage	342	395	volts
DC Cathode-to-Grid Voltage[h]	42	45	volts
DC Plate Current	35	40	mA
DC Grid Current (Approx.)	13	15	mA
Driver Power Output (Approx.)	2.4	3	watts
Useful Power Output (Approx.)	7.5[p]	10[p]	watts

Maximum Circuit Values:

Grid-Circuit Resistance	0.1 max.	0.1 max.	megohm

FREQUENCY MULTIPLIER

Maximum Ratings, *Absolute-Maximum Values:*[d]

For Altitudes up to 60,000 ft.

	CCS[c]	*ICAS*[m]	
DC Plate Voltage	300 max.	350 max.	volts
DC Grid Voltage	–125 max.	–140 max.	volts
DC Plate Current	33 max.	45 max.	mA
DC Grid Current	25 max.	25 max.	mA
DC Cathode Current	45 max.	55 max.	mA
Plate Input	9.9 max.	15.9 max.	watts
Plate Dissipation	6 max.	9.5 max.	watts
Peak Heater-Cathode Voltage:			
Heater negative with respect to cathode	50 max.	50 max.	volts
Heater positive with respect to cathode	50 max.	50 max.	volts

Typical Operation as Tripler to 510 Mc/s in Cathode-Drive Circuit:

	CCS[c]	*ICAS*[m]	
DC Plate-to-Grid Voltage	410	472	volts
DC Cathode-to-Grid Voltage[h]	110	122	volts
DC Plate Current	26	36.5	mA
DC Grid Current (Approx.)	4.1	5.8	mA
Driver Power Output (Approx.)	2.75	4.5	watts
Useful Power Output (Approx.)	2.1[p]	3.4[p]	watts

Maximum Circuit Values:

Grid-Circuit Resistance	0.1 max.	0.1 max.	megohm

---

[a] Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill.

[b] In this class of service, the heater should be allowed to warm up for a minimum of 60 seconds before plate voltage is applied.

[c] Continuous Commercial Service.

[d] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[e]"ON" time is defined as the sum of the duration of all individual pulses which occur during the indicated interval. *Pulse duration* is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak power value. The *peak value* is defined as the maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse.

[f]The magnitude of any spike on the plate voltage pulse should not exceed a value of 2000 volts with respect to cathode and its duration should not exceed 0.01 microsecond measured at the peak-pulse-value level.

[g]In applications where the plate dissipation exceeds 3 watts, it is important that a large area of contact be provided between the plate cylinder and the connector in order to provide adequate heat conduction.

[h]Duty factor is the product of pulse duration and repetition rate. For variable pulse durations and pulse repetition rates, the duty factor is defined as the ratio of time "ON" to total elapsed time in any 500-microsecond interval.

[i]The power output at peak of pulse is obtained from the average power output using the duty factor of the peak pulse. This procedure is necessary since the power output pulse duty factor may be less than the applied voltage pulse duty factor because of a delay in the start of rf power output.

[k]Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

[m]Intermittent Commercial and Amateur Service.

[n]From a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor.

[p]This value of useful power is measured at load of output circuit having an efficiency of about 75 percent.

AVERAGE PLATE CHARACTERISTICS OF TYPE 4058

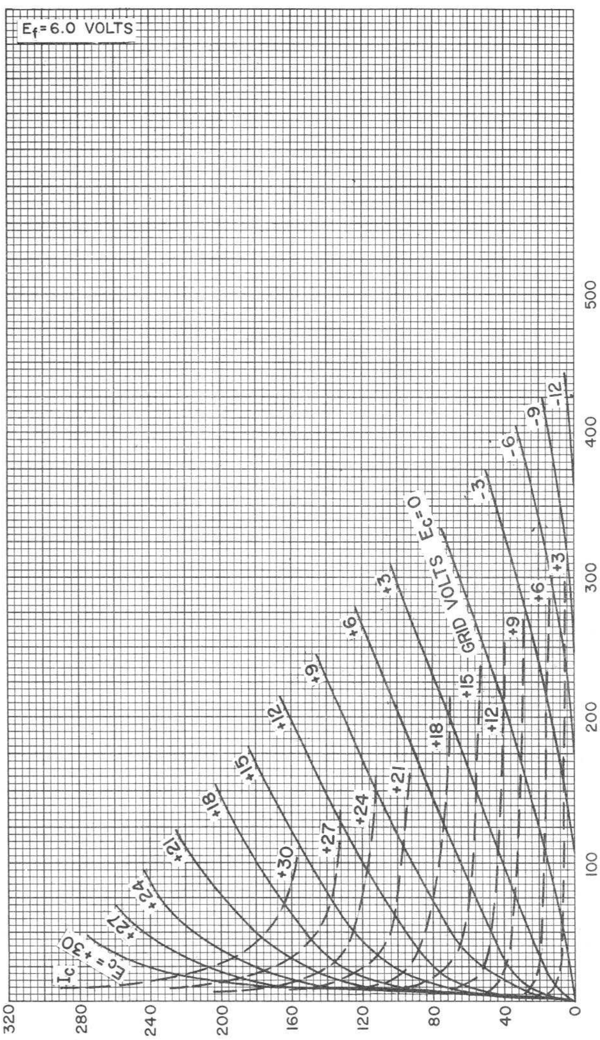


Fig.1

AVERAGE CONSTANT-CURRENT CHARACTERISTICS OF TYPE 4058

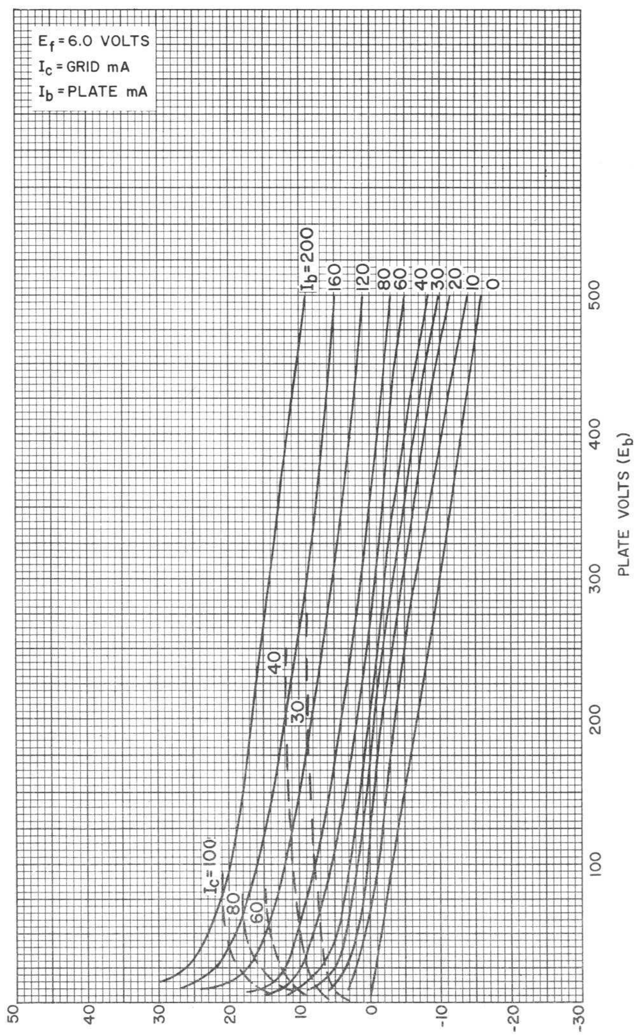
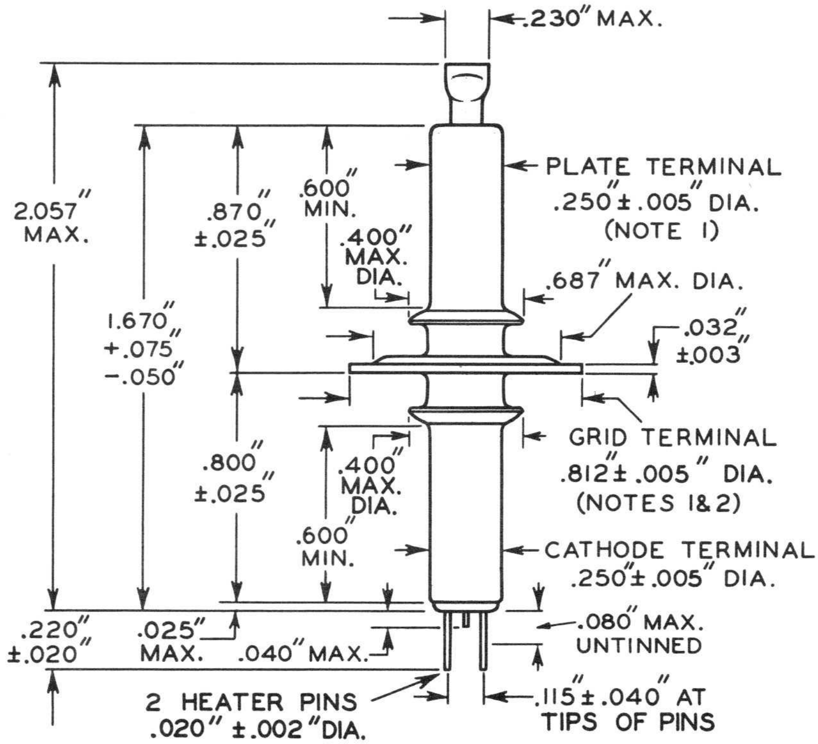


Fig.2

DIMENSIONAL OUTLINE



92CS-7419R3

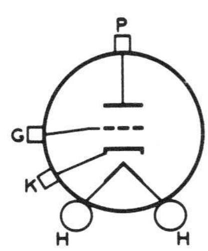
NOTE 1: Max. eccentricity of ℄ (Axis) of plate terminal or grid-terminal flange with respect to the ℄ (Axis) of the cathode terminal is 0.010".

NOTE 2: Tilt of grid-terminal flange with respect to rotational axis of cathode terminal is determined by chucking the cathode terminal, rotating the tube, and gauging the total travel distance of the grid-terminal flange parallel to the axis at a point approximately 0.020" inward from its edge for one complete rotation. The total travel distance will not exceed 0.020".

TERMINAL CONNECTIONS

H: HEATER

K: CATHODE (Cylinder adjacent to heater pins)



G: GRID (Flange between glass sections)

P: PLATE (Cylinder adjacent to pinch-off)

MICROWAVE DEVICES

L-BAND PENCIL-TUBE OSCILLATOR-AMPLIFIER

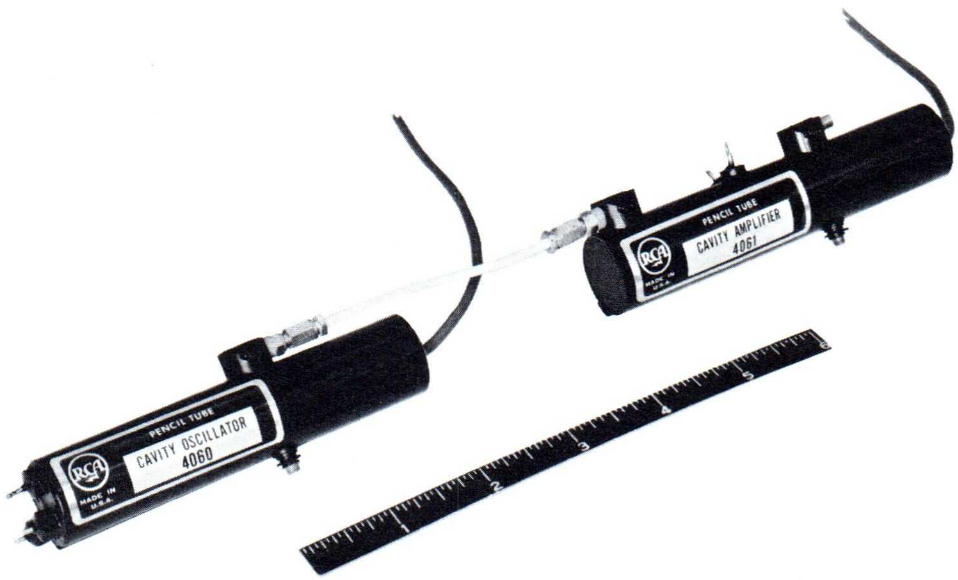
1090 Mc/s 500W PEAK

TYPE

4060-4061

(Formerly A15487-A15488)

INITIAL DATA



RCA-4060-4061 is a ruggedized oscillator-amplifier combination consisting of a grid-pulsed pencil-tube-and-cavity oscillator and a grounded-grid pencil-tube-and-cavity amplifier. These units, designed to implement new airborne transponder systems, are built to satisfy all AIMS requirements.

FEATURES

- Oscillator performance is not affected under open or short circuit conditions in the output circuit of the amplifier
- 45% to 75% lighter than similar transponder cavities
- Meet frequency stability requirements with a mismatch up to 4:1
- Low power drain— dc supply voltage of 1000 volts or less
- Integral design approach permits improved efficiencies

For further information or application assistance on this device, contact your RCA Field Representative or write Microwave Marketing, RCA, Harrison, N.J.

RADIO CORPORATION OF AMERICA
Electronic Components and Devices Harrison, N. J.

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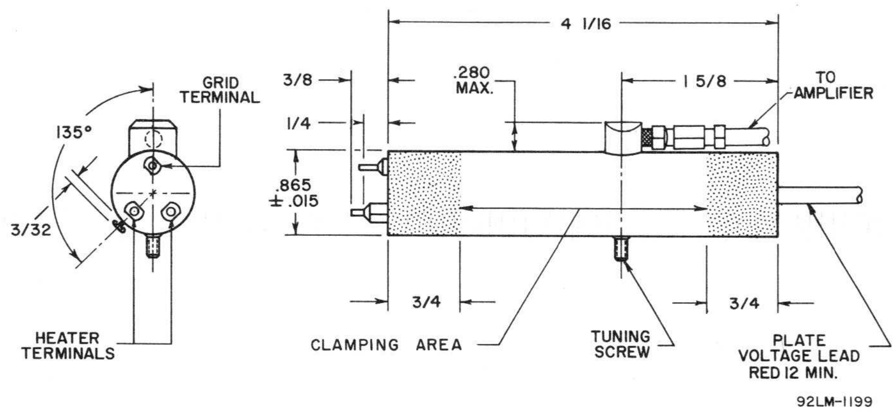
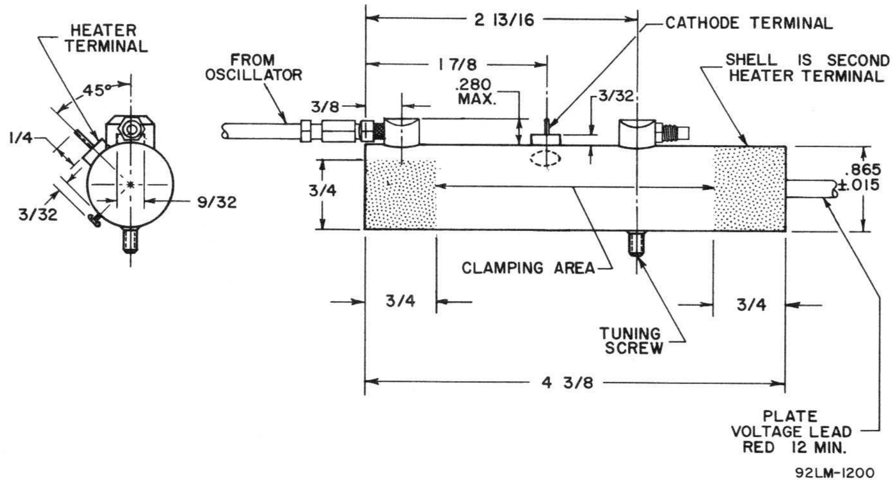
DIMENSIONAL OUTLINE

4060



4061



These units are supplied without the mounting brackets; they are also available with brackets upon request.

DIMENSIONS IN INCHES

This bulletin is to be used in conjunction with the bulletin for RCA-7513.

For your Information
RCA International Division
Licensee Service Harrison, N.J.

4415, 4416

IMAGE ORTHICONS

High Sensitivity Types
For Color Pickup in Black-and-White Studios

RCA-4415 and -4416 are image-orthicon type camera tubes designed especially for color pickup in TV studios having lighting facilities ordinarily considered satisfactory for only black-and-white pickup. The 4415 and 4416 are supplied as a specially selected set of three tubes—two 4415's for the red and green channels, one 4416 for the blue channel—and are intended primarily for color cameras utilizing the principles of simultaneous pickup.

Each tube in the set has closely matched characteristics that insure uniformity of sensitivity and uniformity of background over the entire scanned area of the target. As a result, true color reproduction over the entire picture area is obtained. In addition, each tube in the set employs precision construction and a field mesh to assure good registration of the three color images. Use of the field mesh reduces edge effects such as exaggerated borders between high contrast objects, reduces "beam bending" due to charge pattern on the target, and improves beam trajectory and corner focus. As a result, good registration is achieved under all lighting conditions, dark corners in the picture are eliminated, and improved picture sharpness is obtained.

In order to take full advantage of the precision capabilities of the 4415 and 4416, the color cameras should be equipped with deflecting yokes and focusing coils having precision construction and precision axial alignment with respect to each tube. The resultant effect will be excellent registration of the three images to produce superior pictures on color receivers. In addition, pictures produced on black-and-white receivers will have high resolution and normal tone rendition.

DATA

General:

	Type 4415	*Type 4416*	
Spectral Response	S-10	S-11	
Wavelength of Maximum Response	4500 ± 300	4400 ± 500	angstroms

Performance Data:

	Type 4415 Min.	*Type 4415* Av.	*Type 4415* Max.	*Type 4416* Min.	*Type 4416* Av.	*Type 4416* Max.	
Cathode Radiant Sensitivity at 4400 angstroms.	-	-	-	-	0.040	-	μa/μw
Cathode Radiant Sensitivity at 4500 angstroms.	-	0.028	-	-	-	-	μa/μw
Signal-Output Current (Peak to peak). . . .	4	-	30	4	-	30	μa
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current for Bandwidth of 4.5 Mc. . . .	30:1	37:1	-	30:1	37:1	-	

Performance Characteristics:

Because of the high sensitivity of the 4416 in the blue channel, cameras employing the 4415-4416 set will have greatly increased overall sensitivity. Color reproduction will also be excellent. The set is capable of producing high-quality color pictures when scenes illuminated by incandescent light provide scene-luminance levels of approximately 100 footlamberts with a lens opening of f/8.

Installation Precaution:

The 4416 has S-11 response and is specifically intended for use in the blue channel. Its sensitivity to blue light is nearly twice that of the 4415's. However, its low green response and negligible red response restrict its use to this channel only. Either of the 4415's, which have the panchromatic S-10 response, may be used in the green or red channels. Improved performance is obtained, however, if the most sensitive of the 4415's is placed in the least sensitive of these two channels.

If a replacement tube is desired for any given set of tubes, reference should be made in the replacement order to the serial numbers of the remaining tubes in the set.

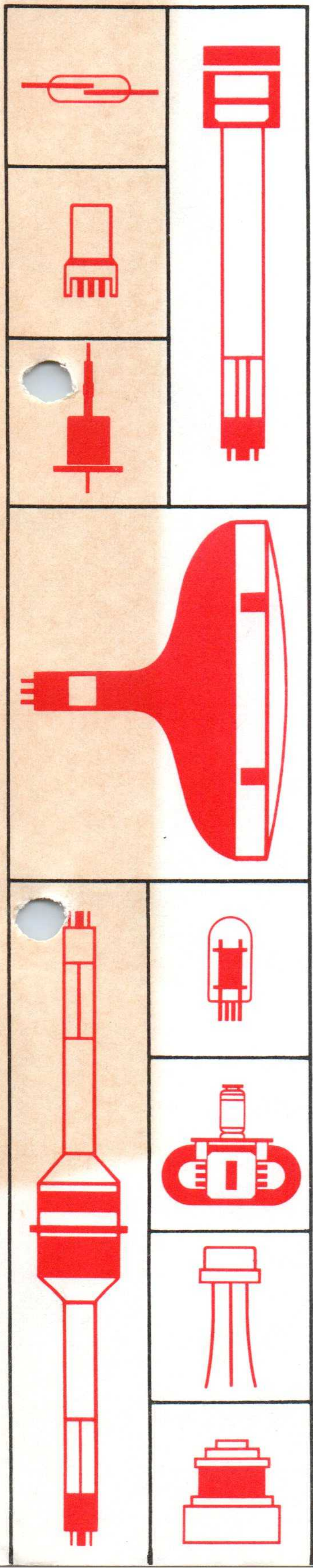
For additional information on the 4415 and 4416, see the following sections in the attached RCA-7513 technical bulletin. Information shown in the 7513 bulletin under *Principles of Operation, Maximum Ratings, Typical Operating Values, Set-Up Procedure,* and *Do's and Don'ts* is directly applicable to the 4415-4416 set. The *Dimensional Outline* and *Basing Diagram* shown for the 7513 also apply to types 4415 and 4416.

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-4441A*
RCA-4459**

NEW HEAD-ON-TYPE MULTIPLIER PHOTOTUBES

RCA-4441A is the first in a series of RCA multiplier phototubes for which tube ruggedness and reliability are assured by 100 per cent environmental testing. The tube is designed to withstand the environmental conditions specified by MIL-E-5272C for equipment mounted on the structures of missiles launched by high-thrust engines.

RCA-4459 is a multialkali-photocathode version of RCA-7850 and is intended for ruby laser detector systems, photometry, and other applications where high sensitivity in conjunction with short rise time capability is required.

Characteristics Summary

	RCA-4441A	RCA-4459
Spectral Response	S-11	S-20
Wavelength of Max. Response	4400 Å	4200 Å
Approx. Spectral Range	3000 to 6500 Å	2900 to 8000 Å
No. of Stages	10	12
Nominal Diameter	1.5"	2"
	@ 1000 volts	@ 2300 volts
Typical Luminous Sensitivity	27 a/lm	1000 a/lm
Typical Current Amplification	$6x10^5$	$6.6x10^6$
Anode Pulse Rise Time	2.8 nanoseconds	2 nanoseconds
Vibration	20 g's	-
Shock	30 g's	-
Acceleration	100 g's	-

Further technical information on the 4441A and 4459 is given in the attached technical bulletins.

November 18, 1963

RCA-4441A

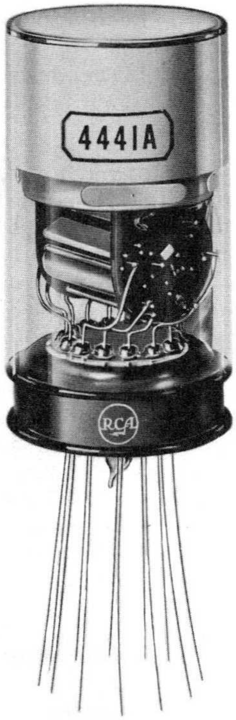
MULTIPLIER PHOTOTUBE

Rugged Vibration-Resistant Structure
S-11 Spectral Response
10-Stage, Head-On Type
1.24" Min. Dia. Flat Face
Semitransparent Photocathode

For Use Under Severe Environmental Conditions

Formerly Developmental Type C70113C

INITIAL DATA



RCA-4441A is a ruggedized, 10-stage, head-on type of multiplier phototube intended for industrial and military nuclear-radiation and low-level light detection-and-measurement applications where severe environmental conditions may be encountered. It is designed specifically for use in missile and rocket applications. The 4441A features an extremely rugged construction and utilizes a special photocathode connection which assures continuous contact with the cathode when the tube is subjected to rough usage. Other design features include a semitransparent cathode having a minimum diameter of 1.24 inches on the inner surface of the face end of the bulb; a face with a flat surface to facilitate the mounting of flat scintillators; ten electrostatically focused multiplying (dynode) stages; and semiflexible leads that may be soldered directly into the associated circuit.

The spectral response of the 4441A covers the range from about 3000 to 6500 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4400 angstroms. The 4441A, therefore, has high sensitivity in the blue and less sensitivity in the red region of the spectrum.

DATA

General:

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 angstroms
Cathode, Semitransparent	Cesium-Antimony
Shape	Flat, Circular
Minimum area	1.2 sq. in.
Minimum diameter	1.24 in.
Window	Lime Glass (Corning[a] No. 0080), or equivalent
Index of refraction	1.51
Dynode Material	Cesium-Antimony
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No. 10	3.2 pf
Anode to all other electrodes	5.0 pf
Maximum Overall Length (Excluding semiflexible leads)	3.18"
Maximum Diameter	1.56"
Bulb	T12
Base	Special
Magnetic Shield	See *footnote* (b)
Operating Position	Any
Weight (Approx.)	3 oz

Maximum Ratings, *Absolute-Maximum Values:*[c]

DC Supply Voltage:		
Between Anode and Cathode	1250 max.	volts
Between Dynode No. 10 and Anode	250 max.	volts
Between Consecutive Dynodes	200 max.	volts
Between Dynode No. 1 and Cathode	300 max.	volts
Average Anode Current[d]	0.75 max.	ma
Ambient Temperature	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No. 1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No. 10 and anode.

With E = 1000 volts (Except as noted)

	Min.	Typical	Max.	
Sensitivity:				
Radiant, at 4400 angstroms	-	2.2×10^{4}	-	a/w
Cathode radiant, at 4400 angstroms	-	0.036	-	a/w
Luminous:				
At 0 cps[e]	10	27	300	a/lm
With dynode No. 10 as output electrode[f]	-	16	-	a/lm
Cathode luminous:				
With tungsten light source[g]	3×10^{-5}	4.5×10^{-5}	-	a/lm
With blue light source[h]	2.8×10^{-8}	-	-	a
Current Amplification	-	6×10^{5}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 20 a/lm[j,k]	-	8×10^{-10}	2.5×10^{-9}	lm
Equivalent Noise Input[m]	-	4×10^{-12}	1.7×10^{-11}	lm
Dark Current to Any Electrode Except Anode at 25° C.	-	-	7.5×10^{-7}	a
Anode-Pulse Rise Time[n]	-	2.8×10^{-9}	-	sec

With E = 750 volts (Except as noted)

Sensitivity:	*Min.*	*Typical*	*Max.*	
Radiant, at 4400 angstroms	-	2.2×10^3	-	a/w
Cathode radiant, at 4400 angstroms	-	0.036	-	a/w
Luminous:				
At 0 cps[e]	-	2.7	-	a/lm
With dynode No.10 as output electrode[f]. . .	-	1.6	-	a/lm
Cathode luminous:				
With tungsten light source[g] .	3×10^{-5}	4.5×10^{-5}	-	a/lm
With blue light source[h]	2.8×10^{-8}	-	-	a
Current Amplification	-	6×10^4	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 20 a/lm[jk]	-	8×10^{-10}	2.5×10^{-9}	lm

SEMI-LOGARITHMIC PRESENTATION OF S-11 SPECTRAL RESPONSE

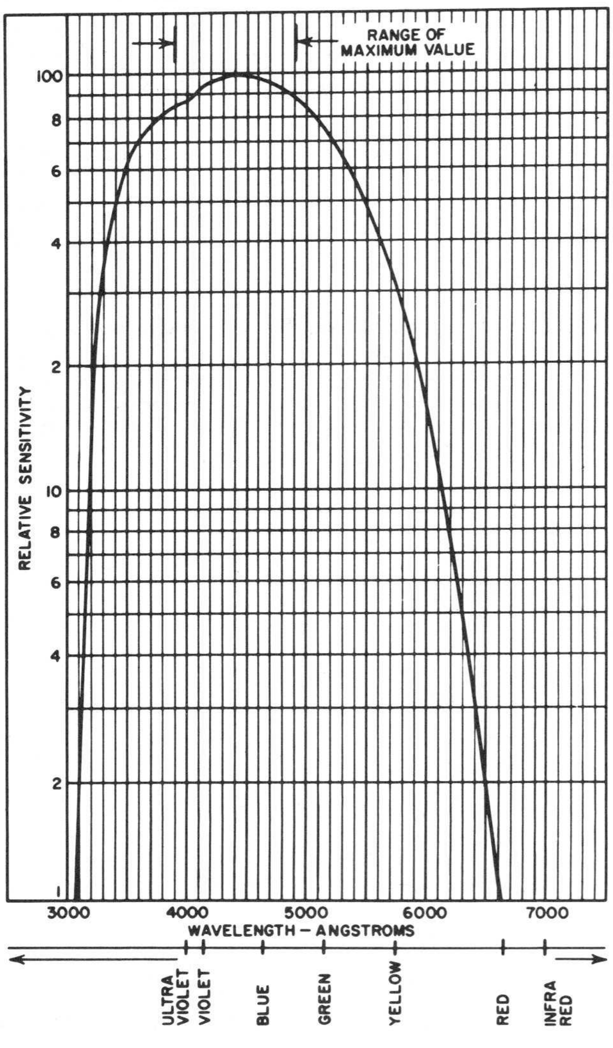


Fig.1

ENVIRONMENTAL TESTS:

The 4441A is designed to withstand environmental tests equivalent to those specified in MIL-E-5272C* for equipment mounted on the structures of missiles propelled or launched by high-thrust rocket engines. The accelerations specified in these tests are applied directly to the tubes.

One-Hundred Per-Cent Shock and Vibration Testing:

Shock. These tests are performed first, per method of MIL-E-5272C*, Par.4.15.5.1, Proc.V, on apparatus which provides a half-wave sinusoidal shock pulse. One-hundred per-cent testing of all 4441A's is performed. Each 4441A (non-operating) is subjected to three impact shocks in each direction of the three orthogonal axes shown in Fig.2. Each impact shock has a peak acceleration of 30 ± 3 g's and a time duration of 11 ± 1 milliseconds. Each tube is subjected to a total of 18 impact shocks.

Vibration. These tests are performed next, on apparatus which applies variable-sinusoidal frequency vibration to the tube, per method of MIL-E-5272C*, par.4.7.14 and par.4.7.14.1, except for the cycle duration. One-hundred per-cent testing of all 4441A's is performed. Each 4441A (operating under the conditions specified under *Tube Rejection Criterion*) is vibrated in each of the three orthogonal axes shown in Fig.2 and as specified in the schedule below. A vibration cycle has a duration of 5 minutes per axis in which time the frequency is varied logarithmically from 20 to 2000 and back to 20 cycles per second. One vibration cycle is performed for each axis and the total test period for each tube is 15 minutes.

Double Amplitude inches	Accelera-tion g's	Fre-quency cps	Cycle Duration Per Axis minutes
0.050 ± 0.005	-	20-87	5
-	20	87-2000	
-	20	2000-87	
0.050 ± 0.005	-	87-20	

Tube Rejection Criterion. After completion of the shock tests, tubes are operated at an anode-to-cathode voltage of 1000 volts with the light level incident on the tube adjusted to provide an anode current of 8 microamperes. Electrical and/or mechanical tube failures due to shock or vibration will be observed during the vibration test when the specified anode current is monitored. Tube rejection criterion for both tests is that the anode current of 8 microamperes will not change more than ± 20 per cent at any time during the vibration test for each axis.

Design Tests:

Vibration. These tests are performed under conditions equivalent to those described in

MIL-E-5272C*, par.4.7.14 and par.4.7.14.1. The vibration cycle has a duration of one hour and two cycles are performed for each of the three orthogonal axes shown in Fig.2. The total test period for each tube is six hours.

Acceleration. These tests are performed in a centrifuge providing unidirectional acceleration by a method equivalent to that specified in MIL-E-5272C*, par.4.16.3, Proc.III except that tubes are subjected for one minute to an increased acceleration test level of 100 ± 10 g's in both directions of the three orthogonal axes shown in Fig.2, and the tubes are non-operating.

ORTHOGONAL AXES OF TUBE USED DURING ENVIRONMENTAL TESTS

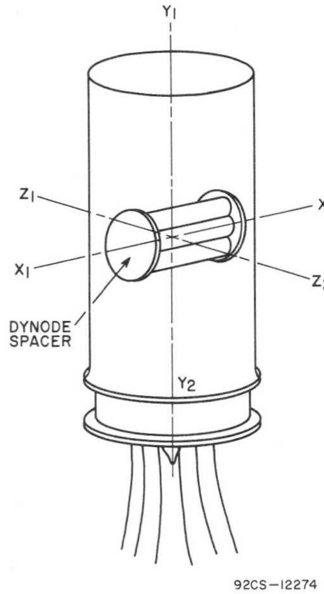


Fig.2

[a] Made by Corning Glass Works, Corning, New York.

[b] 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.

[c] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[e] 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.

[f] An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.10 as the output electrode. With this arrangement, the load is connected in the dynode-No.10 circuit and the anode serves only as collector. The curves shown in *Typical Anode Characteristics* do not apply when dynode No.10 is used as the output electrode.

[g] 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.

[h] 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.

[j] At a tube temperature of 25° C. Dark current may be reduced by use of a refrigerant.

[k] For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

[m] 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.

[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.

* Military Specification MIL-E-5272C (ASG), 13 April 1959; and Amendment 1, 5 January 1960.

OPERATING CONSIDERATIONS

The *semiflexible leads* of the 4441A may be soldered into the associated circuit. When leads of reduced length are soldered, care must be taken to conduct excessive heat away from the lead seals. Otherwise, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.

The *leads are semiflexible* and can be broken. Excessive bending of the leads — especially in the region close to the glass button — is to be avoided.

Electrostatic and/or magnetic shielding of the 4441A may be necessary. When a shield is used it should be connected to a potential near that of the cathode.

Support for the 4441A — if maximum signal-to-noise ratio is desired—may be provided by any suitable arrangement that maintains the external surface of the glass bulb, especially that region near the photocathode, at or near photocathode potential. Should the potential of the glass bulb differ appreciably from photocathode potential, signal-to-noise ratio may decrease because of an increase in dark current and noise output caused by the voltage gradient developed across the bulb wall.

Precautions should be taken to prevent a metal mounting arrangement from contacting the cathode flange unless the mounting arrangement is to be maintained at cathode potential.

Recommended resistance values for the voltage-divider arrangement range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for the voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required wattage rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is near the photocathode. The use of resistance values near 1 megohm per stage may cause deviation from linearity if the voltage-divider current is not maintained at a value several times that of the maximum value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No.7 and No.8, dynodes No.8 and No.9, dynodes No.9 and No.10, and between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 1 megohm per stage make the 4441A more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

The *high voltages* at which the 4441A is operated are very dangerous. Before any part of the circuit is touched, the power supply switch should be turned off and both terminals of any capacitors grounded.

TYPICAL ANODE CHARACTERISTICS

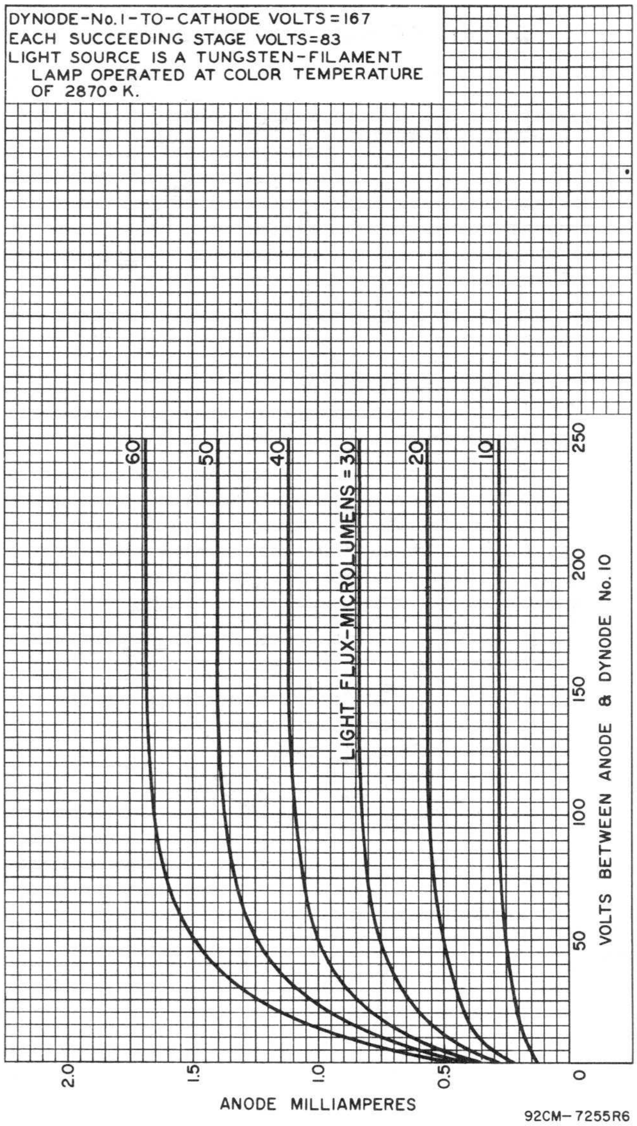


Fig.3

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

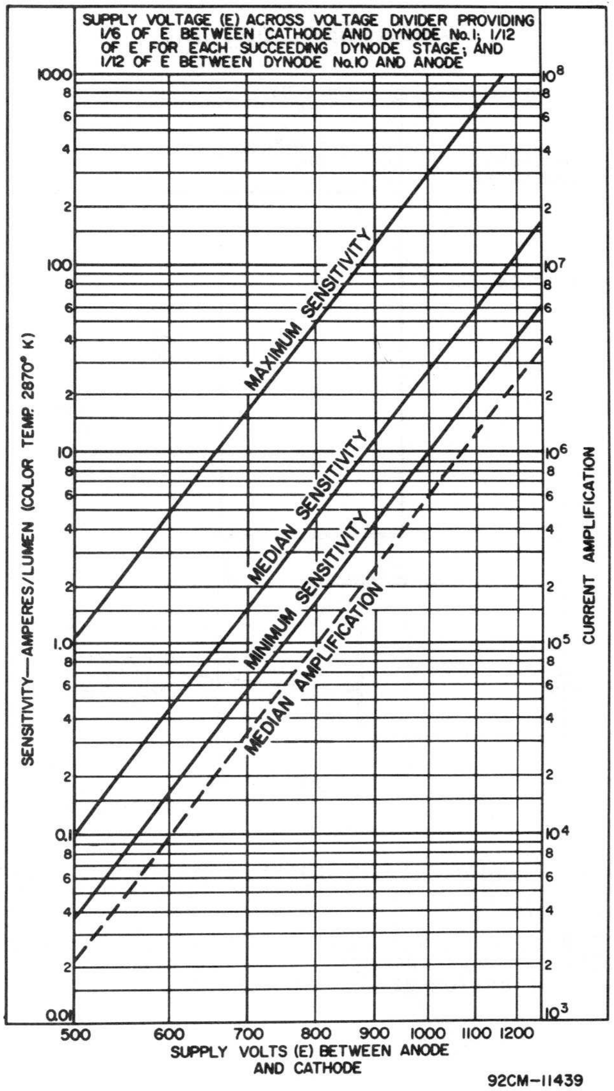


Fig.4

TYPICAL ANODE-DARK-CURRENT CHARACTERISTIC

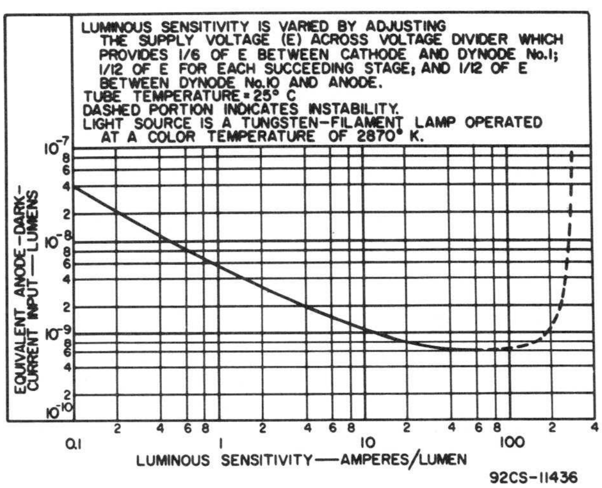
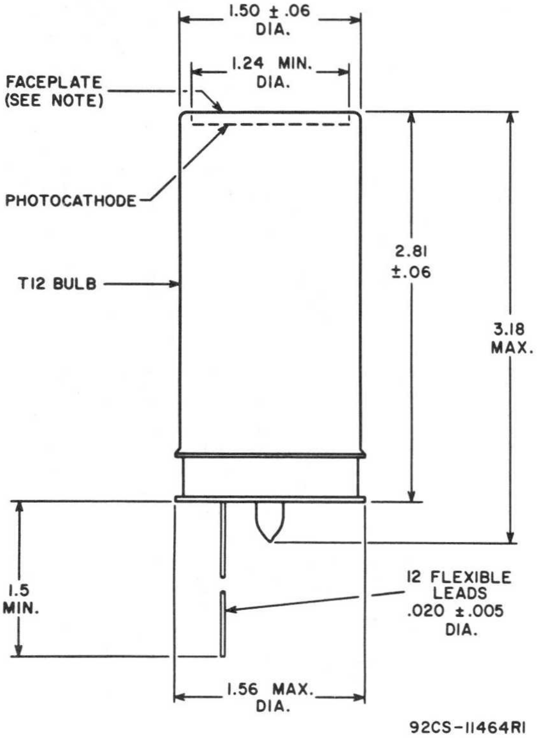


Fig.5

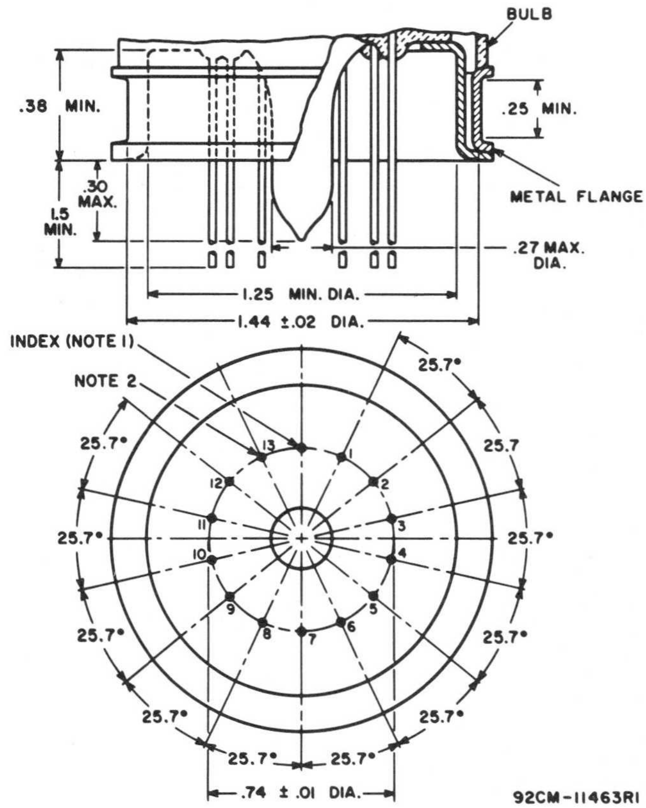
DIMENSIONAL OUTLINE



NOTE: DEVIATION FROM FLATNESS WITHIN THE 1.24"-DIAMETER AREA WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE FLANGE.

DETAIL OF BASE ARRANGEMENT

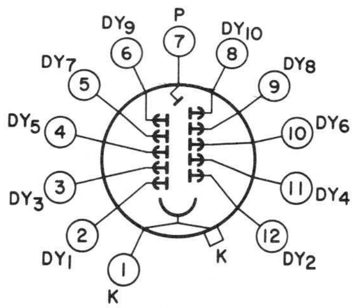


NOTE 1: LEAD IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON FOR INDEXING.

NOTE 2: LEAD No. 13 IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON.

BASING DIAGRAM

Bottom View



Lead 1 and Metal Flange – Photocathode
Lead 2 – Dynode No. 1
Lead 3 – Dynode No. 3
Lead 4 – Dynode No. 5
Lead 5 – Dynode No. 7
Lead 6 – Dynode No. 9
Lead 7 – Anode
Lead 8 – Dynode No. 10
Lead 9 – Dynode No. 8
Lead 10 – Dynode No. 6
Lead 11 – Dynode No. 4
Lead 12 – Dynode No. 2

RCA

4449

IMAGE-CONVERTER TUBE

High Resolution
Electrostatic Focus
Electrostatic Deflection

For High-Speed Photographic
Shutter Service

9.93" Max. Length
4.04" Max. Diameter
(Excluding Side Tip)

INITIAL DATA

Formerly Developmental Type C73435B

RCA-4449 is an electrostatic-focus, electrostatic-deflection type of image-converter tube designed specifically for use as a high-speed light shutter in applications requiring the photography of extremely fast events. It has a resolving capability referred to photocathode of better than 17 line-pairs per millimeter and is capable of providing exposure times as short as 10^{-8} second without significant loss in resolution.

The 4449 utilizes a flat photocathode which has high electrical conductivity and can provide large peak cathode currents without undesirable defocusing effects. The minimum useful diameter of the photocathode is 1.37 inches. The spectral response of the 4449 covers the range from about 3000 to 6500 angstroms. Maximum response occurs in the blue region of the visible spectrum.

The 4449 is also provided with a fine-grain, aluminized P11 phosphor screen which emits high-intensity actinic blue fluorescence and has medium-short persistence. The minimum useful diameter of the phosphor screen is 3 inches.

Other features of the 4449 include a maximum anode voltage-rating of 15 kilovolts, a deflection factor of 1000 to 1300 volts per inch, a peak-to-peak gating (control-grid) voltage requirement of only 230 to 300 volts, and a flat photocathode which permits the use of a wide selection of standard optical lenses.

DATA

General:

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 angstroms
Photocathode, Semitransparent:	
Shape	Flat, Circular
Window:	
Area	9.52 sq. cm (1.48 sq. in.)
Minimum diameter	3.48 cm (1.37 in.)
Index of refraction	1.48
Fluorescent Screen:	
Shape	Flat, Circular
Phosphor	P11, Aluminized
Fluorescence	Blue
Phosphorescence	Blue
Persistence	Medium Short
Window:	
Useful deflection area (Approx.)	23 sq. cm (3.6 sq. in.)
Minimum diameter	7.62 cm (3.00 in.)
Index of refraction	1.48
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	20 $\mu\mu$f
Deflecting electrode DJ1 to deflecting electrode DJ2	1 $\mu\mu$f
Deflecting electrode DJ1 to all other electrodes	6 $\mu\mu$f
Deflecting electrode DJ2 to all other electrodes	6 $\mu\mu$f
Focusing Method	Electrostatic
Deflection Method	Electrostatic

Overall Length	9.87" ± 0.06"
Diameter (Excluding side tip)	3.97" ± 0.07"
Terminals	See *Dimensional Outline*
Operating Position	Any
Weight (Approx.)	28 oz

Maximum Ratings, *Absolute-Maximum Values:*[a]

DC ANODE VOLTAGE[b]	15000 max.	volts
DC GRID-No.2 VOLTAGE[b]	2000 max.	volts
GRID-No.1 VOLTAGE[b]	±200 max.	volts
DEFLECTING ELECTRODE VOLTAGE:		
DJ1 and DJ2[c]	±1500 max.	volts
PEAK PHOTOCATHODE CURRENT[d]	0.02 max.	ampere
PHOTOCATHODE CURRENT DENSITY:		
Peak[d]	0.002 max.	amp/cm^2
Average[e]	0.1 max.	μa/cm^2

Typical Operating Values:

Anode Voltage[b]	15000	volts
Grid-No.2 Voltage[bf]	1200 to 1600	volts
Grid-No.1 Voltage:[b]		
Operating (Minimum)[f]	120 to 190	volts
Cut off (Maximum)	-110	volts
Deflection Factor	1000 to 1300	volts/in.

Characteristics:

With conditions shown under Typical Operating Values and at an ambient temperature of 25° C

	Min.	Median	Max.	
Photocathode Sensitivity:				
Radiant, at 4400 angstroms	-	0.04	-	amp/watt
Luminous, at 0 cps[g]	2×10^{-5}	5×10^{-5}	-	amp/lumen
Paraxial Image Magnification (Cmx)[hj]	0.69	0.77	0.85	
Distortion[hk]	-	-	0.06	
Paraxial Resolution[bm]	17	-	-	line-pairs/mm
Edge Resolution[bmn]	4	-	-	
Radiant Power Gain[p]	50	70	-	
Equivalent Background Screen Brightness Input[q]	-	-	5×10^{-12}	watts/sq. cm
Screen Uniformity Factor[r]	-	-	1.3	
Alignment	-	-	(s)	

[a] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[b] Referred to photocathode.

[c] Referred to anode.

[d] Over an interval not exceeding 1 microsecond.

[e] Averaged over any interval of 8 minutes maximum.

[f] Adjusted to minimize shadowing affects in the displayed image caused by the wires of grid No.1.

