MULTIPLIER PHOTOTUBE
9-STAGE TYPE WITH S-5 RESPONSE

DATA

General:
Spectral Response .................. S-5
Wavelength of Maximum Response. 3400 ± 500 angstroms
Cathode:
Minimum Projected Length* . 15/16"
Minimum Projected Width* . 5/16"
Direct Interelectrode Capacitances:
Anode to Dynode No. 9 . 4 µf
Anode to All Other Electrodes . 6.5 µf
Maximum Overall Length. 3-11/16"
Maximum Seated Length . 3-1/8"
Seated Length to Center of Cathode. 1-15/16" ± 3/32"
Length, Base Seat to Center of Useful Cathode Area . 1-15/16" ± 3/32"
Maximum Diameter. 1-5/16"
Bulb. T-9
Mounting Position . Any
Ease. Small-Shell Submagnal 11-Pin, Non-Hygroscopic
Basing Designation for BOTTOM VIEW ....... 11K

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- Cathode

DIRECTION OF INCIDENT RADIATION

Maximum Ratings, Absolute Values:
ANODE-SUPPLY VOLTAGE (DC or Peak AC)° . 1250 max. volts
SUPPLY VOLTAGE BETWEEN DYNODE NO. 9 and ANODE (DC or Peak AC) . 250 max. volts
PEAK ANODE CURRENT . 5 max. ma
AVERAGE ANODE CURRENT° . 0.5 max. ma
AMBIENT TEMPERATURE . 75 max. °C

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

DC Anode Dark Current* . 0.1 µamp

- Indicates a change.

SEPT. 1, 1950
TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY
MULTIPLIER PHOTOTUBE

Sensitivity:
At 3400 angstroms... — 22600 — μamp/μwatt
Luminous:
Cathode... — 20 — μamp/lumen
Anode:
At 0 cps... 4.5 20 300 amp/lumen
At 100 Mc... — 19 — amp/lumen
Current Amplification... — 1x10⁶ —
Luminous Equivalent Noise Input... — 7x10⁻¹² — lumen
Ultraviolet Equivalent Noise Input... — 6x10⁻¹⁵ — watt

Characteristics:
With 75 volts per dynode stage
and 50 volts between dynode No. 9 and anode
Sensitivity:
At 3400 angstroms... — 3400 — μamp/μwatt
Luminous:
Cathode... — 20 — μamp/lumen
Anode, at 0 cps... — 3 — amp/lumen
Current Amplification... — 150 000 —

§ For conditions the same as shown under Anode Luminous Sensitivity except that the value of light flux is 0.01 lumen and that 100 volts are applied between cathode and all other electrodes connected together as anode.
▲ Measured under conditions specified on sheet "PHOTOTUBE SENSITIVITY AND SENSITIVITY MEASUREMENTS" at the front of this Section.
■ Ratio of anode sensitivity to cathode sensitivity.
★ Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: 100 volts per stage, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.
† Defined the same as Luminous Equivalent Noise Input except that use is made of a monochromatic source having radiation at 2537 angstroms.

SPECTRAL-SENSITIVITY CHARACTERISTIC
of Phototube having S-5 Response
is shown at the front of this Section

OPERATING NOTES
The operating stability of the IP28 is dependent on the magnitude of the anode current and its duration. When the IP28 is operated at high 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.

(continued on next page)

Indicates a change.

SEPT. 1, 1950
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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY
After a period of idleness, the IP28 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 anode current should not exceed 10 microamperes.

© OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

92CM-6264R2
AVERAGE ANODE CHARACTERISTICS

VOLTS/STAGE = 100

LIGHT FLUX: MICROMOLUMENS = 15

ANODE MILLIAMPERES

JUNE 26, 1950
TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY
92CM-6632R2
EQUIVALENT-NOISE-INPUT CHARACTERISTIC

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

9-STAGE, SIDE-ON TYPE

For Detection and Measurement of Ultraviolet and Visible Radiation

GENERAL

Spectral Response .................................................. S-5
Wavelength of Maximum Response ......................... 3400 ± 500 angstroms
Cathode, Opaque .................................................. Cs-Sb
  Minimum projected length ....................................... 15/16 inch
  Minimum projected width ....................................... 5/16 inch
Window ........................................... Ultraviolet-Transmitting Glass
  Index of refraction at 5893 angstroms ..................... 1.47

Dynodes
  Substrate ...................................................... Ni
  Secondary-emitting surface ................................... Cs-Sb
  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 inch
Maximum Seated Length ...................................... 3-1/8 inch
Length from Base Seat to Center of
  Useful Cathode Area ......................................... 1-15/16 ± 3/32 inch

Maximum Diameter ................................................ 1-5/16 inch
Operating Position .............................................. Any
Weight (Approx.) .................................................. 1.6 oz

Envelope .......................................................... JEDEC T9
Base .............................................................. Small-Shell Submagnal II-Pin,
  (JEDEC Group 2, No.B11-88), Non-hygroscopic
Socket ........