[g] For conditions where the light source is a tungsten-filament lamp having a lime glass envelope (Corning Glass Code No.0080, or equivalent). The lamp is operated at a color temperature of 2870° K. A light input of 0.01 lumen is used to irradiate a 1/2-inch diameter of the photocathode.

[h] Defined as the ratio of the separation of two diametrically opposite image points on the screen to the separation of the corresponding image points on the photocathode.

[j] Determined as follows: the image incident on the photocathode is perpendicular to the grid-No.1 wires and consists of 2 parallel lines on a bright background approximately 0.160" in length and separated by a distance of 0.160" ± 0.002". The image on the photocathode is focused and positioned so that the separation between the image lines is an equal distance on both sides of the geometric center of the photocathode. The line spacing on the screen is measured adjacent to the faint image of the center grid-No.1 wire.

[k] A second magnification value (Emx) is measured under the conditions established in (j) except that the lines are separated by a distance of 1.00" ± 0.01". Distortion (D) is defined by the equation:

$$D = \frac{Emx}{Cmx} - 1$$

[m] Determined with a resolution pattern consisting of horizontal and vertical bars. The limiting resolution value is measured adjacent to the faint image of the center grid-No.1 wire and applies to both vertical and horizontal resolution.

[n] Measured at the edge of a 1-inch diameter circle positioned concentric with the geometric center of the photocathode under the same conditions established in (m).

[p] Under the following conditions: light incident on the photocathode is transmitted through a blue filter (Corning C.S. No.5-58, glass code No.5113 polished to 1/2 stock thickness — Manufactured by the Corning Glass Works, Corning, New York) from a tungsten-filament lamp having a lime glass envelope. The lamp is operated at a color temperature of 2870° K. A 1/2-inch diameter of the photocathode is irradiated and the value of light flux incident on the filter is 0.1 lumen. A calibrated receiver having S-11 spectral response and masked to have a 1/2-inch-diameter aperture is positioned 12 inches from the screen of the 4449. The output current (I_1) of the receiver is noted. The same receiver is then positioned to receive the radiant flux originally incident on the photocathode and its output current (I_2) is noted. Radiant power gain (G) is defined by the equation:

$$G = 1840 \times \frac{I_1}{I_2}$$

The coefficient 1840 is derived by assuming that the integrated light radiated by the screen is 80 per cent of that value that would be obtained if the light emitted by the screen has a cosine distribution.

[q] Defined as that value of incident radiation required to cause an increase in screen brightness equal to the screen background brightness.

[r] The ratio of the luminance values of the brightest area to the darkest area of the screen with the entire photocathode uniformly illuminated. The value of incident illumination on the photocathode is 1 footcandle and the light spot on the screen has a diameter of 0.10" ± 0.01".

[s] A trace produced on the screen when the center of the photocathode is irradiated with a 0.025-inch diameter light spot and an ac voltage is applied to the deflecting electrodes will not deviate more than 4° from the plane passing through the center of the recessed ball cap of grid No.1 and the major axis of the tube. The angle produced by the trace and the faint images of the grid wires that are observed when the photocathode is uniformly illuminated will be 90° ± 3°.

GENERAL CONSIDERATIONS

An image to be viewed is focused by means of an objective lens on the semitransparent photocathode, as shown in Fig. 1. Grid No. 1, grid No. 2, and the anode comprise an electrostatic converging lens which produces on the phosphor screen an electron image of the photocathode illumination pattern. The application of a voltage having a suitable "staircase" waveform to the electrostatic deflecting plates permits the positioning of a series of time-sequential displays on the phosphor screen. For maximum detail, the image size on the photocathode should always be as large as possible and the images positioned on the screen close together. If a single image exposure is desired, the image size on the photocathode can have a diameter as large as 1-3/8 inches.

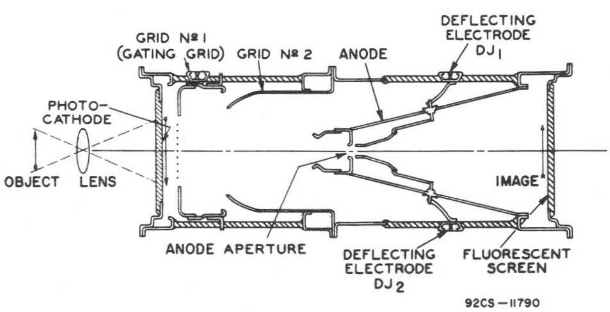


Fig. 1 - Schematic Arrangement of Type 4449.

OPERATING CONSIDERATIONS

Handling and Support. The 4449 should be handled and supported when mounted by the metal flanges at both ends of the tube.

Care must be taken that the semiflexible leads making connection to the recessed ball caps of the tube are of sufficient length to eliminate any possibility of introducing stress or strain in the glass-to-metal seals of the tube.

Magnetic shielding of the 4449 is required to minimize the effects of extraneous fields on tube performance. It is to be noted that ac magnetic fields are particularly objectionable in that they seriously impair tube resolution. If an iron or steel case is used, care should be taken in its construction to insure that the case is completely demagnetized.

The *spectral response* of the 4449 covers the range from about 3000 to 6500 angstroms, as shown in Fig. 2. Maximum response occurs at approximately 4400 angstroms.

The *spectral-energy emission characteristic and the persistence characteristic* for the P11 phosphor employed by the 4449 are shown in Fig. 3 and Fig. 4, respectively.

To *prevent degradation in the resolution of deflected images* care must be taken to assure that the deflecting voltage is free of ac ripple and that shielded semiflexible leads are used for making connection to the deflecting electrode terminals.

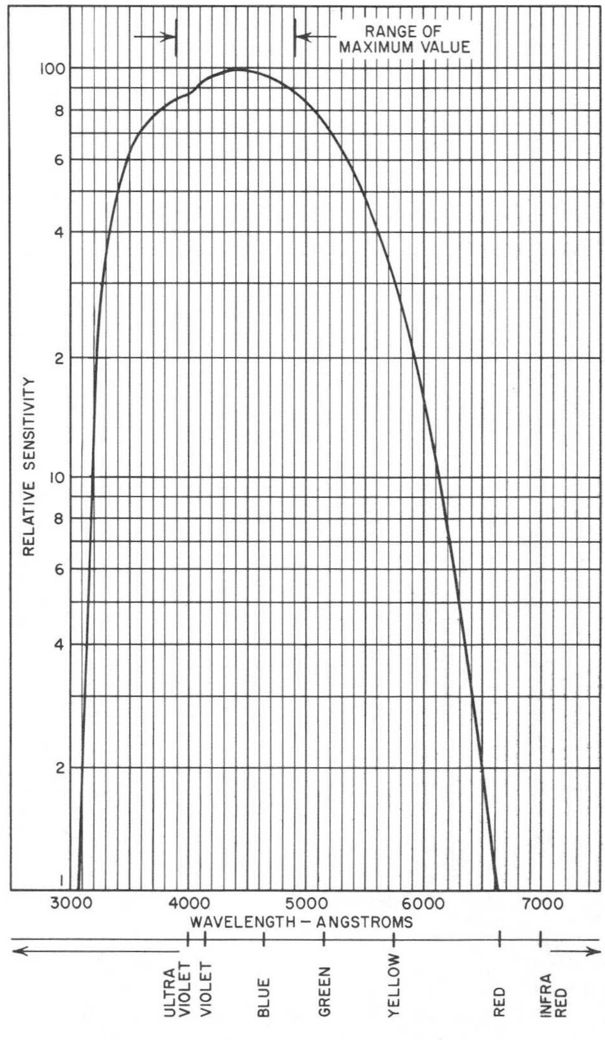


Fig. 2 - Semi-Logarithmic Presentation of S-11 Response.

Exposure Time. In practice, the shutter speeds attainable with the 4449 are limited by the ability of the external circuitry to supply to grid No. 1 good rectangular-wave pulses of sufficiently short duration. With perfect pulse-forming circuits, the minimum exposure time of the 4449 is limited by electron transit time which for an anode voltage of 15 kilovolts is in the order of 10^{-9} seconds. Electrons are defocused if they are not beyond the influence of the gating (control) grid when its voltage returns to cutoff value at the end of the gating pulse.

The high voltage at which the 4449 is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the user from coming in contact with the high voltage. Precautions must include safeguards which eliminate all hazards to operating personnel. In the use of high-voltage tubes, such as the 4449, it should always be remembered that high voltage may appear at normally low-potential points in the circuit because of capacitor breakdown or incorrect circuit connections. Before any part of the circuit is touched, the voltage-supply switch should be turned off and both terminals of any capacitors grounded.

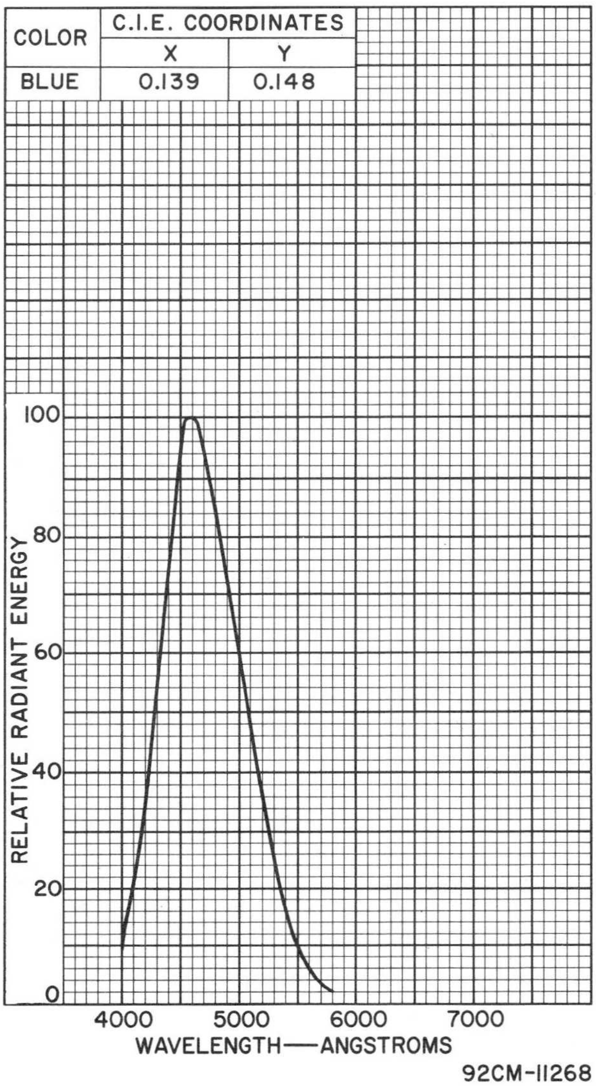


Fig.3 - Spectral-Energy Emission Characteristic of Phosphor No.11.

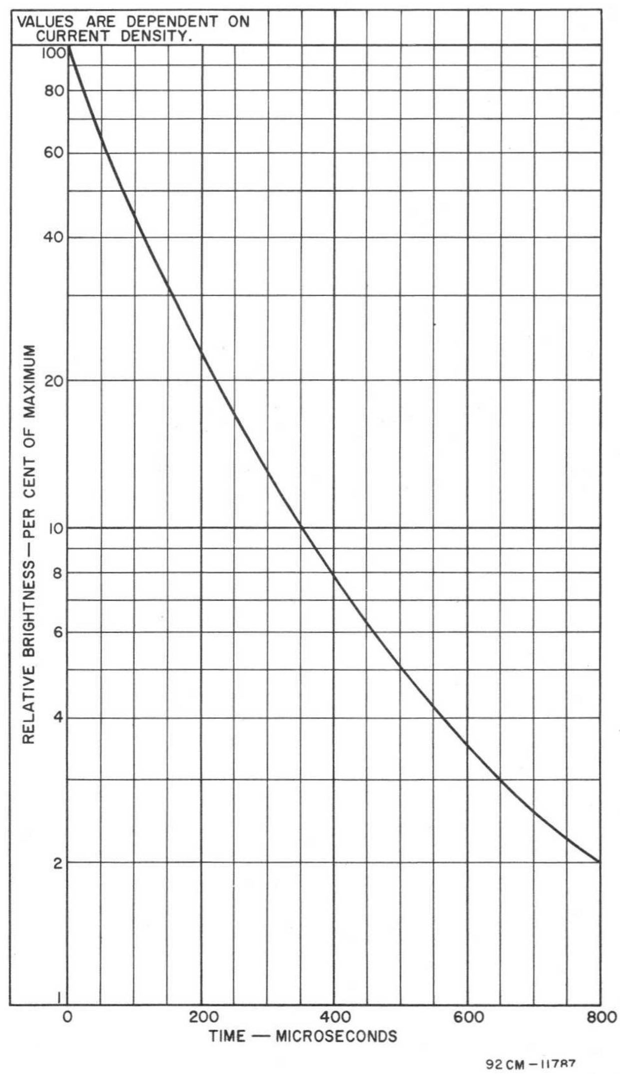
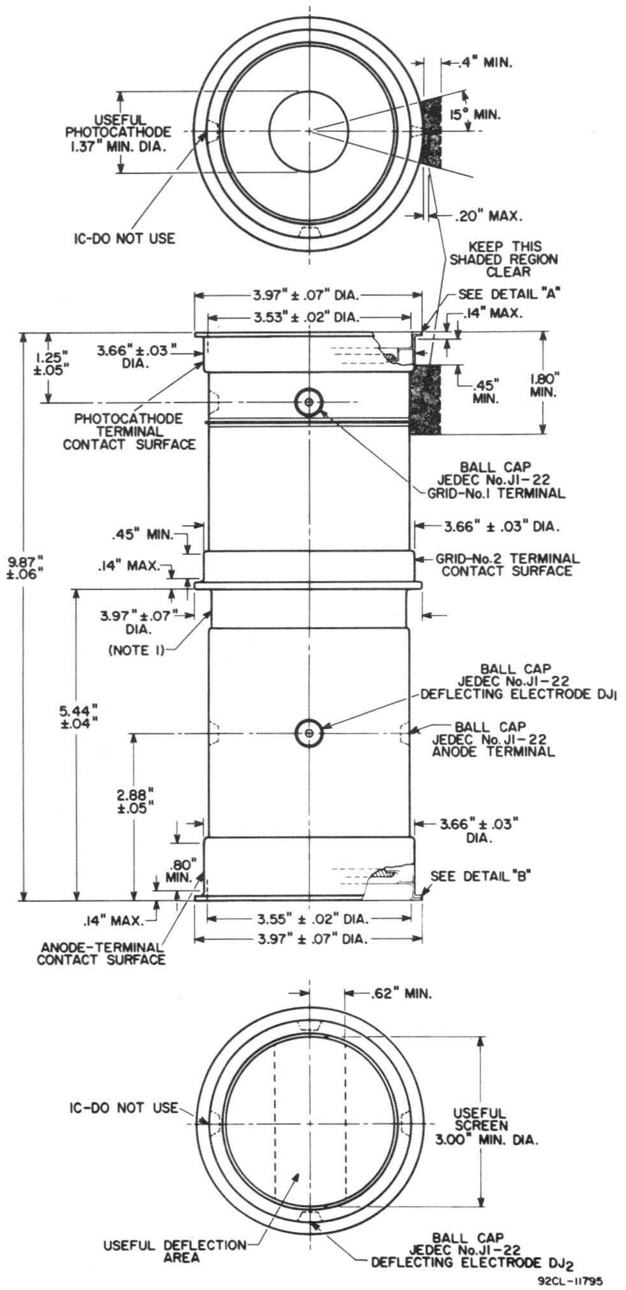
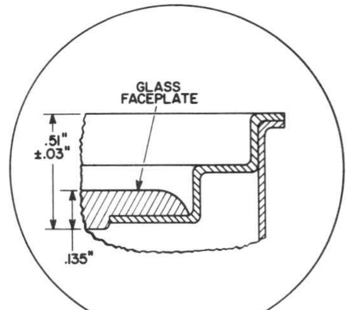


Fig.4 - Typical Persistence Characteristic of Phosphor No.11.

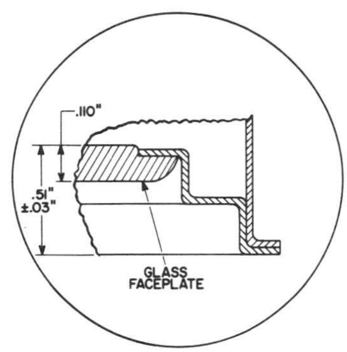
DIMENSIONAL OUTLINE



DETAIL "A"



DETAIL "B"



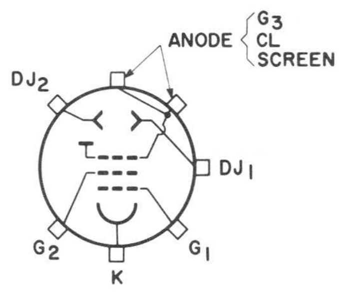
NOTE 1: NOT TO BE USED FOR MECHANICAL SUPPORT OR ELECTRICAL CONNECTION.

NOTE 2: THE PLANE PASSING THROUGH THE CENTER OF THE RECESSED BALL CAP DJ2 AND THE MAJOR AXIS OF THE TUBE WILL NOT DEVIATE MORE THAN 3° FROM THE PLANE PASSING THROUGH THE CENTER OF THE RECESSED BALL CAP DJ1 AND THE MAJOR AXIS OF THE TUBE.

NOTE 3: THE PLANE PASSING THROUGH THE CENTER OF THE RECESSED BALL CAP DJ1 AND THE MAJOR AXIS OF THE TUBE WILL NOT DEVIATE MORE THAN 5° FROM THE PLANE PASSING THROUGH THE CENTER OF THE RECESSED BALL CAP FOR GRID No. 1 AND THE MAJOR AXIS OF THE TUBE.

BASING DIAGRAM

DIRECTION OF LIGHT:
PERPENDICULAR TO PHOTOCATHODE
END OF TUBE



G_1: GRID No.1

G_2: GRID No.2

DJ1: DEFLECTING ELECTRODE

K: PHOTOCATHODE

DJ2: DEFLECTING ELECTRODE

ANODE: (Grid No.3, Collector, Screen)

RCA

RCA-4459

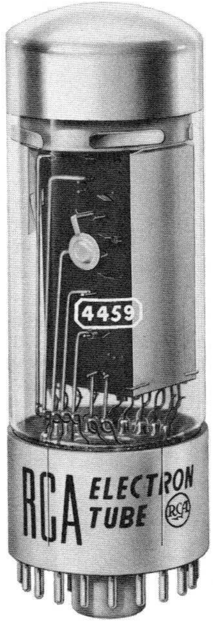
MULTIPLIER PHOTOTUBE

1.68" Dia., Semi-transparent Spherical Photocathode

12-Stage, Head-on Type, Spherical Faceplate
High Current Amplification—Extremely Short Rise Time
Enclosed, In-Line Dynode Structure
S-20 Response

2.06" Max. Diameter
6.31" Max. Length
Bidecal 20-Pin Base

RCA-4459 is a 12-stage, head-on type of multiplier phototube intended for use in near-infrared ruby-laser detector systems, flying-spot scanning applications, photometry, and other applications which require low dark current as well as high sensitivity over the visible and near-infrared regions of the spectrum. In addition, its high blue sensitivity, high current amplification in conjunction with an extremely short rise time capability, and very small spread in electron transit time make the 4459 particularly useful in scintillation counters.



The 4459 utilizes an enclosed, in-line dynode structure, a focusing electrode with external connection for shaping the field which directs photoelectrons from the photocathode onto the first dynode, and a semitransparent photocathode on the inner surface of the spherical face end of the bulb. The enclosed, in-line dynode structure is instrumental in preventing both light feedback and ion feedback within the tube as well as providing internal electrostatic and light shielding. The spherical photocathode surface of the 4459 assures uniform collection by dynode No.1 of electrons from all parts of the useful photocathode area and together with the electrode configuration minimizes variation in electron-transit time between the photocathode and dynode No.1.

The spectral response of the 4459 covers the range from about 2900 to 8000 angstroms, with maximum response at approximately 4200 angstroms, as shown in Fig.1. It will be noted that the response extends beyond the visible region into the blue region on the one end and well into the red and near-infrared regions on the other end.

The 4459 utilizes a multialkali photocathode which is characterized by high sensitivity, low thermionic dark emission, and high conductivity even at low temperatures. The 4459 may be cooled to liquid-nitrogen temperature to reduce its low thermionic dark current to an extremely low value without sacrificing its conductivity to such an extent that its current-carrying capability is seriously impaired in normal multiplier-phototube applications.

DATA

General:

Spectral Response	S-20
Wavelength of Maximum Response	4200 ± 500 angstroms
Cathode, Semitransparent	Potassium-Sodium-Cesium-Antimony (Multialkali)
Shape	Spherical, Circular
Minimum projected area	2.2 sq. in.
Minimum diameter	1.68 in.
Window	Borosilicate Glass (Corning[a] No.7056), or equivalent
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"
Bulb	T16
Base	Small-Shell Bidecal 20-Pin, (JEDEC No.B20-102), Non-hygroscopic
Socket	Cinch[b] No.20-PM, or equivalent
Magnetic Shield	See *footnote* (c)
Operating Position	Any
Weight (Approx.)	7 oz

Maximum Ratings, *Absolute-Maximum Values:*[d]

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 and cathode	600 max.	volts
Average Anode Current[e]	1 max.	ma
Ambient-Temperature Range	-200 to +85	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing electrode voltages shown in Table 1. 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.	*Typical*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	-	4.3×10^5	-	a/w
Cathode radiant, at 4200 angstroms	-	0.064	-	a/w
Luminous,[f] at 0 cps	250	1000	12000	a/lm

TABLE 1

VOLTAGE TO BE PROVIDED BY DIVIDER	
Between	6.95% of Supply Voltage (E) multiplied by
Cathode and Dynode No.1	2.0
Dynode No.1 and Dynode No.2	1.4
Dynode No.2 and Dynode No.3	1.0
Dynode No.3 and Dynode No.4	1.0
Dynode No.4 and Dynode No.5	1.0
Dynode No.5 and Dynode No.6	1.0
Dynode No.6 and Dynode No.7	1.0
Dynode No.7 and Dynode No.8	1.0
Dynode No.8 and Dynode No.9	1.0
Dynode No.9 and Dynode No.10	1.0
Dynode No.10 and Dynode No.11	1.0
Dynode No.11 and Dynode No.12	1.0
Dynode No.12 and Anode	1.0
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.

	Min.	*Typical*	*Max.*	
Cathode luminous:				
With tungsten light source[g]	1.1×10^{-4}	1.5×10^{-4}	-	a/lm
With blue light source[h] . . .	5.5×10^{-8}	-	-	a
With red light source[j] . . .	3×10^{-7}	5×10^{-7}	-	a
Current Amplification.	-	6.6×10^{6}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 300 a/lm[k]	-	1×10^{-10}	1.3×10^{-9}	lm
Anode-Pulse Rise Time[n]	-	2×10^{-9}	-	sec
Greatest Delay Between Anode Pulses: Due to position from which electrons are simultaneously released within a circle centered on tube face having a diameter of —				
1.4".	-	3×10^{-10}[p]	-	sec
1.6".	-	5×10^{-10}[p]	-	sec

With E = 1800 volts (Except as noted)

	Min.	*Typical*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms . . .	-	4.3×10^{4}	-	a/w
Cathode radiant, at 4200 angstroms . . .	-	0.064	-	a/w
Luminous, at at 0 cps[f] . . .	-	100	-	a/lm
Cathode luminous:				
With tungsten light source[g]	1.1×10^{-4}	1.5×10^{-4}	-	a/lm
With blue light source[h] . . .	5.5×10^{-8}	-	-	a
With red light source[j] . . .	3×10^{-7}	5×10^{-7}	-	a
Current Amplification.	-	6.6×10^{5}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 300 a/lm[k]	-	1×10^{-10}	1.3×10^{-9}	lm
Equivalent Noise Input[m].	-	1.1×10^{-12}	2.4×10^{-12}	lm

[a] Made by Corning Glass Works, Corning, New York.

[b] Made by Cinch Manufacturing Company, 1026 South Homan Avenue, Chicago 24, Illinois.

[c] 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.

[d] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[f] 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.

[g] 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.

[h] 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.

[j] 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 At a tube temperature of 25° C. Dark current may be reduced by use of a refrigerant.

m 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.

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.

SEMI-LOGARITHMIC PRESENTATION OF S-20 RESPONSE

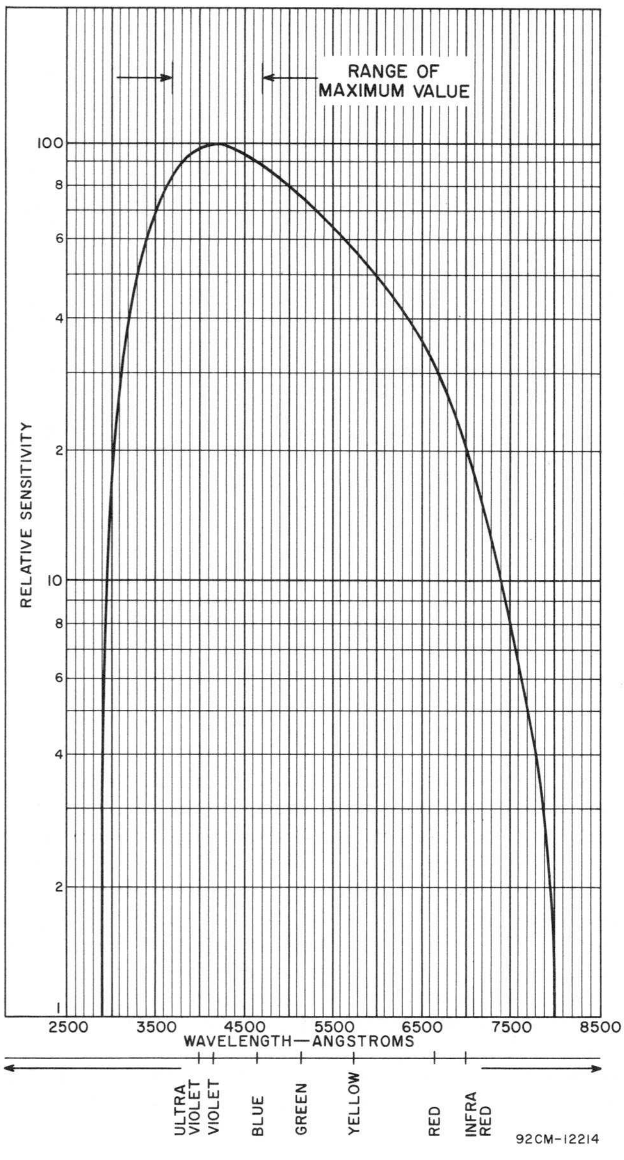


Fig.1

OPERATING CONSIDERATIONS

Terminal Connections. The *base pins* of the 4459 fit a bidecal 20-contact socket, such as Cinch No.20-PM, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that incident light falls on the face end of the tube.

SCHEMATIC ARRANGEMENT OF STRUCTURE

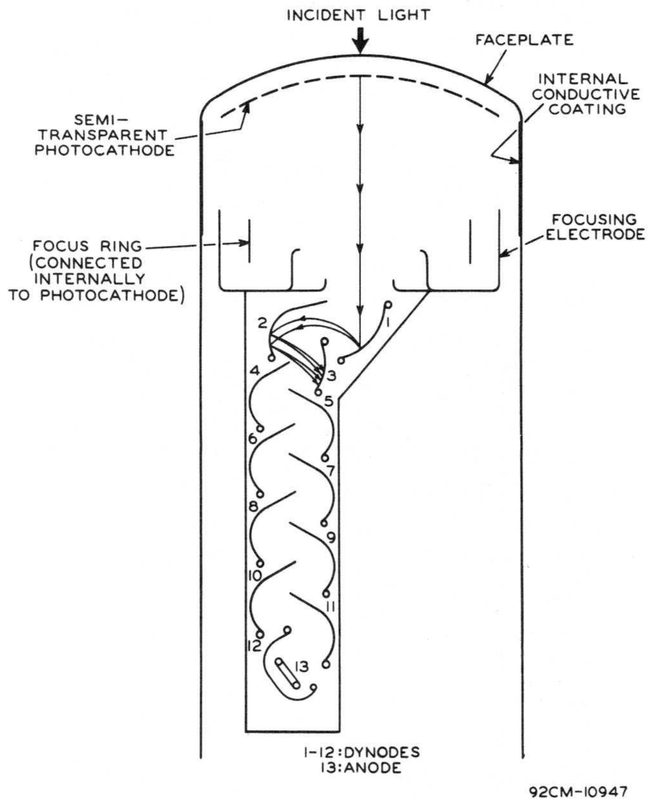


Fig.2

In general, *supply voltages* for the electrodes of the 4459 should be provided as shown in Table I.

The operating voltage between dynode No.12 and anode should be kept as low as will permit operation over the knee of the anode characteristic curves shown in Fig.3. It will be seen that this condition occurs in the approximate range of 100 to 150 volts. However, when high-pulse currents are drawn, saturation results from space-charge limitations and higher voltage will be required.

With low operating voltage between dynode No.12 and anode, leakage current to the anode is reduced. To obtain the desired operating voltage between dynode No.12 and anode, it is necessary to increase the supply voltage between these electrodes by an amount equal to the voltage drop across a particular output load.

The *focusing-electrode potential* may be adjusted between that of the photocathode and that of dynode No.1 to optimize the magnitude, uniformity, and speed of response. The voltage for the focusing electrode can be obtained by connecting the focusing electrode to the arm of a potentiometer between the cathode and dynode No. 1 in the voltage divider. Optimum focusing-electrode voltage will fall within an approximate 20-volt range between 60 and 70 per cent of dynode-No. 1-to-cathode voltage as shown in Fig. 4. However, where simplicity in voltage-divider design is desired, the focusing electrode may be connected directly to dynode No. 1 with little resulting decrease in output current.

TYPICAL ANODE CHARACTERISTICS

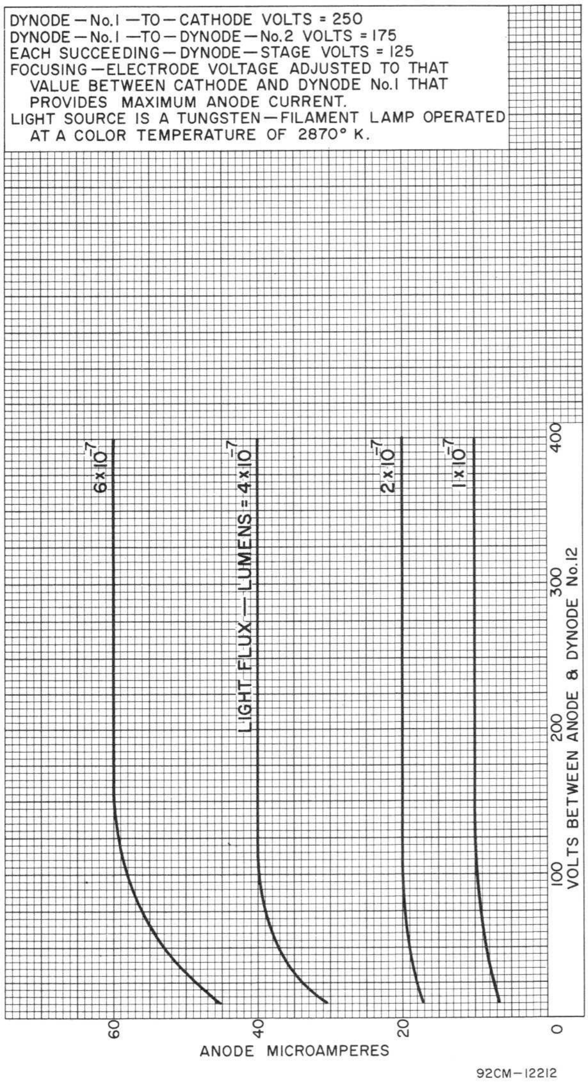


Fig.3

In applications where it is desired to keep statistical fluctuations to a minimum, e.g., as in nuclear radiation spectroscopy, the potential between cathode and dynode No. 1 should not be less than 300 volts. Relatively little additional statistical-fluctuation decrease will result by increasing this voltage to the maximum rating of 600 volts.

Current amplification may be controlled or the output signal may be modulated by varying the voltage on one or more of the dynodes with the voltages on the other stages held constant. It is recommended that any of the central dynodes— 4 through 10—perform this control or modulation function. Using this system, a monotonic variation—a continuous variation without subsidiary maxima or minima— of output current is obtained. The characteristic of Fig. 5 shows the effect on output current as the voltage applied to dynode No. 5 is varied between -900 and -700 volts referred to anode. The location of the peak value shown in Fig. 5 may vary from tube to tube over a 20-volt range. In this characteristic, the dynode-No. 5 voltage has been arbitrarily selected as the voltage to be varied. The shape of this characteristic is independent of anode-to-cathode supply voltage. Dynode Nos. 1, 2, 3, and 11 are less suited for continuous current-amplification control and have characteristics which differ from that of Fig. 5.

AVERAGE FOCUSING-ELECTRODE VOLTAGE CHARACTERISTIC

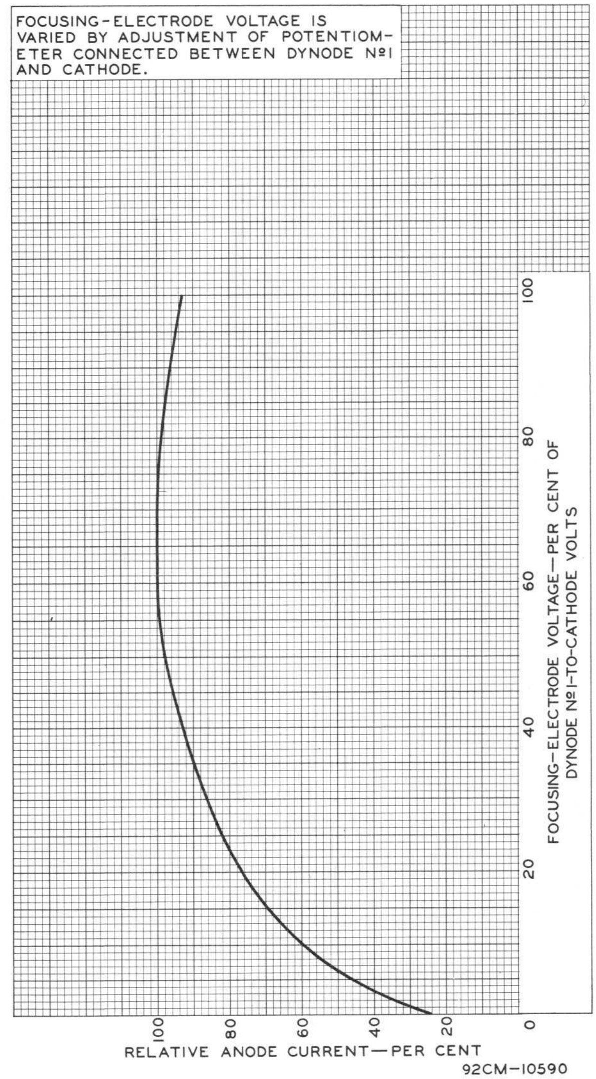


Fig.4

A greater latitude in control of current amplification may be obtained by varying the voltages that are applied to two or more dynodes.

However, to prevent distortion in the characteristic due to interaction of the interstage fields, the dynodes selected should be separated by two or preferably three dynodes operated at normal voltage. For example, current-amplification control that is substantially independent of field interaction may be obtained by varying the voltages applied to dynode No. 4 and dynode No. 8.

TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF DYNODE-No.5 VOLTS

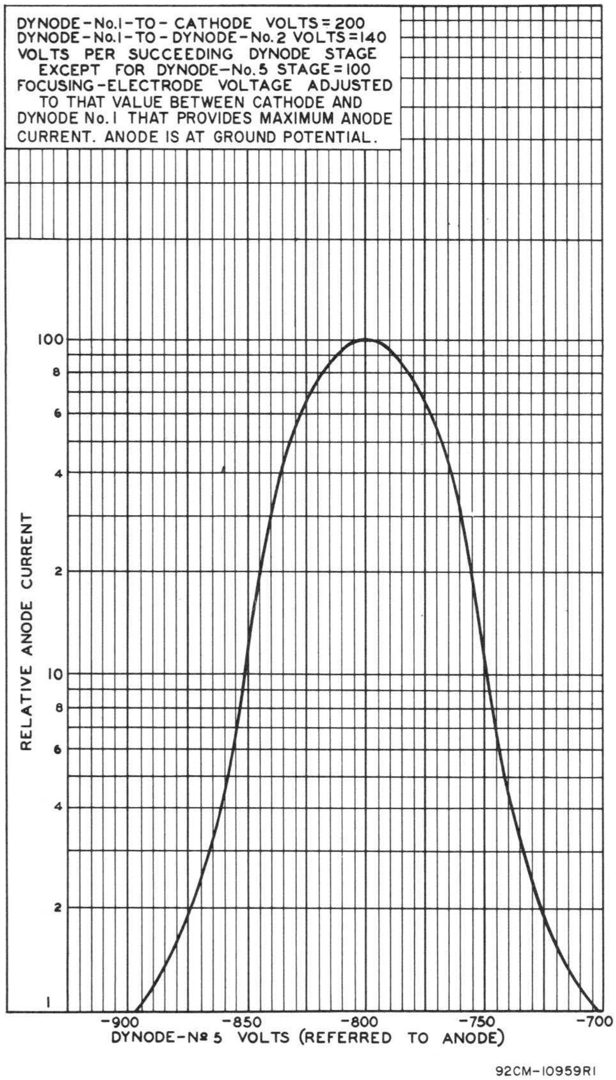


Fig.5

A very small *dark current* is observed when voltage is applied to the electrodes of the 4459 in complete darkness. Among the components contributing to dark current are pulses produced by electrons thermionically released from the cathode, secondary electrons released by ionic bombardment of the dynodes, support rods, or cathode, and by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected.

When the application utilizes *continuous luminous excitation and dc anode current*, and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.6 which shows the equivalent anode-dark-current input as a function of luminous sensitivity and the curve in Fig.7 which shows luminous sensitivity as a function of the supply voltage.

TYPICAL ANODE-DARK-CURRENT CHARACTERISTIC

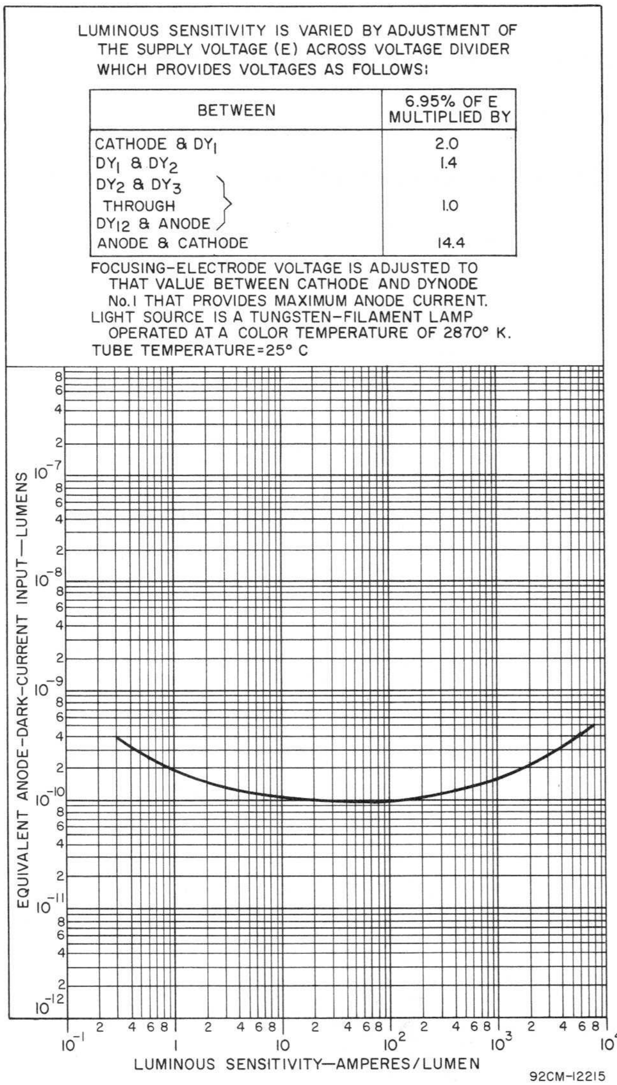


Fig.6

In applications where maximum current amplification with unusually low dark current is required, the *use of a refrigerant*, such as dry ice, to cool the bulb of the 4459 is recommended. The resulting reduction in dark current lowers the detection threshold to give improved operation.

Exposing the 4459 to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

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 on the severity of the operating conditions. After a period of idleness, the 4459 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 1 milliampere is recommended when stability of operation is important. When maximum stability is required, the average anode current should not exceed 10 microamperes.

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

The dc *supply voltages* for each dynode and for the anode can be supplied by spaced taps on a voltage divider across a regulated dc power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the current in the divider should be several times

SENSITIVITY AND AMPLIFICATION CHARACTERISTICS

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

BETWEEN	6.95 % OF E MULTIPLIED BY
CATHODE & DY_1	2.0
DY_1 & DY_2	1.4
DY_2 & DY_3 THROUGH DY_{12} & ANODE	1.0
ANODE & CATHODE	14.4

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

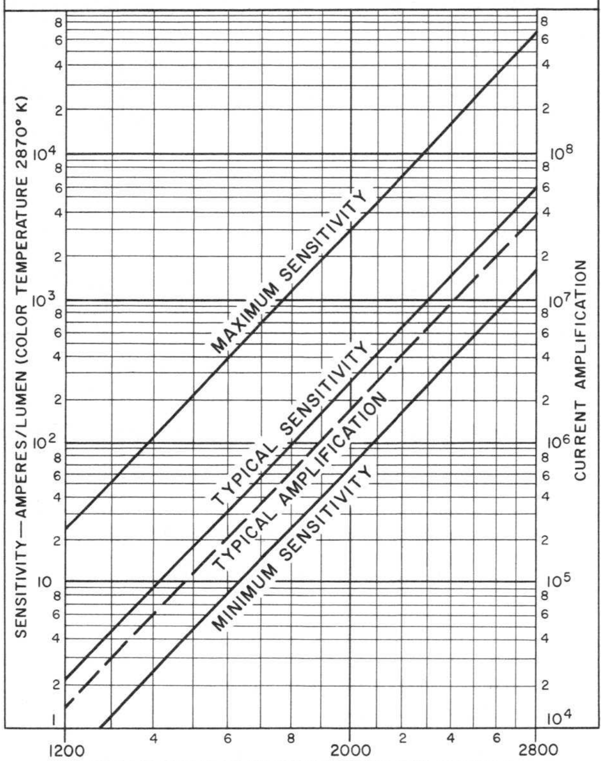
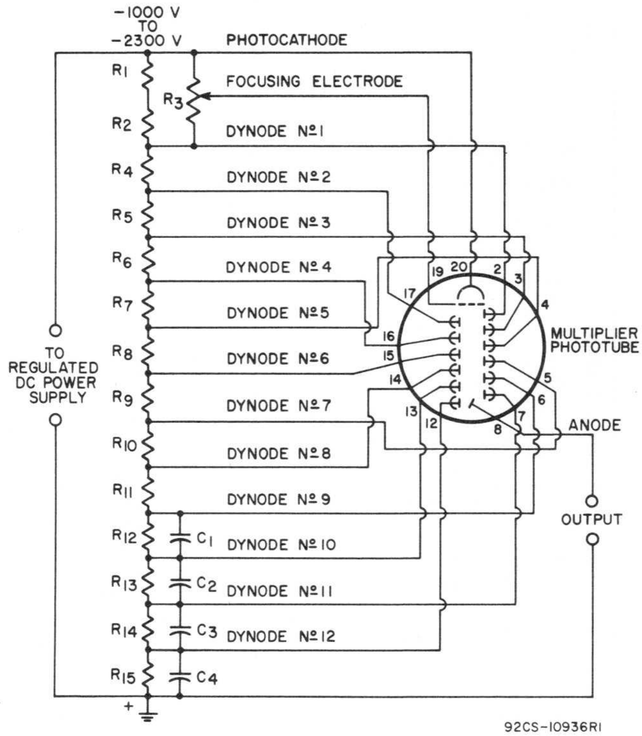


Fig.7

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



C_1 = 0.005 µf, ceramic, 500 volts (dc working)
C_2 = 0.01 µf, ceramic, 500 volts (dc working)
C_3 = 0.02 µf, ceramic, 500 volts (dc working)
C_4 = 0.05 µf, ceramic, 500 volts (dc working)
R_1, R_2 = 18000 ohms, 2 watts
R_3 = 2.5 megohms, 2 watts, adjustable
R_4 = 24000 ohms, 2 watts
R_5 through R_{15} = 18000 ohms, 2 watts

Note: Capacitors C_1 through C_4 should be connected at tube socket for optimum high-frequency performance.

Fig.8

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

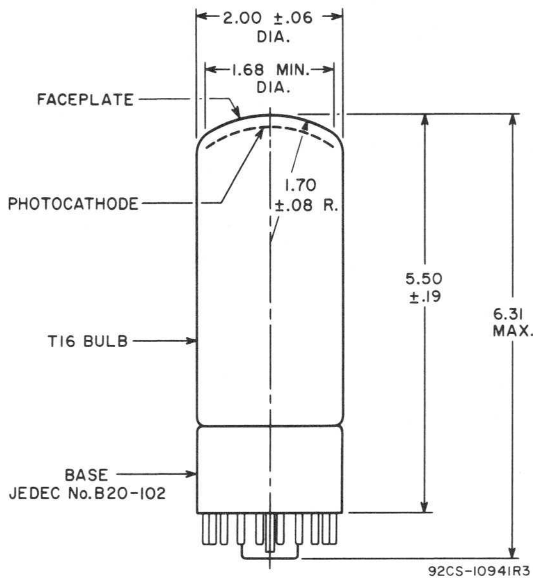
the maximum value of anode current. The resistance value of the voltage divider should be adequate to prevent variation of dynode potentials by the signal current.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit. It is to be noted that when the 4459 is operated in this manner, the electrostatic shield should be connected to the cathode for maximum signal-to-noise ratio. A typical voltage-divider arrangement for use with the 4459 is shown in Fig. 8.

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.

In the use of the 4459, 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.

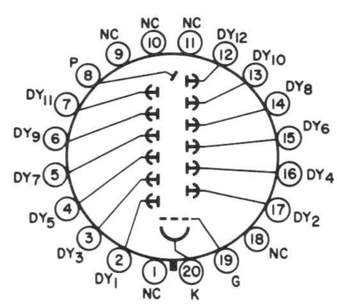
DIMENSIONAL OUTLINE



Dimensions in Inches

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

BASING DIAGRAM
Bottom View



20E

Pin 1 – No 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 – No Connection
Pin 10 – No Connection

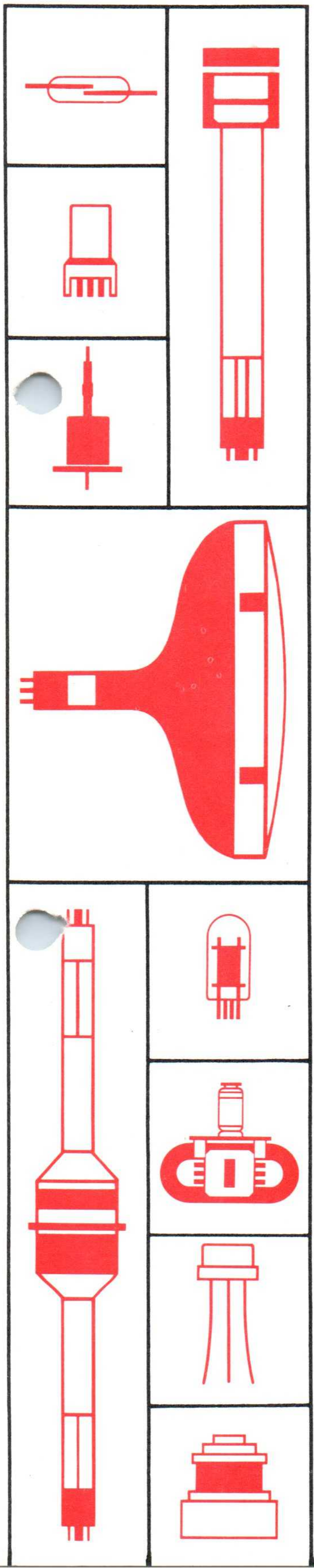
Pin 11 – No Connection
Pin 12 – Dynode No.12
Pin 13 – Dynode No.10
Pin 14 – Dynode No.8
Pin 15 – Dynode No.6
Pin 16 – Dynode No.4
Pin 17 – Dynode No.2
Pin 18 – No Connection
Pin 19 – Focusing Electrode
Pin 20 – Photocathode

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-4460*

NEW RUGGEDIZED 3/4"-DIAMETER MULTIPLIER PHOTOTUBE DESIGNED TO MEET THE SPECIFICATIONS OF MIL-E-5272C

Joining RCA's line of ruggedized multiplier phototubes is the new 4460, a short 3/4"-diameter 10-stage head-on type having S-11 response and intended for compact equipment where rough tube usage may occur. Among the outstanding features of this tube are:

- Very rugged construction—
  Tube is designed to meet MIL-E-5272C specifications for vibration, shock, and acceleration
- Small size—
  3/4"-diameter, 3.38"-overall length
- Fast time-resolution characteristics—
  Anode-pulse rise time = 2.1 nanoseconds (typical)
  Electron transit time = 23 nanoseconds (typical)

A bulletin giving detailed technical information is attached for your convenience.

March 2, 1964

* Formerly Dev. Type C70102

RCA-4460

MULTIPLIER PHOTOTUBE

0.5" Min. Diameter
Concave Semitransparent Photocathode

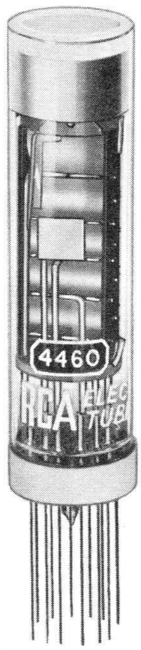
Ruggedized, 3/4"-Diameter,
Fast Response Type for Use
Under Severe Environmental Conditions
S-11 Response

0.78" Max. Diameter
3.38" Max. Length
(Excluding Semiflexible Leads)

Formerly Developmental Type C70102

INITIAL DATA

RCA-4460 is a short, ruggedized, 3/4"-diameter, 10-stage, head-on type of multiplier phototube designed for low-level light and nuclear-radiation detection-and-measurement systems. Its rugged construction and small size enhance its use in compact equipment in industrial and military applications where severe environmental conditions may be encountered.



Design features of the 4460 include a semitransparent photocathode on the concave inner surface of the face end of the bulb having a minimum useful diameter of 0.5 inch, a face with a flat surface to facilitate the mounting of flat scintillators, ten electrostatically focused dynode stages having an in-line arrangement, and semiflexible leads that may be soldered directly into the associated circuit.

The spectral response of the 4460 covers the range from about 3000 to 6500 angstroms, as shown in Fig.1. Maximum response occurs at approximately 4400 angstroms. The 4460, therefore, has high sensitivity to the blue and less sensitivity to the red regions of the visible spectrum.

Typical quantum efficiency as a function of wavelength for the 4460 is shown in Fig.2.

DATA

General:

Spectral Response S-11
Wavelength of Maximum Response . 4400 ± 500 angstroms
Cathode, Semitransparent . . . . Cesium-Antimony
  Minimum area . . . . 0.2 sq. in.
  Minimum diameter . . . . 0.5 in.
Window . . Lime Glass (Corning[a] No.0080), or equivalent
  Shape . . . . Plano-concave
  Index of refraction at 5893 angstroms 1.51
Dynode Material . . . . Copper-Beryllium
Direct Interelectrode Capacitances (Approx.):
  Anode to dynode No.10 . . . . 2.4 pf
  Anode to all other electrodes . . . . 3.2 pf
Maximum Overall Length (Excluding semiflexible leads) . . . . 3.38"
Maximum Diameter . . . . 0.78"
Bulb T6
Base . . Small-Button Thirteenar 12-Semiflexible Lead, (JEDEC No.E12-72), and Protective Shell
Magnetic Shield . . . . See *Footnote* (b)
Operating Position . . . . Any
Weight (Approx.) . . . . 0.9 oz

Maximum Ratings, *Absolute-Maximum Values:*[c]

Supply Voltage (DC or Peak AC):		
Between Anode and Cathode	1500 max.	volts
Between Anode and Dynode No.10 . .	300 max.	volts
Between Consecutive Dynodes	250 max.	volts
Between Dynode No.1 and Cathode . .	400 max.	volts
Average Anode Current[d]	0.5 max.	ma
Ambient Temperature	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1250 volts (Except as noted)

	Min.	*Typical*	*Max.*	
Sensitivity:				
Radiant at 4400 angstroms	-	6×10^{3}	-	a/w
Cathode radiant, at 4400 angstroms . .	-	0.048	-	a/w
Luminous:				
At 0 cps[e]	3	7.5	60	a/lm
Cathode luminous:				
With tungsten light source[f]	4×10^{-5}	6×10^{-5}	-	a/lm
With blue light source[g]	4×10^{-8}	6×10^{-8}	-	a
Current Amplification .	-	1.25×10^{5}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 7.5 a/lm[h]	-	8×10^{-10}	2×10^{-9}	lm
Equivalent Noise Input[j]	-	3×10^{-12}	1×10^{-11}	lm

Anode-Pulse Rise Time[k]	-	2.1×10^{-9}	-	sec
Electron Transit Time[m]	-	2.3×10^{-8}	-	sec
Quantum Efficiency at 4300 angstroms . . .	-	14	-	%

ENVIRONMENTAL TESTS—

The 4460 is designed to withstand the shock, vibration, and acceleration tests shown below which are equivalent to those specified in MIL-E-5272C* for equipment mounted on the structures of missiles propelled or launched by high-thrust rocket engines. The accelerations specified in these tests are applied directly to the tubes.

One-Hundred Per-Cent Shock and Vibration Testing:

Each 4460 is subjected in sequence to shock and then to vibration as specified below with the tube non-operating.

Shock. These tests are performed first, per method of MIL-E-5272C*, Par. 4.15.5.1, Proc.V, on apparatus which provides a half-wave sinusoidal shock pulse. One-hundred per-cent testing of all 4460's is performed. Each 4460 is subjected to three impact shocks in each direction of the three orthogonal axes shown in Fig.3. The peak acceleration of the impact shock is 30 ± 3g's and the time duration is 11 ± 1 milliseconds. Each tube is subjected to a total of 18 impact shocks.

Vibration. These tests are performed next, on apparatus which applies variable-sinusoidal frequency vibration to the tube, per method of MIL-E-5272C*, par. 4.7.14 and par. 4.7.14.1. One-hundred per-cent testing of all 4460's is performed. Each 4460 is vibrated in each of the three orthogonal axes shown in Fig.3 and as specified in the schedule below. A vibration cycle has a duration of 5 minutes per axis in which time the frequency is varied logarithmically from 20 to 2000 and back to 20 cycles per second. One vibration cycle is performed for each axis and the total test period for each tube is 15 minutes.

Double Amplitude inches	Acceleration g's	Frequency cps	Cycle Duration per axis minutes
0.050 ± 0.005	-	20-87	5
-	20 ± 2	87-2000	
-	20 ± 2	2000-87	
0.050 ± 0.005	-	87-20	

Tube Rejection Criterion. Upon completion of the *One-Hundred Per-Cent Shock and Vibration Testing* each tube is tested at a anode-to-cathode voltage of 1250 volts under the conditions shown under *Characteristics Range Values for Equipment Design* and will meet the specified values.

Design Tests:

Vibration. These tests are performed under conditions equivalent to those described in MIL-E-5272C*, par. 4.7.14 and par. 4.7.14.1. The vibration cycle has a duration of one hour and two cycles are performed for each of the three orthogonal axes shown in Fig.3. The total test period for each tube is six hours. Tubes are operating during the test.

Acceleration. These tests are performed in a centrifuge providing unidirectional acceleration by a method equivalent to that specified in MIL-E-5272C*, par. 4.16.3, Proc.III, except that tubes are subjected for one minute to an increased acceleration test level of 100 ± 10 g's in both directions of the three orthogonal axes shown in Fig.3, and the tubes are non-operating.

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a Made by Corning Glass Works, Corning, New York.

b Magnetic shielding in the form of foil or tape as available from the Magnetic Shield Division, Perfection Mica Company, 1322 North Ellston, Chicago 24, Illinois, or equivalent.

c The maximum ratings in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

d Averaged over any interval of 30 seconds maximum.

e 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.

f 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.

g 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.

h At a tube temperature of 25° C. Dark current may be reduced by use of a refrigerant such as dry ice.

j 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.

k 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.

m 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.

* Military Specification MIL-E-5272C (ASG), 13 April 1959; and Amendment 1, 5 January 1960.

OPERATING CONSIDERATIONS

The *semiflexible leads* of the 4460 may be soldered into the associated circuit. If desired, the leads may be trimmed to within 1/4 inch of the protective shell. When leads of reduced length are soldered, care must be taken to conduct excessive heat away from the lead seals. Otherwise, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.

Electrostatic and/or magnetic shielding of the 4460 may be necessary. When a shield is used it should be connected to a potential near that of the cathode.

Support for the 4460—if maximum signal-to-noise ratio is desired—may be provided by any suitable arrangement that maintains the external surface of the glass bulb, especially that region near the photocathode, at or near photocathode potential. Should the potential of the glass bulb differ appreciably from photocathode potential, signal-to-noise ratio may decrease because of an increase in dark current and noise output caused by the voltage gradient developed across the bulb wall.

In many applications, maximum signal-to-noise ratio is not essential. The support may therefore be at any reasonable potential and its position on the bulb is not critical. *However, under no circumstances is a clamp to be fastened to the protective shell.*

Exposing the 4460 to *strong ultraviolet radiation*, such as that from fluorescent lighting, may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 4460 is dependent on the magnitude of the anode current and its duration. When the 4460 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 on the severity of the operating conditions. After a period of idleness, the 4460 usually recovers a substantial percentage of such loss in sensitivity.

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, the average anode current should not exceed 10 microamperes.

For optimum tube performance it is also recommended that the 4460 be operated at or below room temperature.

A typical voltage-divider arrangement for use with the 4460 is shown in Fig.8. Recommended resistance values for the voltage divider range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for the voltage divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required wattage rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is near the photocathode. The use of resistance values near 1 megohm per stage may cause deviation from linearity if the voltage-divider current is not maintained at a value several times that of the maximum value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No.9 and No.10, and between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 1 megohm per stage make the 4460 more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

The high voltages at which the 4460 is operated are very dangerous. Before any part of the circuit is touched, the power supply switch should be turned off and both terminals of any capacitors grounded.

SEMI-LOGARITHMIC PRESENTATION
OF S-11 RESPONSE

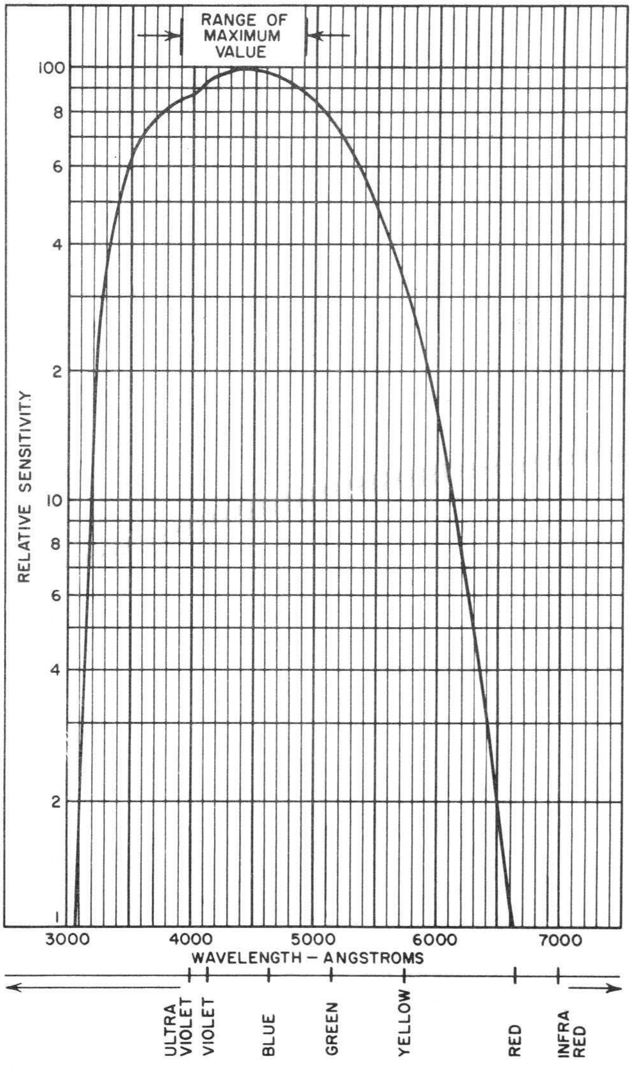


Fig. 1

TYPICAL QUANTUM EFFICIENCY AS
A FUNCTION OF WAVELENGTH

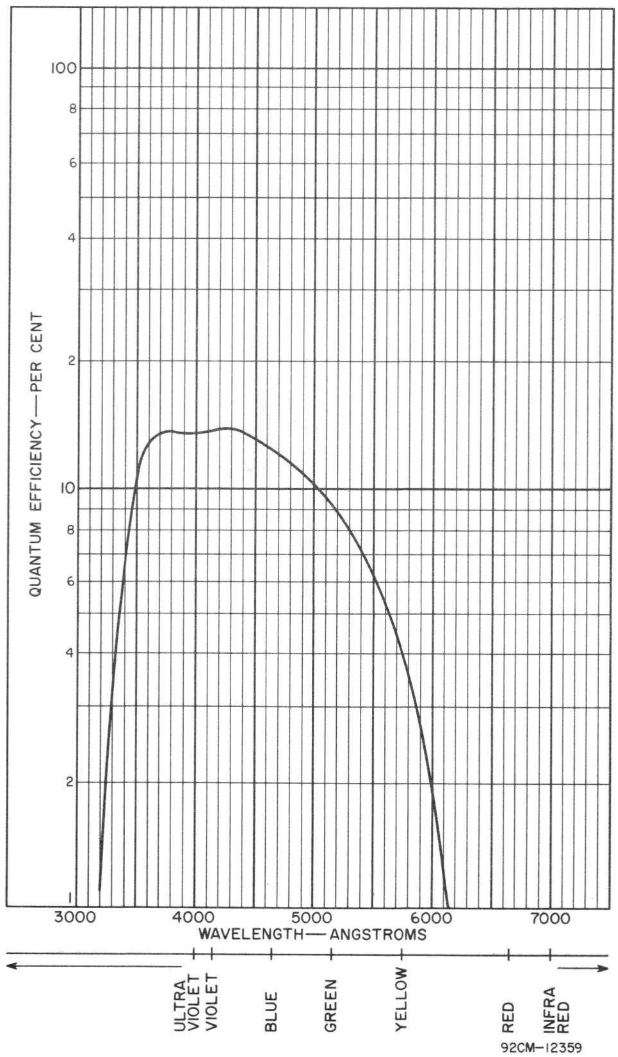
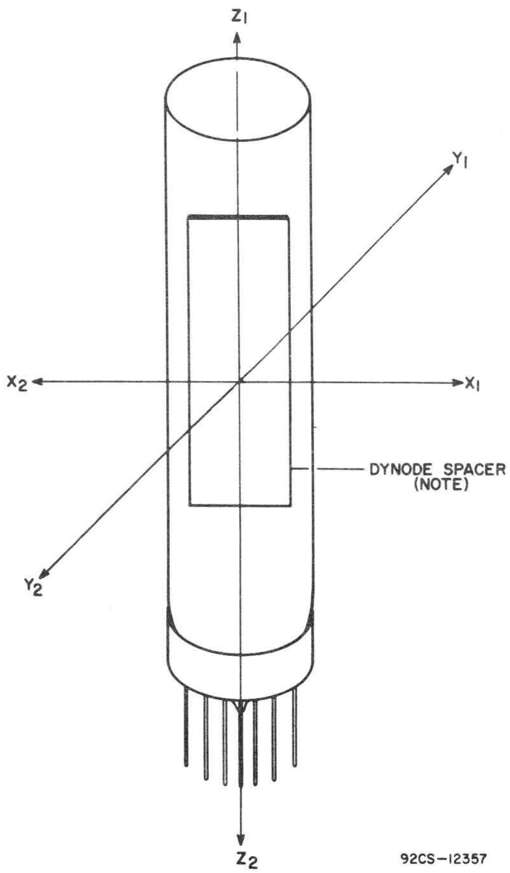


Fig. 2

ORTHOGONAL AXES USED DURING ENVIRONMENTAL TESTS



NOTE: THE PLANE OF EACH DYNODE SPACER IS PARALLEL TO THE X-Z PLANE. THE Z-AXIS IS THE MAJOR AXIS OF THE TUBE.

Fig.3

TYPICAL TIME RESOLUTION CHARACTERISTICS

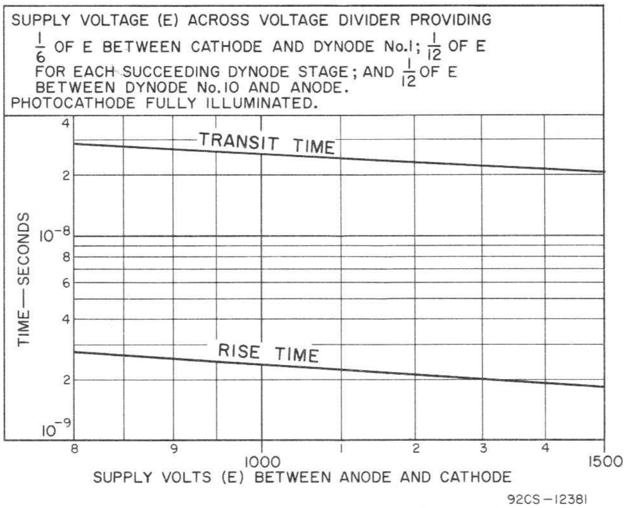


Fig.4

TYPICAL ANODE-DARK-CURRENT CHARACTERISTIC

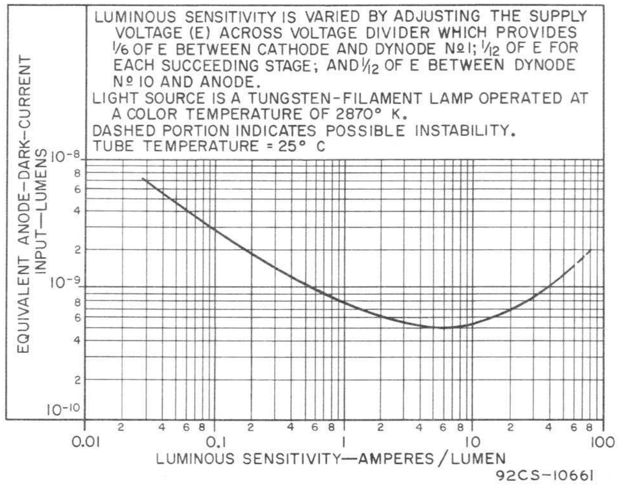


Fig.5

AVERAGE ANODE CHARACTERISTICS

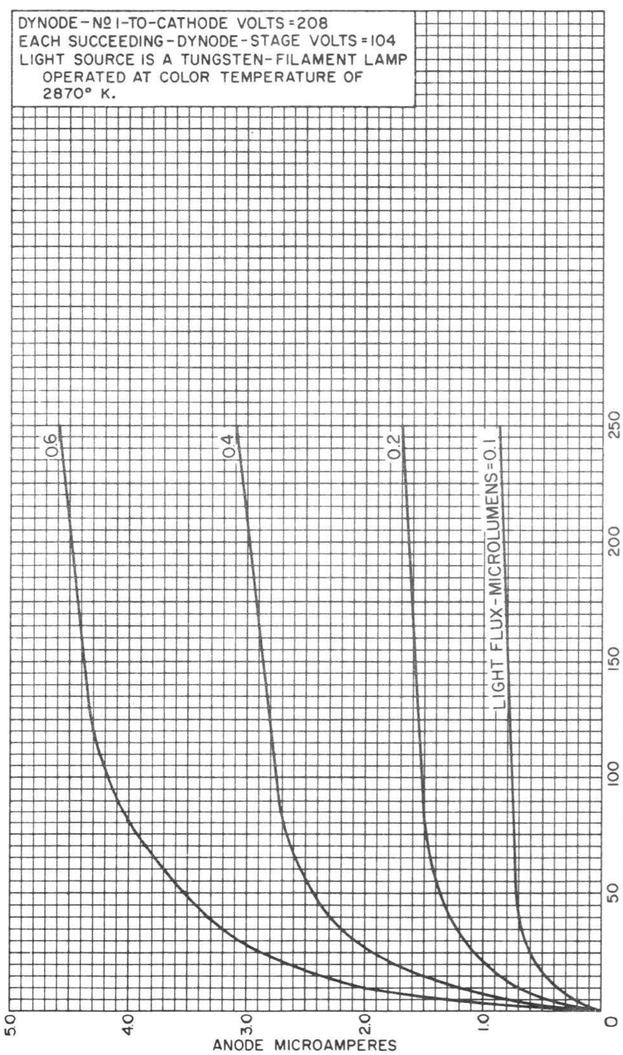


Fig.6

SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

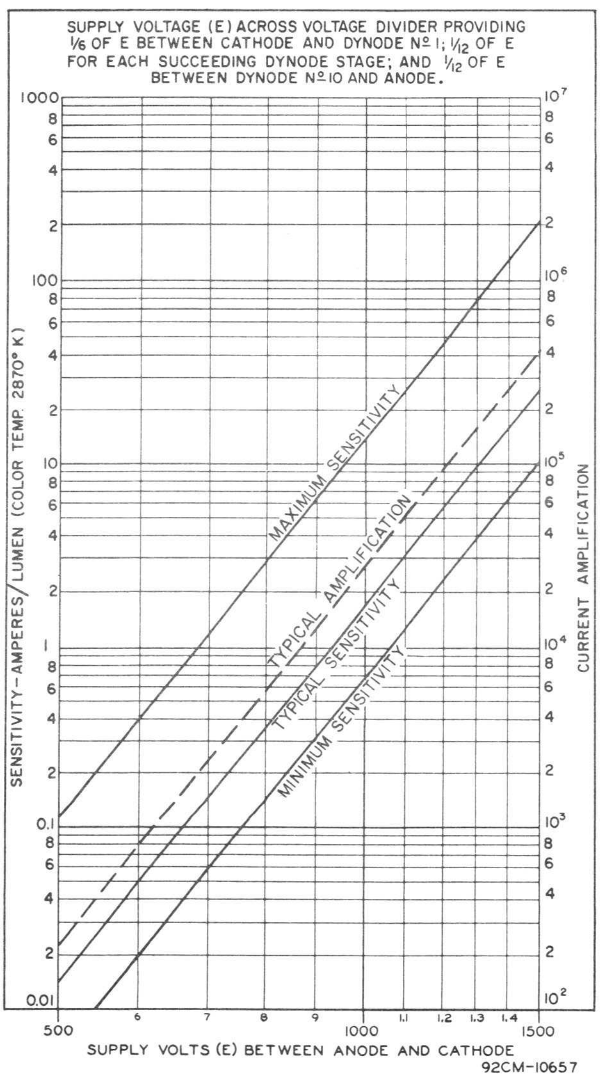
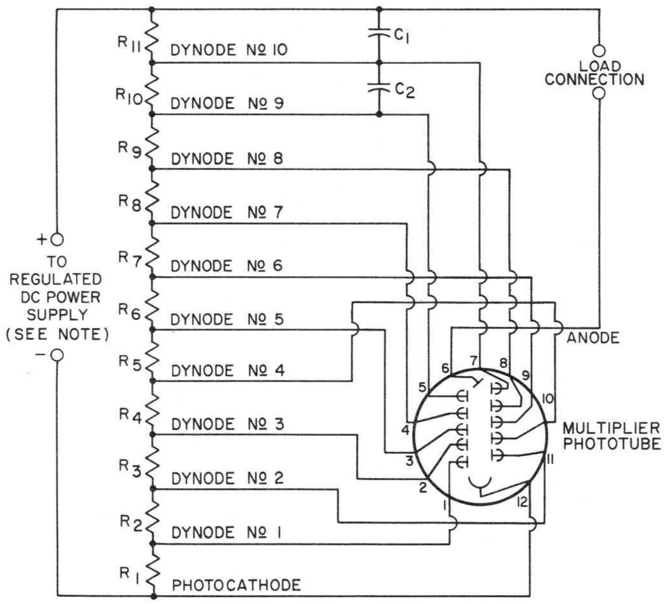


Fig.7

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



92CS-10656R1

NOTE: ADJUSTABLE BETWEEN APPROXIMATELY 500 AND 1500 VOLTS DC.

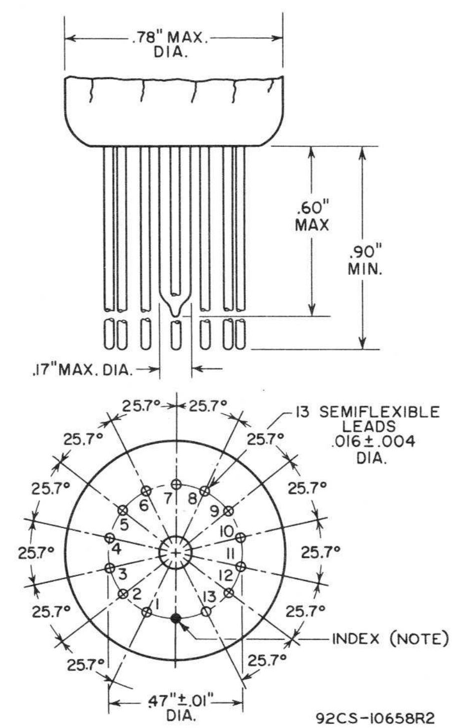
C_1, C_2: 0.01 μf, 500 volts (dc working)

R_1: 91,000 ohms, 2 watts

R_2 through R_{11}: 47,000 ohms, 1 watt

Fig.8

SMALL-BUTTON THIRTEENAR BASE



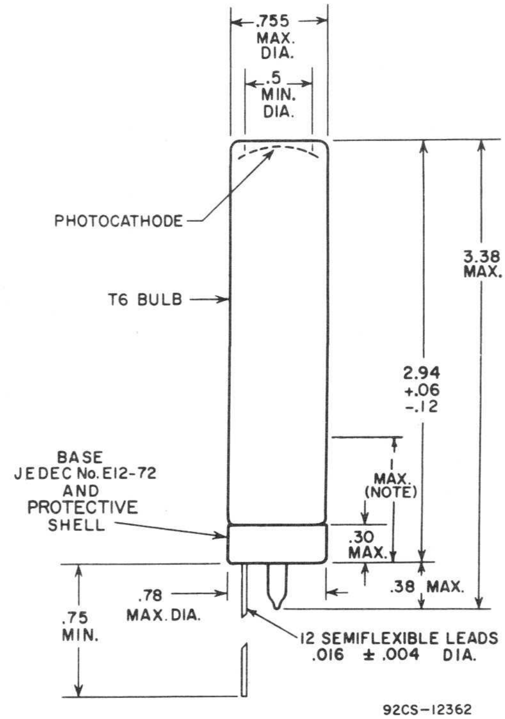
92CS-10658R2

JEDEC No.		LEADS
E13-71	13-LEAD BASE*	1,2,3,4,5,6,7,8,9,10,11,12,13
E12-72	12-LEAD BASE**	1,2,3,4,5,6,7,8,9,10,11,12

* LEAD No.14 IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON FOR INDEXING.

** LEAD No.13 IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON.

DIMENSIONAL OUTLINE

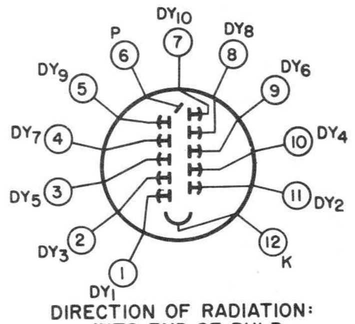


Dimensions in Inches

NOTE: WITHIN THIS LENGTH, MAXIMUM DIAMETER OF TUBE IS 0.78".

BASING DIAGRAM

Bottom View



DIRECTION OF RADIATION: INTO END OF BULB

12BG

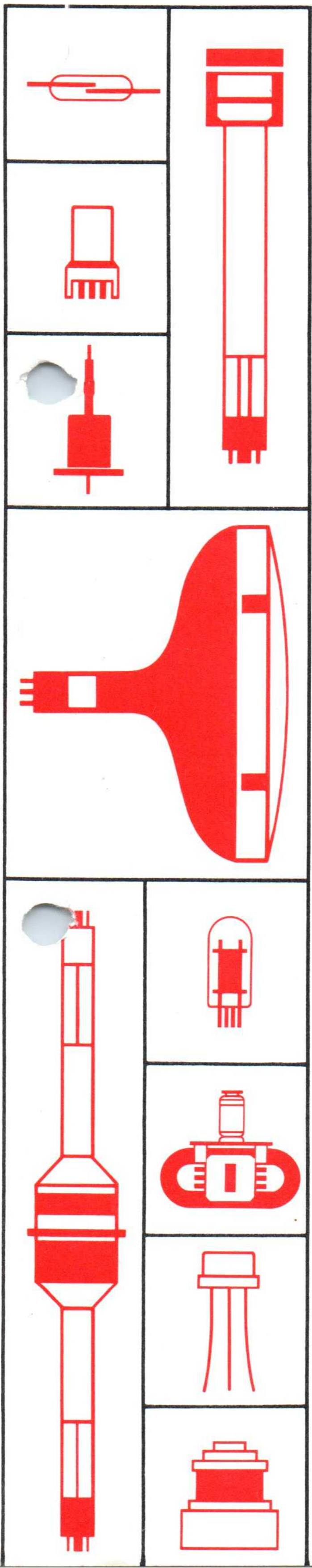
LEAD 1: DYNODE No.1	LEAD 7: DYNODE No.10
LEAD 2: DYNODE No.3	LEAD 8: DYNODE No.8
LEAD 3: DYNODE No.5	LEAD 9: DYNODE No.6
LEAD 4: DYNODE No.7	LEAD 10: DYNODE No.4
LEAD 5: DYNODE No.9	LEAD 11: DYNODE No.2
LEAD 6: ANODE	LEAD 12: PHOTOCATHODE

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-4461*

NEW, RUGGEDIZED, 10-STAGE, 1½-INCH DIAMETER HEAD-ON TYPE OF MULTIPLIER PHOTOTUBE

Ruggedness and reliability of the new RCA-4461 under adverse environmental conditions is enhanced by 100 per-cent testing for both shock and vibration. This new tube, which is designed to meet the specifications of MIL-E-5272C for equipment mounted on the structures of missiles launched by high-thrust engines, is similar to the recently announced RCA-4441A except it employs copper-beryllium dynodes.

MAJOR FEATURES AND CHARACTERISTICS

- 100% testing for:

Shock	30 g's
Vibration	20 g's

- Rugged construction
- S-11 spectral response
- Copper-beryllium dynodes

A bulletin giving detailed technical information is attached for your convenience.

* Formerly Dev. Type C70114

March 16, 1964

THE MOST TRUSTED NAME IN ELECTRONICS

Rugged Vibration-Resistant Structure
S-11 Spectral Response
10-Stage, Head-On Type
1.24" Min. Dia. Flat Semitransparent Photocathode

RCA-4461

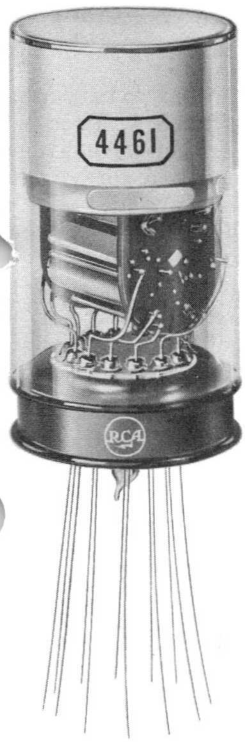
MULTIPLIER PHOTOTUBE

For Use Under Severe Environmental Conditions

Formerly Developmental Type C70114

INITIAL DATA

RCA-4461 is a ruggedized, 10-stage, head-on type of multiplier phototube intended for industrial and military nuclear-radiation and low-level light detection-and-measurement applications where severe environmental conditions may be encountered. It is designed specifically for use in missile and rocket applications.



The 4461 has an extremely rugged construction and utilizes a special photocathode connection which assures continuous contact with the cathode when the tube is subjected to rough usage.

Other features include a semitransparent cathode having a minimum diameter of 1.24 inches on the inner surface of the face end of the bulb, a face with a flat surface to facilitate the mounting of scintillators, ten electrostatically-focused dynode stages, and semiflexible leads that may be soldered directly into the associated circuit.

The spectral response of the 4461 covers the range from about 3000 to 6500 angstroms, as shown in Fig.1. Maximum response occurs at approximately 4400 angstroms. The 4461, therefore, has high sensitivity in the blue region and less sensitivity in the red region of the spectrum.

Typical quantum efficiency as a function of wavelength for the 4461 is shown in Fig.3.

DATA

General:

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 angstroms
Cathode, Semitransparent	Cesium-Antimony
Minimum area	1.2 sq.in.
Minimum diameter	1.24 in.
Window	Lime Glass (Corning[a] No.0080), or equivalent
Shape	Plano-plano
Index of refraction at 5893 angstroms	1.51
Dynode Material	Copper-Beryllium
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	3.2 pf
Anode to all other electrodes	5.0 pf
Maximum Overall Length (Excluding semiflexible leads)	3.18"
Maximum Diameter	1.56"
Bulb	T12
Base	Special
Magnetic Shield	See *footnote* (b)
Operating Position	Any
Weight (Approx.)	2.2 oz

Maximum Ratings, *Absolute-Maximum Values:*[c]

DC Supply Voltage:		
Between anode and cathode	1500 max.	volts
Between anode and dynode No.10	250 max.	volts
Between consecutive dynodes	200 max.	volts
Between dynode No.1 and cathode	400 max.	volts
Average Anode Current[d]	1 max.	ma
Average Cathode Current[de]	2 max.	μa
Ambient Temperature	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1250 volts (Except as noted)

	Min.	*Typical*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	-	8×10^{3}	-	a/w
Cathode radiant, at 4400 angstroms	-	0.048	-	a/w
Luminous:				
At 0 cps[f]	3	10	90	a/lm
With dynode No.10 as output electrode[g]	-	6	-	a/lm
Cathode luminous:				
With tungsten light source[h]	4×10^{-5}	6×10^{-5}	-	a/lm
With blue light source[j]	4×10^{-8}	6×10^{-8}	-	a
Current Amplification	-	1.7×10^{5}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 10 a/lm[k]	-	5×10^{-10}	2×10^{-9}	lm
Equivalent Noise Input[mn]	-	2.8×10^{-12}	1.8×10^{-11}	lm
Anode-Pulse Rise Time[p]	-	2.4×10^{-9}	-	sec

SEMI-LOGARITHMIC PRESENTATION OF S-11 SPECTRAL RESPONSE

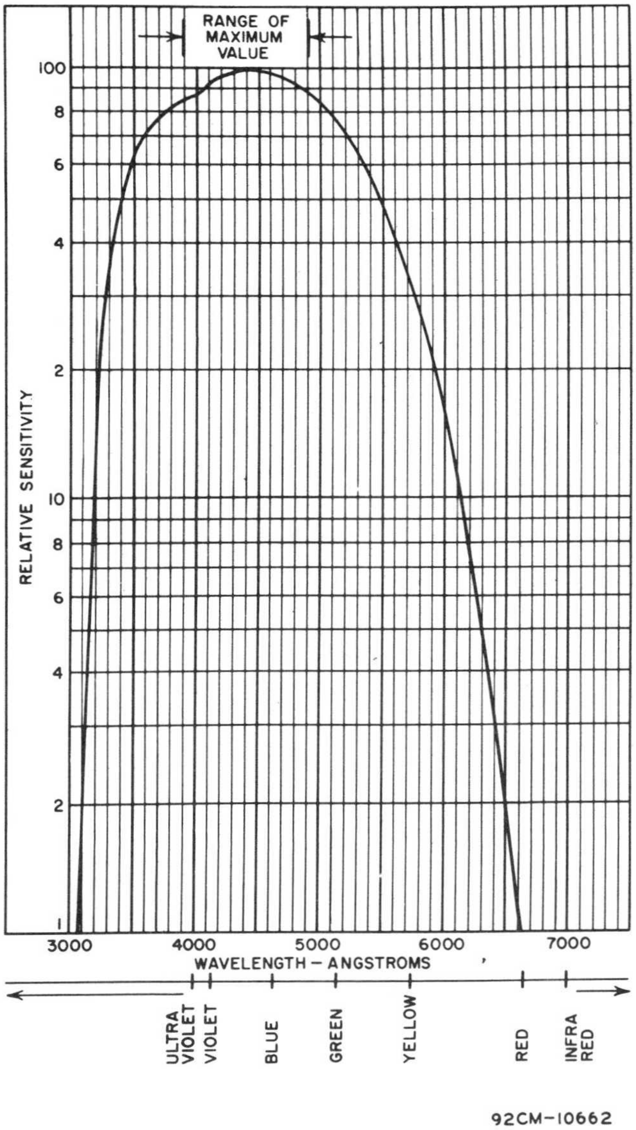


Fig.1

Electron Transit Time[q].	-	2.9×10^{-8}	-	sec
Quantum Efficiency at 4300 angstroms. .	-	14	-	%

With E = 750 volts (Except as noted)

	Min.	Typical	Max.	
Sensitivity:				
Radiant, at 4400 angstroms.	-	1.8×10^{2}	-	a/w
Cathode radiant, at 4400 angstroms.	-	0.048	-	a/w
Luminous:				
At 0 cps[f].	-	0.22	-	a/lm
Cathode luminous:				
With tungsten light source[h]. .	4×10^{-5}	6×10^{-5}	-	a/lm
With blue light source[j]. .	4×10^{-8}	6×10^{-8}	-	a
Current Amplification.	-	3.7×10^{3}	-	
Equivalent Anode-Dark-Current Input at a luminous sensitivity of 10 a/lm[k].	-	5×10^{-10}	2×10^{-9}	lm
Anode-Pulse Rise Time[p].	-	3.1×10^{-9}	-	sec
Electron Transit Time[q].	-	3.8×10^{-8}	-	sec

ENVIRONMENTAL TESTS:

The 4461 is designed to withstand environmental tests equivalent to those specified in MIL-E-5272C* for equipment mounted on the structures of missiles propelled or launched by high thrust rocket engines. The accelerations specified in these tests are applied directly to the tubes.

One-Hundred Per-Cent Shock and Vibration Testing:

Shock. These tests are performed first, per method of MIL-E-5272C*, par.4.15.5.1, Proc.V, on apparatus which provides a half-wave sinusoidal shock pulse. One-hundred per-cent testing of all 4461's is performed. Each 4461 (non-operating) is subjected to three impact shocks in each direction of the three orthogonal axes shown in Fig.2. Each impact shock has a peak acceleration of 30 ± 3 g's and a time duration of 11 ± 1 milliseconds. Each tube is subjected to a total of 18 impact shocks.

Vibration. These tests are performed next, on apparatus which applies variable sinusoidal frequency vibration to the tube, per method of MIL-E-5272C*, par.4.7.14 and par.4.7.14.1, except for the cycle duration. One-hundred per-cent testing of all 4461's is performed. Each 4461 (operating under the conditions specified under *Tube Rejection Criterion*) is vibrated in each of the three orthogonal axes shown in Fig.2 and as specified in the schedule below. A vibration cycle has a duration of 5 minutes per axis in which time the frequency is varied logarithmically from 20 to 2000 and back to 20 cycles per second. One vibration cycle is performed for each axis and the total test period for each tube is 15 minutes.

Double Amplitude inches	Accelera-tion g's	Fre-quency cps	Cycle Duration Per Axis minutes
0.050 ± 0.005	-	20-87	5
-	20 ± 2	87-2000	
-	20 ± 2	2000-87	
0.050 ± 0.005	-	87-20	

Tube Rejection Criterion. After completion of the shock tests, tubes are operated at an anode-to-cathode voltage of 1250 volts with the light level incident on the tube adjusted to provide an anode current of approximately 8 microamperes. Electrical and/or mechanical tube failures due to shock or vibration will be observed during the vibration test when the specified anode current is monitored. Tube rejection criterion for both tests is that the anode current of 8 microamperes will not change more than ±20 per cent upon completion of the vibration test for each axis.

DESIGN TESTS:

Vibration. These tests are performed under conditions equivalent to those described in MIL-E-5272C*, par.4.7.14 and par.4.7.14.1. The double-amplitude, acceleration, and frequency levels are as shown in the above table. The vibration cycle has a duration of one hour and two cycles are performed for each of the three orthogonal axes shown in Fig.2. The total test period for each tube is six hours.

Acceleration. These tests are performed in a centrifuge providing unidirectional acceleration by a method equivalent to that specified in MIL-E-5272C*, par.4.16.3, Proc.III except that tubes are subjected for one minute to an increased acceleration test level of 100 ± 10 g's in both directions of the three orthogonal axes shown in Fig.2, and the tubes are non-operating.

ORTHOGONAL AXES OF TUBE USED DURING ENVIRONMENTAL TESTS

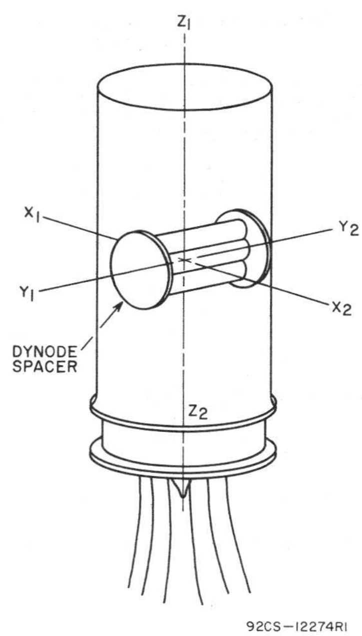


Fig.2

[a] Made by Corning Glass Works, Corning, New York.

[b] Magnetic shielding material in the form of foil or tape as available from the James Millen Manufacturing Company, 150 Exchange Street, Malden 48, Massachusetts, or equivalent.

[c] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[e] For a uniformly illuminated area of 0.5 square inches minimum.

[f] 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.

[g] An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.10 as the output electrode. With this arrangement, the load is connected in the dynode-No.10 circuit and the anode serves only as collector. The curves shown in Fig.6 do not apply when dynode No.10 is used as the output electrode.

[h] 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.

[j] 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.

[k] At a tube temperature of 25° C. Dark current may be reduced by use of a refrigerant.

[m] For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1250 volts is recommended.

[n] 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.

[p] 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.

[q] 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.

* Military Specification MIL-E-5272C (ASG), 13 April 1959; and Amendment 1, 5 Jan. 1960.

TYPICAL QUANTUM EFFICIENCY AS A FUNCTION OF WAVE LENGTH

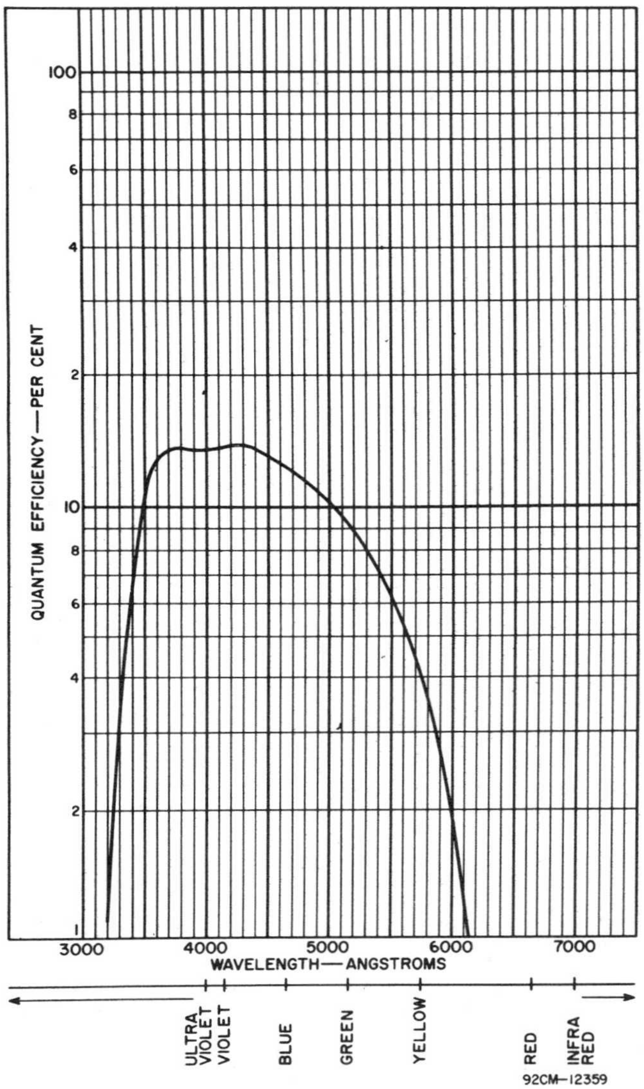


Fig.3

OPERATING CONSIDERATIONS

The *semiflexible leads* of the 4461 may be soldered into the associated circuit. When leads of reduced length are soldered, care must be taken to conduct excessive heat away from the lead seals. Otherwise, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.

The *leads are semiflexible* and can be broken. Excessive bending of the leads—especially in the region close to the glass button—is to be avoided.

Electrostatic and/or magnetic shielding of the 4461 is usually required. A magnetic field having an intensity of 1 gauss will reduce the anode output current approximately 50 per cent when the field is along the Y_1-Y_2 axis shown in Fig.2, and the 4461 is operated at an anode-to-cathode voltage of 1250 volts. When a shield is used it should be connected to a potential near that of the cathode.

Support for the 4461—if maximum signal-to-noise ratio is desired—may be provided by any suitable arrangement that maintains the external surface of the glass bulb, especially that region near the photocathode, at or near photocathode potential. Should the potential of the glass bulb differ appreciably from photocathode potential, signal-to-noise ratio may decrease because of an increase in dark current and noise output caused by the voltage gradient developed across the bulb wall. The metal flange should never be used for mechanical clamping purposes because of the possibility of breaking the glass-to-metal seals.

Precautions should also be taken to prevent a metal mounting arrangement from contacting the cathode flange unless the mounting arrangement is to be maintained at cathode potential.

Exposing the 4461 to *strong ultraviolet radiation,* such as that from fluorescent lighting, may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

TYPICAL TIME RESOLUTION CHARACTERISTICS

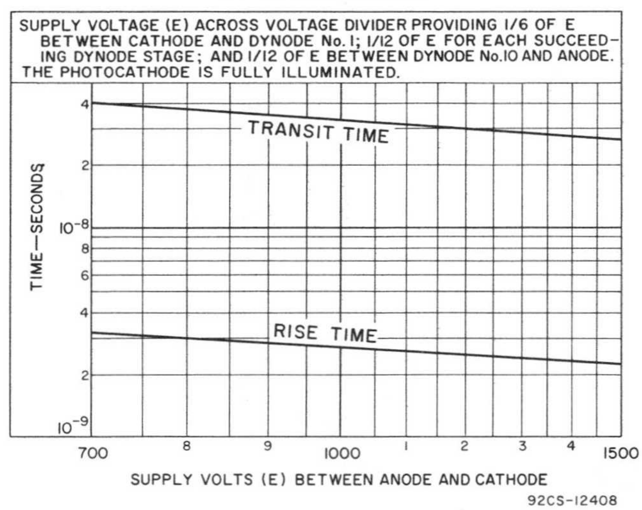


Fig.4

The *operating stability* of the 4461 is dependent on the magnitude of the anode current and its duration. When the 4461 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 on the severity of the operating conditions. After a period of idleness, the 4461 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 1 milliampere is recommended when stability of operation is important. When maximum stability is required, the average anode current should not exceed 10 microamperes.

For optimum tube performance it is also recommended that the 4461 be operated at or below room temperature.

TYPICAL SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

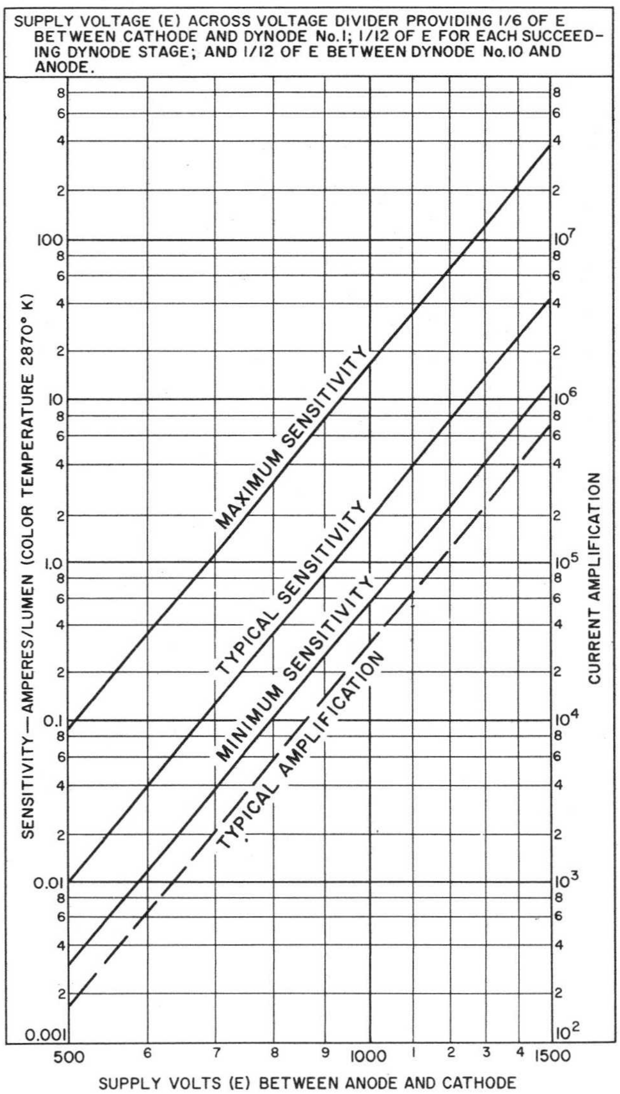


Fig. 5

the resistors increase. Phototube noise may also increase due to heating if the divider network is near the photocathode. The use of resistance values near 1 megohm per stage may cause deviation from linearity if the voltage-divider current is not maintained at a value several times that of the maximum value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors

TYPICAL ANODE CHARACTERISTICS

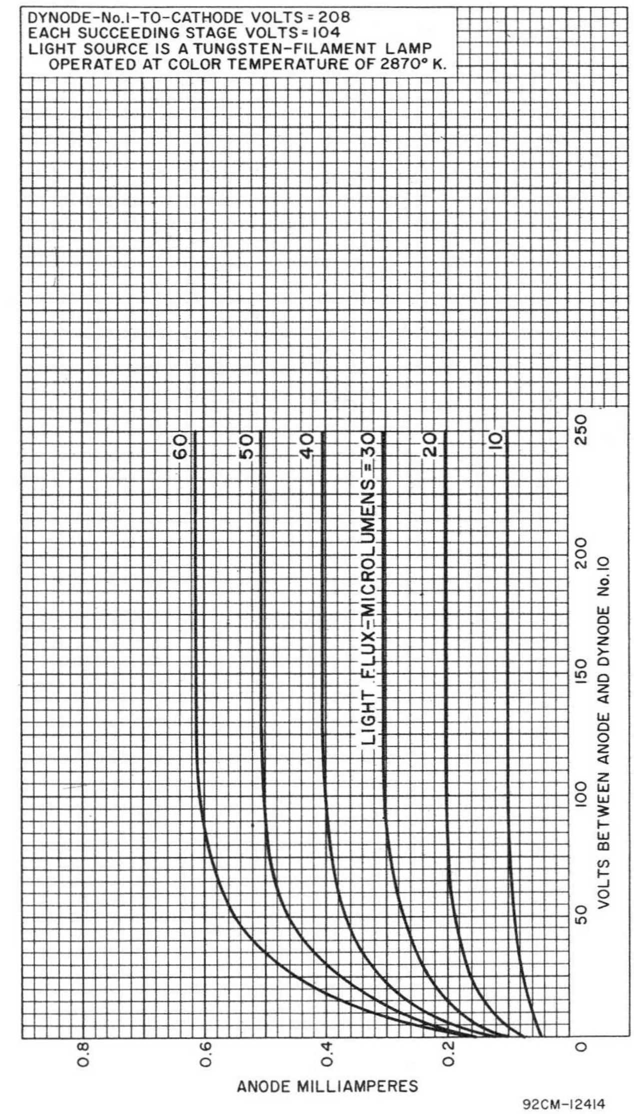


Fig.6

A typical voltage-divider arrangement for use with the 4461 is shown in Fig.8. *Recommended resistance values* for the voltage-divider arrangement range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for the voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required wattage rating of

between the leads for dynodes No.7 and No.8, dynodes No.8 and No.9, dynodes No.9 and No.10, and between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 1 megohm per stage make the 4461 more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

The *high voltages* at which the 4461 is operated are very dangerous. Before any part of the circuit is touched, the power supply switch should be turned off and both terminals of any capacitors grounded.

TYPICAL ANODE-DARK-CURRENT CHARACTERISTIC

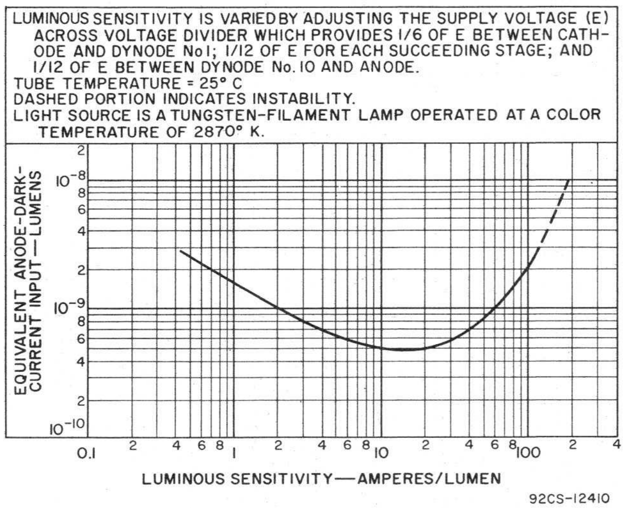
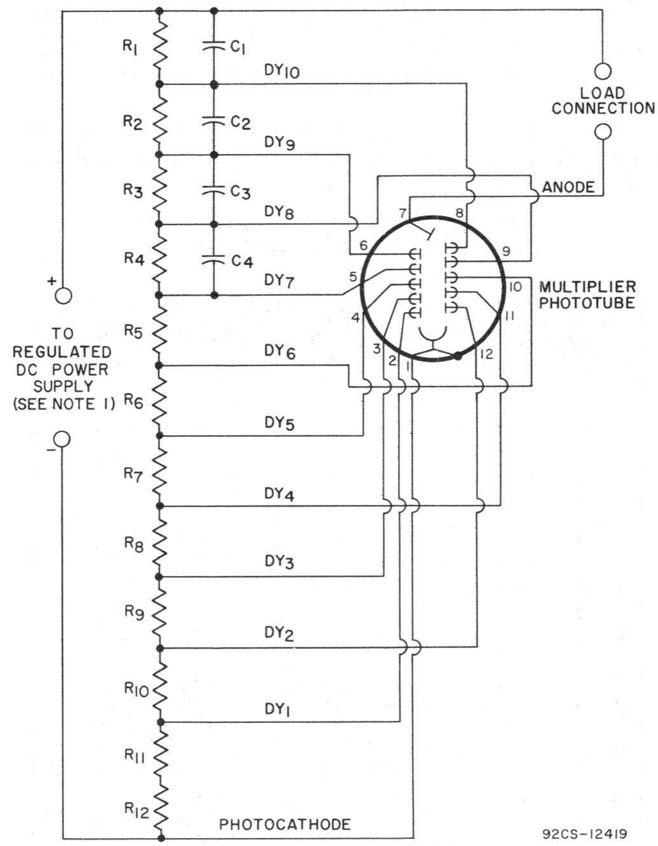


Fig.7

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT



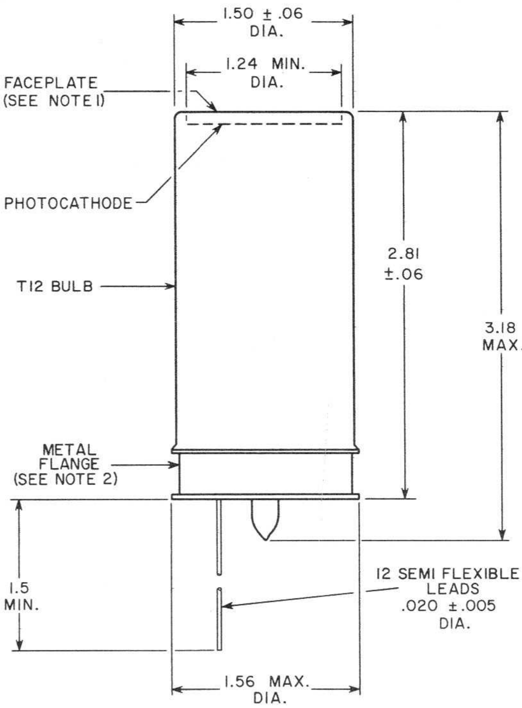
C_1: 0.05 μf, 500 volts (dc working)
C_2: 0.02 μf, 500 volts (dc working)
C_3: 0.01 μf, 500 volts (dc working)
C_4: 0.005 μf, 500 volts (dc working)
R_1 through R_{12}: 33,000 ohms, 2 watts

Note 1: Adjustable between approximately 500 and 1500 volts dc.

Note 2: Capacitors C_1 through C_4 should be connected at tube socket for optimum high-frequency performance.

Fig.8

DIMENSIONAL OUTLINE



92CS-11464R2

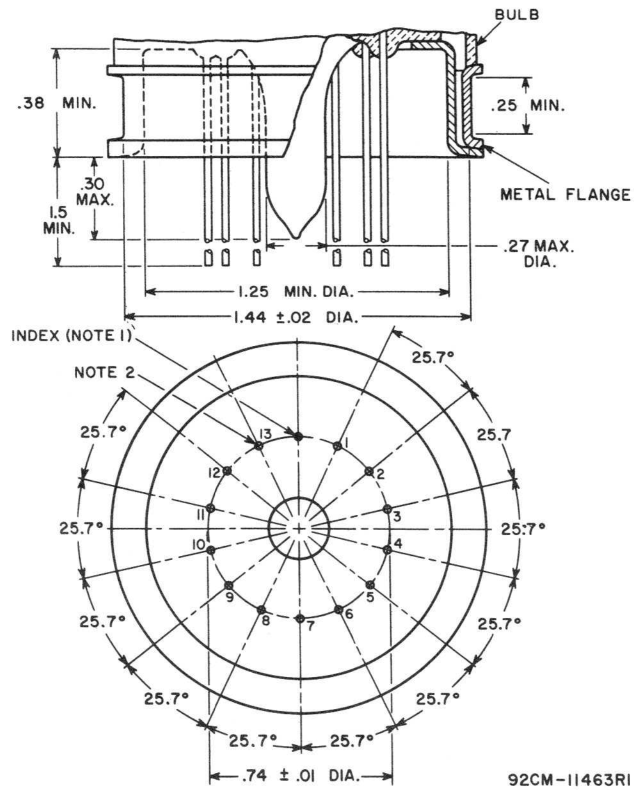
DIMENSIONS IN INCHES

NOTE 1: DEVIATION FROM FLATNESS WITHIN THE 1.24"-DIAMETER AREA WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

NOTE 2: THE METAL FLANGE SHOULD NEVER BE EMPLOYED FOR MECHANICAL MOUNTING PURPOSES.

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE FLANGE.

DETAIL OF BASE ARRANGEMENT



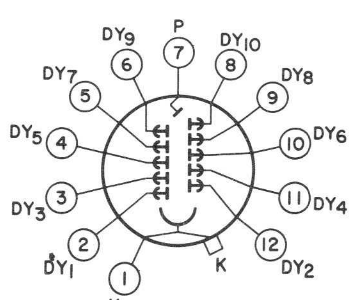
92CM-11463R1

DIMENSIONS IN INCHES

NOTE 1: LEAD IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON FOR INDEXING.

NOTE 2: LEAD No.13 IS CUT OFF WITHIN 0.04 INCH OF THE GLASS BUTTON.

BASING DIAGRAM
Bottom View



DIRECTION OF LIGHT:
INTO END OF BULB

Lead 1 and Metal Flange – Photocathode
Lead 2 – Dynode No.1
Lead 3 – Dynode No.3
Lead 4 – Dynode No.5
Lead 5 – Dynode No.7
Lead 6 – Dynode No.9
Lead 7 – Anode
Lead 8 – Dynode No.10
Lead 9 – Dynode No.8
Lead 10 – Dynode No.6
Lead 11 – Dynode No.4
Lead 12 – Dynode No.2

RCA

Focusing Method:
Image-Converter Section—Electrostatic
Image-Orthicon Section—Magnetic

Deflection Method:
Image-Orthicon Section—Magnetic

RCA-4470

IMAGE-INTENSIFIER ORTHICON

For Extremely Low-Light-Level Television

RCA-4470 is an image-intensifier orthicon type of television camera tube designed to provide high resolution at extremely low levels of scene illumination. It combines the elements of the image-converter tube with those of the image orthicon and is intended for use with illumination levels on the first photocathode (image-converter section) of 1×10^{-6} footcandle, or less. Operation at light levels higher than this value increases signal retention on the target, and can cause permanent tube damage if such operation is prolonged and the object being viewed is stationary. Typical center resolution of the 4470 with 1×10^{-6} footcandle illumination on the first photocathode is about 480 TV lines.

The 4470 employs a thin-film semiconductive target which results in high tube sensitivity, improved resolution by minimizing lateral charge leakage, and extends useful tube life by minimizing permanent conditions of "target burn" and "sticking picture".

Another feature of the 4470 is the use of multialkali photosurfaces which provide high photocathode sensitivities over the entire visible range. This characteristic of the response permits gray-scale rendition in nearly true tonal gradation.

DATA

General:

Maximum Overall Length . . . . 22.44"
Greatest Diameter . . . . 5.016"
Operating Position . . . The tube should never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with the base up makes an angle of less than 20° with the vertical.
Weight (Approx.) . . . . 4 lbs 14 oz

Image-Converter Section:
Spectral Response S-20
Wavelength of Maximum Response . . 4200 ± 500 angstroms
First Photocathode, Semitransparent:
Useful size of . . . . 2" max. Diagonal
Focusing Method . . . . Electrostatic

Image-Orthicon Section:
Heater, for Unipotential Cathode:
Voltage (AC or DC) . . . . 6.3 ± 10% volts
Current . . . . 0.6 ampere

Direct Interelectrode Capacitance:
Anode to all other electrodes . . . . 12 pF
Focusing Method . . . . Magnetic
Deflection Method . . . . Magnetic
Shoulder Base . . . . Keyed Jumbo Annular 7-Pin
End Base . Small-Shell Diheptal 14-Pin (JEDEC No.B14-45)
Socket . . . . Cinch Part No.3M14,[a] or equivalent
Minimum Deflection-Coil Inside Diameter . . . . 2-3/8"
Deflecting Coil . . . Cleveland Electronics, Part No.OY-1,[b] or equivalent
Deflection-Coil Length . . . . 5"
Focusing Coil . . . . Cleveland Electronics, Part No.OF-2,[b] or equivalent
Focusing-Coil Length . . . . 10"
Alignment Coil . . . Cleveland Electronics, Part No.OA-3,[b] or equivalent
Alignment-Coil Length . . . . 15/16"

Maximum Ratings, *Absolute-Maximum Values:*[c]

Maximum Continuous Operating Photocathode Illumination	1×10^{-6}	fc
Storage-Temperature Range	0 to 50	°C
Image-Converter Section:		
First Photocathode Voltage[d]	-15000	volts
Grid-No.7 Voltage (With respect to First Photocathode)	1800	volts
Image-Orthicon Section:		
Second Photocathode Voltage	-550 max.	volts
Grid-No.6 Voltage	-550 max.	volts
Target Voltage:		
Positive Value	10 max.	volts
Negative Value	10 max.	volts
Grid-No.5 Voltage	150 max.	volts
Grid-No.4 Voltage	300 max.	volts
Grid-No.3 Voltage	400 max.	volts
Grid-No.2 & Dynode-No.1 Voltage	350 max.	volts
Grid-No.1 Voltage:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
Anode-Supply Voltage[e]	1350 max.	volts
Voltage Per Multiplier Stage	350 max.	volts
Operating Temperature:		
Of any part of bulb[f]	35 max.	°C
At 3"-diameter end of tube (target section)	25 min.	°C

Temperature Difference:		
Between target section and any part hotter than image-orthicon target section. . . .	5 max.	°C

Typical Operating Values:

Image-Converter Section:		
First Photocathode Voltage[d] . . .	-10000 to -15000	volts
Grid-No.7 (Focusing Electrode) Voltage.	89% to 93% of First Photocathode Voltage	
Image-Orthicon Section:		
Second Photocathode Voltage . . .	-400 to -540	volts
Grid-No.6 Voltage (Approx. 75% of Second Photocathode Voltage)	-300 to -405	volts
Target-Cutoff Voltage[g]	-3 to +1	volts
Grid-No.5 Voltage (Decelerator) .	0 to 125	volts
Grid-No.4 Voltage (Beam Focus).	160 to 220	volts
Grid-No.3 Voltage[h]	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff	-45 to -115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Target-Temperature Range	35 to 45	°C
Minimum Peak-to-Peak Blanking Voltage	5	volts
Field Strength at Center of Focusing Coil[i]	75	gauss
Field Strength of Alignment Coil.	0 to 3	gauss

a Made by Cinch Manufacturing Co., 1026 South Homan Ave., Chicago 24, Illinois.

b Made by Cleveland Electronics Inc., 1974 East 61st Street, Cleveland, Ohio.

c The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

d An optimum value of image-converter-section supply voltage is supplied with each individual 4470.

e Dynode voltage values are shown under *Typical Operating Values*.

f The operating temperature may be 50° C max. within a distance of 7" from the diheptal base end of the tube.

g Normal setting of target voltage is +2 volts from target cutoff. The target supply voltage should be adjustable from -3 to +5 volts.

h Adjust to give the most uniformly shaded picture near maximum signal.

i Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with indicator located outside of and at the image end of the focusing coil.

GENERAL CONSIDERATIONS

Signal current produced in the 4470 is directly proportional to the incident light level. Noise, on the other hand, is proportional to the square root of scanning-beam current. Therefore, maximum signal-to-noise ratio is obtained only when that value of beam current necessary to just discharge the scene highlights is employed. The maximum ratio of signal-to-noise attainable from the 4470 approaches the signal-to-noise ratio of the photoelectron image of the first photocathode. This ratio is low, however, due to the small number of quanta available at the very low light levels at which the 4470 is operated and also because the quantum efficiency of the photocathode is less than unity.

CAMERA MODIFICATIONS

When the 4470 is used in image-orthicon cameras, the following instructions and camera modifications should be followed:

1. The camera should be of good electrical and mechanical design.

2. A high-voltage source must be provided to supply the necessary voltage for the image-converter section of the 4470. The positive terminal of this voltage supply should be grounded and the negative terminal of the supply should be adjustable from −10 kV to −15 kV for optimum operation of the tube. This high-voltage supply should be connected to a voltage-divider network, such as that shown in Fig.5, to obtain the proper photocathode and grid-No.7 voltages.

3. A spherical corrective lens system should be employed with the first photocathode (image-converter section) to minimize "pin-cushioning" effects. The photocathode radius of curvature is 4.0". The faceplate glass is 0.045" thick.

4. The video signal should be passed through a 2-megacycle low-pass filter to obtain optimum

signal-to-noise ratio at threshold light levels.

5. Support for the image-converter section of the 4470 must be provided. Such support may be provided by any convenient method that does not introduce undue pressure to the "potting" material and thereby reduces its voltage-isolation properties. In addition, the mounting arrangement should not introduce torsion or forces that are perpendicular to the major axis of the tube. Any tube retaining plug or lens housing placed at the image-converter section (front end) of tube should be made of high-grade insulating material.
6. The 4470 should be operated with the key pin of the base in the direction of vertical scanning.

SET-UP PROCEDURE

The set-up procedure described below should be followed carefully to obtain optimum performance from the 4470. Care must be exercised at all times to prevent the inadvertent exposure of the 4470 to direct illumination from the sun or other bright light sources. The maximum first photocathode illumination level should not exceed 1×10^{-6} footcandle.

The 4470 should be inserted in its socket with all camera voltages in the "off" position. Before applying the heater voltage make sure that no light is incident on the photocathode, i.e., make sure that all camera doors and light shields are closed and that the camera lens is capped. Allow the 4470 to warm up for 2 minutes with only heater voltage applied.

Carefully check the camera lens system for the proper combination of neutral-density filter and lens aperture that limits the illumination on the first photocathode to 1×10^{-6} footcandle from a test chart or set-up scene. Now, uncap the lens after the lens system has been so adjusted. Apply the specified image-converter voltage to that section. NOTE: A specified voltage which assures proper image-converter section operation is supplied with each individual 4470.

Turn on scanning and image-orthicon-section voltage as indicated under *Typical Operating Values* making certain that the image-orthicon beam control (grid No.1) is adjusted to its most negative position and that the target-voltage control is adjusted to -3 volts, or its most negative position. The deflecting circuits must be adjusted for maximum output to assure overscanning of the target.

Next, slowly adjust the beam control (grid No.1) until noise or a rough-textured picture of dynode No.1 appears on the monitor. Cap the camera lens. Then adjust the beam control (grid No.1) and beam-focus control (grid No.4) so that the small white dynode spot appears on the monitor.

Then adjust the alignment-coil current so that the small white dynode spot does not move when the beam-focus control (grid No.4) is varied, but simply goes in and out of focus. During alignment of the beam, and also during operation of the tube, always keep the beam current as low as possible to give the best picture quality and to prevent excessive noise.

After the tube has warmed up for 1/4 hour, uncap the lens and point the camera at the test pattern or test scene, again making sure the light level on the first photocathode is between 1×10^{-7} and 1×10^{-6} footcandle. The target voltage is then increased until the test pattern is just discernible on the monitor. This value of target voltage is known as the "target-cutoff voltage". The target voltage should then be raised exactly 2 volts above the cutoff-voltage value, and the beam-current control adjusted to give just sufficient beam current to discharge the highlights.

Then adjust the lens to produce best optical focus and the voltage on the second (image orthicon) photocathode as well as the voltage on grids No.4 and No.7 to produce the sharpest picture.

At this point, attention should be given to the grid-No.5 and grid-No.3 voltage controls. Grid No.5 is used to control the landing of the beam on the target and consequently the uniformity of signal output. The grid-No.5 voltage control should be adjusted to produce a picture that has most uniform shading from center to edge with the lens iris adjusted to permit operation at the highest light level involved in the application. The value of grid-No.5 voltage should be as high as possible consistent with uniform shading. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The grid-No.3 voltage control should be adjusted to produce the maximum signal output and uniformity.

Now with a test pattern consisting of a straight line centered on the face of the 4470 adjust the voltage on grid No.6 along with the voltage on the second photocathode to produce a sharply focused straight line on the monitor. Improper adjustment of the grid-No.6 voltage control will result in the straight-line pattern being reproduced with a slight S-shape.

Scanning may be adjusted until the target just fills the monitor picture.

The above adjustments constitute a rough setup of the 4470. Final adjustments necessary for the 4470 to produce the best possible picture include realignment of the beam with the lens capped. Beam alignment is necessary after each change of the grid-No.5 voltage control and sometimes after each adjustment of the grid-No.3 voltage control.

With the camera operating at the desired illumination level, the beam current should be slowly decreased by adjusting the grid-No.1 voltage control to the point where the beam is just sufficient to discharge the highlights of the picture. Each change of scene illumination should be accompanied by appropriate changes in beam current and amplifier gain to obtain the best contrast and signal-to-noise ratio for each new scene condition.

For stand-by operation, adjust scanning for overscan, cap camera lens, turn off image-converter voltage, and keep the beam and target voltage on.

To turn the 4470 off, put the camera in the standby operation described above, then adjust the target voltage to -3 volts, or its most negative position, turn the beam control (grid No.1) to its most negative position and immediately thereafter turn off all other image-orthicon voltages. To turn tube on again, repeat the set-up procedure.

S-20 SPECTRAL RESPONSE CHARACTERISTIC

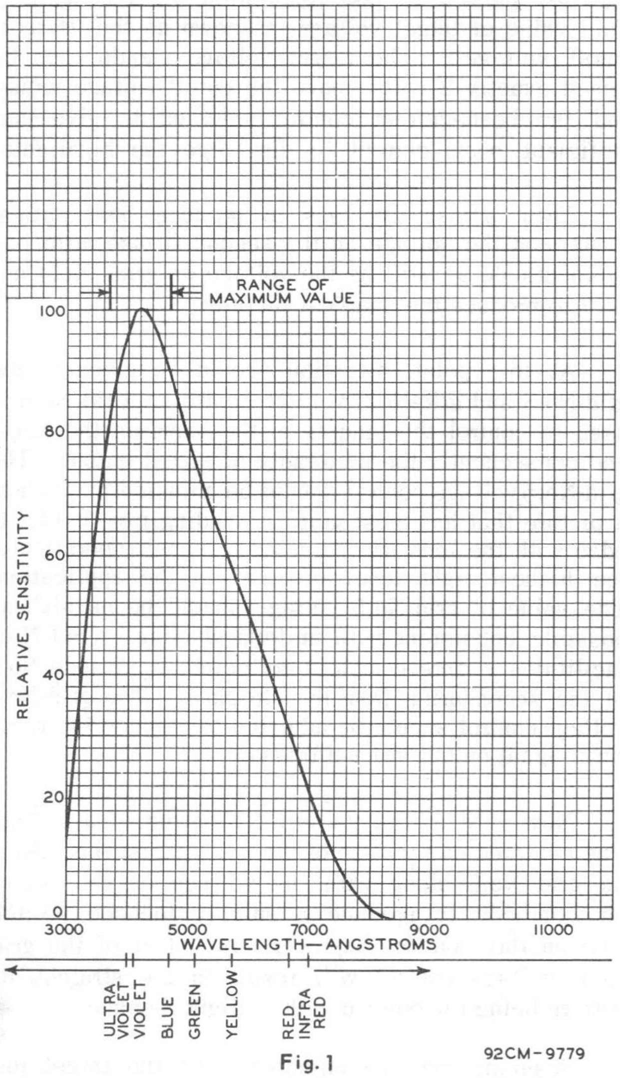


Fig. 1

TYPICAL LIMITING RESOLUTION CHARACTERISTIC

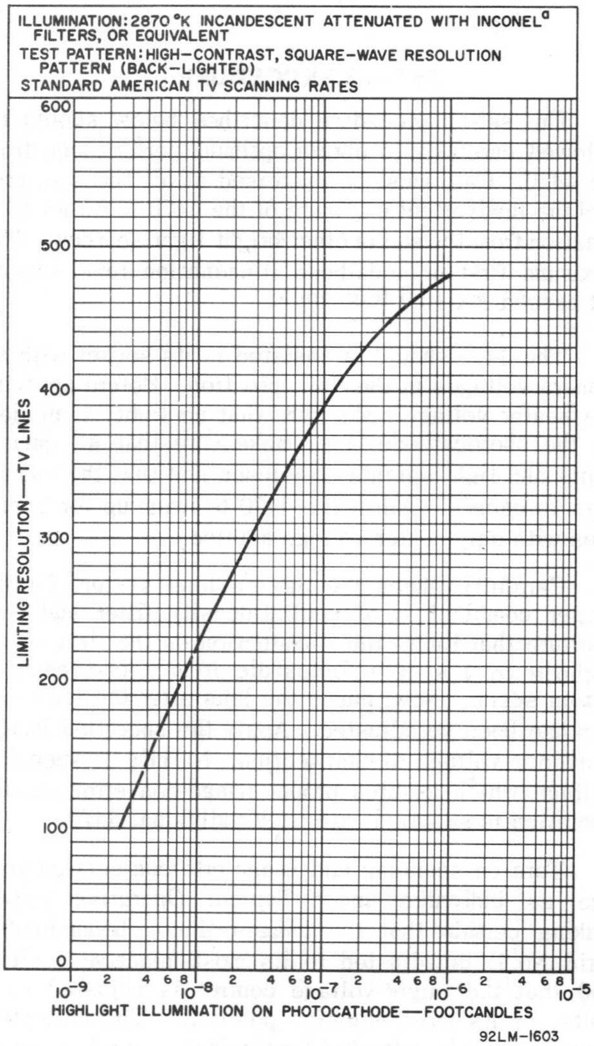


Fig.2

[a] A product of Eastman Kodak Co. (Wratten Division), Rochester 4, N.Y.

TYPICAL SIGNAL-TO-NOISE CHARACTERISTIC

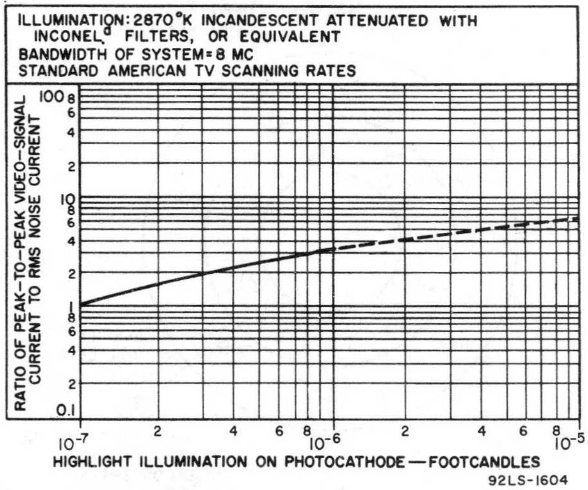


Fig.3

TYPICAL LIGHT TRANSFER CHARACTERISTIC

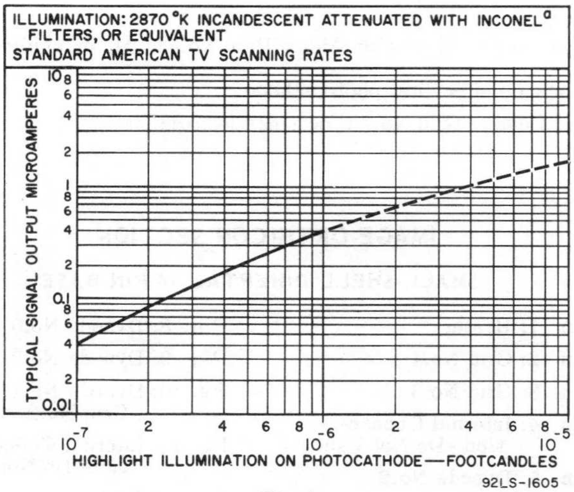


Fig.4

TYPICAL IMAGE-CONVERTER SECTION VOLTAGE-DIVIDER ARRANGEMENT

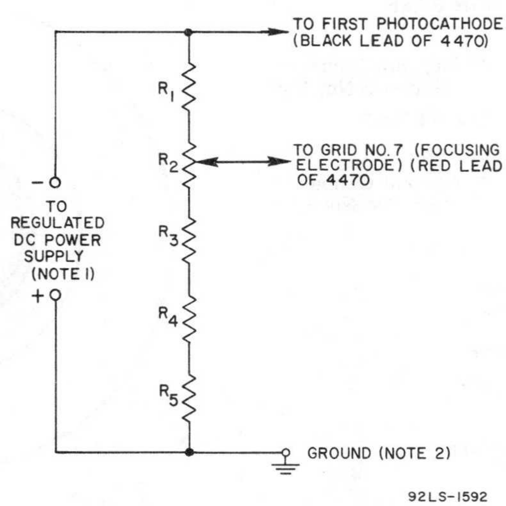


Fig. 5

R_1, R_3: 5 megohms, 2 watts, RPC HBMW, or equivalent

R_2: 5-megohm potentiometer, 2 watts, Clarostat Series 51, or equivalent

R_4, R_5: 30 megohms, 2 watts, RPC HBMW, or equivalent

NOTE 1: Adjustable between approximately 10 kV and 15 kV.

NOTE 2: The positive high voltage lead should also be connected to the camera power supply ground.

NOTE 3: All components of this voltage-divider network must be isolated from ground. The control shaft of the focusing-electrode potentiometer (R_2) must be of insulating material and protrude through the wall of the housing through a grounding bushing. The compartment in which this voltage-divider network is housed should be filled with LTV-602 clear potting compound, or equivalent. This voltage-divider network, packaged in suitable housing with high-voltage leads and connectors, is available from RCA as Dev. Part No.C21054.

IMAGE-CONVERTER SECTION

Two leads fitted with Alden Part No.8111M, or equivalent.

Black Lead -- First photocathode

Red Lead -- Grid No.7 (Focusing Electrode)

IMAGE-ORTHICON SECTION

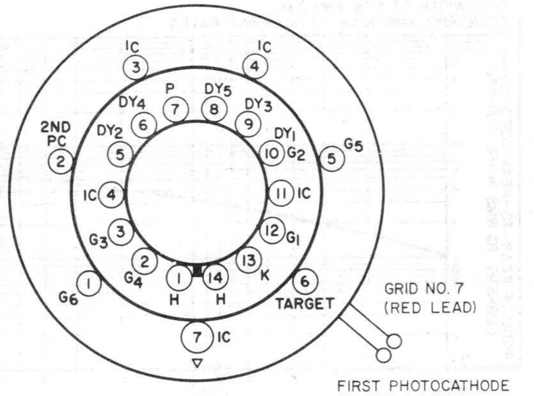
SMALL-SHELL DIHEPTAL 14-PIN BASE

Pin 1: Heater
Pin 2: Grid No.4
Pin 3: Grid No.3
Pin 4: Internal Connection--Do Not Use
Pin 5: Dynode No.2
Pin 6: Dynode No.4
Pin 7: Anode
Pin 8: Dynode No.5
Pin 9: Dynode No.3
Pin 10: Dynode No.1, Grid No.2
Pin 11: Internal Connection--Do Not Use
Pin 12: Grid No.1
Pin 13: Cathode
Pin 14: Heater

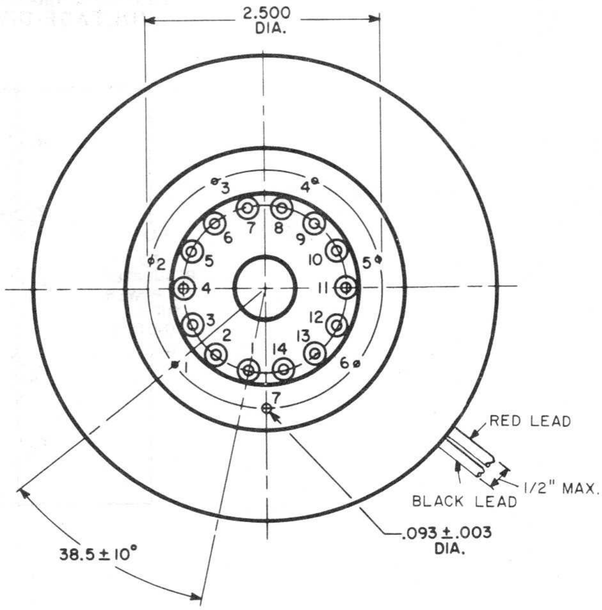
KEYED JUMBO ANNULAR 7-PIN BASE

Pin 1: Grid No.6
Pin 2: Second Photocathode
Pin 3: Internal Connection--Do Not Use
Pin 4: Internal Connection--Do Not Use
Pin 5: Grid No.5
Pin 6: Target
Pin 7: Internal Connection--Do Not Use

BASING DIAGRAM
Bottom View



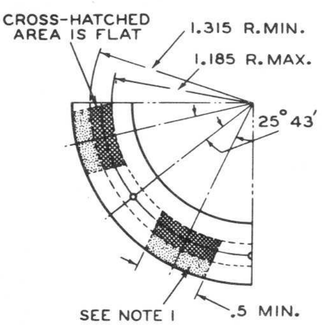
Direction of Light: Perpendicular to Large End of Tube



Enlarged Bottom View

Dimensions in Inches

Detail of Bottom View of Jumbo Annular Base



NOTE 1: Dotted area is flat or extends toward diheptal-base end of tube by 0.060" max.

ANNULAR BASE GAUGE

Angular variations between pins as well as eccentricity of neck cylinder with respect to photocathode cylinder are held to tolerances such that pins and neck cylinder will fit flat-plate gauge with:

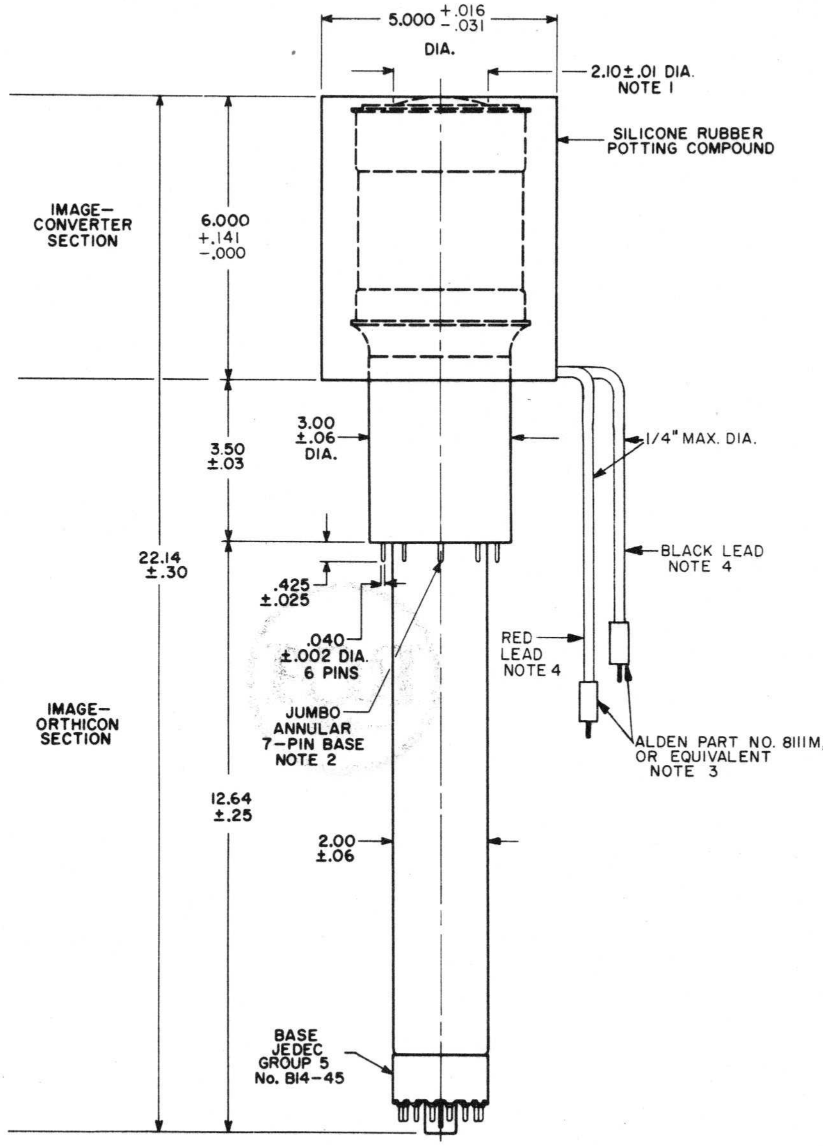
a. Six holes having diameter of 0.065" ± 0.001" and one hole having diameter of 0.150" ± 0.001". All holes have depth of 0.265" ± 0.001". The six 0.065" holes are enlarged by 45° taper to depth of 0.047". All holes are spaced at angles of 51°26' ± 5' on circle diameter of 2.500" ± 0.001".

b. Seven stops having height of 0.187" ± 0.001", centered between pin holes, to bear against flat areas of base.

c. Rim extending out a minimum of 0.125" from 2.812" diameter and having height of 0.126" ± 0.001".

d. Neck-cylinder clearance hole having diameter of 2.200" ± 0.001".

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

Note 1: The window area of the first photocathode is concentric with the image-converter section cylinder, and the image-orthicon section cylinders within 0.100" of the major axis of the tube.

Note 2: The index of the annular base and the key of the diheptal base are aligned within ± 7° with reference to the annular index pin.

Note 3: Alden Products Company, 9140 North Main Street, Brockton 64, Mass.

Note 4: Lead length is 28" ± 1/4" from potting to end of plug.

RCA

This bulletin is to be used in conjunction with technical bulletin for type 6914.

4476

IMAGE-CONVERTER TUBE

Electrostatic Focus	Monovoltage Type	2.975" Max. Length
High Resolution	S-1 Response	1.905" Max. Diameter

RCA-4476 is identical to RCA-6914 in all respects except for the following performance characteristics.

Characteristics at an Anode Voltage (DC)[a] of 16000 Volts and an Ambient Temperature of 22° C:

Minimum Conversion Index[b]	19.2	
Minimum Resolution[c]	60	line-pairs per mm

[a] Referred to photocathode.

[b] Ratio of luminous flux from fluorescent screen to the product of the luminous flux incident on Corning No.2540 Infrared Filter (Melt No.1613, 2.61 mm thick), or equivalent, and the filter factor of 11.6 per cent. The light source is a tungsten-filament lamp operated at a color temperature of 2870° K.

[c] The resolution, both horizontally and vertically in a 0.24-inch-diameter circle centered on the photocathode, is determined with a pattern consisting of alternate black and white lines of equal width. Any two adjacent lines are designated as a "line-pair".

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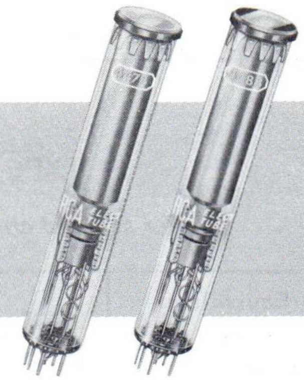
CTPI

RCA-4478, RCA-4488
VIDICONS

Magnetic Focus
Magnetic Deflection



Low-Cost Television Pickup
in Non-Critical Consumer Product and
General Industrial Closed-Circuit TV

This bulletin is to be used in conjunction with technical bulletin for RCA-7735B.

RCA-4478 and 4488 are low-cost vidicon type camera tubes designed for televising live scenes in educational, industrial, and other closed-circuit TV applications where broadcast-quality scene reproduction is not essential.

The 4478 is specifically recommended for non-critical consumer product TV systems and the 4488 for general industrial surveillance pickup where the superior performance of the 7735B is not required.

The major differences between these two tubes is that the 4488 is more stringently controlled for blemishes, streaks, and smudges; has higher limiting resolution; and slightly greater signal output current.

These tubes employ a high-sensitivity, low-lag photoconductive surface. When used with conventional optical components they will provide satisfactory service at the light levels commonly found in educational and industrial areas.

The values shown under **DATA, General, Maximum Ratings,** and **Typical Operation and Performance Data** in the attached 7735B bulletin are identical with those for the 4478 and 4488 except for the following items.

DATA

General:

Type 4478:

Photoconductive Layer:

Orientation of quality rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.

Typical Operation and Performance Data:

	Type 4478	Type 4488	
Grid-No.1 Voltage for Picture Cutoff[a]	−45 to −110	−45 to −100	volts
Limiting Resolution:[b]			
At center of picture—			
→ Typical value	650	700	TV lines

Average-Sensitivity Operation — 1.0 Footcandle on Faceplate

	Type 4478	Type 4488	
Faceplate Illumination (Highlight)	1.0	1.0	fc
Target Voltage[c,d]	10 to 70	12 to 53	volts
Dark Current[e]	0.035	0.030	μA
Signal-Output Current:[f]			
→ Typical	0.265	0.270	μA

→ Indicates a change.

a With no blanking voltage on grid No.1.

b Amplitude response values will be correspondingly lower than those of type 7735B.

c The target voltage for each tube must be adjusted to that value which gives the desired operating signal current.

d Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

e The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

f Defined as the component of the highlight target current after the dark-current component has been subtracted.

Spurious Signal Test

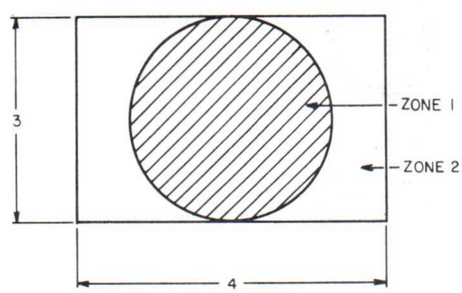


Fig. 1

This test is performed using a uniformly diffused white test pattern that is separated into two zones as shown in Fig. 1. The 4478 and 4488 are operated under the conditions specified under *Typical Operation and Performance Data* as shown in the 7735B bulletin with the lens adjusted to provide a target current of 0.3 microampere. The tubes are adjusted to provide maximum picture resolution. Spurious signals are evaluated by size which is represented by equivalent numbers of raster lines in a 525 TV line system. Allowable spot size for each zone is shown in Table 1. To be classified as a spot, a contrast ratio of 1.5:1 must exist for white spots and 2:1 for black spots. Smudges, streaks, or mottled and grainy background must have a contrast ratio of 1.5:1 to constitute a reject item.

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8-67
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TYPE 4478

For scanned area of 1/2" x 3/8"

Equivalent Number of Raster Lines	Zone 1 Allowed Spots	Zone 2 Allowed Spots
over 6	0	0
6 but not including 4	0	2
4 but not including 1	3	4
1 or less	*	*

TYPE 4488

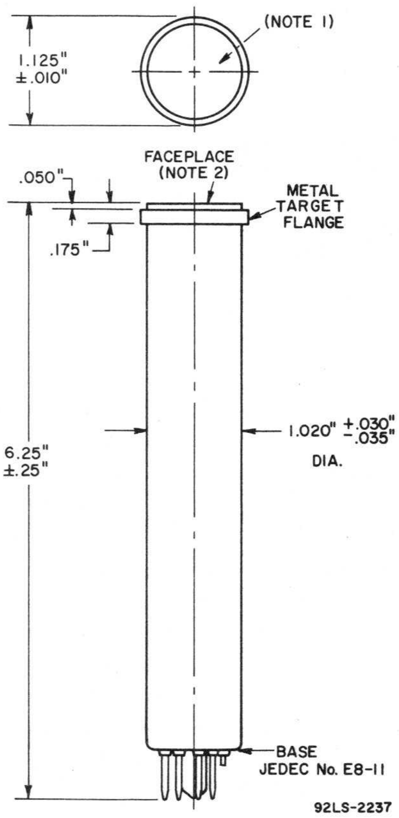
For scanned area of 1/2" x 3/8"

Equivalent Number of Raster Lines	Zone 1 Allowed Spots	Zone 2 Allowed Spots
over 4	0	0
4 but not including 3	0	1
3 but not including 1	2	3
1 or less	*	*

Minimum separation between any 2 spots greater than 1 raster line is limited to 16 raster lines.

*Spots of this size are allowed unless concentration causes a smudged appearance.

DIMENSIONAL OUTLINE

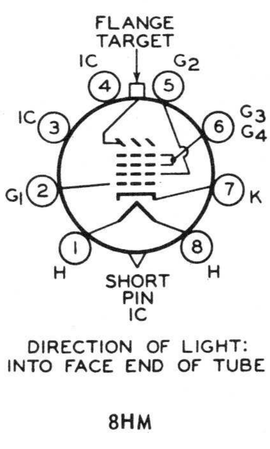


Note 1: Type 4488 has portion of face masked similar to type 7735B.

Note 2: Faceplate glass is Corning No.7056 having a thickness of 0.094" ± 0.012".

BASING DIAGRAM

Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: INTERNAL CONNECTION–DO NOT USE
PIN 4: INTERNAL CONNECTION–DO NOT USE
PIN 5: GRID No.2
PIN 6: GRIDS No.3 AND No.4
PIN 7: CATHODE
PIN 8: HEATER
FLANGE: TARGET
SHORT INDEX PIN: INTERNAL CONNECTION–MAKE NO CONNECTION

Typical Operating Values:

Unless otherwise specified all values are positive with respect to cathode

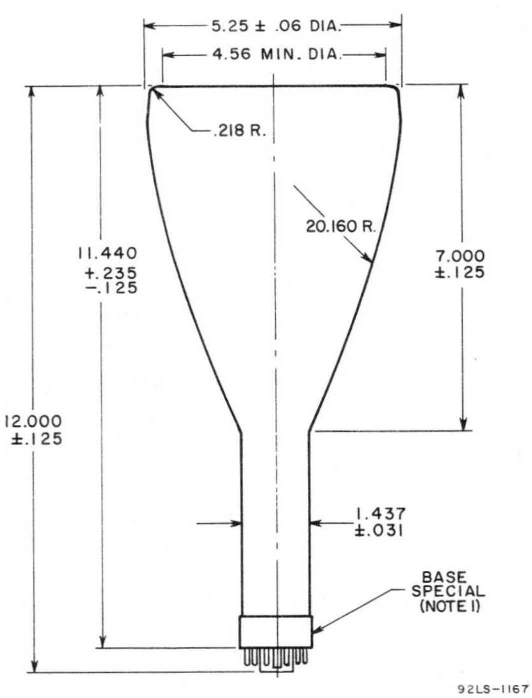
Anode Voltage	2200 volts
Grid-No.3 (Focusing-Electrode) Voltage	750 to 1000 volts
Grid-No.1 Voltage for visual cutoff of focused spot	−60 to −140 volts
Deflection Factors:	
DJ1 and DJ2	84 to 106 volts dc/inch
DJ3 and DJ4	67 to 83 volts dc/inch

Maximum Circuit Values:

Grid-No.1–Circuit Resistance	1.5 max. megohms
Resistance in any Deflecting Electrode Circuit[a]	5 max. megohms

[a]It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

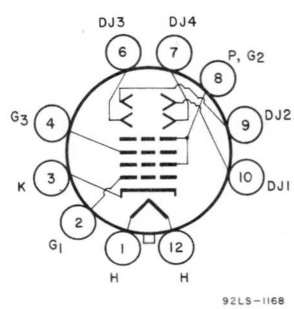
The plane through the tube axis and pin 4 may vary from the trace produced by DJ1 and DJ2 by an angular tolerance (measured about the tube axis) of 10°. Angle between DJ1 - DJ2 trace and DJ3 - DJ4 trace is 90° ± 3°.

DJ1 and DJ2 are nearer the screen; DJ3 and DJ4 are nearer the base. With DJ1 positive with respect to DJ2, the spot will be deflected toward pin 4; likewise, with DJ3 positive with respect to DJ4, the spot will be deflected toward Pin 1.

NOTE 1: Base is identical to short small-shell duodecal JEDEC No.B12-207 except pin No.5 and pin No.11 are omitted.

BASING DIAGRAM

Bottom View



Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Cathode
Pin 4: Grid No.3
Pin 6: Deflecting Electrode DJ3
Pin 7: Deflecting Electrode DJ4
Pin 8: Anode, Grid No.2
Pin 9: Deflecting Electrode DJ2
Pin 10: Deflecting Electrode DJ 1
Pin 12: Heater

OSCILLOGRAPH-TYPE CATHODE-RAY TUBE | RCA-4499

ELECTROSTATIC DEFLECTION • ELECTROSTATIC FOCUS

RCA-4499 is a short, 5"-diameter electrostatic-focus, electrostatic-deflection oscillograph type cathode-ray tube. It has a flat face and employs a medium persistence P1 phosphor screen. It is intended for general oscillographic applications in which recurrent wave phenomena are to be observed visually.

DATA

General

Electrical:

Heater Current at 6.3 volts	0.6 A
Focusing Method	Electrostatic
Deflection Method	Electrostatic
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	10 pF
Cathode to all other electrodes	5.5 pF
DJ1 to DJ2	2.5 pF
DJ3 to DJ4	3.0 pF
DJ1 to all other electrodes	10.5 pF
DJ2 to all other electrodes	8.5 pF
DJ3 to all other electrodes	8.5 pF
DJ4 to all other electrodes	9.5 pF

Optical:

Faceplate	Clear Glass
Shape	Flat, circular
Minimum Useful Screen Diameter	4.56"
Phosphor	P1
Fluorescence and Phosphorescence	Yellowish-Green
Persistence	Medium

Mechanical:

Tube Dimensions:	
Overall Length	12.000" ± 0.125"
Greatest Diameter	5.25" ± 0.06"
Base	Special, Small-shell duodecal, 10-pin
Bulb	J42 Dev.66
Operating Position	Any
Weight	2 lbs

Maximum and Minimum Ratings, *Absolute-Maximum Values*

Anode Voltage	2800	max. volts
Grid-No.3 (Focusing-Electrode) Voltage	1100	max. volts
Grid-No.1 Voltage:		
Negative Bias Value	200	max. volts
Positive Bias Value	0	max. volts
Positive Peak Value	2	max. volts
Heater Voltage	6.9	max. volts
	5.7	min. volts
Peak Heater-Cathode Voltage:		
Heater Negative with respect to cathode	125	max. volts
Heater positive with respect to cathode	125	max. volts

Typical Operating Values:

Unless otherwise specified all values are positive with respect to cathode

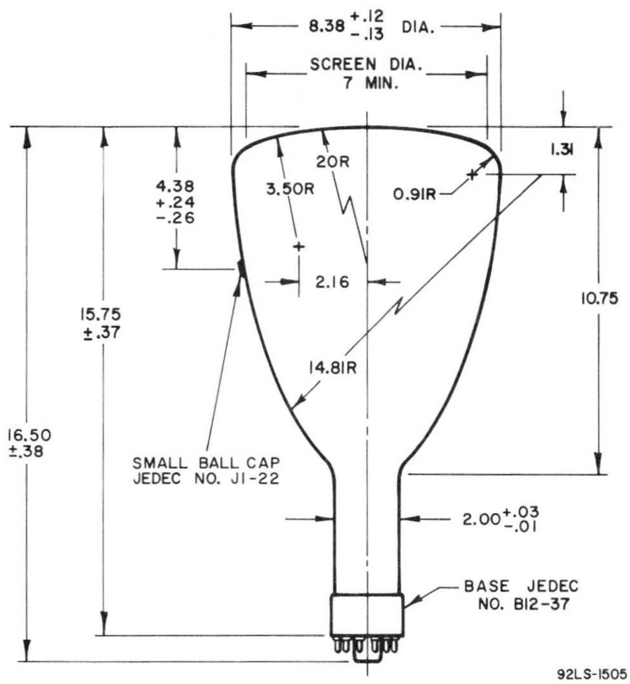
Post-Deflection Accelerator Voltage	6000 volts
Anode Voltage	3000 volts
Grid-No.3 (Focusing-Electrode) Voltage	750 to 1200 volts
Grid-No.1 Voltage for visual cutoff of focused spot	–58 to –93 volts
Deflection Factors:	
DJ1 and DJ2	107 to 129 volts dc/inch
DJ3 and DJ4	85 to 101 volts dc/inch

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max. megohms
Resistance in any Deflecting Electrode Circuit[a]	5 max. megohms

[a]It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

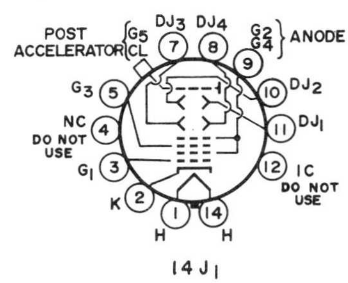
℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

The plane through the tube axis and pin 5 may vary from the trace produced by DJ1 and DJ2 by an angular tolerance (measured about the tube axis) of ±10°. Angle between DJ1 - DJ2 trace and DJ3 - DJ4 trace is 90° ± 3°.

DJ1 and DJ2 are nearer the screen; DJ3 and DJ4 are nearer the base. With DJ1 positive with respect to DJ2, the spot will be deflected toward pin 5; likewise, with DJ3 positive with respect to DJ4, the spot will be deflected toward pin 2.

BASING DIAGRAM

Bottom View

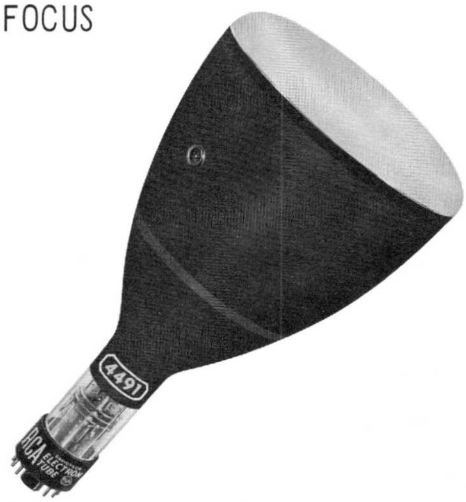


Pin 1: Heater
Pin 2: Cathode
Pin 3: Grid No.1
Pin 4: No Connection - Do Not Use
Pin 5: Grid No.3
Pin 7: Deflecting Electrode DJ3
Pin 8: Deflecting Electrode DJ4
Pin 9: Anode (Grids No.2 & No.4)
Pin 10: Deflecting Electrode DJ2
Pin 11: Deflecting Electrode DJ 1
Pin 12: Internal Connection - Do Not Use
Pin 14: Heater
Cap: Post-Accelerator (Grid No.5 & Collector)

OSCILLOGRAPH-TYPE CATHODE-RAY TUBE

RCA-4491

ELECTROSTATIC DEFLECTION • ELECTROSTATIC FOCUS POST-DEFLECTION ACCELERATOR



RCA-4491 is an 8"-diameter electrostatic-focus, electrostatic-deflection type cathode-ray tube having a post-deflection accelerator. It has a curved face and employs a P31 phosphor screen of high luminous efficiency. The 4491 is intended for use in general oscillographic applications for observing low- or medium-speed recurring phenomena.

DATA

GENERAL

Electrical:

Heater Voltage (AC or DC)	6.3 volts
Heater Current at 6.3 volts	0.6 A
Focusing Method	Electrostatic
Deflection Method	Electrostatic
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	6 pF
Cathode to all other electrodes	7.5 pF
DJ1 to DJ2	3 pF
DJ3 to DJ4	2 pF
DJ1 to all other electrodes	9 pF
DJ2 to all other electrodes	9 pF
DJ3 to all other electrodes	7 pF
DJ4 to all other electrodes	7 pF

Optical:

Faceplate	Clear Glass
Shape	Curved, circular
Minimum Useful Screen Diameter	7"
Phosphor	P31
Fluorescence and Phosphorescence	Green
Persistence	Medium-Short

Mechanical:

Tube Dimensions:	
Overall Length	16.50"±0.38"
Greatest Diameter	8.50"
Base	Medium-shell diheptal 12-pin (JEDEC No.B12-37)
Bulb	J67A1A
Operating Position	Any
Weight (Approx.)	3 lbs

Maximum and Minimum Ratings, *Absolute-Maximum Values*

Post-Deflection Accelerator Voltage	8000 max. volts
Anode Voltage	4000 max. volts
Grid-No.3 (Focusing-Electrode) Voltage	2000 max. volts
Grid-No.1 Voltage:	
Negative Bias Value	200 max. volts
Positive Bias Value	0 max. volts
Positive Peak Value	2 max. volts
Heater Voltage	6.9 max. volts 5.7 min. volts
Peak Heater-Cathode Voltage:	
Heater Negative with respect to cathode	125 max. volts
Heater Positive with respect to cathode	125 max. volts

Typical Operating Values:

Unless otherwise specified all values are positive with respect to cathode

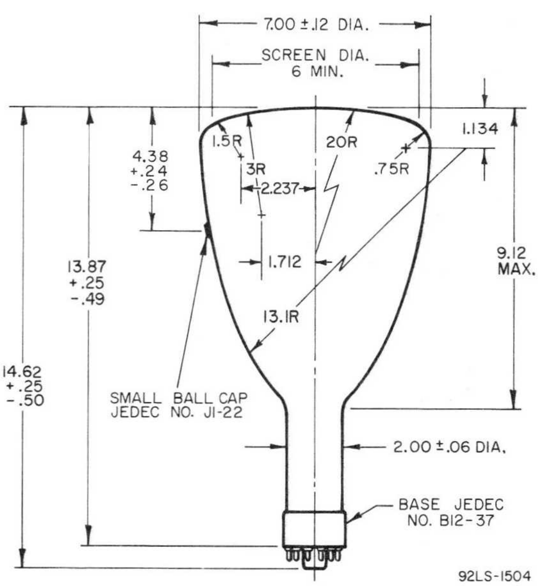
Post-Deflection Accelerator Voltage	6000 volts
Anode Voltage	3000 volts
Grid-No.3 (Focusing-Electrode) Voltage	750 to 1200 volts
Grid-No.1 Voltage for visual cutoff of focused spot	–58 to –93 volts
Deflection Factors:	
DJ1 and DJ2	133 to 153 volts dc/inch
DJ3 and DJ4	99 to 115 volts dc/inch

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max. megohms
Resistance in any Deflecting Electrode Circuit[a]	5 max. megohms

[a]It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

DIMENSIONAL OUTLINE



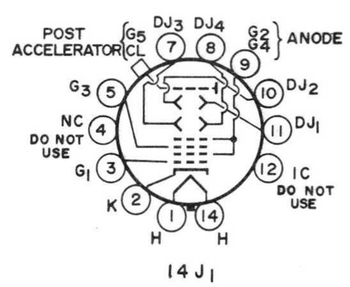
DIMENSIONS IN INCHES

℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

The plane through the tube axis and pin 5 may vary from the trace produced by DJ1 and DJ2 by an angular tolerance (measured about the tube axis) of $\pm 10^{\circ}$. Angle between DJ1 - DJ2 trace and DJ3 - DJ4 trace is $90^{\circ} \pm 3^{\circ}$.

DJ1 and DJ2 are nearer the screen; DJ3 and DJ4 are nearer the base. With DJ1 positive with respect to DJ2, the spot will be deflected toward pin 5; likewise, with DJ3 positive with respect to DJ4, the spot will be deflected toward pin 2.

BASING DIAGRAM
Bottom View

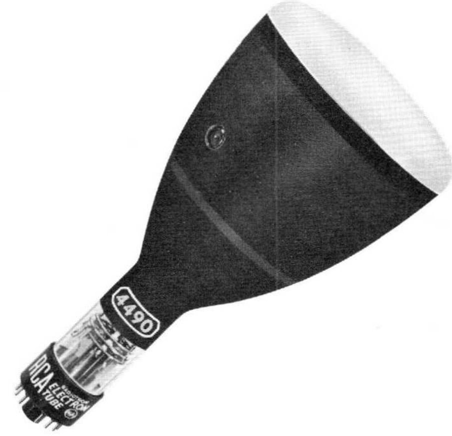


Pin 1: Heater
Pin 2: Cathode
Pin 3: Grid No.1
Pin 4: No Connection - Do Not Use
Pin 5: Grid No.3
Pin 7: Deflecting Electrode DJ3
Pin 8: Deflecting Electrode DJ4
Pin 9: Anode (Grids No.2 & No.4)
Pin 10: Deflecting Electrode DJ2
Pin 11: Deflecting Electrode DJ1
Pin 12: Internal Connection - Do Not Use
Pin 14: Heater
Cap: Post-Accelerator (Grid No.5 & Collector)

OSCILLOGRAPH-TYPE CATHODE-RAY TUBE

RCA-4490

ELECTROSTATIC DEFLECTION • ELECTROSTATIC FOCUS POST-DEFLECTION ACCELERATOR



RCA-4490 is a 7"-diameter electrostatic-focus, electrostatic-deflection type cathode-ray tube having a post-deflection accelerator. It has a curved face and employs a P31 phosphor screen of high luminous efficiency. The 4490 is intended for use in general oscillographic applications for observing low- or medium-speed recurring phenomena.

DATA

GENERAL

Electrical:

Heater Voltage (AC or DC)	6.3 volts
Heater Current at 6.3 volts	0.6 A
Focusing Method	Electrostatic
Deflection Method	Electrostatic
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	6 pF
Cathode to all other electrodes	7.5 pF
DJ1 to DJ2	3 pF
DJ3 to DJ4	2 pF
DJ1 to all other electrodes	9 pF
DJ2 to all other electrodes	9 pF
DJ3 to all other electrodes	7 pF
DJ4 to all other electrodes	7 pF

Optical:

Faceplate	Clear Glass
Shape	Curved, circular
Minimum Useful Screen Diameter	6"
Phosphor	P31
Fluorescence and Phosphorescence	Green
Persistence	Medium-Short

Mechanical:

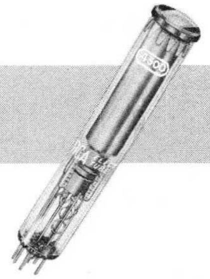
Tube Dimensions:	
Overall Length	14.62"+0.25" –0.50"
Greatest Diameter	7.12"
Base	Medium-shell diheptal 12-pin (JEDEC No.B12-37)
Bulb	J56H1A
Operating Position	Any
Weight (Approx.)	3 lbs

Maximum and Minimum Ratings, *Absolute-Maximum Values:*

Post-Deflection Accelerator Voltage	8000 max. volts
Anode Voltage	4000 max. volts
Grid-No.3 (Focusing-Electrode) Voltage	2000 max. volts
Grid-No.1 Voltage:	
Negative Bias Value	200 max. volts
Positive Bias Value	0 max. volts
Positive Peak Value	2 max. volts
Heater Voltage	6.9 max. volts
	5.7 min. volts
Peak Heater-Cathode Voltage:	
Heater Negative with respect to cathode	125 max. volts
Heater Positive with respect to cathode	125 max. volts

RCA-4500

VIDICON



High-Sensitivity Type
For Use in Applications
Where Scene Motion is Limited and
For Slow-Scan TV Pickup Service

RCA-4500 is a high-sensitivity 1"-diameter vidicon type camera tube designed especially for operation at very low light levels in applications where there is a limited amount of motion in the scene. It is useful in a wide variety of television pickup systems including picture transmission at slow-scan rates, industrial surveillance of stationary scenes, and in low light level TV applications where persistence, or lag, is not a primary limitation.

Comparative performance characteristics and data are presented for both standard TV scan rates and for slow-scan rates. For standard TV scan rates, faceplate illumination is specified in footcandles; for slow-scan rates, faceplate exposure is specified in footcandle-seconds. The 4500 typically will provide a signal output current of 0.1 microampere at a faceplate illumination of 0.05 footcandle when operated in a standard vidicon TV camera. This same signal level is obtained typically with an exposure of 0.5 footcandle-second in a non-interlaced slow-scan system operating at a frame time of 2 seconds. Performance characteristics for a given application are dependent upon the operating scan mode that is employed.

Substitution of the 4500 in cameras using other 1"-diameter magnetic-focus and magnetic-deflection vidicons usually requires modification of the maximum target-voltage range, especially when automatically controlled, to accommodate the lower maximum target voltage of the 4500. This modification is necessary to prevent the photoconductive surface of the 4500 from switching from a low-velocity to a high-velocity scan mode. Such switching results in reverse picture polarity and in other undesirable target-discharge characteristics.

When used in slow-scan applications, the longer lag of the 4500 can be controlled by inserting a high-speed multi-frame erase cycle in the picture-generating sequence. In systems where it is desirable to retain generated picture images for relatively long periods of time, the extended lag characteristic of this tube is highly desirable.

The spectral response characteristic of the 4500 approaches that of the human eye. Peak response, however, is shifted toward the red.

CHARACTERISTICS

- **Excellent Signal Storage –**
  90% of initial signal read-out at the end of 10 seconds.
- **High Signal Output to Dark Current Ratio –**
  0.16 μA signal current at 0.02 μA dark current with 0.1 footcandle illumination on tube face. Target voltage of 25 volts typically.
- **Extended Lag –**
  40% to 60% of initial signal output current after one scanning frame.
- **Good Resolution –**
  600 TV lines at 300 volts
  700 TV lines at 750 volts

DATA

General:

Heater, for Unipotential Cathode:
Voltage (AC or DC) . . . . 6.3±10% volts
Current at 6.3 volts . . . . 0.6 A
Direct Interelectrode Capacitance:[a]
Target to all other electrodes . . . . 4.6 pF
Spectral Response . . . . See *Fig.10*
Photoconductive Layer:
Maximum useful diagonal of rectangular image (4 x 3 aspect ratio). . . . . 0.62 inch
Orientation of quality rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin. The masking is for orientation only and does not define the proper scanned area of the photoconductive layer.
Focusing Method . . . . Magnetic
Deflection Method . . . . Magnetic
Overall Length . . . . 6.25"±0.25"
Greatest Diameter . . . . 1.125"±0.010"
Bulb T8
Base . . . . . Small-Button Ditetrar 8-Pin, (JEDEC No.E8-11)
Socket . . . . Cinch[b] No.54A18088, or equivalent
Focusing Coil . . . . . Cleveland Electronics[c,d] No.VF-115-5, or equivalent
Deflecting Yoke . . . . Cleveland Electronics[c,d] No.VY-111-3, or equivalent
Alignment Coil . . . . . Cleveland Electronics[c,d] No.VA-118, or equivalent
Operating Position . . . . Any
Weight (Approx.) . . . . 2 oz

Maximum Ratings, *Absolute-Maximum Values:*[e]
For scanned area of 1/2" x 3/8"

Grid-No.3 & Grid-No.4 Voltage	1000 max.	volts
Grid-No.2 Voltage	750 max.	volts
Grid-No.1 Voltage:		
Negative bias value	300 max.	volts
Positive bias value	0 max.	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
Target Voltage	60 max.	volts
Dark Current	0.10 max.	μA
Peak Target Current[f]	0.6 max.	μA
Faceplate:		
Illumination[g]	1000 max.	fc
Temperature Range:		
Storage	−20 to +70	°C
Operating	−10 to +55	°C

Typical Operation and Performance Data
For Standard TV Scan Rates

For scanned area of 1/2" x 3/8" – Faceplate temperature of 30° C	*Low-Voltage Operation*	*High-Voltage Operation*	
Grid-No.4 (Decelerator) & Grid-No.3 (Beam-Focus Electrode) Voltage	250[h] to 300	750	volts
Grid-No.2 (Accelerator) Voltage	300	300	volts
Grid-No.1 Voltage for Picture Cutoff[j]	−45 to −100	−45 to −100	volts
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02μA and 0.2μA	0.70	0.70	
Visual Equivalent Signal-to-Noise Ratio (Approx.)[k]	300:1	300:1	
Lag – Per Cent of Initial Value of Signal-Output Current 1/20 Second After Illumination is Removed:[m]			
Typical value	55	55	%
Minimum Peak-to-Peak Blanking Voltage:			
When applied to grid No.1	75	75	volts
When applied to cathode	20	20	volts
Limiting Resolution:			
At center of picture– Typical value	600	700	TV lines
Amplitude Response to a 400 TV Line Square-Wave Test Pattern at Center of Picture	20	30	%
Field Strength at Center of Focusing Coil[n]	40	60	gauss
Peak Deflecting-Coil Current:			
Horizontal	185	375	mA
Vertical	25	43	mA
Field Strength of Adjustable Alignment Coil	0 to 4	0 to 4	gauss

Average-Light-Level Operation
1.0 Footcandle on Faceplate

Faceplate Illumination (Highlight)	1.0	fc
Target Voltage[p, q]	7 to 25	volts
Dark Current[r]	0.005	μA
Signal-Output Current:[s]		
Typical	0.4	μA

Low-Light-Level Operation
0.1 Footcandle on Faceplate

Faceplate Illumination (Highlight)	0.1	fc
Target Voltage[p, q]	15 to 45	volts
Dark Current[r]	0.02	μA
Signal-Output Current:[s]		
Typical	0.16	μA

Typical Operation and Performance Data
For Slow-Scan Applications

Typical Target Voltage	30	volts
Typical Dark Current	8	nA
Typical Exposure	0.25	footcandle-seconds
Typical Signal Output at frame time of:		
1 second	160	nA
2 seconds	70	nA
4 seconds	30	nA
6 seconds	19	nA
10 seconds	10	nA
Lag, or Residual Signal-Time to reach 5 per-cent level	5 to 10	frames
Amplitude Response to 400 TV lines	50	%
Signal Storage – Time to decay to 50 per-cent level	80	seconds

---

[a]This capacitance, which effectively is the output impedance of the 4500 is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

[b]Made by Cinch Manufacturing Corporation, 1026 S. Homan Ave., Chicago 24, Illinois.

[c]Made by Cleveland Electronics Inc., 1974 East 61st St., Cleveland, Ohio.

[d]These components are chosen to provide tube operation with minimum beam-landing error.

[e]The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[f]Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

[g]For conditions where "white light" is uniformly diffused over entire tube face.

[h]Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

[i]With no blanking voltage on grid No.1.

[k]Measured with high-gain, low-noise, cascode-input-type amplifier having bandwidth of 5 MHz and a peak signal-output current of 0.35 microampere. Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of the highlight video-signal current to rms noise current, multiplied by a factor of 3.

[m]For initial signal-output current of 0.3 microampere and a dark current of 0.02 microampere.

[n]The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

[p]The target voltage for each 4500 must be adjusted to that value which gives the desired operating signal current.

[q]Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

[r]The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

[s]Defined as the component of the highlight target current after the dark-current component has been subtracted.

COMPONENT LOCATIONS

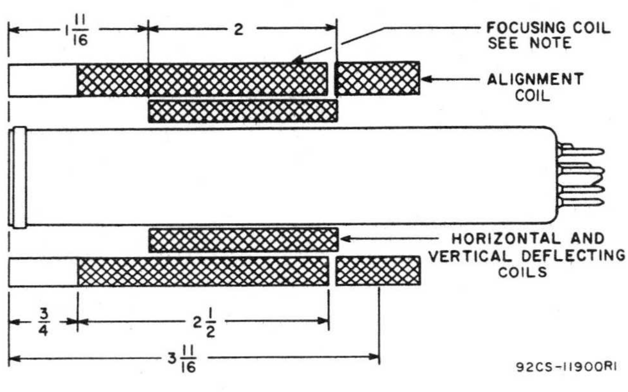


Fig.1

RANGE OF DARK CURRENT

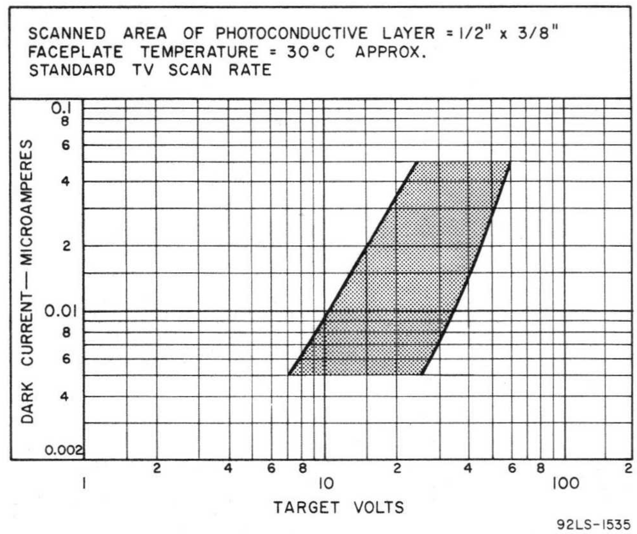


Fig.2

OPERATING INSTRUCTIONS

General Information:

The *target connection* may be made by a suitable spring-finger contact bearing against the edge of the metal ring at the face end of the tube.

The *deflecting yoke and focusing coil* used with the 4500 are designed to cause the scanning beam to land perpendicularly to the target at all points of the scanned area with minimum beam-landing error and resultant superior uniformity of sensitivity and focus over the scanned area. The recommended location of these components is shown in *Fig.1*.

During operation the *faceplate temperature* of the 4500 should not exceed 55° C (131° F). Operation at a faceplate temperature of about 30° C (86° F) is recommended. The 4500 should be operated at a steady temperature to maintain dark current at a preselected level and thereby insure optimum and stable day-to-day operation. If temperature control cannot be made in the camera installation, changes in target voltage may be required from time to time. The range of target voltage for various dark current levels is shown in *Fig.2*. Individual 4500's will have substantially identical performance characteristics when operated with an identical value of dark current.

Proper-size scanning of the photoconductive target area should always be used. Both overscanning and underscanning impair performance. Overscanning, which produces a smaller-than-normal picture on the monitor, adversely affects corner resolution, signal uniformity, and geometrical accuracy. Underscanning, which produces a larger-than-normal picture on the monitor, should never be permitted as it may cause a permanent change in sensitivity and dark current of the underscanned area with a resulting loss in resolution and sensitivity. An underscanned area showing such a change will be visible when proper-size scanning is restored.

Failure of scanning even for a few seconds may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 4500 during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No.1 voltage to cut-off, biasing the target negatively, or removing the grid-No.4 & grid-No.3, and grid-No.2 electrode voltages. Circuits should be incorporated to perform one or more of these functions automatically the instant scanning power

LIGHT TRANSFER CHARACTERISTICS

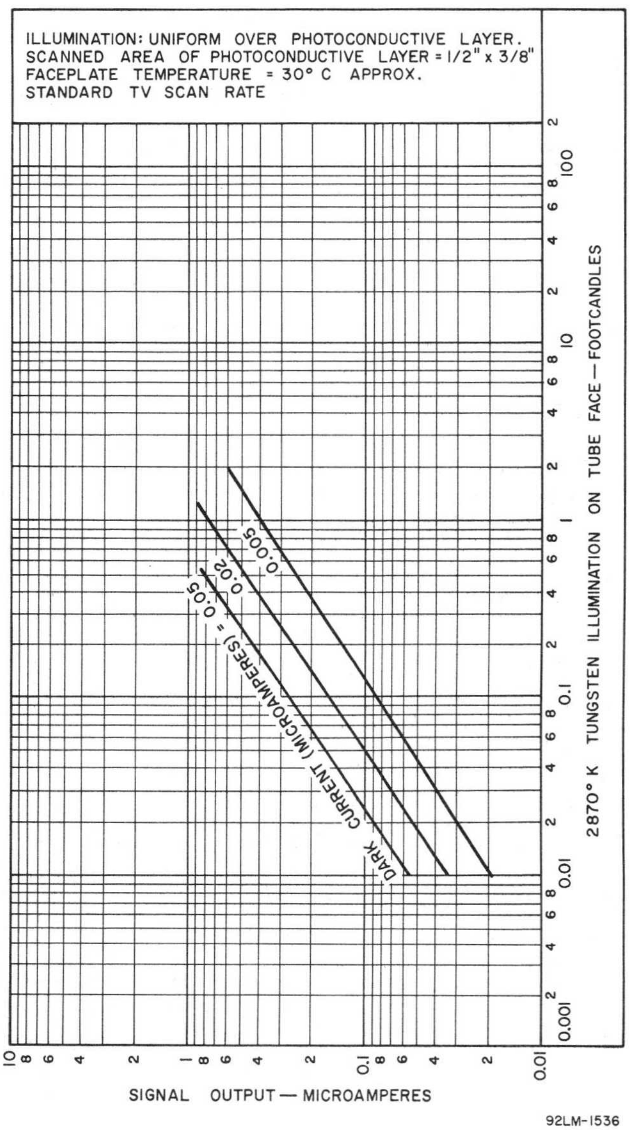


Fig.3

TYPICAL PERSISTENCE CHARACTERISTICS

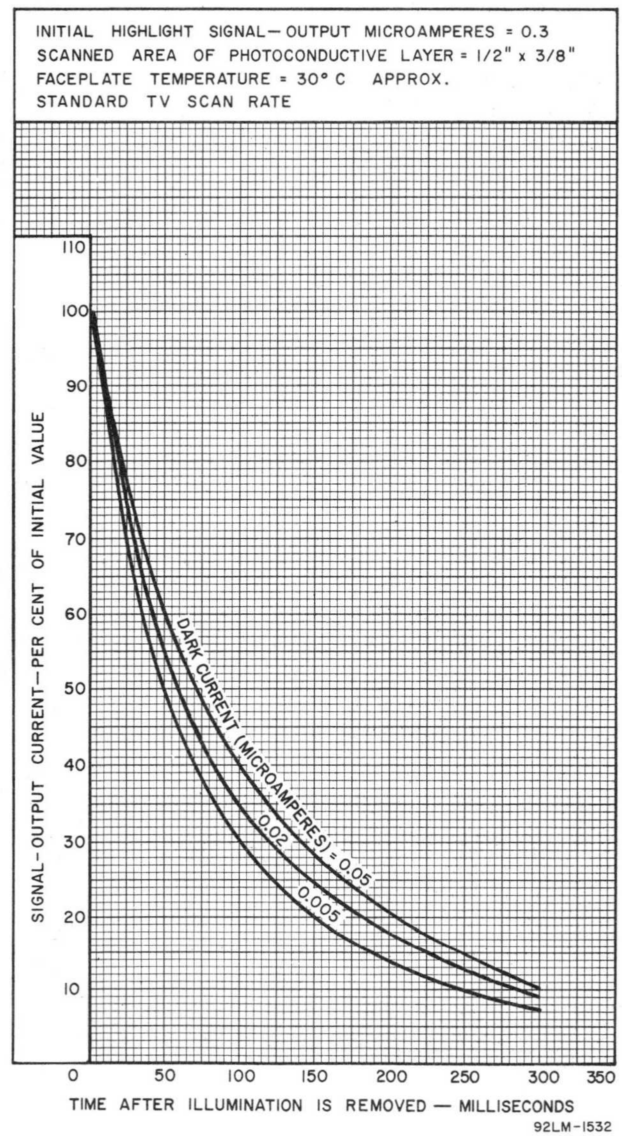


Fig.4

fails or is reduced, at any time, to an abnormally low value.

The *lens of the camera* should always be capped when the camera is not in use or is being transported to avoid the inadvertent exposure of the photoconductive layer to an image of the sun or other very intense source of illumination. The focusing of the image of a very bright light source on the tube face can cause permanent damage to the photoconductive layer even though no voltage is applied to the tube.

UNCOMPENSATED HORIZONTAL SQUARE-WAVE RESPONSE

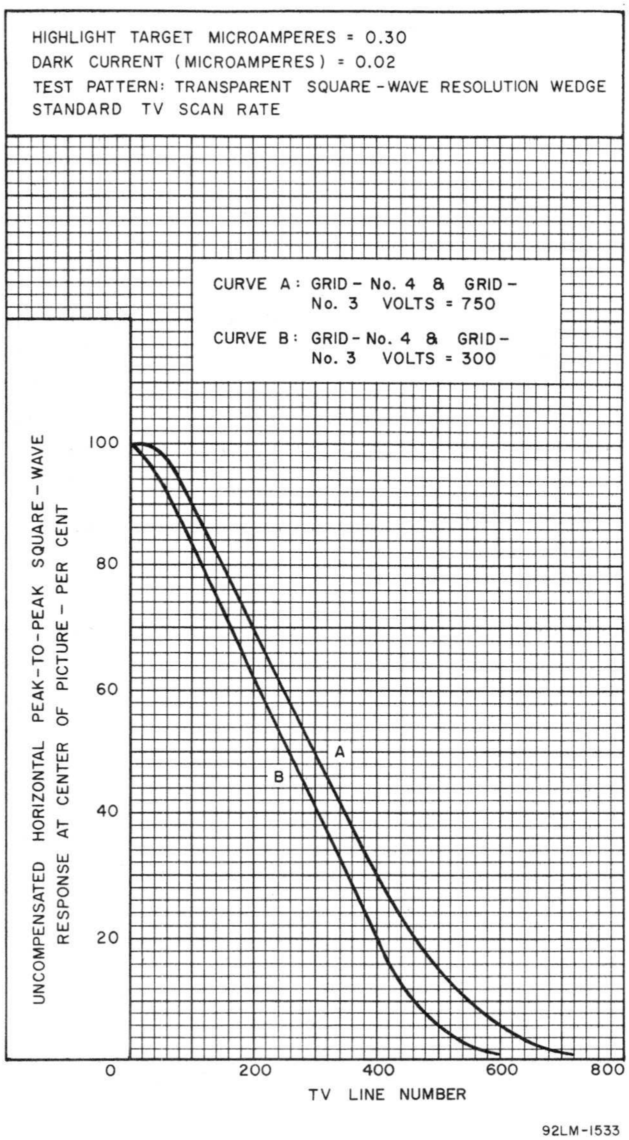


Fig.5

Operation at Standard TV Scan Rates

The *average "gamma", or slope,* of the light transfer characteristic curves shown in *Fig.3* is approximately 0.70. This value is relatively constant and is applicable for the light levels required to obtain signal currents in the 0.02 to 0.8 μA range at dark current values of 0.005 to 0.05 μA.

The *range of persistence or lag* of the photoconductive surface is shown in *Fig.4*. The curve shows the decay in signal-output current from an initial value of 0.3 microamperes after the illumination is cut off but with scanning maintained.

As shown in *Fig.5*, a substantial increase in both limiting resolution and amplitude response of the 4500 may be obtained by increasing the operating voltages on grid No.4 and grid No.3. The focusing-coil field strength must be increased and more deflecting power is required at higher electrode voltages as indicated under *Typical Operation and Performance Data.*

Operation at higher electrode voltages may introduce additional beam-landing errors that may be partially compensated for by repositioning the deflecting components. Full compensation may require the application of a modulating voltage of suitable waveform, at both horizontal and vertical scan rates, to the cathode, grid-No.1, and grid-No.2 of the 4500.

SIGNAL OUTPUT AS A FUNCTION OF SCAN SPEED FOR SEVERAL VALUES OF ILLUMINATION

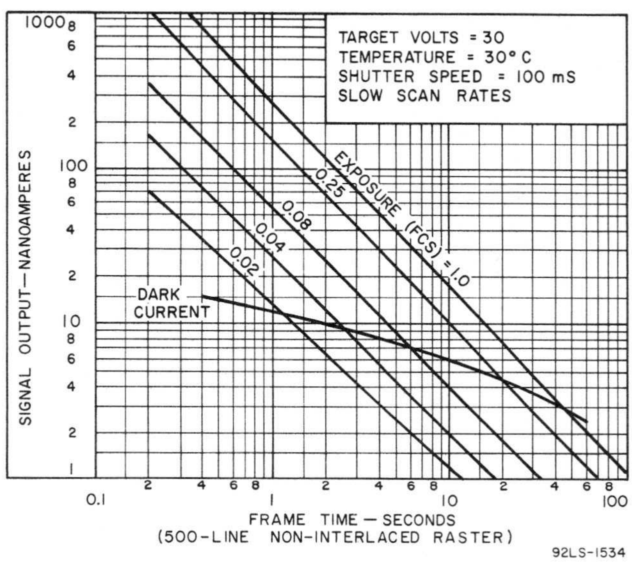


Fig.6

Operation at Slow-Scan Rates

The light transfer characteristic curves for the 4500 at slow-scan rates are shown in *Fig.6*. These curves show the rate of change of signal-output as a function of scan speed for a number of light energy values within the limits of its normal operating range at a typical constant target voltage of 30 volts.

Lag, or residual signal, characteristics at slow scan rates are shown in *Fig.7*. The decay of signal or, more properly, rate of erase is dependent on the number of scans rather than on any absolute elapsed-time base.

TYPICAL PERSISTENCE CHARACTERISTICS

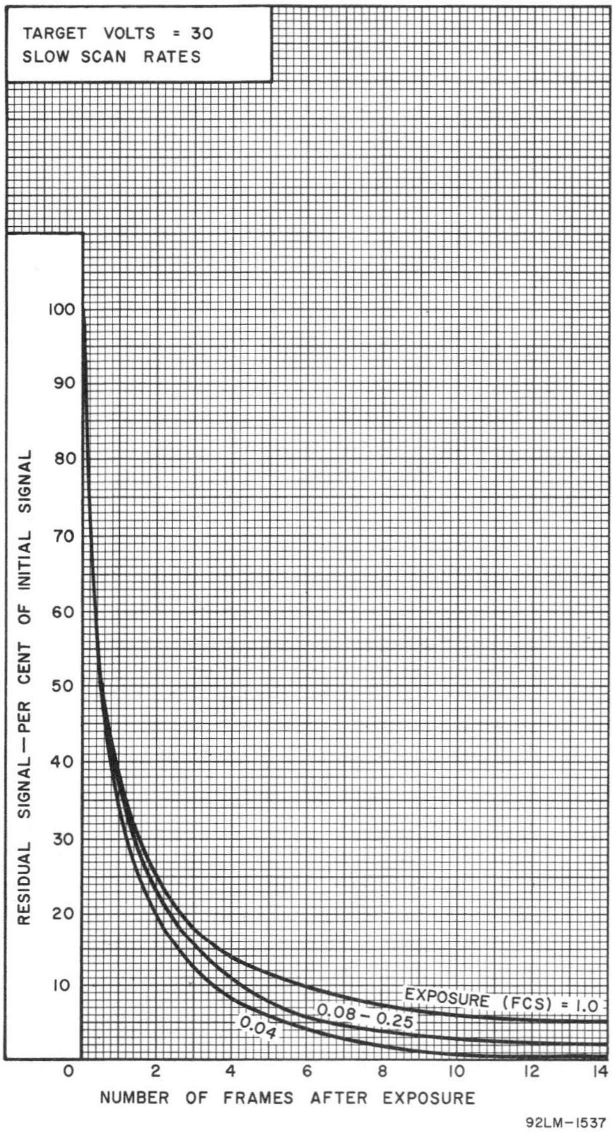


Fig.7

TYPICAL RESPONSE TO 400 TV LINE INFORMATION

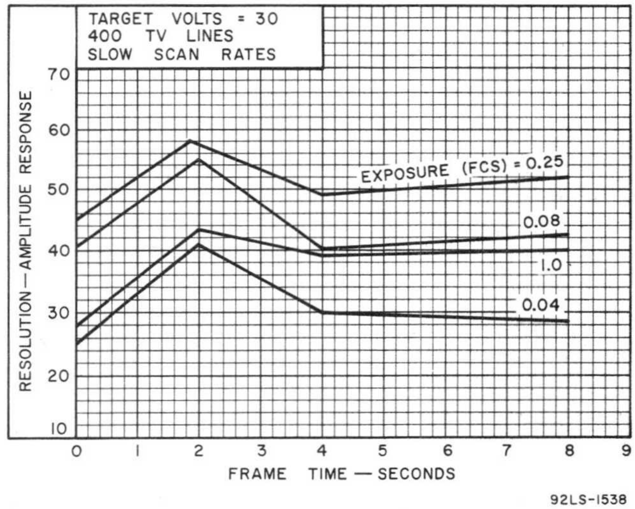


Fig.8

The 4500 typically requires 5 to 10 frames to reduce the signal to less than 5 per cent, and this requirement is essentially independent of frame scan rate. Thus, if the scan rate is 1 frame per second, it will take at least 5 seconds to reach the 5 per cent level. Similarly, if the scan rate is 5 frames per second, it will only take 1 second; if a 5 second frame rate is employed, it will take 25 seconds or more to reach the same level. The residual signal characteristics are not critically affected

TYPICAL STORAGE CHARACTERISTICS

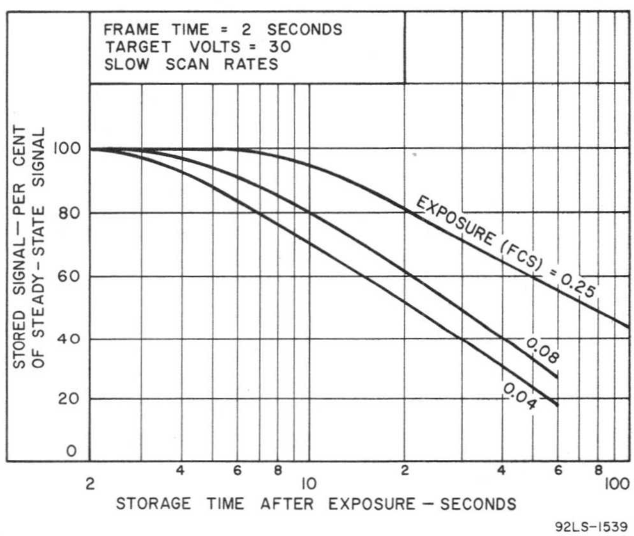


Fig.9

by light intensity or by operating target voltage. However, higher light exposure levels and higher target voltages usually result in more rapid erasure.

The *amplitude response* to image detail of a selected fine picture detail of 400 TV lines as a function of frame scan rate is shown in *Fig.8*. The four curves represent four typical light levels within the normal operating range of the 4500.

Under comparable operating conditions, the resolution capability of the 4500 is higher when slow-scan rates are employed than when standard TV scan rates are used. The range of usefulness at slow scan rates is normally limited by the signal-output level attainable rather than by any extreme changes in resolution.

Signal storage capability at a frame time of two seconds is shown in *Fig.9*. Operation at frame times of 20 to 80 seconds is practical. However, slower scan speed results in longer storage capability while fast scan speed provides faster decay. Higher target voltages will also decrease the storage capability of the 4500.

TYPICAL SPECTRAL RESPONSE

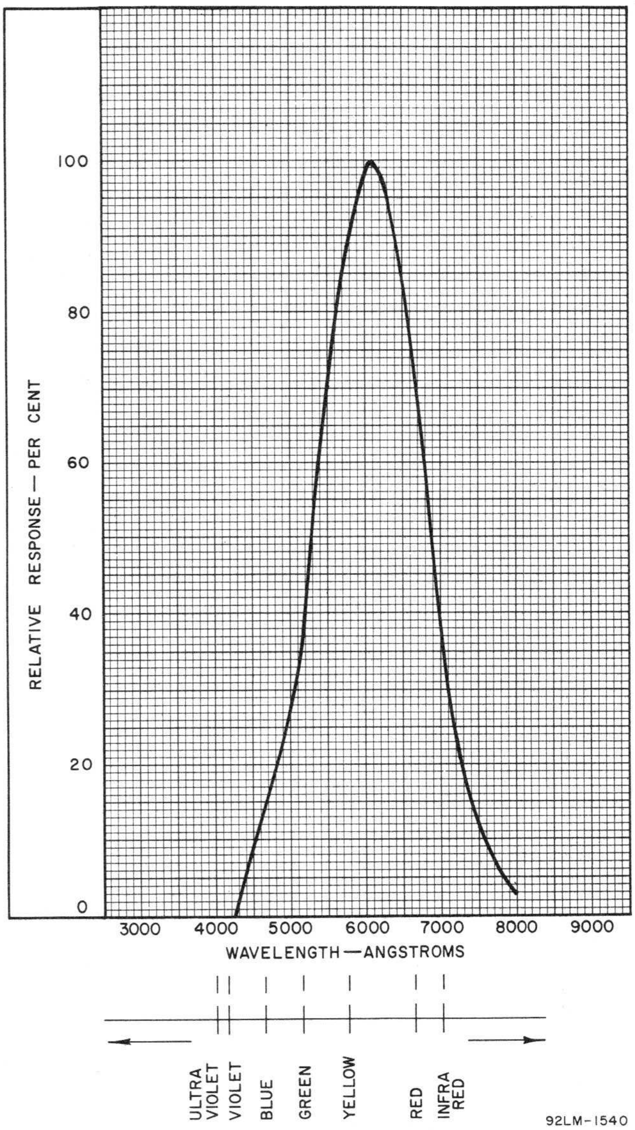


Fig.10

DOS and DON'TS

Here are the "dos" - -

1. Adjust camera scanning to utilize maximum useful area of photoconductive layer.
2. Orient the Vidicon so that horizontal scan is essentially parallel to the plane passing through tube axis and short index pin.
3. Align electron beam.
4. With lens capped, adjust target voltage for each individual Vidicon to the highest value that will still give uniform background.
5. Match any visible raster pattern on photoconductive layer with new scan by reorienting the vidicon as required.
6. Use only sufficient beam current to bring out picture highlights.
7. Open lens iris or increase the scene illumination to obtain the "snappiest" picture without noticeable smear from moving objects. Target voltage should be reduced if light on the tube and/or resultant signal is excessive.
8. Always cap lens when transporting camera (see "Don'ts" 5).

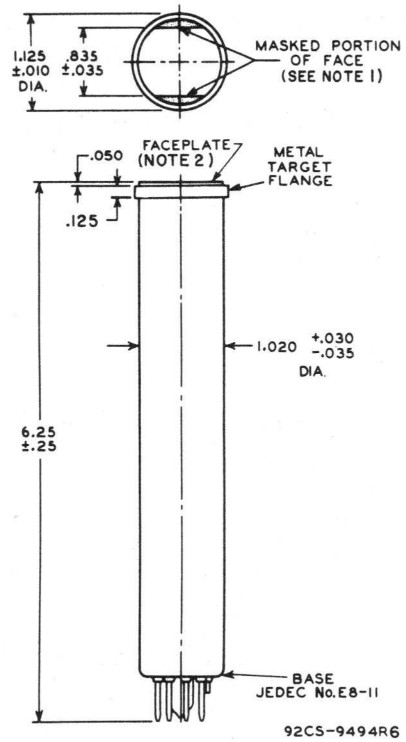
Here are the "don'ts" - -

1. Don't underscan the photoconductive layer.
2. Don't change camera size and centering controls once the scanned area of photoconductive layer has been properly positioned.
3. Don't rotate Vidicon from its original operating position in deflecting yoke.
4. Don't turn beam of Vidicon on without normal scanning or remove scanning before beam of Vidicon is turned off.
5. DON'T ALLOW IMAGE OF THE SUN OR OTHER VERY INTENSE SOURCE OF ILLUMINATION TO BE FOCUSED ON PHOTOCONDUCTIVE LAYER AT ANY TIME.

REFERENCES

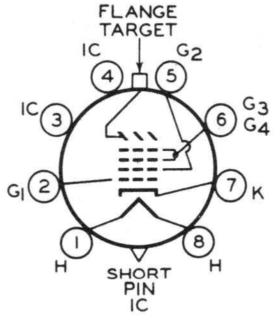
1. R. E. Johnson, "*Vidicon Performance Characteristics at Slow Scan Rates*", RCA Review, Vol. XXVII, No.1, March 1966.
2. Max H. Mesner, "*Television's Toughest Challenge*", Electronics, May 17, 1965.

DIMENSIONAL OUTLINE



NOTE 1: Straight sides of masked portions are parallel to the plane passing through tube axis and short index pin.
NOTE 2: Faceplate glass is Corning No.7056 having a thickness of 0.094"±0.012".

BASING DIAGRAM
Bottom View



DIRECTION OF LIGHT: INTO FACE END OF TUBE

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Internal Connection—Do not use
Pin 4: Internal Connection—Do not use
Pin 5: Grid No.2
Pin 6: Grids No.3 and No.4
Pin 7: Cathode
Pin 8: Heater
Flange: Target
Short Index Pin: Internal Connection—Make no Connection

OSCILLOGRAPH-TYPE CATHODE-RAY TUBE

RCA-4510

ELECTROSTATIC DEFLECTION • ELECTROSTATIC FOCUS POST-DEFLECTION ACCELERATOR

RCA-4510 is a short, 5"-diameter electrostatic-focus, electrostatic-deflection type cathode-ray tube having a post-deflection accelerator. It has a flat face and employs a long persistence P7 phosphor screen which exhibits purplish-blue fluorescence of medium-short persistence and yellowish-green phosphorescence which persists for several minutes under conditions of adequate excitation and low ambient light. The 4510 is intended for use in general oscillographic applications for observing extremely low-speed or medium-speed recurrent or non-recurrent phenomena.

DATA

GENERAL

Electrical:

Heater Voltage (AC or DC)	6.3 volts
Heater Current at 6.3 volts	0.6 A
Focusing Method	Electrostatic
Deflection Method	Electrostatic
Direct Interelectrode Capacitances (Approx.):	
Grid No.1 to all other electrodes	10 pF
Cathode to all other electrodes	5.5 pF
DJ1 to DJ2	2.5 pF
DJ3 to DJ4	3 pF
DJ1 to all other electrodes	10.5 pF
DJ2 to all other electrodes	8.5 pF
DJ3 to all other electrodes	8.5 pF
DJ4 to all other electrodes	9 pF

Optical:

Faceplate	Clear Glass
Shape	Flat, circular
Minimum Useful Screen Diameter	4.56"
Phosphor	P7
Fluorescence	Purplish-Blue
Phosphorescence	Yellowish-Green
Persistence	Long

Mechanical:

Tube Dimensions:	
Overall Length	12.00" ± 0.13"
Greatest Diameter	5.31"
Base	Special, Small-shell duodecal, 10 pin
Bulb	J42 Dev.67
Operating Position	Any
Weight (Approx.)	2 lbs

Maximum and Minimum Ratings, *Absolute-Maximum Values*

Post-Deflection Accelerator Voltage	6000 max. volts
Anode Voltage	3000 max. volts
Grid-No.3 (Focusing-Electrode) Voltage	1200 max. volts
Grid-No.1 Voltage:	
Negative Bias Value	200 max. volts
Positive Bias Value	0 max. volts
Positive Peak Value	2 max. volts
Heater Voltage	6.9 max. volts 5.7 min. volts
Peak Heater-Cathode Voltage:	
Heater Negative with respect to cathode	125 max. volts
Heater positive with respect to cathode	125 max. volts

Typical Operating Values:

Unless otherwise specified all values are positive with respect to cathode

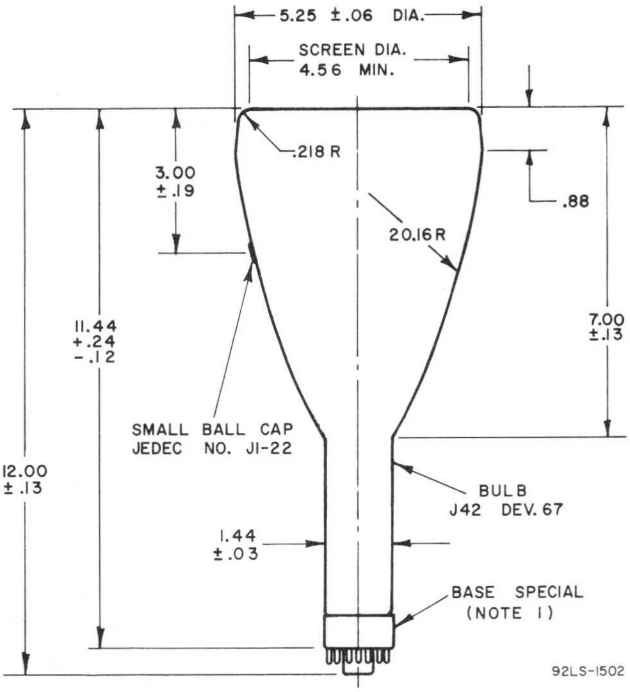
Post-Deflection Accelerator Voltage	3000 volts
Anode Voltage	1500 volts
Grid-No.3 (Focusing-Electrode) Voltage	475 to 725 volts
Grid-No.1 Voltage for visual cutoff of focused spot	–40 to –94 volts
Deflection Factors:	
DJ1 and DJ2	69 to 91 volts dc/inch
DJ3 and DJ4	57 to 73 volts dc/inch

Maximum Circuit Values:

Grid-No.1–Circuit Resistance	1.5 max. megohms
Resistance in any Deflecting Electrode Circuit[a]	5.0 max. megohms

[a]It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

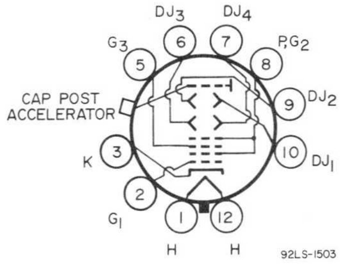
The plane through the tube axis and pin 1 may vary from the trace produced by DJ3 and DJ4 by an angular tolerance (measured about the tube axis) of 10°. Angle between DJ1 – DJ2 trace and DJ3 – DJ4 trace is 90° ± 3°.

DJ1 and DJ2 are nearer the screen; DJ3 and DJ4 are nearer the base. With DJ1 positive with respect to DJ2, the spot will be deflected toward pin 5; likewise, with DJ3 positive with respect to DJ4, the spot will be deflect-toward Pin 1.

NOTE 1: Base is identical to short small-shell duodecal JEDEC No.B12-207 except pin No.4 and pin No.11 are omitted.

BASING DIAGRAM

Bottom View



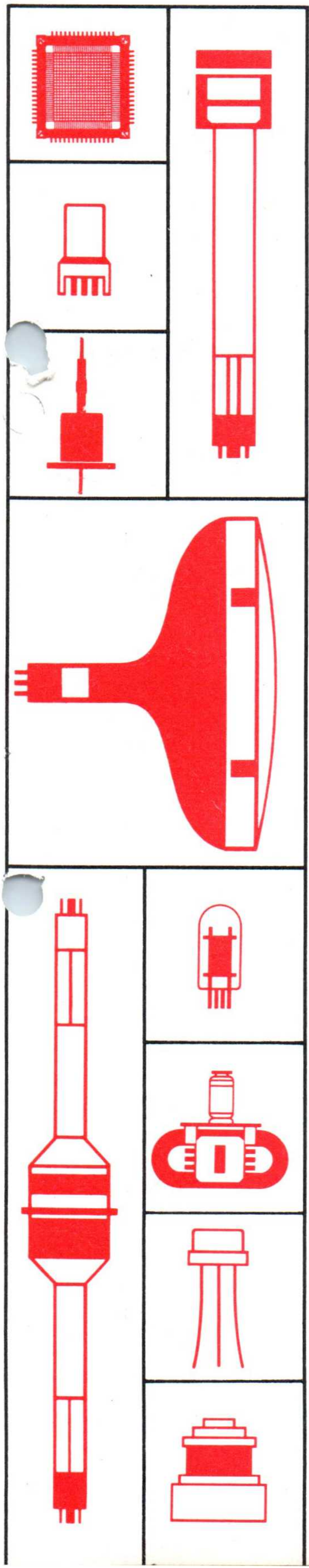
Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Cathode
Pin 5: Grid No.3
Pin 6: Deflecting Electrode DJ3
Pin 7: Deflecting Electrode DJ4
Pin 8: Anode, Grid No.2
Pin 9: Deflecting Electrode DJ2
Pin 10: Deflecting Electrode DJ1
Pin 12: Heater
Cap: Post Accelerator (Grid No.5 & Collector)

NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL LICENSING / HARRISON, N. J.

LICENSEE SERVICE



NOW...

RCA-4518

JOINS THE RECENTLY ANNOUNCED RCA-4516 AND -4517 BIALKALI PHOTOMULTIPLIER TUBES

APPLICATIONS:
- → Scintillation Counting
- → Low Light Level Detection and Measurement

CAPABILITY:
- Cathode Quantum Efficiency – 24% at 4000 Å
- Anode Dark Current – 2.4×10^{-10} A at 7 A/lm
- Anode-Pulse Rise Time – 2.3 ns at 1500 V
- Electron Transit Time – 27 ns at 1500 V
- Pulse Height Resolution – 9% with Cs^{137} and 2" x 2" NaI(T1) Scintillator

FEATURES:

BIALKALI PHOTOCATHODE
- 2-Inch Diameter, Head-On Type
- Flat Faceplate for Mounting Scintillators

COPPER-BERYLLIUM DYNODES
- 10-Stage, Circular-Cage, Electrostatically-Focused
- High-Stability

ADDITIONAL INFORMATION: A technical bulletin giving detailed information on the 4518 is attached for your convenience.

March 10, 1967

THE MOST TRUSTED NAME IN ELECTRONICS

RCA-4518

RCA

PHOTOMULTIPLIER TUBE

10-STAGE, HEAD-ON TYPE
2.31" MAX. DIAMETER, 5.81" MAX. LENGTH
Bialkali Photocathode of High Quantum Efficiency
Circular-Cage Electrostatically-Focused Dynode Structure

Formerly Dev. Type C7164N

RCA-4518 is a 2"-diameter, 10-stage, head-on photomultiplier tube designed for pulse counting and other low light level detection and measurement systems. It employs a bialkali photocathode, has copper-beryllium dynodes and features high quantum efficiency, low dark current, and good time resolution characteristics.

SPECTRAL RESPONSE CHARACTERISTICS

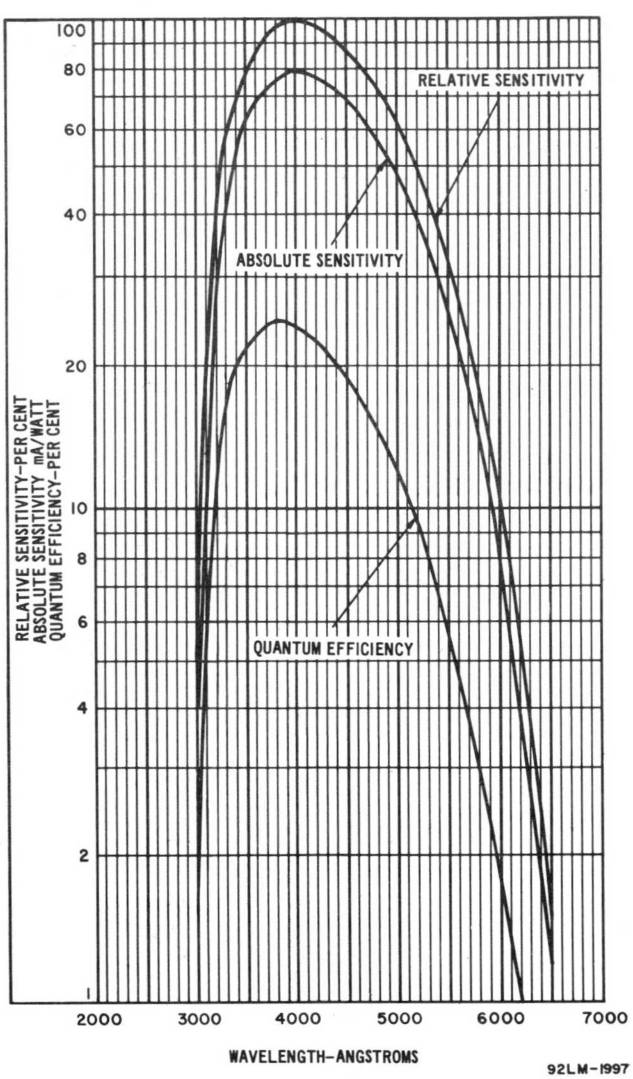


Fig. 1

The 4518 is well suited for use in counting low energy particles, released by low activity radioactive materials, when used in conjunction with suitable scintillators.

The spectral response of the 4518, at the 10-percent points, covers the approximate range from 3100 to 6000 angstroms as shown in *Fig.1*. Maximum response occurs at about 4000 angstroms, and peak cathode quantum efficiency at about 3800 angstroms.

TYPICAL CHARACTERISTICS

- **Bialkali Photocathode Having High Quantum Efficiency –**
  24% at 4000 angstroms
- **Anode Dark Current –**
  2.4 x 10^{-10} ampere at an equivalent luminous sensitivity of 7 amperes per lumen and at 22° C
- **Fast Time Resolution Characteristics –**
  Anode-Pulse Rise Time:
  2.3 nanoseconds at 1500 volts
  Electron Transit Time:
  27 nanoseconds at 1500 volts
- **Pulse Height Resolution –**
  9% with Cs^{137} and 2" x 2" NaI (Tl) scintillator

FEATURES

- **High-Stability Copper-Beryllium Dynodes**
- **Flat Faceplate for Mounting Scintillators**
- **Circular-Cage Electrostatically-Focused Dynode Structure**

DATA

General:

Spectral Response	See *Fig.1*
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Shape	Spherical Section
Minimum projected area	2.2 in^2
Minimum diameter	1.68 in.
Window	Corning[a] No.0080, or equivalent
Shape	Plano-Concave
Index of refraction at 4360 angstroms	1.523
Dynodes:	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	Circular-Cage Electrostatic-Focus Type
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	4.4 pF
Anode to all other electrodes	7 pF
Maximum Overall Length	5.81 in.
Seated Length	4.87 in. ± 0.19 in.
Maximum Diameter	2.31 in.
Bulb	T-16
Base	Medium-Shell Diheptal 14-Pin (JEDEC No.B14-38), Non-hygroscopic
Socket	Cinch-Jones[b] No.3M14, or equivalent
Magnetic Shield	Millen[c] No.80802B, or equivalent
Operating Position	Any
Weight (Approx.)	5.2 oz

Maximum Ratings, *Absolute-Maximum Values:*[d]

DC Voltage:		
Between anode and cathode	2000 max.	volts
Between anode and dynode No.10	250 max.	volts
Between consecutive dynodes	400 max.	volts
Between dynode No.1 and cathode	300 max.	volts
Between focusing electrode and cathode	400 max.	volts
Average Anode Current[e]	0.5 max.	mA
Ambient-Temperature Range[f]	−100 to +85	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing voltages as shown in Table I, except as noted.

With E = 1500 volts except as noted

Sensitivity	Min.	Typical	Max.	
Radiant[g] at 4000 angstroms	–	3.9×10^4	–	A/W
Cathode Radiant[h] at 4000 angstroms	–	0.079	–	A/W
Luminous:				
With tungsten light source[i]	13	33	200	A/lm
With blue light source[k]	2×10^{-5}	5×10^{-5}	3×10^{-4}	A
Cathode Luminous:				
With tungsten light source[m]	–	6.7×10^{-5}	–	A/lm
With blue light source[n]	8×10^{-10}	1×10^{-9}	–	A
Quantum Efficiency at 4000 angstroms	–	24	–	%
Current Amplification	–	5×10^5	–	

With E = 1500 volts except as noted **(Continued)**

Anode Dark Current[p]	–	2.4×10^{-10}	5×10^{-10}	A
Equivalent Anode-Dark-Current Input	–	3×10^{-11}[q]	–	lm
	–	2.5×10^{-14}[r]	–	W
Dark-Pulse Spectrum[s]	–	*See Fig.6*	–	
Pulse-Height Resolution[t]	–	9	–	%
Anode-Pulse Rise Time[u,v]	–	2.3×10^{-9}	–	s
Electron Transit Time[u,w]	–	2.7×10^{-8}	–	s

TABLE I

TYPICAL POTENTIAL DISTRIBUTION

Between:	7.75% of Supply Voltage (E) Multiplied by:
Cathode and Dynode No.1	1.8
Dynode No.1 and Dynode No.2	1.4
Dynode No.2 and Dynode No.3	1.5
Dynode No.3 and Dynode No.4	1.2
Dynode No.4 and Dynode No.5	1.0
Dynode No.5 and Dynode No.6	1.0
Dynode No.6 and Dynode No.7	1.0
Dynode No.7 and Dynode No.8	1.0
Dynode No.8 and Dynode No.9	1.0
Dynode No.9 and Dynode No.10	1.0
Dynode No.10 and Anode	1.0
Anode and Cathode	12.9

Focusing Electrode is connected to arm of potentiometer between cathode and dynode No.1. The focusing-electrode voltage is varied between 10% and 60% of dynode No.1 potential (referred to cathode) to give maximum anode current.

[a]Made by Corning Glass Works, Corning, New York 14830.

[b]Made by Cinch Manufacturing Co., 1026 S. Homan Ave., Chicago, Ill. 60624

[c]Made by James Millen Manufacturing Co., 150 Exchange St., Malden, Mass. 02148

[d]The *maximum ratings* in the tabulated data are established in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum Value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[f]Tube operation at room temperature or below is recommended.

[g]This value is calculated from the typical luminous sensitivity rating using a conversion factor of 1190 lumens per watt.

[h]This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1190 lumens per watt.

[i]These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-5} \text{ (lm)}}$$

The value of 0.15 is the average value of the ratio of the anode current measured under the conditions specified in footnote (j) to the anode current measured under the same conditions but with the blue filter removed.

[k]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 10 microlumens.

[m]This value is calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

The value of 0.15 is the average value of the ratio of the cathode current measured under the conditions specified in footnote (m) to the cathode current measured under the same conditions but with the blue filter removed.

[n]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 100 microlumens and 200 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 C. S. No.5-58, polished to 1/2 stock thickness). The light flux incident on

the filter is 10 microlumens. The supply voltage (E) is adjusted to obtain an anode current of 10 microamperes. Sensitivity of the 4518 under these conditions is approximately equivalent to 7 amperes per lumen. Dark current is measured with no light incident on the tube.

[q]With supply voltage (E) adjusted to give an equivalent luminous sensitivity of 7 amperes per lumen.

[r]At 4000 angstroms. This value is calculated from the EADCI value in lumens using a conversion factor of 1190 lumens per watt.

[s]Measured under the following conditions: A Nuclear Data Model No.ND-180 Multichannel Pulse-Height Analyzer is used. The single-photoelectron pulse height is established by fully illuminating the photocathode with a weak light source, such as a tungsten-filament lamp operated at a low color temperature, to assure the high probability of single photoelectron emission from the photocathode of the 4518. The intensity of the light source is adjusted for approximately 50 per cent counting loss. The dark-pulse spectrum is then obtained, using the same gain setting of the Multichannel Pulse-Height Analyzer, with the light source removed.

[t]Pulse-height resolution is defined as the quotient of the full width of the photopeak at half height by the pulse height at maximum count rate under the following conditions: The 662 keV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 2" x 2" thallium-activated sodium-iodide scintillator [NaI(Tl)-type 8D8] are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97 Street, Cleveland 6, Ohio, and is rated by the manufacturer as having a resolution capability of 7.5%. The Cs^{137} source is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 4518 by a coupling fluid such as Dow Corning Corp., Type DC200 (viscosity of 60,000 centistokes) — Manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

[u]Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of (E) between cathode and dynode No.1; 1/12 of (E) for each succeeding dynode stage; and 1/12 of (E) between dynode No.10 and anode. Focusing electrode potential is adjusted as shown in Table I.

[v]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.

[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

Terminal Connections:

The *base pins* of the 4518 fit a diheptal 14-contact socket, such as Cinch-Jones No.3M14 or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that incident light falls on the face end of the tube.

Operating Stability:

The *operating stability* of the 4518 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 stability is of prime importance, the use of an average anode current of 1 microampere or less is recommended.

Cathode Current:

Peak cathode current of 1×10^{-8} ampere at a tube temperature of 22° C or 1×10^{-10} ampere at -100° 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.

Operating Voltages:

In general, the operating potential between anode and cathode should not be less than 500 volts. The suggested voltage distribution shown in Table I, is a typical, average distribution for obtaining a good compromise between output current and time and energy resolution. However, it may be necessary to individually adjust these distribution voltages by as much as ±15% to obtain optimum current amplification, pulse-height resolution, or time resolution.

Typical voltage-divider arrangements for use with the 4518 are shown in *Fig.11* and *Fig.12*. Recommended resistance values for the voltage dividers range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for any voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required power rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is mounted near the photocathode.

The use of high resistance values 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 value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No.7 and No.8, dynodes No.8 and No.9, dynodes No.9 and No.10, and between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 10 megohms per stage make the 4518 more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

TYPICAL TIME-RESOLUTION CHARACTERISTICS

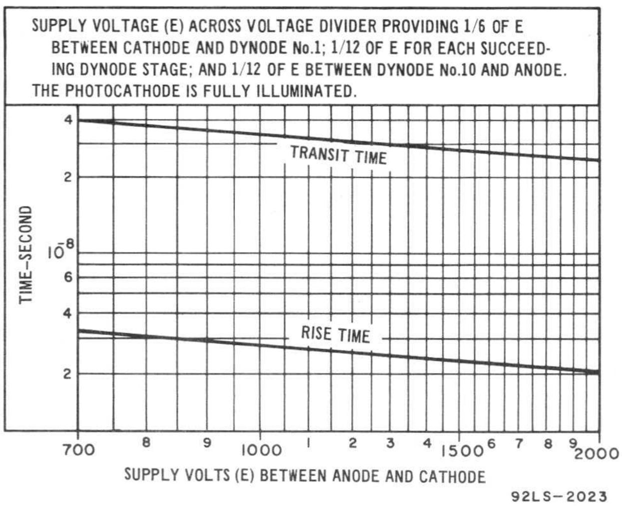


Fig. 2

The *operating voltage between dynode No.10 and anode* should be kept as low as will permit operation over the knee of the anode characteristic curves shown in *Fig.3*. With low operating voltage between dynode No.10 and anode, the ohmic leakage current to the anode is reduced. Operation over the knee occurs in the approximate range of 10 to 70 volts for the light level range shown in *Fig.3*. Under high pulse current conditions, saturation due to space-charge limitations will occur and higher voltage will be required. To obtain the suggested operating voltage between dynode No.10 and anode, it is necessary to increase the supply voltage between these electrodes by an amount equal to the voltage drop across a particular output load.

In scintillation counting and other pulse applications, it is recommended that the negative high-voltage terminal of the power supply be grounded and that a high-voltage coupling capacitor be used to take the signal from the anode, as shown in *Fig.12*.

In applications where the incident light is steady or varies slowly and the DC component of the anode current is required, the positive terminal of the high-voltage power supply may be grounded, as shown in *Fig.11*.

TYPICAL ANODE CHARACTERISTICS

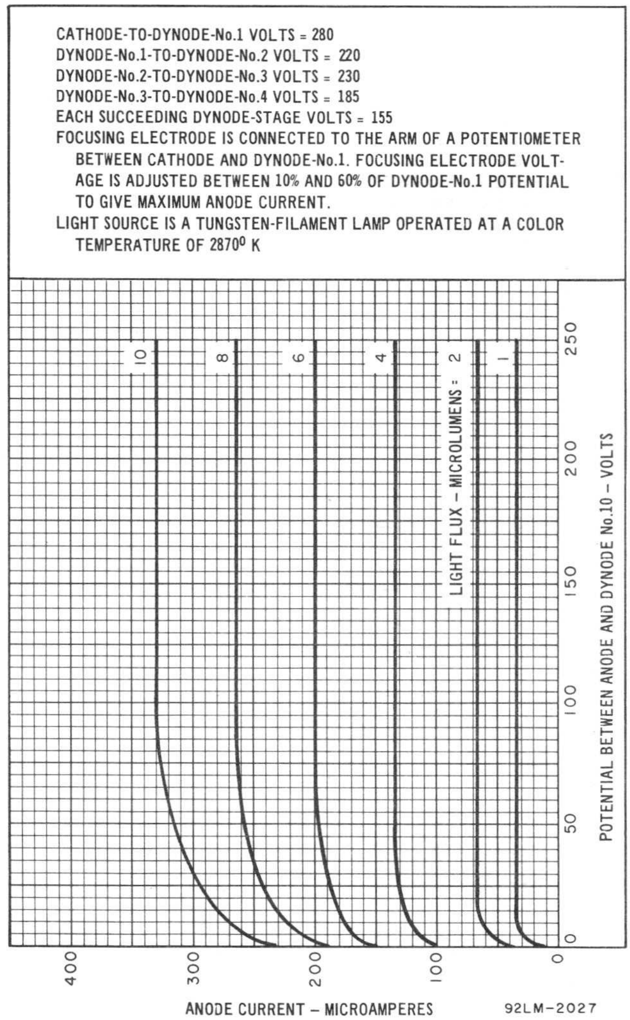


Fig. 3

When the 4518 is operated in either manner, the electrostatic shield must be connected to the cathode for maximum signal-to-noise ratio, and to prevent possible damage to the tube.

The high voltages at which the 4518 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.

In the use of the 4518, 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 all capacitors grounded.

SENSITIVITY AND CURRENT-AMPLIFICATION CHARACTERISTICS

THE SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE-DIVIDER WHICH DISTRIBUTES THE VOLTAGE AS FOLLOWS:

BETWEEN:	7.75% OF E MULTIPLIED BY:
CATHODE AND DYNODE No.1	1.8
DYNODE No.1 AND DYNODE No.2	1.4
DYNODE No.2 AND DYNODE No.3	1.5
DYNODE No.3 AND DYNODE No.4	1.2
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	12.9

FOCUSING ELECTRODE VOLTAGE IS ADJUSTED FOR MAXIMUM ANODE CURRENT

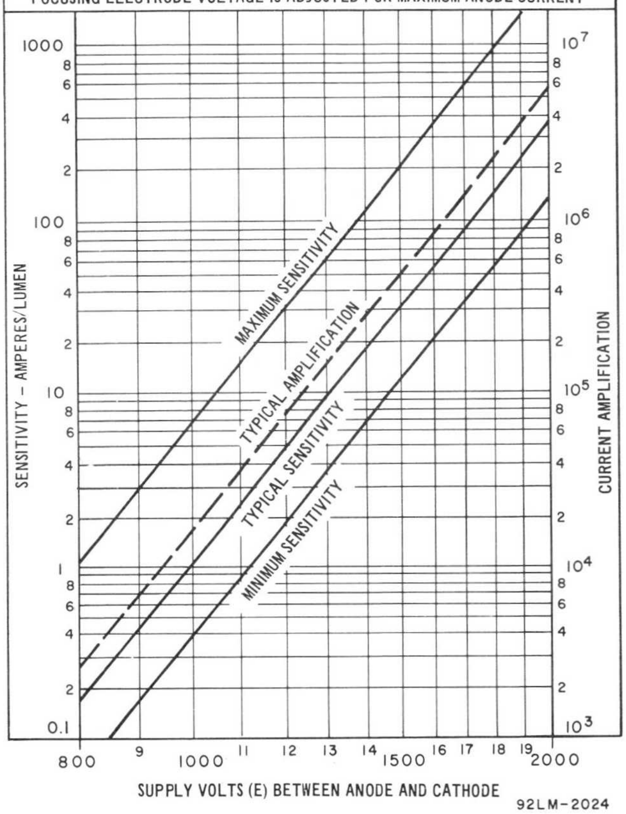


Fig. 4

Dark Current:

A very small *anode dark current* is observed when voltage is applied to the electrodes of the 4518 in complete darkness. Among the components contributing to dark current are ohmic leakage between the anode and adjacent elements and pulses produced by electrons thermionically released from the cathode, secondary electrons released by ionic bombardment of the dynodes, support rods, or cathode, and by cold emission from the electrodes.

SPECTRAL ENERGY DISTRIBUTION OF 2870° K LIGHT SOURCE AFTER PASSING THROUGH INDICATED FILTER

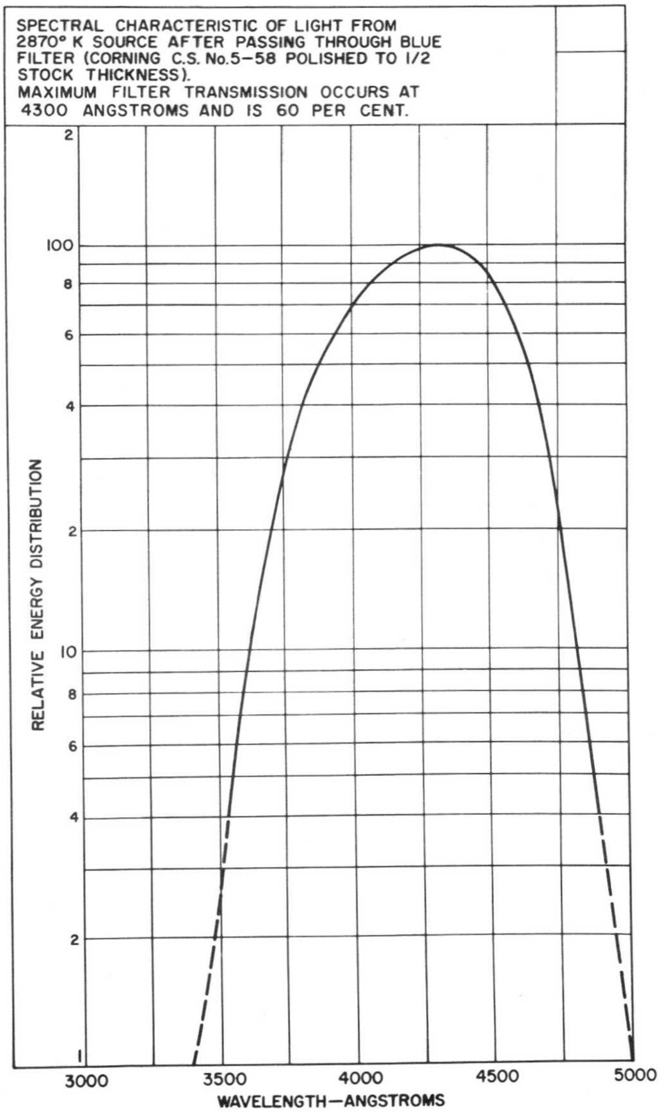


Fig. 5

A *temporary increase in anode dark current* by as much as 2 orders of magnitude may occur if these tubes are exposed momentarily to ultraviolet radiation from sources such as fluorescent room lighting even though voltage is not applied to the tubes. The increase in dark current may persist for a period of 24 to 48 hours following such irradiation.

The *use of a refrigerant,* such as dry ice, to cool the 4518 is recommended in those applications where maximum current amplification with minimum dark current is required. It should be noted, however, that at reduced temperatures the resistance of the cathode increases, thereby reducing the maximum peak anode current. (See *Cathode Current*-page 4.)

A *typical spectrum of dark-pulses* for the 4518 at a temperature of 22° C is shown in *Fig.6*. The dashed portion of *Fig.6* shows the location of the single photoelectron peak. This curve was measured with a constant light source operated at low color temperature to insure high probability of single photoelectron emission. Dark pulses were subtracted. The intensity of the light source was adjusted for an approximate 50 per cent counting loss.

A Nuclear Data Model No.ND-180 Multichannel Pulse-Height Analyzer – manufactured by Nuclear Data, Inc., Palatine, Ill., or equivalent – and a Tennelec Model No.TC-170 Preamplifier – manufactured by Tennelec Instrument Co., Inc., Box D, Oak Ridge, Tenn., or equivalent – were used to measure pulse height. The Multi-

TYPICAL DARK-PULSE SPECTRUM

CATHODE-TO-DYNODE No.1 VOLTAGE = 280
DYNODE No.1-TO-DYNODE No.2 VOLTAGE = 220
DYNODE No.2-TO-DYNODE No.3 VOLTAGE = 230
DYNODE No.3-TO-DYNODE No.4 VOLTAGE = 185
EACH SUCCEEDING DYNODE-STAGE VOLTAGE = 155
ANODE-TO-CATHODE VOLTAGE = 2000
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO GIVE MAXIMUM ANODE CURRENT
DASHED PORTION INDICATES LOCATION OF SINGLE PHOTOELECTRON PEAK. THIS PORTION OF CURVE IS NORMALIZED TO COINCIDE WITH SINGLE PHOTOELECTRON PEAK OF DARK PULSE SPECTRUM AND IS OBTAINED WITH PHOTOCATHODE FULLY ILLUMINATED BY A TUNGSTEN-FILAMENT LAMP OPERATED AT A LOW COLOR TEMPERATURE. DARK PULSES ARE SUBTRACTED.
SOLID-LINE PORTION INDICATES DARK-PULSE SPECTRUM.
TUBE TEMPERATURE = 22° C.
ONE PHOTOELECTRON PULSE HEIGHT = 4 COUNTING CHANNELS.
INTEGRATING TIME CONSTANT = 30 μ SEC. (R_L = 300 k, C = 100 pF).

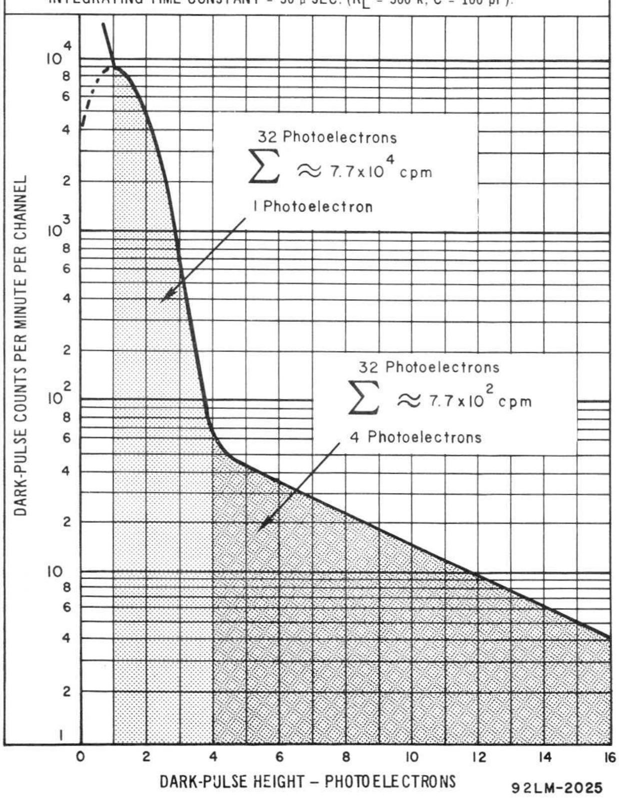


Fig. 6

TYPICAL DARK CURRENT AND EADCI CHARACTERISTICS

LUMINOUS SENSITIVITY IS VARIED BY ADJUSTMENT OF THE SUPPLY POTENTIAL (E) ACROSS A VOLTAGE DIVIDER WHICH DISTRIBUTES (E) AS FOLLOWS:

BETWEEN:	7.75% OF E MULTIPLIED BY:
CATHODE AND DYNODE No.1	1.8
DYNODE No.1 AND DYNODE No.2	1.4
DYNODE No.2 AND DYNODE No.3	1.5
DYNODE No.3 AND DYNODE No.4	1.2
EACH SUCCEEDING DYNODE STAGE	1.0
ANODE AND CATHODE	12.9

FOCUSING ELECTRODE VOLTAGE IS ADJUSTED FOR MAXIMUM ANODE CURRENT
TUBE TEMPERATURE = 22° C

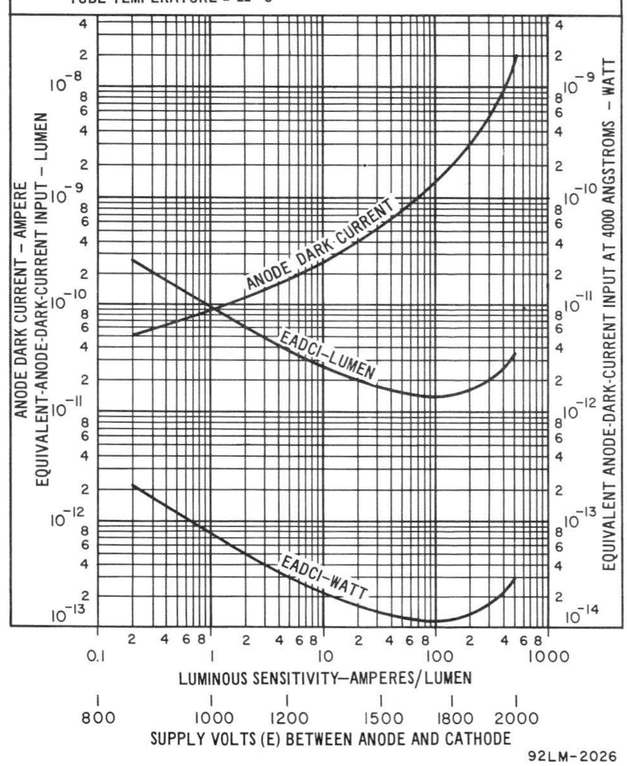


Fig. 7

channel Pulse-Height Analyzer was set for 128 channel operation, with 4 channels per photoelectron pulse height. Sixteen photoelectron heights (64 channels) are shown in the dark-pulse spectrum of Fig.6.

The solid-line portion of *Fig.6* shows the differential dark-pulse spectrum. The high slope of this curve in the pulse region of less than 1 photoelectron is assumed to be due to electron emission from the first and second dynode surfaces. The discriminator threshold of the associated circuitry should be adjusted so that pulses of less than one photoelectron height are rejected.

The slope of the curve for the pulse-height region between 1 and 4 photoelectrons is as expected for single photoelectron emission from the photocathode and for the multiplication processes at the first and second dynodes.

The slope of the curve for the pulse-height region greater than 4 photoelectrons is assumed to be caused by electron emission from the photocathode due to processes such as ion bombardment.

TYPICAL EFFECT OF INDICATED MAGNETIC FIELD ON ANODE CURRENT

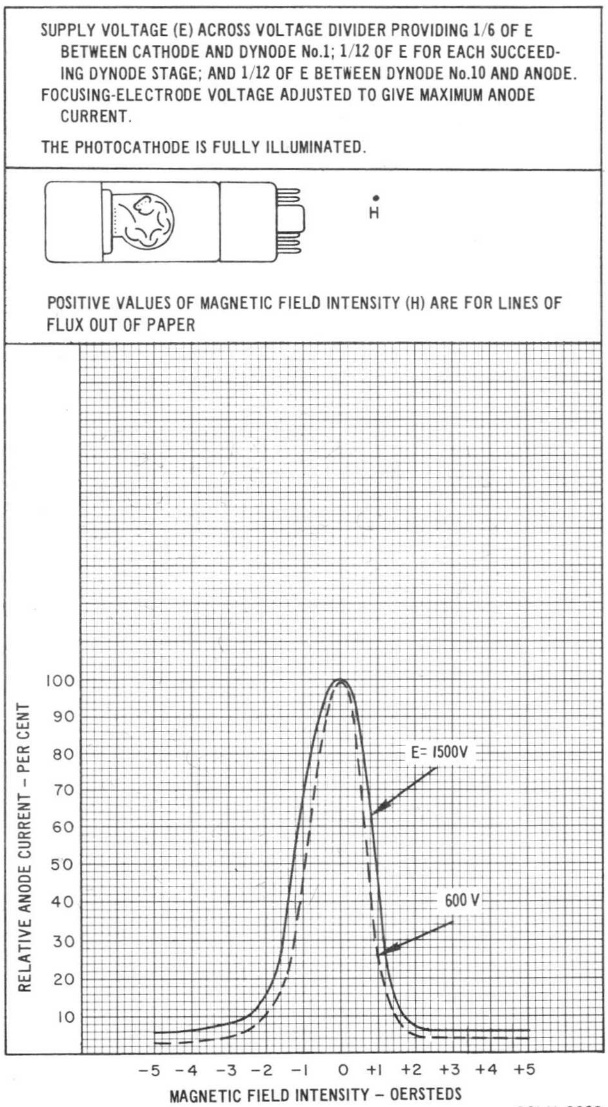


Fig. 8

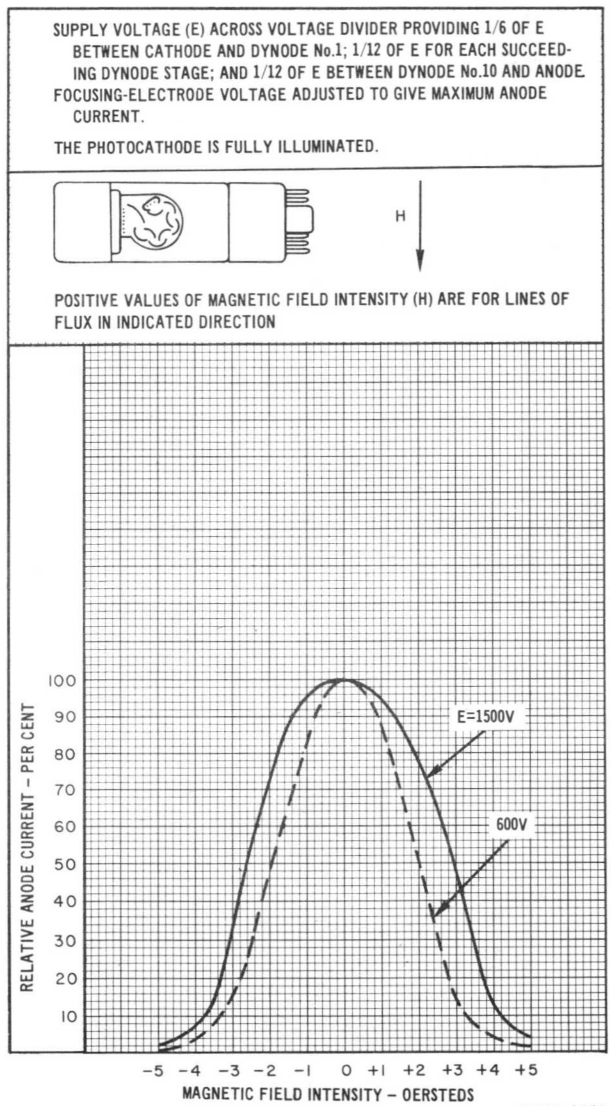


Fig. 9

Shielding:

Electrostatic and magnetic shielding of the 4518 is ordinarily required. When a shield is used, it must be at cathode potential. The application of high voltage, with respect to cathode, to insulating or other materials supporting or shielding the 4518 at the photocathode end of the tube should not be permitted unless such materials are chosen to limit leakage current to the tube envelope to 1×10^{-12} ampere or less.

TYPICAL EFFECT OF INDICATED MAGNETIC FIELD ON ANODE CURRENT

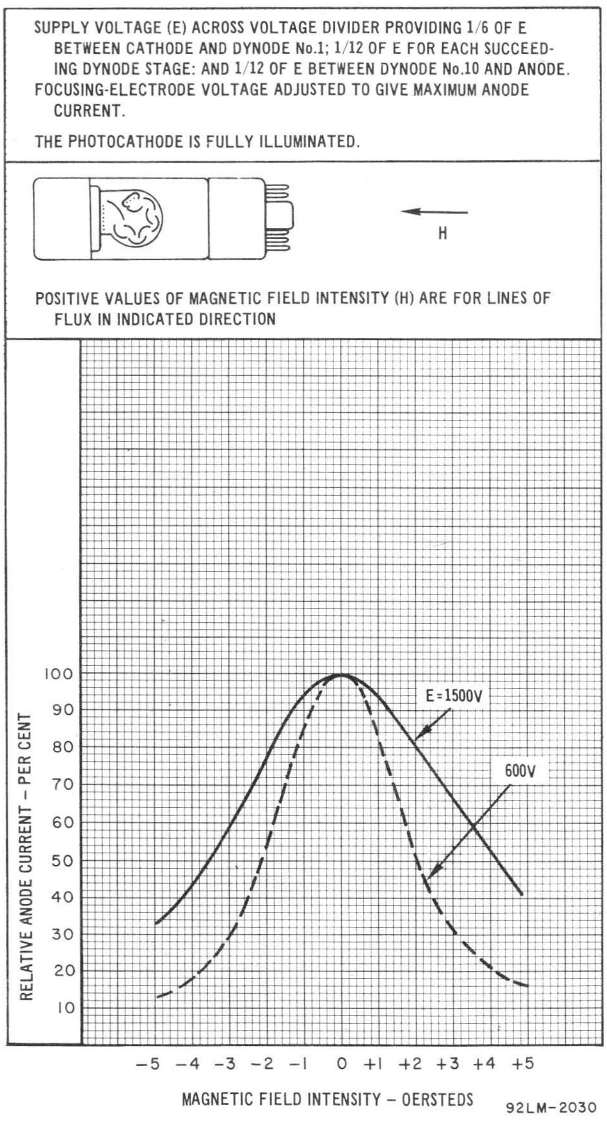


Fig. 10

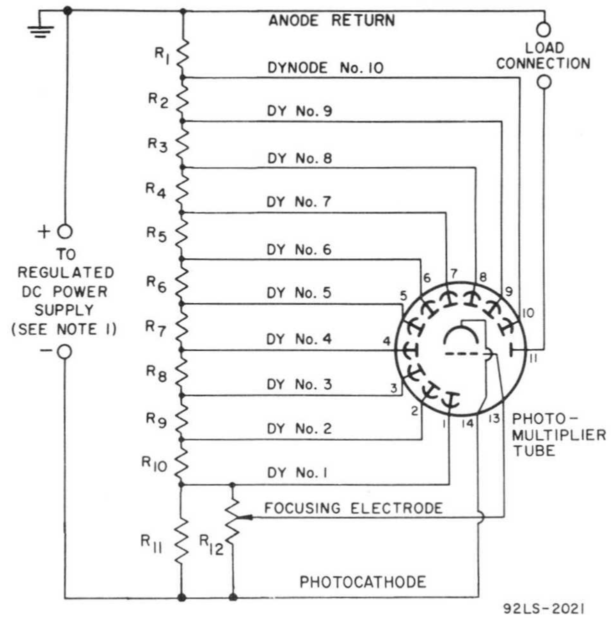
In addition to increasing dark current and noise output because of voltage gradients developed across the bulb wall, such high voltage may produce minute leakage current to the cathode, through the tube envelope and insulating materials, which can permanently damage the tube.

Magnetic shielding of the 4518 is ordinarily required. The curves of *Figs.8, 9,* and *10* show the effect of variation in magnetic-field intensity on the anode current for a tube with no magnetic shielding. As seen in *Fig.8* with a supply voltage (E) of 1500 volts distributed as shown and with a magnetic field of +0.9 oersteds parallel to the dynode surfaces, the anode current is typically reduced to approximately 50 per cent of the "no field" value.

It is to be noted that the use of an external shield at high negative potential presents a safety hazard. *Extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light and ultraviolet-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 4518.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT WHICH PERMITS DIRECT COUPLING TO THE ANODE



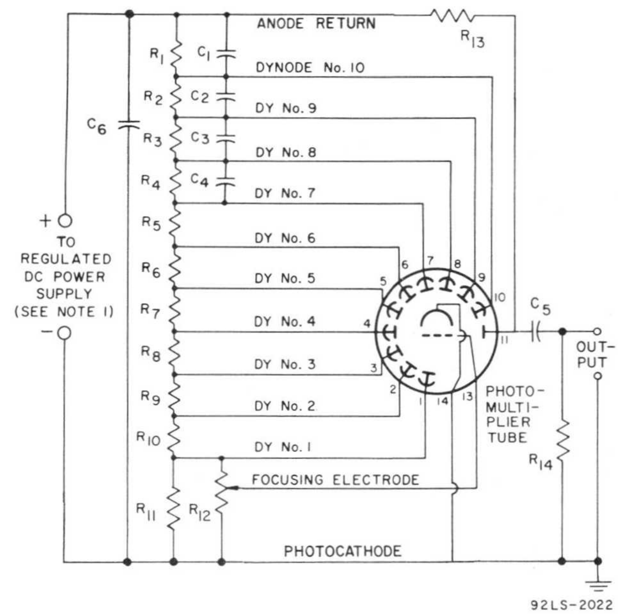
R_1 through R_7: 390,000 ohms, 1/2 watt
R_8: 470,000 ohms, 1/2 watt
R_9: 620,000 ohms, 1/2 watt
R_{10}: 560,000 ohms, 1/2 watt
R_{11}: 720,000 ohms, 1/2 watt
R_{12}: 5 megohms, 1/2 watt, adjustable

Note 1: Adjustable between approximately 500 and 2000 volts dc.

Note 2: Component values are dependent upon nature of application and output signal desired. See discussion on *Typical Voltage Divider Arrangements* – Page 4.

Fig. 11

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR USE IN SCINTILLATION-COUNTING APPLICATIONS



C_1: 0.05 μF, 500 volts (dc working)
C_2: 0.02 μF, 500 volts (dc working)
C_3: 0.01 μF, 500 volts (dc working)
C_4: 0.005 μF, 500 volts (dc working)
C_5 and C_6: 0.005 μF, 3000 volts (dc working)
R_1 through R_7: 390,000 ohms, 1/2 watt
R_8: 470,000 ohms, 1/2 watt
R_9: 620,000 ohms, 1/2 watt
R_{10}: 560,000 ohms, 1/2 watt
R_{11}: 720,000 ohms, 1/2 watt
R_{12}: 5 megohms, 1/2 watt, adjustable
R_{13}: 1 megohm, 1/2 watt
R_{14}: 100,000 ohms, 1/2 watt

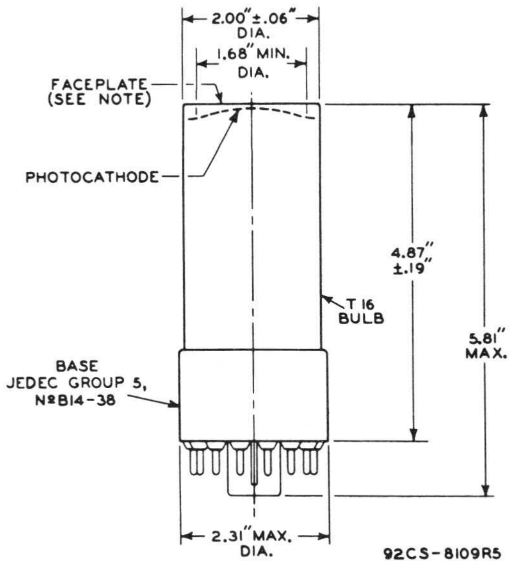
Note 1: Adjustable between approximately 500 and 2000 volts dc.

Note 2: Capacitors C_1 through C_6 should be connected at tube socket for optimum high-frequency performance

Note 3: Component values are dependent upon nature of application and output signal desired. See discussion on *Typical Voltage Divider Arrangements* – Page 4.

Fig. 12

DIMENSIONAL OUTLINE



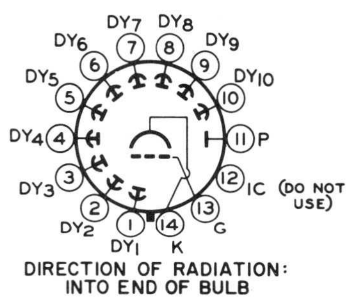
DIMENSIONS IN INCHES

℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

Note: Within 1.68" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

BASING DIAGRAM
Bottom View

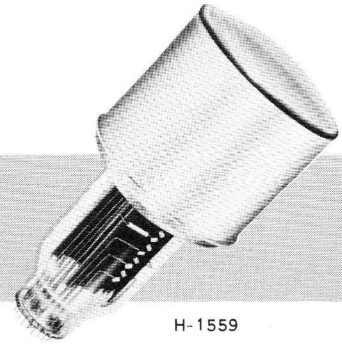
Pin 1: Dynode No.1
Pin 2: Dynode No.2
Pin 3: Dynode No.3
Pin 4: Dynode No.4
Pin 5: Dynode No.5
Pin 6: Dynode No.6
Pin 7: Dynode No.7



Pin 8: Dynode No.8
Pin 9: Dynode No.9
Pin 10: Dynode No.10
Pin 11: Anode
Pin 12: Internal Connection — Do Not Use
Pin 13: Focusing Electrode
Pin 14: Photocathode

14AA

RCA



H-1559

RCA-4522

Photomultiplier Tube

Formerly RCA Dev. Type C70133

5.25"-Diameter, 14-Stage, Head-On Type Employing a Bialkali Photocathode and an In-Line Electrostatically-Focused Dynode Structure.

RCA-4522 is a 14-stage, 5"-diameter, head-on type of photomultiplier tube intended primarily for use in nuclear physics applications, especially when a high degree of time definition is required. It features high quantum efficiency, ultraviolet response, uniform electron collection from the major portion of the photocathode, fast response, low dark current, high current amplification and a 50-ohm output transmission line.

The relative spectral response of the 4522 covers the approximate range from 2200 to 5800 angstroms at the 10 per cent points as shown in **Figure 1.** Maximum relative response occurs at about 4000 angstroms; and peak cathode quantum efficiency, at about 3600 angstroms.

Typical Spectral Response Characteristics

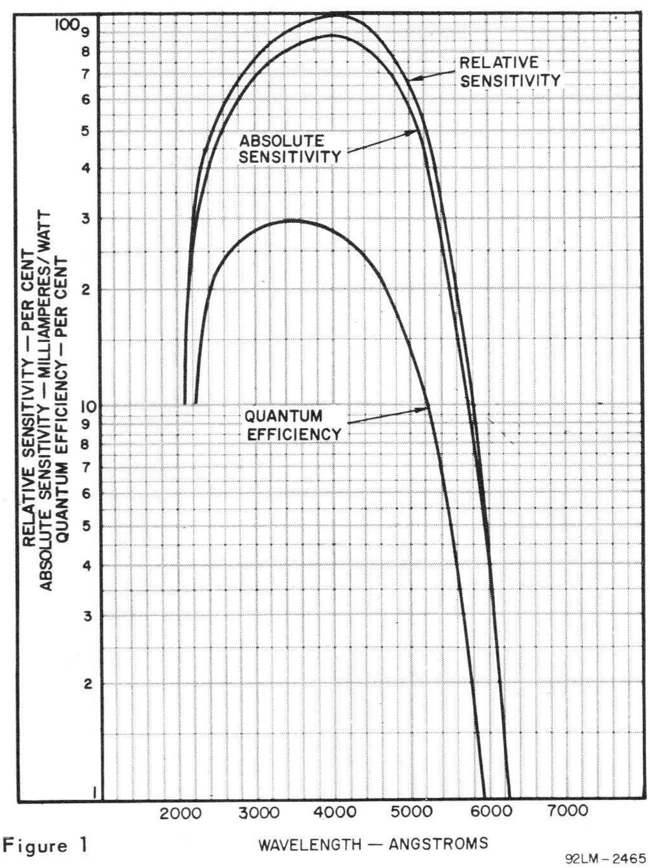


Figure 1

Typical Characteristics

- **Quantum Efficiency:** at 3600 Å — **29%**
- **Current Amplification:** at 2000 V — **3×10^7**
- **Anode Dark Current:** at 2.3×10^6 A/W (2000 A/lm) and 22° C — **6×10^{-8} A**
- **Anode Pulse-Current Capability:** at 3000 V
  - Linear: **0.13 A**
  - Saturated: **0.32 A**
- **Time Resolution Characteristics:** at 3000 V
  - Anode-Pulse Rise Time: **2.9×10^{-9} s**
  - Electron Transit Time: **6.6×10^{-8} s**
- **Pulse Height Resolution:** with Cs^{137} source, NaI (T1) Scintillator — **7.5%**
- **Mean Gain Deviation:** for 24 hours at 1000 counts per second — **1%**

Features

- **UV Response to 2200 Å**
- **Anode Transmission-Line Characteristic Impedance – 50 ohms**
- **4.5" Minimum Diameter Photocathode**
- **High Stability Copper-Beryllium Dynodes**
- **Available Accessories**
  - **RCA-AJ2144 and AJ2145, Sockets:** The AJ2145 is supplied with the 4522
  - **RCA-AJ2142, Faceplate Adapter (Light pipe):** To provide a flat input surface, especially for mounting of scintillators
  - **RCA-AJ2143, Socket Adapter:** To allow replacement of types 58AVP and 58DVP by RCA-4522

RCA Electronic Components

Supersedes 1-68
Printed in U.S.A. | 6-68

Data

General:

Spectral Response	See **Figure 1**
Wavelength of Maximum Response	4000 ± 500 Å
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Shape	Spherical Section
Minimum projected area	16 in^2 (103 cm^2)
Minimum diameter	4.5 in (11.4 cm)
Window	UV-transmitting, Corning[a] No.9741, or equivalent
Shape	Spherical Section
Index of refraction at 4047 angstroms	1.48
Dynodes:	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	In-Line Electrostatic-Focus
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.14	5.5 pF
Anode to all other electrodes	7.0 pF
Maximum Overall Length	12 in (30.5 cm)
Maximum Diameter	5.25 in (13.3 cm)
Base	See Base Drawing
Socket	RCA-AJ2144 or AJ2145
Magnetic Shield	See Note (**b**)
Operating Position	Any
Weight (Approx.)	21 oz (590 g)

Maximum and Minimum Ratings, *Absolute-Maximum Values:*[c]

DC Supply Voltage:		
Between anode and cathode:		
With Voltage Distribution A or B, shown in Table I	3000 max.	V
With Voltage Distribution C, shown in Table I	3500 max.	V
Between anode and dynode No.14	600 max.	V
Between dynode No.14 and dynode No.13	800 max.	V
Between other consecutive dynodes	400 max.	V
Between dynode No.1 and cathode	300 max.	V
	300 min.	V
Average Anode Current[d]	0.5 max.	mA
Ambient-Temperature Range	-100 to +85	°C

Characteristics Range Values for Equipment Design:

With a DC Supply Voltage (E) = 2000 Volts (Except as noted)

Voltage Distribution A, Table I

	Min.	Typ.	Max.	
Anode Sensitivity:				
Radiant[e] at 4000 Å	–	2.6×10^6	–	A/W
Luminous[f] (2870° K)	6.5×10^2	2.3×10^3	6.5×10^3	A/lm
With blue light source[g] (2870° K + C.S. No.5-58)	8.5×10^{-6}	3×10^{-5}	8.5×10^{-5}	A

	Min.	Typ.	Max.	
Cathode Sensitivity:				
Radiant[h] at 4000 Å	–	8.8×10^{-2}	–	A/W
Luminous[i] (2870° K)	–	7.7×10^{-5}	–	A/lm
With blue light source[k] (2870° K + C.S. No.5-58)	8×10^{-10}	1×10^{-9}	–	A
Cathode Quantum Efficiency at 3600 Å	–	29	–	%
Current Amplification	–	3×10^{7}	–	
Anode Dark Current[m]	–	6×10^{-8}	1×10^{-6}	A
Equivalent Anode Dark Current Input	–	3×10^{-11}[n]	5×10^{-10}[n]	lm
	–	2.6×10^{-14}[p]	–	W

With E = 2500 volts

Voltage Distribution B, Table I

	Min.	Typ.	Max.	
Pulse Height Resolution[q]	–	7.5	–	%
Mean Gain Deviation[r]	–	1	–	%
Dark Pulse Specturm		See **Figure 5**		

With E = 3000 volts

Voltage Distribution A, Table I

	Min.	Typ.	Max.	
Anode-Pulse Rise Time[s]	–	2.9×10^{-9}	–	s
Electron Transit Time[t]	–	6.6×10^{-8}	–	s

With E = 3000 volts

Voltage Distribution C, Table I

	Min.	Typ.	Max.	
Pulse Current:[u]				
Linear[v]	–	0.13	–	A
Saturated	–	0.32	–	A

[a] Made by Corning Glass Works, Corning, New York 14830.

[b] Magnetic shielding is available from manufacturers such as the Magnetic Shield Division, Perfection Mica Co., 1322 North Elston, Chicago 22, Illinois.

[c] The maximum ratings in the tabulated data are established in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[d] Averaged over any 500-microsecond interval.

[e] This value is calculated from the typical anode luminous sensitivity rating using a conversion factor of 1140 lumens per watt.

[f] These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.13 \times \text{Light Flux of } 1 \times 10^{-7} \text{ (lm)}}$$

The value of 0.13 is an average value. It is the ratio of the cathode current measured under the conditions specified in footnote (k) to the cathode current measured under the same conditions but with the blue filter removed.

TABLE I			
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:	C 3.85% of K-P Voltage (E) Multiplied by:
K - Dy1	3	♦	6
Dy1 - Dy2	1	1	1
Dy2 - Dy3	1	1.5	1.5
Dy3 - Dy4	1	1	1
Dy4 - Dy5	1	1	1
Dy5 - Dy6	1	1	1
Dy6 - Dy7	1	1	1
Dy7 - Dy8	1	1	1
Dy8 - Dy9	1	1	1
Dy9 - Dy10	1	1	1
Dy10 - Dy11	1	1	1
Dy11 - Dy12	1	1	1.5
Dy12 - Dy13	1	1	2
Dy13 - Dy14	1	1	4
Dy14 - P	1	1	2
Dy1 - P	—	14.5	—
K - P	17	—	26
Focusing electrode▲ is connected to Dynode-No.1 voltage.			

● Use distribution B for optimum pulse-height resolution performance. See page 7, under Operating Voltage, **OPERATING CONSIDERATIONS.**

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

▲ Focusing electrode may be connected to arm of potentiometer between cathode and dynode No.1; the focusing-electrode voltage is varied to give maximum anode current.

g 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 2870° K. The value of light flux incident on the filter is 0.1 microlumen.

h This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1140 lumens per watt.

i These values are calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.13 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

The value of 0.13 is an average value. It is the ratio of the cathode current measured under the conditions specified in footnote (k) to the cathode current measured under the same conditions but with the blue filter removed.

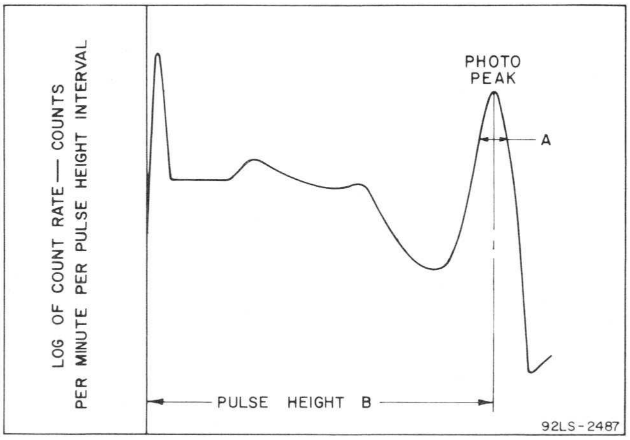
k Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 100 microlumens and 300 volts are applied between cathode and all other electrodes connected as anode.

m At a tube temperature of 22° C. Light incident on the cathode is transmitted through a blue filter (Corning C.S. 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.

n With supply voltage E adjusted to give a calculated value of anode luminous sensitivity of 2000 amperes per lumen.

p At 4000 Å. Calculated from the luminous EADCI value using a conversion factor of 1140 lumens per watt.

q With a supply voltage E of 2500 volts across a voltage divider providing electrode voltages shown in Table I, Distribution B. Anode load is a 10-kilohm resistor in parallel with a total capacitance of 1000 pF. Under pulse conditions, the interstage voltages of the tube should not deviate more than 2% from the interstage voltage values during no-signal conditions. 662 keV photons from a one-microcurie Cs^{137} source and a cylindrical 5" dia. x 4" thallium-activated sodium-iodide scintillator NaI (TI)-type Harshaw■ 20A16, Serial No.CW-675 or equivalent are used. The Cs^{137} source is in direct contact with the metal end of the scintillator container. The faceplate end of the crystal is coupled to the faceplate adapter (RCA-AJ2142) by an optical coupling material such as Dow Corning* 20-057. Pulse-height resolution in per cent is defined as 100 times the ratio of the width of the photopeak at half the maximum count rate in the photopeak height (A) to the pulse height at maximum photopeak count rate (B).



r Under the same conditions as shown in (q) except the tube is operated for a period of 1 hour with the radiation source located at the point providing a pulse count rate of 1000 counts per second. Following this time interval, the pulse height is sampled at 1-hour intervals for a period of 24 hours.

Mean Gain Deviation in per cent is defined as follows:

$$MGD = \frac{\sum_{i=1}^{i=n} \left| \bar{p} - p_i \right|}{n} \bullet \frac{100}{\bar{p}}$$

where $\bar{p}$ = mean pulse height
p_i = pulse height at the "ith" reading
n = total number of readings

s Anode pulse rise time is the time interval between the 10 per cent and 90 per cent values of the maximum anode pulse height when the cathode is fully illuminated with light source approximating a step function and which has a negligible rise time.

t 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.

u 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 tube should not deviate more than 2 per cent from the recommended voltage distribution shown by Voltage Distribution C of Table I. Capacitors are connected across the individual resistors making up the voltage-divider arrangement to insure this operating condition.

v Maximum deviation from linearity is 5 per cent.

■Made by Harshaw Chemical Corporation, 1945 East 97 Street, Cleveland 6, Ohio.

*Made by Dow Corning Corp., Midland, Michigan.

Typical Time Resolution Characteristics

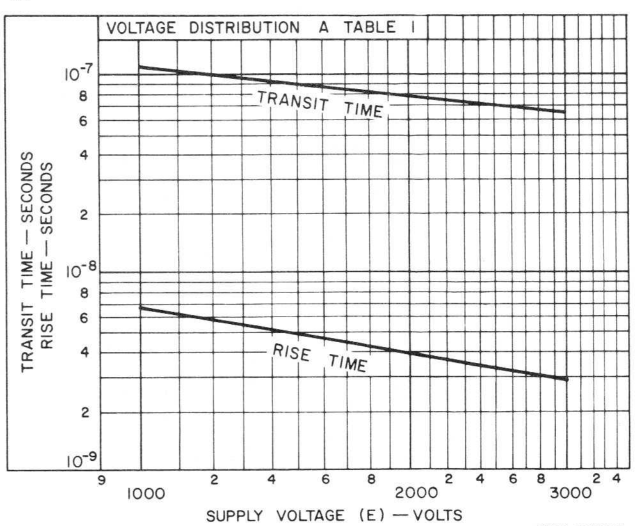


Figure 2

Operating Considerations

Terminal Connections

The base pins of the tube fit a 21-contact socket such as the RCA-AJ2144 and the AJ2145. The AJ2145 is a Teflon* socket designed specifically for chassis mounting and is supplied with a permanently attached metal flange. The AJ2144 is a Teflon socket supplied with an unattached Teflon clamp ring to permit chassis mounting, but the ring can be discarded to permit any desired mounting arrangement.

The 4522 can replace types 58AVP and 58DVP by use of Socket Adapter, RCA-AJ2143.

Sensitivity and Current Amplification Characteristics

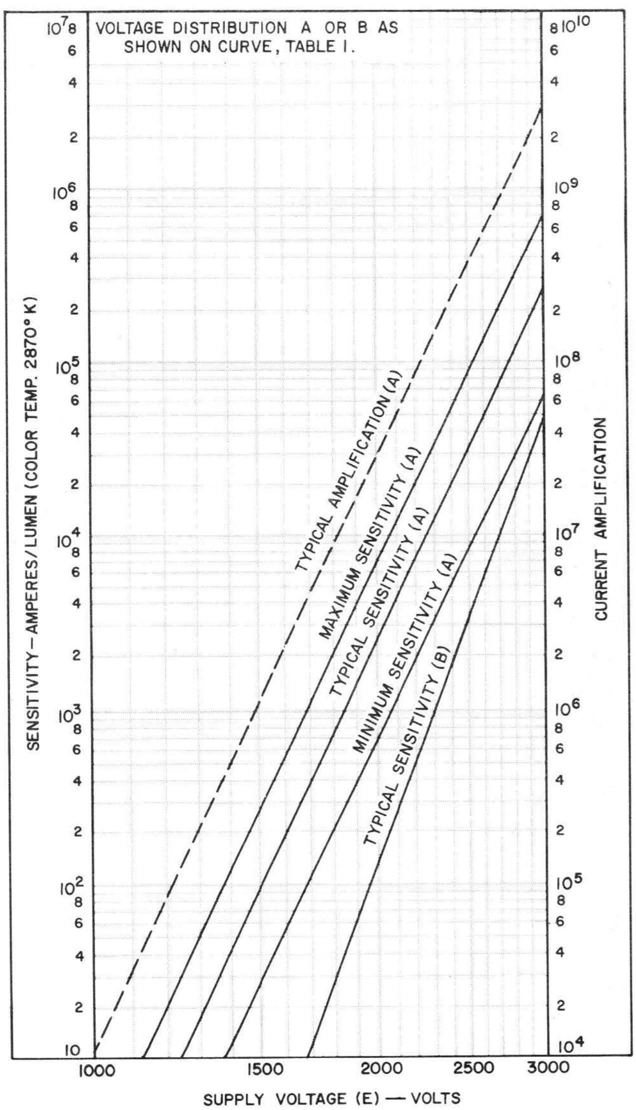


Figure 3

Cathode Current

A peak cathode current of 1 x 10^{-9} ampere at a tube temperature of 22° C or 1 x 10^{-11} ampere at -100° 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 by the first dynode. Photocathode resistivity increases with decreasing temperature.

Anode Dark Current

Anode dark current and equivalent anode dark current input as functions of luminous sensitivity at a temperature of +22° C are shown in **Figure 4.** Dark current can be reduced by use of a refrigerant.

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. This increase in dark current may persist for a period of from 6 to 24 hours after such irradiation.

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*Teflon is a registered trademark of the DuPont de Nemours, E.I. & Co., Inc., Wilmington, Del.

Typical EADCI and Anode Dark Current Characteristics

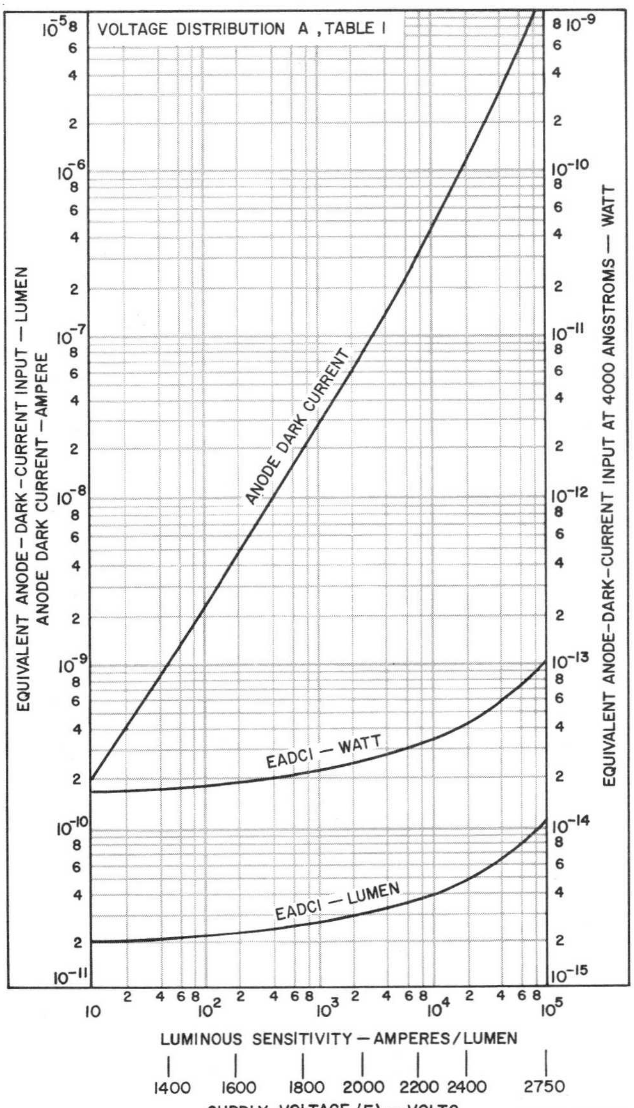


Figure 4

Typical Dark-Pulse Spectrum

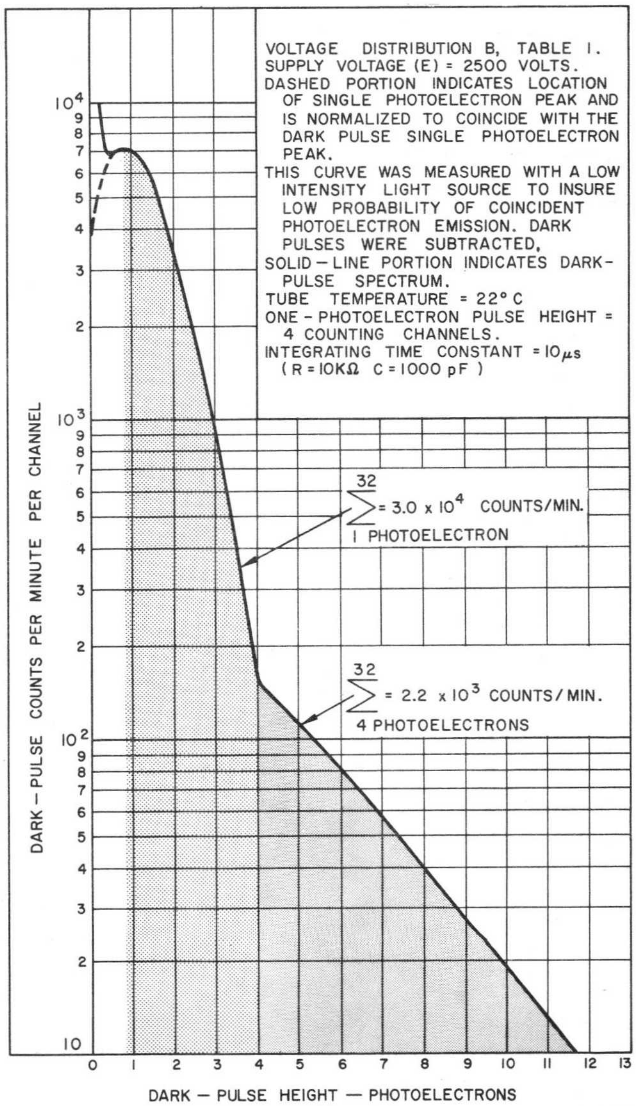


Figure 5

A typical tube with voltage applied in total darkness for a period of 24 hours often exhibits a lower value of Anode Dark Current than that shown under Characteristic Range Values.

Noise

A typical dark pulse spectrum for the 4522 is shown in **Figure 5.** The dashed-line portion shows the location of the single photoelectron peak. This curve was measured with a low intensity light source to insure low probability of coincident photoelectron emission.

The solid-line portion of **Figure 5** shows the differential dark noise spectrum. The rapid change in slope of this curve in the pulse height region of less than 1/2 photoelectron is assumed to be due to electron emission from the first and second dynode surfaces.

The slope of the curves for the pulse height region between 1 and 4 photoelectrons is as expected for single photoelectron emission from the photocathode and the multiplication processes at the first and second dynodes.

The slope of the curve for the pulse height region greater than 4 photoelectrons is presumed to be caused by electron emission from the photocathode due to such processes as ion bombardment.

When using the 4522 with counting systems care should be taken to choose the upper and lower discriminator threshold levels to optimize counting efficiency with respect to noise background. In particular, operation in the region below a pulse height of 1 photoelectron should be avoided because of the large number of noise events generated in the multiplier structure.

Operating Stability

The operating stability of the 4522 is dependent on the magnitude of the average anode current.

The use of an average anode current well below the the maximum rated value of 500 microamperes is recommended when stability of operation is important. When maximum stability is required, the average anode current should not exceed 0.1 microampere.

Operating Voltages

Table I shows three electrode voltage distributions recommended for the 4522.

Voltage Distribution A is used to measure the tube performance values listed under "Characteristic Range Values" on page 2 and is suggested for general purpose applications.

Typical Effect of Indicated Magnetic Field on Anode Current

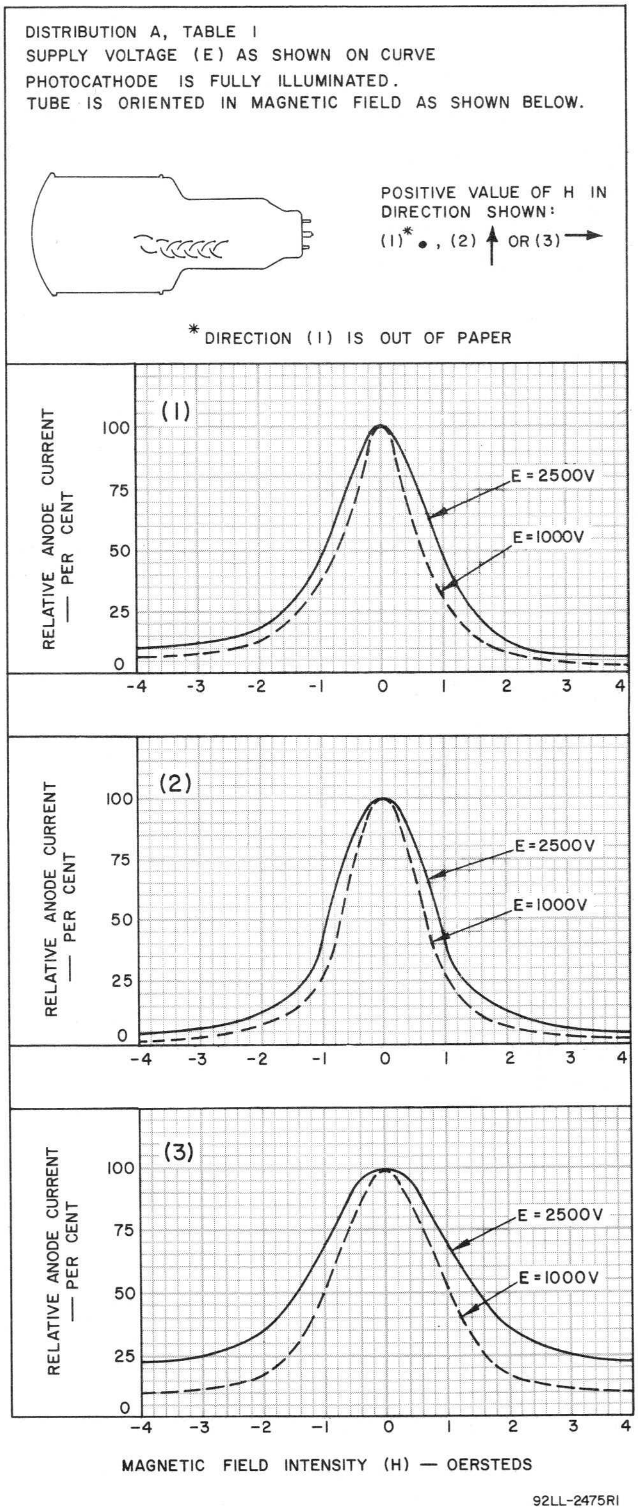


Figure 6

Voltage Distribution B is recommended where high dynode-No.1 gain is important, such as in low light level and scintillation counting applications. Voltage Distribution B maintains the cathode-to-dynode-No.1 voltage at 660 volts; it is especially useful when the supply voltage is adjusted over a wide range to achieve large changes in anode sensitivity. A suggested circuit using voltage distribution B is shown in **Figure 9.**

Voltage Distribution C is recommended for high peak-pulse current applications.

If desired, the focusing-electrode potential may be adjusted between photocathode voltage and dynode-No.1 voltage to optimize the magnitude, uniformity, and speed of response. The voltage for the focusing electrode can be obtained by connecting the focusing electrode to the arm of a potentiometer in the cathode and dynode No.1 portion of the voltage divider. Optimum focusing-electrode voltage for best collection efficiency will be approximately between 80 and 100 per cent of the cathode-to-dynode No.1 voltage as shown in **Figure 7.** However, where simplicity in voltage-divider design is desired, the focusing electrode may be connected directly to dynode No.1 with little resulting decrease in output current.

The operating voltage between dynode No.14 and anode should be kept as low as will permit operation above the knee of the anode characteristic curves shown in **Figure 8.** With low operating voltage between dynode No.14 and anode, the ohmic leakage current to the anode is reduced. Operation above the knee occurs at approximately 170 volts for the light levels shown in **Figure 8.** However, when high pulse currents are drawn, saturation results from space-charge limitations and higher voltage will be required. To assure operation above the knee. it is necessary to increase the supply voltage between dynode No.14 and anode by an amount equal to the voltage drop across a particular output load.

The operating voltages for the 4522 can be supplied by spaced taps on a voltage divider across a regulated dc power supply. The current through the voltage divider will depend on the voltage regulation and linearity required by the application. In general, the current in the divider should be at least 10 times greater than the largest value of anticipated anode current. The voltage-divider values should be adequate to prevent variation of dynode voltages by signal current.

When the ratio of peak anode current to average anode current is high, noninductive high-quality capacitors should be employed across the latter stages of the tube to serve as "electron charge reservoirs" over

Typical Focusing Electrode Characteristic

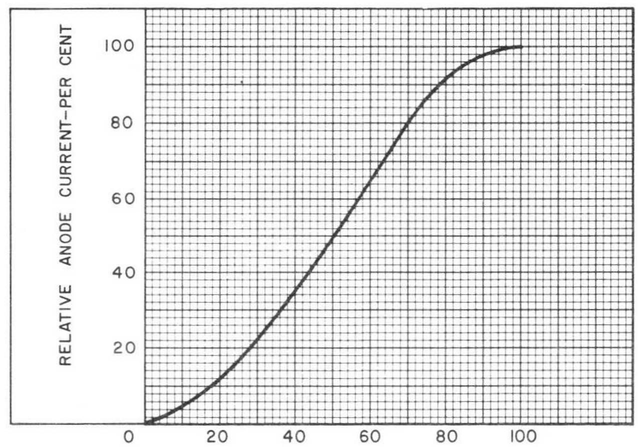


Figure 7

92LS-2471R1

Typical Anode Characteristics

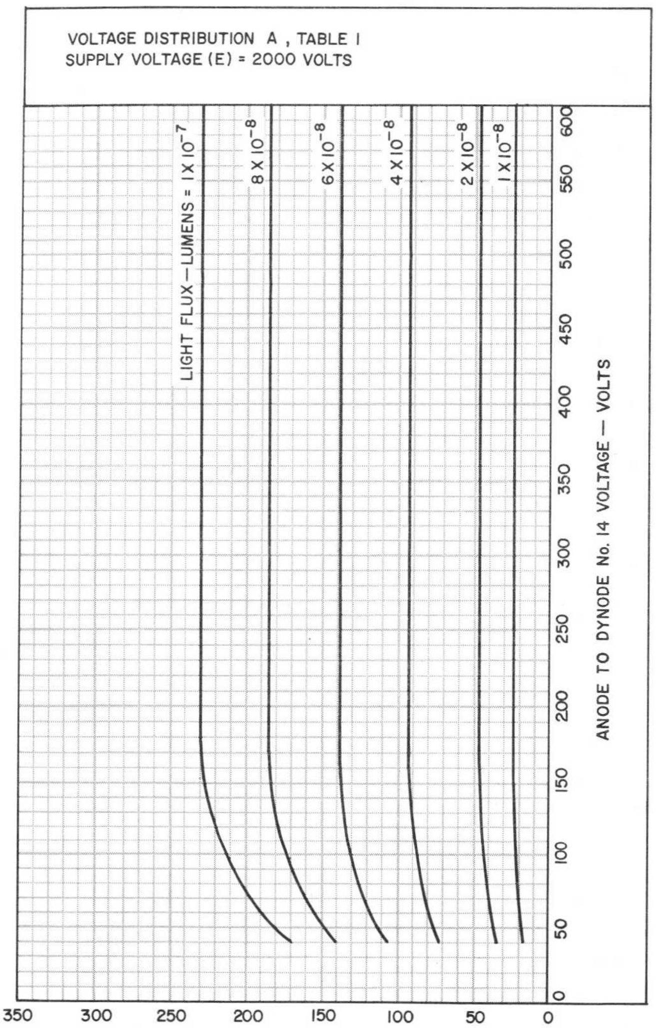


Figure 8

92LM-2473R1

the duration of the pulse. 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 the interstage voltages during the pulse duration. Resistance 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. In most pulse applications, it is recommended that the **negative high-voltage** terminal be grounded.

In applications where it is essential that the negative high-voltage terminal is not grounded, it is necessary that leakage current to the glass faceplate of the tube be less than 1×10^{-12} amperes. In addition to increasing dark current and noise output because of voltage gradients developed across the glass faceplate, such high voltage may produce minute leakage current to the cathode, through the glass faceplate and insulating materials, which can permanently damage the tube.

Typical voltage-divider arrangements for use with the tube are shown in **Figures 9** and **10**. 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 network 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.

The supply voltage may be applied in 500-volt steps up to 2000 volts, and 200-volt steps from 2000 to 3000 volts and with no less than 1 minute between each step.

Non-inductive damping resistors in series with each of the dynode leads of the latter stages of the tube may be used in high peak current applications to suppress spurious oscillations. Typical values for these resistors are in the range of 5 to 50 ohms. These values are chosen to provide sufficient damping while minimizing the voltage drop across the resistors.

The high voltages at which the tube is operated are very dangerous. Care should be taken in the design of apparatus to prevent personnel from coming in contact with these high voltages. Precautions should include the enclosure of high-voltage 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 4522, 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.

Shielding

Magnetic shielding of the tube is generally required. Magnetic shielding materials are available from manufacturers such as the Magnetic Shield Division, Perfection Mica Company, 1322 North Elston, Chicago 22, Illinois. The curves in **Figure 6** show the effect of magnetic fields on anode current under the conditions indicated. With increase in voltage between anode and cathode, the effect of a given magnetic field will cause less decrease in anode current.

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*.

Typical Circuit Arrangement for Scintillation-Counting Applications

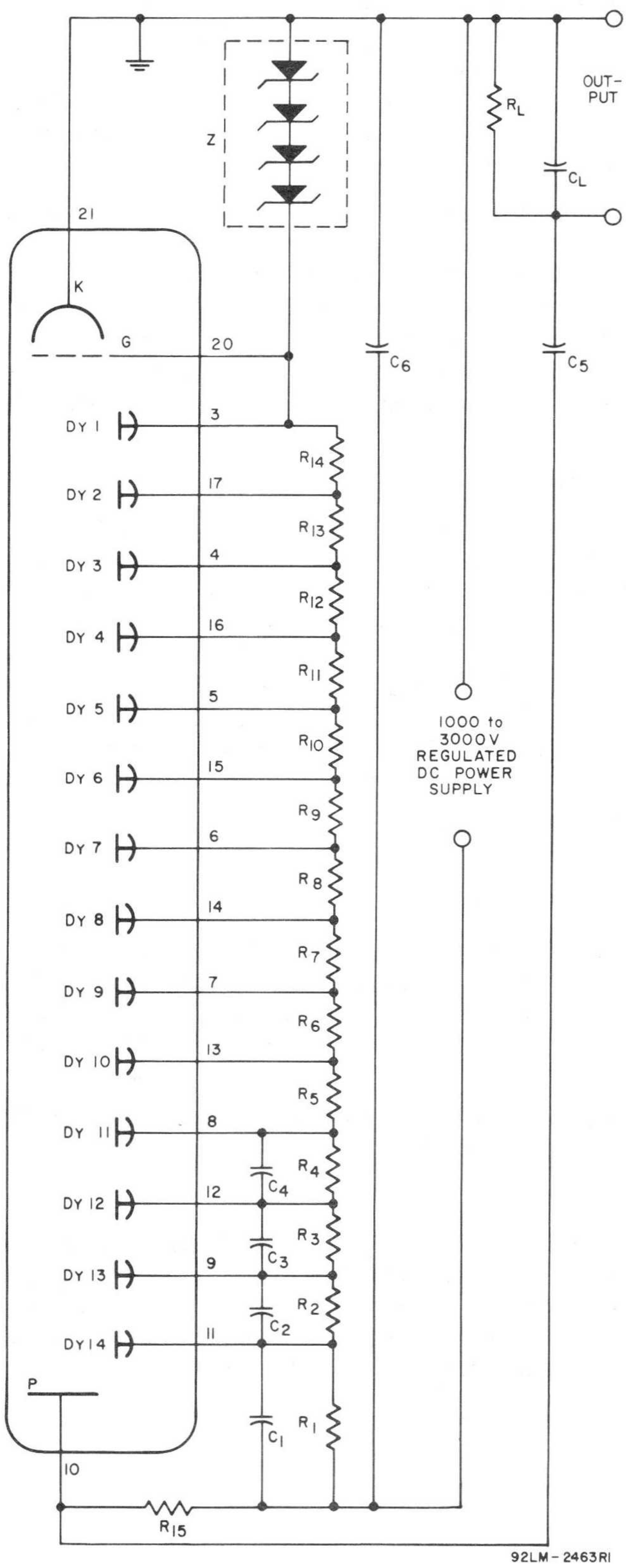


Figure 9

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

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

Z: (2)-150 V, 1W zener diodes, or equivalent
(2)-180 V, 1W zener diodes, or equivalent

Note: The value of the load elements, R_L and C_L, depend on the application:

$R_L C_L$ = 10 microseconds for most applications

Typical Circuit Arrangement for Fast Pulse Response and High Peak Current Applications

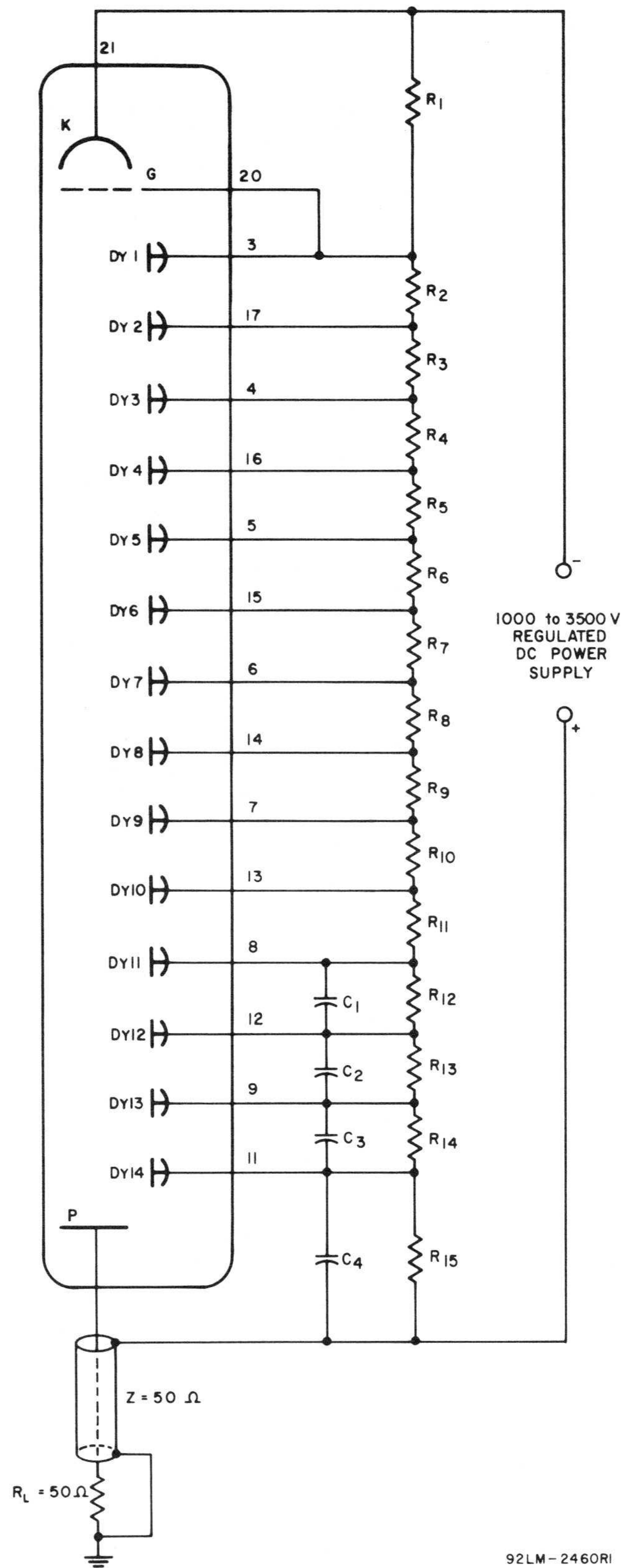


Figure 10

Fast Pulse Response Applications, to 3000 V

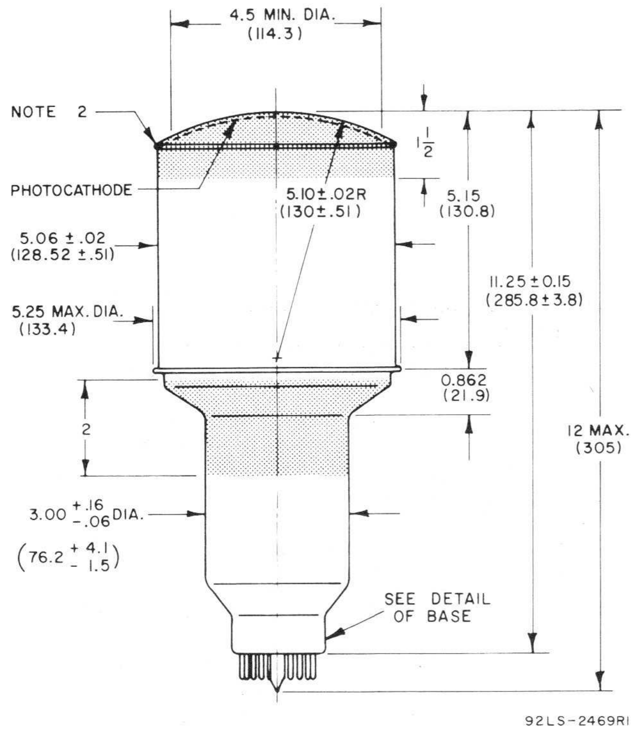
C_1: 0.005 μF, Ceramic Disc, 500 V
C_2: 0.01 μF, Ceramic Disc, 500 V
C_3: 0.02 μF, Ceramic Disc, 500 V
C_4: 0.05 μF, Ceramic Disc, 500 V
R_1: 300 KΩ (3-100 KΩ, 5%, 1/2 W in series)
R_2 through R_{15}: 100 KΩ, 5%, 1/2 W

High Peak Current Applications, to 3500 V

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 KΩ (3-56 KΩ, 5%, 2 W, in series)
R_2, R_4 through R_{11}: 27 KΩ, 5%, 1 W
R_3, R_{12}: 39 KΩ, 5%, 2 W
R_{13}, R_{15}: 54 KΩ (2-27 KΩ, 5%, 1 W, in series)
R_{14}: 108 KΩ (4-27 KΩ, 5%, 1 W, in series)

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

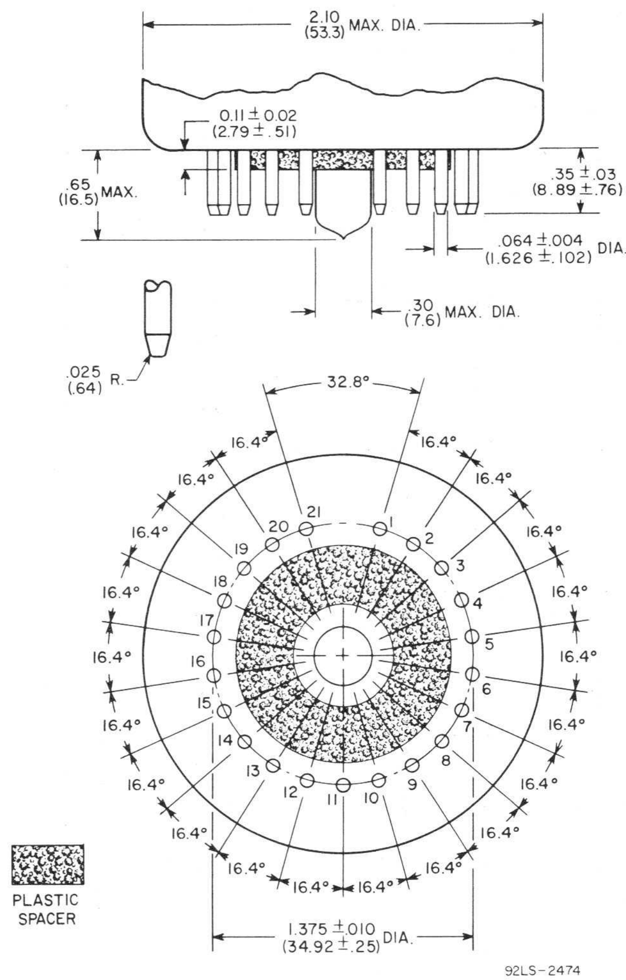
Dimensional Outline



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

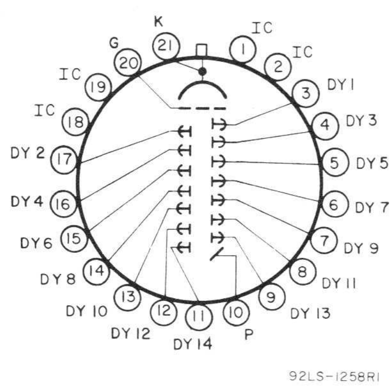
Note 2: See *Operating Considerations, Mounting.*

Detail of Base



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

Basing Diagram (Bottom View)

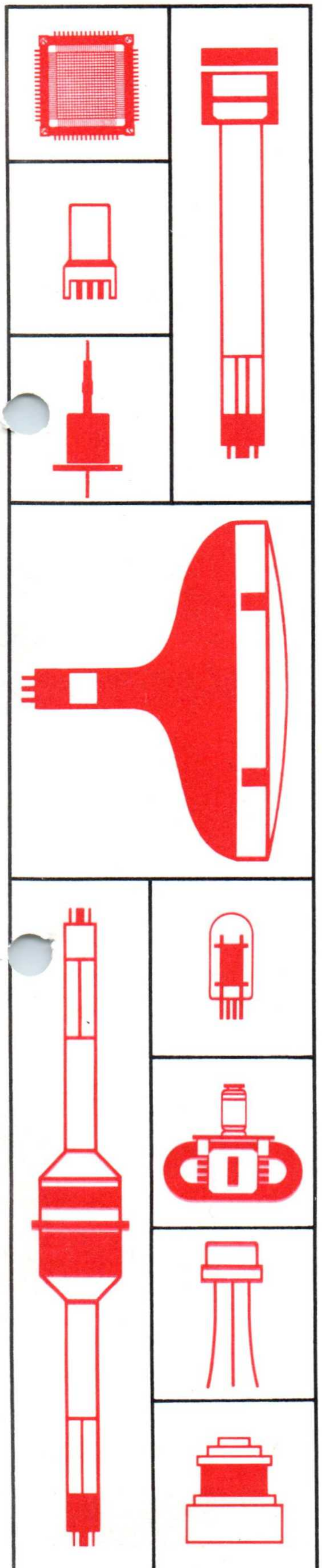


NEW PRODUCT ANNOUNCEMENT

RADIO CORPORATION OF AMERICA

INTERNATIONAL DIVISION / HARRISON, N. J.

LICENSEE SERVICE



RCA-4524

PHOTOMULTIPLIER TUBE

WITH BIALKALI PHOTOCATHODE

NOW! A 3"-diameter, 10-stage, head-on type photomultiplier tube having a bialkali photocathode and a venetian-blind type dynode structure. The RCA-4524 features high quantum efficiency, low dark current, high current amplification and excellent photo-electron collection from all parts of the photocathode.

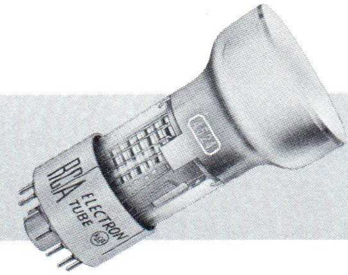
The relative spectral response of the RCA-4524, defined between the 10-per-cent response points, covers the approximate range of 3100 to 6000 angstroms, maximum relative spectral response occurs at about 4000 angstroms, and peak cathode quantum efficiency at about 3800 angstroms.

- Cathode Quantum Efficiency is Typically 22% of 4000 Å
- Anode Dark Current is Typically 1×10^{-9} A at a Sensitivity of 13 A/lm and 22° C
- Current Amplification is Typically 4.5×10^{5}
- Faceplate is Flat for Easier Scintillator Mounting

ADDITIONAL INFORMATION: A bulletin giving detailed information on the 4524 is attached for your convenience.

October 19, 1966

RCA-4524



PHOTOMULTIPLIER TUBE

3"-Diameter, 10-Stage, Head-On Type
Bialkali Photocathode of High Quantum Efficiency
Venetian-Blind Dynode Structure

Formerly Dev. Type C70030E

RCA-4524 is a 3"-diameter, 10-stage, head-on photomultiplier tube employing a bialkali photocathode and a copper-beryllium venetian-blind dynode structure. It is intended especially for use in scintillation counters for the detection and measurement of nuclear radiation. The 4524 features high quantum efficiency, low dark current, high current amplification, and excellent photoelectron collection from all parts of the photocathode.

The 4524 is relatively insensitive to the effects of extraneous magnetic fields and is independent of critical interstage voltage adjustments for maximum anode current output.

The spectral response of the 4524, at the 10-percent points, covers the approximate range from 3100 to 6000 angstroms as shown in Fig. 1. Maximum relative response occurs at about 4000 angstroms, and peak cathode quantum efficiency at about 3800 angstroms.

TYPICAL SPECTRAL RESPONSE CHARACTERISTICS

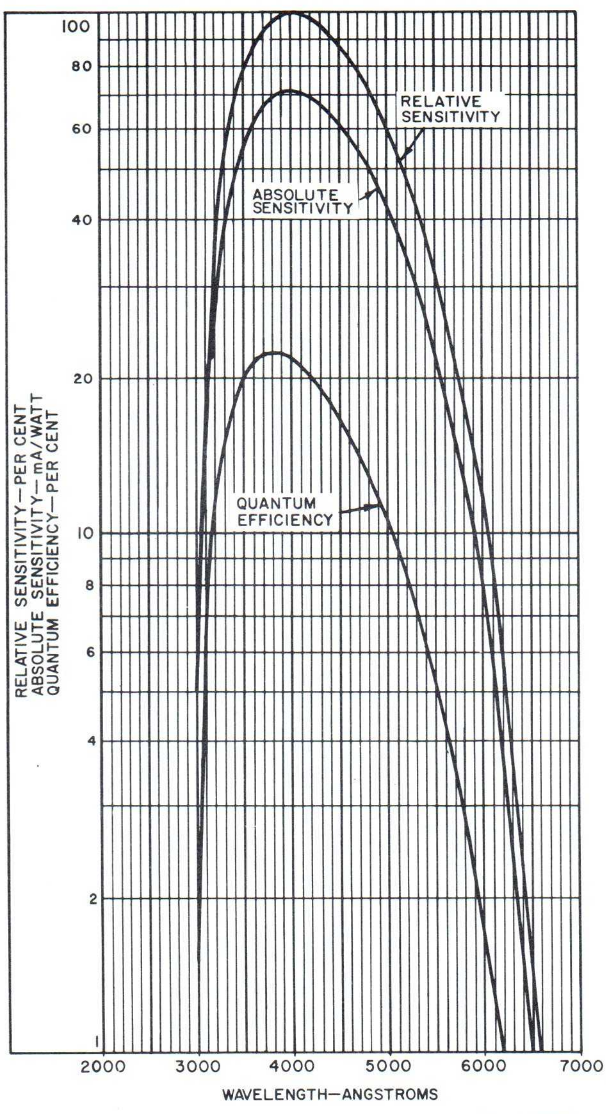


Fig. 1

TYPICAL CHARACTERISTICS

- **Bialkali Photocathode Having High Quantum Efficiency – 22% at 4000 Angstroms**
- **Anode Dark Current –**
  1 x 10^{-9} amperes at a luminous sensitivity of 13 A/lm and 22° C
- **High Stability Copper-Beryllium Dynodes**
- **Photocathode Having Minimum Useful Diameter of 2.59"**
- **Excellent Photoelectron Collection From All Parts of the Photocathode**
- **Pulse Height Resolution –**
  7.5%, Cs^{137} source, 3" x 3" NaI(Tl) scintillator
- **Mean Gain Deviation –**
  1% for 16 hours at 10,000 counts per second
  1% for a count rate change of 10,000 to 1,000 cps
- **Flat Faceplate for Mounting Scintillators**

DATA

General:

Spectral Response	See *Fig.1*
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode, Semitransparent	Cesium-Potassium-Antimony (Bialkali)
Shape	Flat, circular
Minimum area	5.27 in^2
Minimum diameter	2.59 in
Window	Corning[a] No.0080, or equivalent
Shape	Plano-plano
Index of refraction at 4360 angstroms	1.523
Dynodes:	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	Venetian-Blind Type
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	7.0 pF
Anode to all other electrodes	8.5 pF
Maximum Overall Length	6.31 in
Seated Length	5.38 ± 0.18 in
Maximum Diameter	3.06 in
Bulb	J24
Base	Medium-Shell Diheptal 14-Pin (JEDEC Group 5, No.B14-38)
Socket	Cinch[b] No.3M14, or equivalent
Magnetic Shield	Millen[c] Part No.80803J, or equivalent
Operating Position	Any
Weight (Approx.)	9 oz

Maximum Ratings, *Absolute-Maximum Values:*[d]

DC Supply Voltage:		
Between anode and cathode	2500 max.	volts
Between anode and dynode No.10	300 max.	volts
Between consecutive dynodes	300 max.	volts
Between dynode No.1 and cathode	600 max.	volts
Between focusing electrode and cathode	600 max.	volts
Average Anode Current[e]	0.5 max.	mA
Ambient-Temperature Range	–100 to +85	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1, 1/12 of E for each succeeding dynode stage, and 1/12 of E between dynode No.10 and anode, except as noted. Focusing-electrode voltage is adjusted to that value between 50 and 100 per cent of dynode-No.1 potential (referred to cathode) which provides maximum anode current.

With E = 1500 volts except as noted	*Min.*	*Typical*	*Max.*	
Sensitivity:				
Radiant[f] at 4000 angstroms	–	3.2×10^4	–	A/W
Cathode Radiant[g] at 4000 angstroms	–	0.071	–	A/W
Luminous:				
With tungsten light source[h]	10	27	100	A/lm
With blue light source[i]	1.5×10^{-5}	4×10^{-5}	1.5×10^{-4}	A
Cathode Luminous:				
With tungsten light source[k]	–	6×10^{-5}	–	A/lm
With blue light source[m]	7×10^{-10}	9×10^{-10}	–	A
Quantum Efficiency at 4000 angstroms	–	22	–	%

With E = 1500 volts except as noted (Cont'd.):

	Min.	Typical	Max.	
Current Amplification	–	4.5×10^5	–	
Anode Dark Current[n]	–	1×10^{-9}	3×10^{-9}	A
Equivalent Anode-Dark-Current Input	–	7.7×10^{-11}[p]	–	lm
	–	6.5×10^{-14}[q]	–	W
Dark-Pulse Spectrum[r]	–	See Fig. 8	–	
Pulse Height Resolution[r,s]	–	7.5	–	%
Mean Gain Deviation:[r,t]				
With count rate change of 10,000 to 1,000 cps[u]	–	1	–	%
For period of 16 hours at a count rate of 10,000 cps[v]	–	1	–	%
Anode Pulse Rise Time[w]	–	1.4×10^{-8}	–	sec
Electron Transit Time[x]	–	6.5×10^{-8}	–	sec

[a]Made by Corning Glass Works, Corning, New York.

[b]Made by Cinch Manufacturing Company, 1026 South Homan Avenue, Chicago 24, Illinois.

[c]Made by James Millen Manufacturing Company, 150 Exchange Street, Malden 48, Mass.

[d]The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

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

[f]This value is calculated from the typical luminous sensitivity rating using a conversion factor of 1190 lumens per watt.

[g]This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1190 lumens per watt.

[h]These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-5}\ \text{(lm)}}$$

The value of 0.15 is the average value of the ratio of the anode current measured under the conditions specified in footnote (j) to the anode current measured with the blue filter removed.

[i] 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) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 10 microlumens.

[k] This value is calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.15 \times \text{Light Flux of } 1 \times 10^{-4} \text{ (lm)}}$$

The value of 0.15 is the average value of the ratio of the cathode current measured under the conditions specified in footnote (m) to the cathode current measured under the same conditions but with the blue filter removed.

[m] 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) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux incident on the filter is 1×10^{-4} lumen and 300 volts are applied between cathode and all other electrodes connected as anode.

[n] At a tube temperature of 22° C. Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness). The light flux incident on the filter is 10 microlumens. The supply voltage E is adjusted to obtain an anode current of 20 microamperes. Sensitivity of the 4524 under these conditions is approximately equivalent to 13 amperes per lumen. Dark current is measured with no light incident on the tube.

[p] With supply voltage E adjusted to give an equivalent luminous sensitivity of 13 amperes per lumen.

[q] At 4000 angstroms. This value is calculated from the EADCI value in lumens using a conversion factor of 1190 lumens per watt.

[r] With the following voltage distribution: 3/13 of E between cathode and dynode No.1, 1/13 of E for each succeeding dynode stage, and 1/13 of E between dynode No.10 and anode. Focusing-electrode voltage is adjusted to that value between 50 and 100 per cent of dynode-No.1 potential (referred to cathode) which provides maximum anode current.

[s] Pulse height resolution is defined as the quotient of the full width of the photopeak at half height by the pulse height at maximum count rate under the following conditions: The 662 keV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 3" x 3" thallium-activated sodium-iodide scintillator [NaI(Tl)–type 12D12] are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97 Street, Cleveland 6, Ohio, and is rated by the manufacturer as having a resolution capability of 7.5%. The Cs^{137} source is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the 4524 by a coupling fluid such as Dow Corning Corp., Type DC200 (viscosity of 60,000 centistokes) – manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

[t] Mean gain deviation is defined as follows:

$$\text{MGD} = \frac{\sum_{i=1}^{i=n} \left|\bar{p} - p_i\right|}{n} \quad \frac{100}{\bar{p}}$$

Where:

$\bar{p}$ = mean pulse height
p_i = pulse height at the "i th" reading
n = total number of readings

[u]Under the following conditions: The scintillator and Cs^{137} radiation source of (s) are employed. The radiation source is initially centered, on the major axis of the tube and the scintillator, at a point providing a pulse count rate of 10,000 cps. The pulse height of the photopeak is measured under this condition. Next, the radiation source is moved rapidly, in approximately 30 seconds, to a new position that is equivalent to a count rate of 1,000 cps. The new position is also centered in the major axis of the tube. The pulse height under this condition is measured. Mean gain deviation is defined as shown in (t).

[v]Under the same conditions as shown in (u) except the tube is operated for a period of 1/2 hour with the radiation source located at the point providing a pulse count rate of 10,000 cps. Following this time interval, the pulse height is sampled, at this count rate, at 1-hour intervals for a period of 16 hours. Mean gain deviation is defined as shown in (t).

[w]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.

[x]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

Terminal Connections:

The *base pins* of the 4524 fit a diheptal 14-contact socket, such as Cinch No.3M14, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that incident light falls on the face end of the tube.

Cathode Current:

Peak cathode current of 1×10^{-9} ampere at a tube temperature of 22^{o} C or 1×10^{-11} ampere at -100^{o} 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. Photocathode resistivity increases with decreasing temperature.

Operating Stability:

The *operating stability* of the 4524 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 stability is of prime importance, the use of an average anode current of 1 microampere or less, commensurate with satisfactory output signal, is recommended.

Operating Voltages:

In general, the operating potential between anode and cathode should not be less than 800 volts.

The *operating voltage between dynode No.10 and anode* should be kept as low as will permit operation over the knee of the anode characteristic curves shown in Fig.4. With low operating voltage between dynode No.10 and anode, the ohmic leakage current to the anode is reduced. Operation over the knee occurs in the approximate range of 50 to 100 volts for the light level range shown in Fig.4. Under high pulse current conditions, saturation due to space-charge limitations will occur and higher voltage will be required. To obtain the suggested operating voltage between dynode No.10 and anode, it is necessary to increase the supply voltage between these electrodes by an amount equal to the voltage drop across a particular output load.

SCHEMATIC ARRANGEMENT OF STRUCTURE

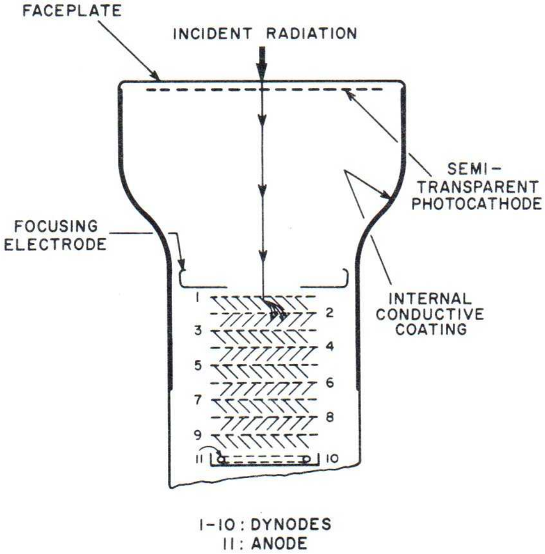


Fig. 2

SENSITIVITY AND CURRENT AMPLIFICATION CHARACTERISTICS

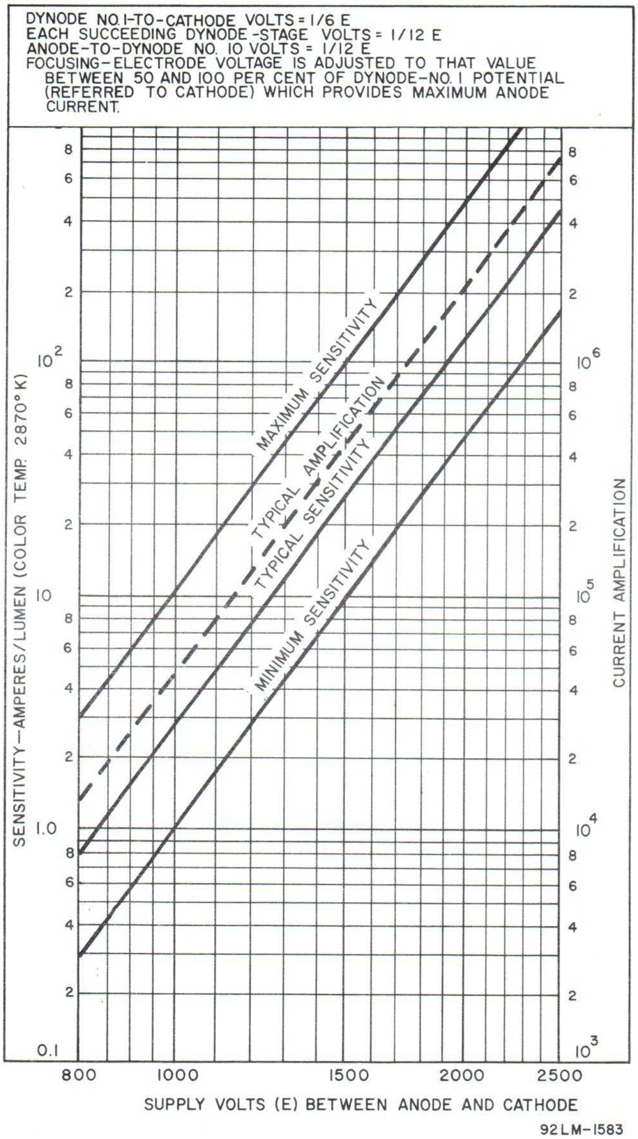


Fig. 3

TYPICAL ANODE CHARACTERISTICS

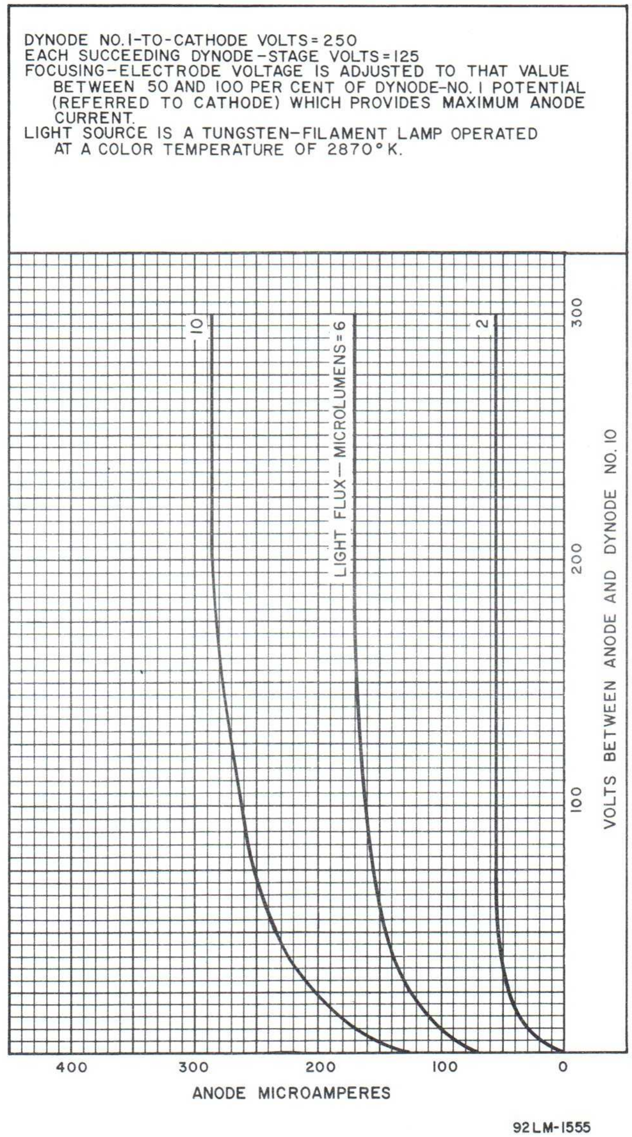


Fig. 4

Typical voltage-divider arrangements for use with the 4524 are shown in Fig. 12 and Fig. 13. Recommended resistance values for the voltage dividers range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for any voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required power rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is mounted near the photocathode. The use of resistance values near 1 megohm 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 value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No.7 and No.8, dynodes No.8 and No.9, dynodes No.9 and No.10, and between dynode No.10 and anode return. In addition to non-linearity and pulse-limiting effects, the use of resistance values exceeding 1 megohm per stage make the 4524 more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

To optimize the magnitude and uniformity of response, the *focusing-electrode potential* should be adjusted to that value between 50 and 100 per-cent of dynode No.1 potential (referred to cathode) which provides maximum anode current. The focusing electrode may be connected to the arm of a potentiometer as shown in Fig.12 and Fig.13.

TYPICAL TIME RESOLUTION CHARACTERISTICS

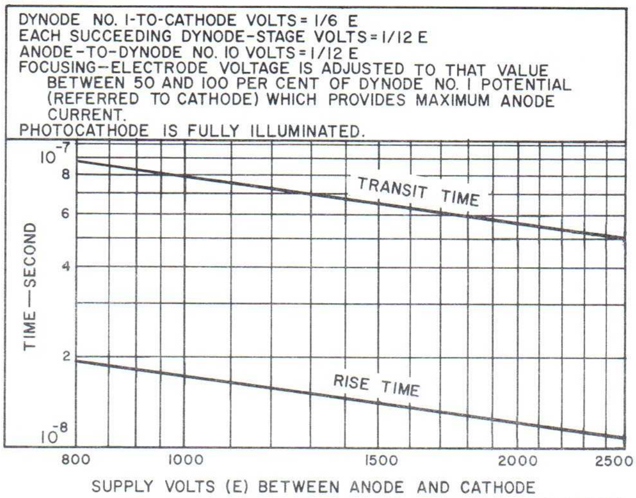


Fig. 5

In scintillation counting and other pulse applications it is recommended that the negative high-voltage terminal of the power supply be grounded and that a high-voltage coupling capacitor be used to take the signal from the anode, as shown in Fig.13, or from the latter dynode stages. In applications where the incident light is steady, or varies slowly, and the DC component of the anode current is required, the positive terminal of the high-voltage power supply may be grounded, as shown in Fig.12. When the 4524 is operated in either manner, the electrostatic shield must be connected to the cathode for maximum signal-to-noise ratio, and to prevent possible damage to the tube.

The high voltages at which the 4524 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.

In the use of the 4524, 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.

Current Amplification and Dynode Modulation:

Critical adjustment of the individual dynode voltages for maximum output current from the 4524 is not essential, as shown by the characteristic of Fig.6. This characteristic of the 4524, however, may be used to control output current or to modulate the output signal by varying the voltage on one or more of the dynodes with the voltages on the other stages held constant. If this control method is utilized, it is recommended that any of the central dynodes – 3, 4, 5, 6, 7, or 8 – perform this control or modulation function. The

TYPICAL CHARACTERISTIC OF OUTPUT CURRENT AS A FUNCTION OF DYNODE-No.5 VOLTS

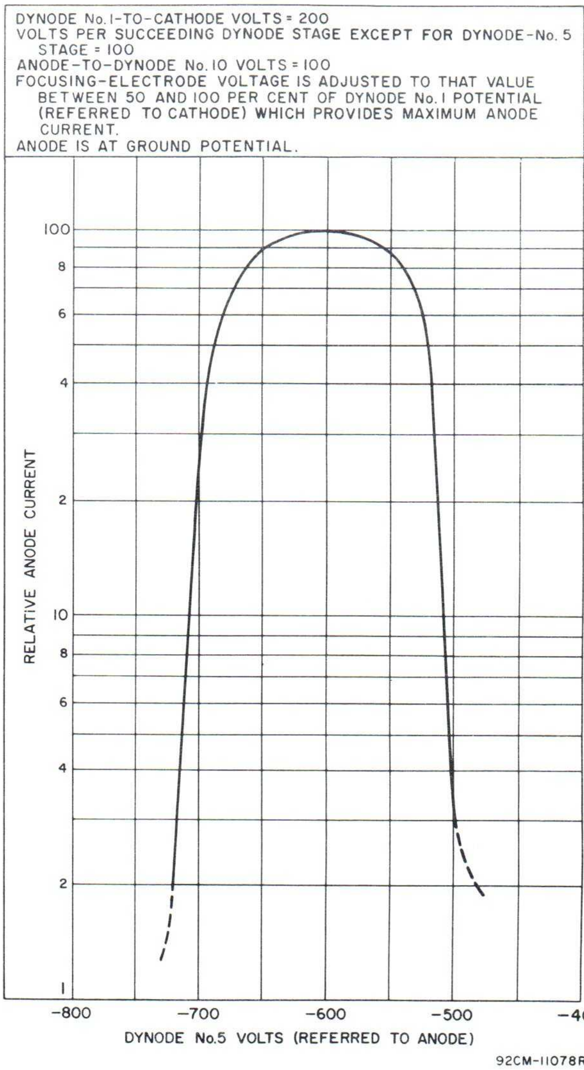


Fig. 6

characteristic of Fig.6 shows the effect on output current as the voltage applied to dynode No.5 is varied between −725 and −475 volts referred to anode. In this characteristic, the dynode-No.5 voltage has been arbitrarily selected as the voltage to be varied. Dynodes 1, 2, and 9 are less suited for continuous current-amplification control and have characteristics which differ from that of Fig.6.

A greater latitude in control of current amplification may be obtained by varying the voltages that are applied to two or more dynodes. However, to prevent distortion in the characteristic due to interaction of the interstage fields, the dynodes selected should be separated by two or preferably three dynodes operated at normal voltage. For example, current-amplification control that is substantially independent of field interaction may be obtained by varying the voltages applied to dynode No.4 and dynode No.8.

Dark Current:

A very small *anode dark current* is observed when voltage is applied to the electrodes of the 4524 in complete darkness. Among the components contributing to dark current are ohmic leakage between the anode and adjacent elements and pulses produced by electrons thermionically released from the cathode, secondary electrons released by ionic bombardment of the dynodes, support rods, or cathode, and by cold emission from the electrodes.

A *temporary increase in anode dark current,* by as much as 2 orders of magnitude, may occur if these tubes are exposed momentarily to high-intensity ultraviolet radiation from sources such as fluorescent room lighting even though voltage is not applied to the tubes. The increase in dark current may persist for a period of 24 to 48 hours following such irradiation.

The use of a refrigerant, such as dry ice, to cool the 4524 is recommended in those applications where maximum current amplification with minimum dark current is required. It should be noted, however, that at reduced temperatures the resistance of the cathode increases, thereby reducing the allowable peak cathode current.

A *typical dark-pulse spectrum* for the 4524 at a temperature of 22° C is shown in Fig.8. The dashed portion of Fig.8 shows the location of the single photoelectron peak. This curve was measured with a constant light source operated at low color temperature to insure high probability of single photoelectron emission. Dark pulses were subtracted. The intensity of the light source was adjusted for an approximate 50 per-cent counting loss.

TYPICAL EADCI AND ANODE DARK CURRENT CHARACTERISTICS

LUMINOUS SENSITIVITY IS VARIED BY ADJUSTMENT OF THE SUPPLY VOLTAGE (E).
DYNODE NO.1-TO-CATHODE VOLTS = 1/6 E
EACH SUCCEEDING DYNODE-STAGE VOLTS = 1/12 E
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-NO.1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
LIGHT SOURCE IS A TUNGSTEN-FILAMENT LAMP OPERATED AT A COLOR TEMPERATURE OF 2870°K.

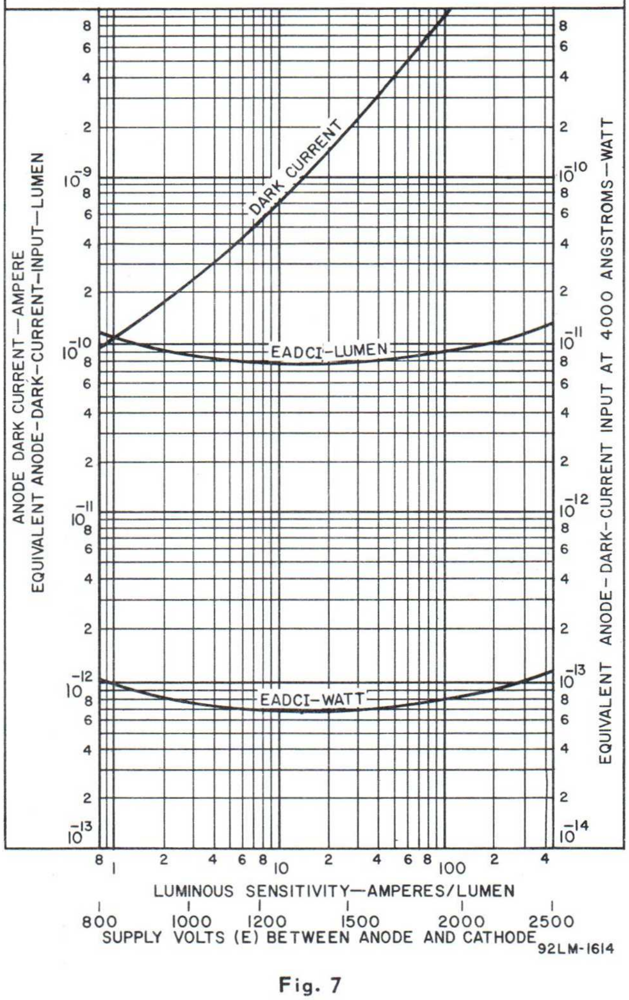


Fig. 7

A Nuclear Data Model No.ND-130A Multichannel Pulse Height Analyzer – manufactured by Nuclear Data, Inc., Palatine, Ill., or equivalent – and a Tennelec Model No.TC-170 Preamplifier – manufactured by Tennelec Instrument Co., Inc., Box D, Oak Ridge, Tenn., or equivalent – were used to measure pulse height. The Multichannel Pulse Height Analyzer was set for 256 channel operation, with 8 channels per photoelectron pulse height.

The solid-line portion of Fig.8 shows the differential dark-pulse spectrum. The high slope of this curve in the pulse region of less than 1 photoelectron is assumed to be due to electron emission from the first and second dynode surfaces. The discriminator threshold of the associated circuitry should be adjusted so that operation does not take place in this region.

The slope of the curve for the pulse-height region between 1 and 4 photoelectrons is as expected for single photoelectron emission from the photocathode and for the multiplication processes at the first and second dynodes.

The slope of the curve for the pulse-height region greater than 4 photoelectrons is assumed to be caused by electron emission from the photocathode due to processes such as ion bombardment.

Shielding:

Electrostatic and magnetic shielding of the 4524 may be required in some applications. When a shield is used, it must be at cathode potential. The application of high voltage, with respect to cathode, to insulating or other materials supporting or shielding the 4524 at the photocathode end of the tube should not be permitted unless such materials are chosen to limit leakage current to the tube envelope to 1 x 10^{-12} ampere or less. In addition to increasing dark current and noise output because of voltage gradients developed across the bulb wall, such high voltage may produce minute leakage current to the cathode, through the tube envelope and insulating materials, which can permanently damage the tube.

TYPICAL DARK-PULSE SPECTRUM

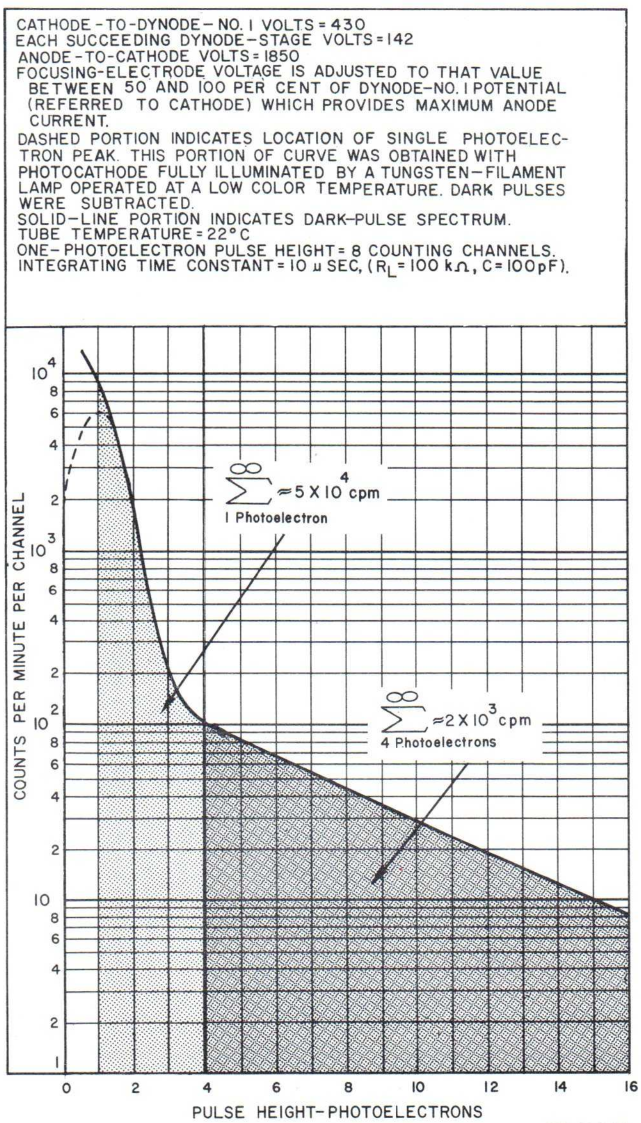


Fig. 8

TYPICAL EFFECT OF MAGNETIC FIELD ON ANODE CURRENT

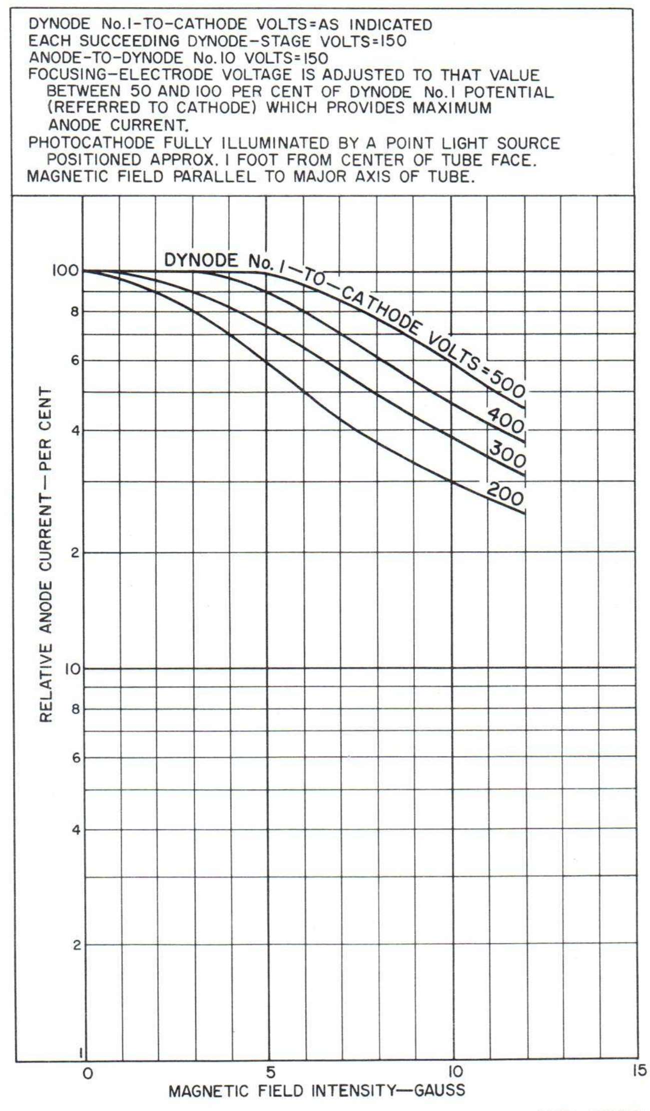


Fig. 9

Magnetic shielding of the 4524 is ordinarily required. The curves of Figs.9 and 10 show the effect of variation in magnetic-field strength on the anode current for a tube with no magnetic shielding. As seen in Fig.10, with 300 volts between cathode and dynode No.1 and with a magnetic field of 10 gauss perpendicular to the major axis of the tube, the anode current is typically reduced to approximately 14 per cent of the "no-field" value.

However, with increase in voltage between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current. When the magnetic field is parallel to the major axis of the tube, the effect is least.

It is to be noted that the use of an external shield at high negative potential presents a safety hazard. *Extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light and ultraviolet-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 4524.

TYPICAL EFFECT OF MAGNETIC FIELD
ON ANODE CURRENT

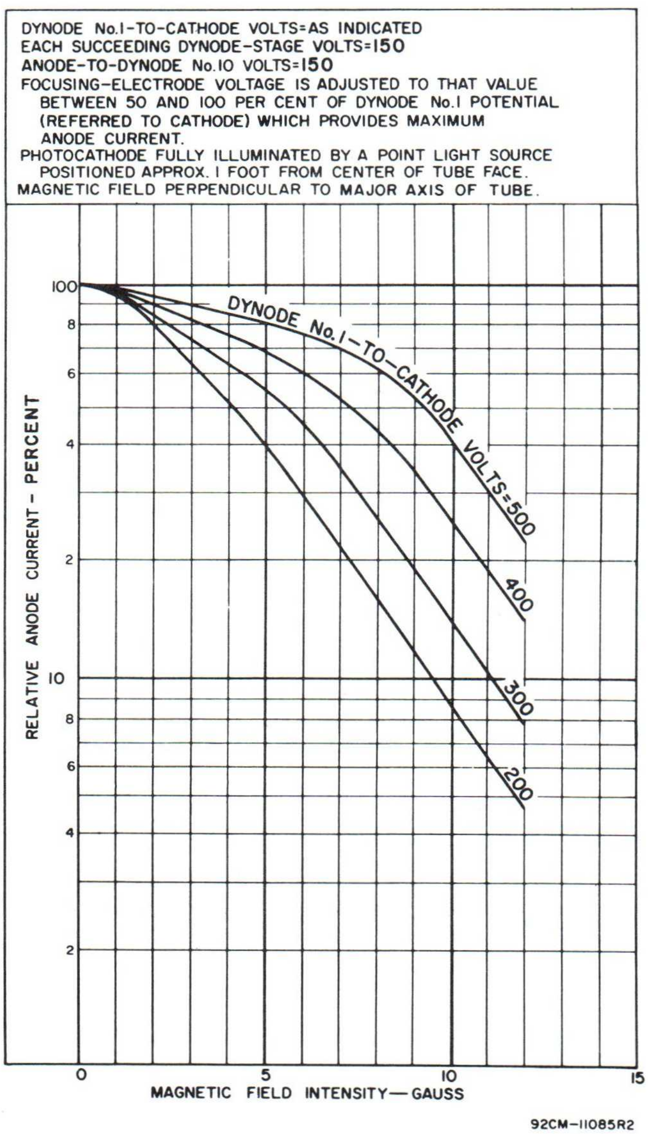


Fig. 10

SPECTRAL ENERGY DISTRIBUTION OF
2870° K LIGHT SOURCE AFTER
PASSING THROUGH INDICATED FILTER

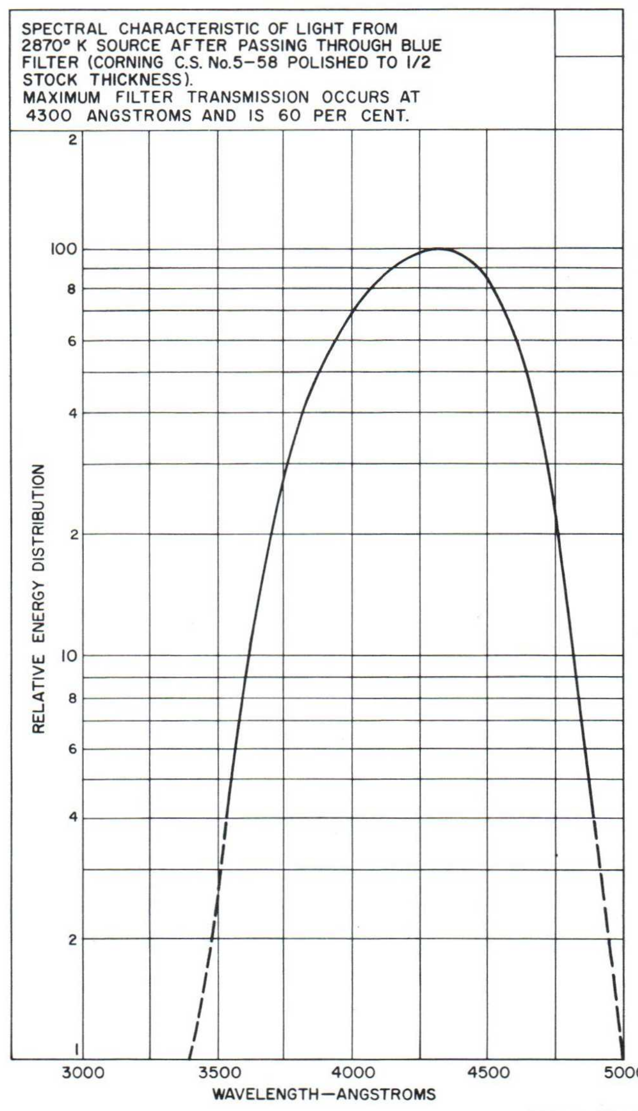
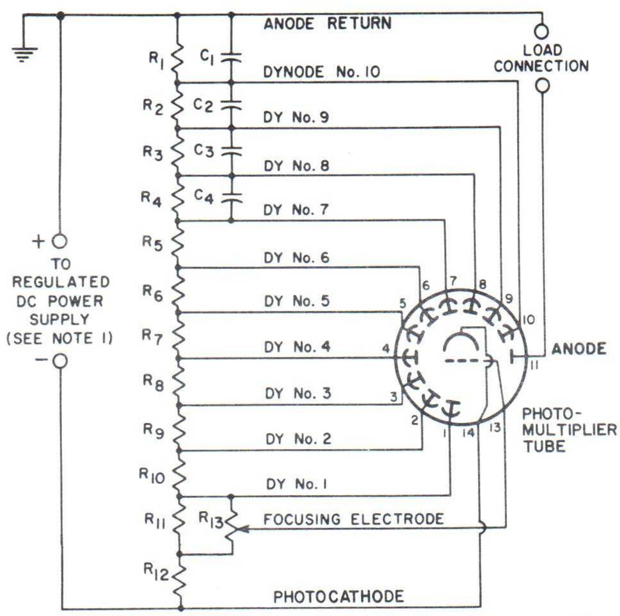


Fig. 11

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR GENERAL PHOTOMETRIC APPLICATIONS



92LM-1611

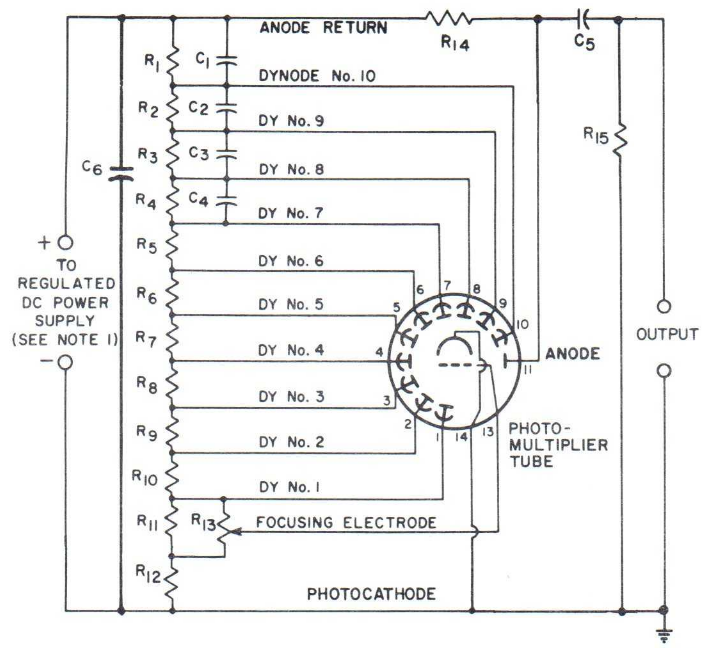
R_1 through R_{12}: 470,000 ohms, 1/2 watt
R_{13}: 5 megohms, 1/2 watt, adjustable

Note 1: Adjustable between approximately 800 and 2500 volts dc.

Note 2: Component values are dependent upon nature of application and output signal desired. See discussion on *Typical Voltage Dividers* – Page 6.

Fig. 12

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR SCINTILLATION-COUNTING APPLICATIONS



92LM-1612

C_1: 0.05 μF, 500 volts (dc working)
C_2: 0.02 μF, 500 volts (dc working)
C_3: 0.01 μF, 500 volts (dc working)
C_4: 0.005 μF, 500 volts (dc working)
C_5 and C_6: 0.005 μF, 3000 volts (dc working)
R_1 through R_{10}: 470,000 ohms, 1/2 watt
R_{11} and R_{12}: 750,000 ohms, 1/2 watt
R_{13}: 5 megohms, 1/2 watt, adjustable
R_{14}: 1 megohm, 1/2 watt
R_{15}: 100,000 ohms, 1/2 watt

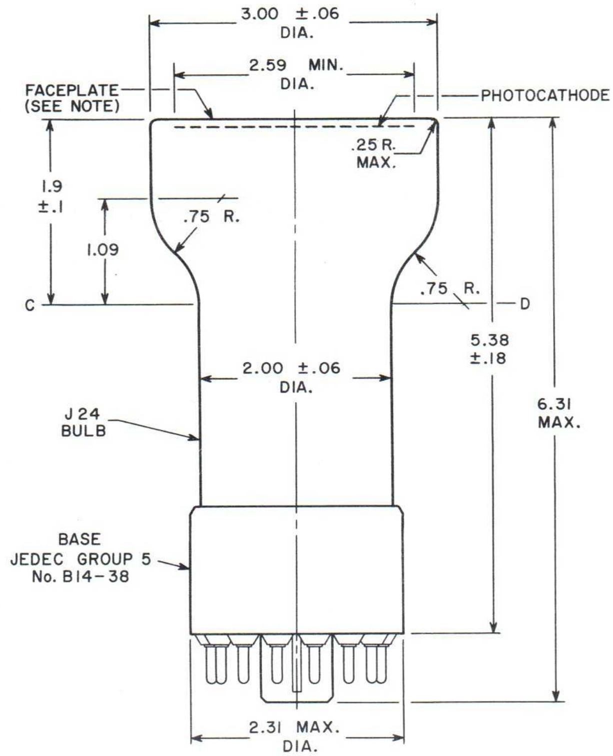
Note 1: Adjustable between approximately 800 and 2500 volts dc.

Note 2: Capacitors C_1 through C_5 should be connected at tube socket for optimum high-frequency performance.

Note 3: Component values are dependent upon nature of application and output signal desired. See discussion on *Typical Voltage Dividers* – Page 6.

Fig. 13

DIMENSIONAL OUTLINE



92CM-1108QR2

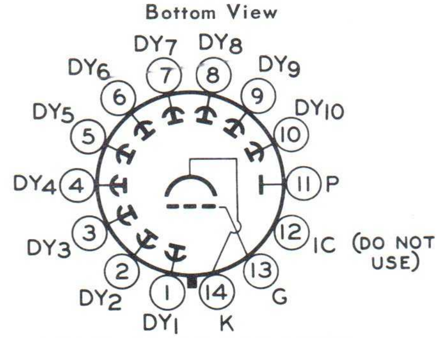
DIMENSION IN INCHES

℄ of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

NOTE: Within 2.59" diameter, deviation from flatness of external surface of faceplate will not exceed 0.010" from peak to valley.

BASING DIAGRAM

Bottom View



DIRECTION OF RADIATION:
INTO END OF BULB
14AA

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: Dynode No.10
Pin 11: Anode
Pin 12: Internal Connection—Do Not Use
Pin 13: Focusing Electrode
Pin 14: Photocathode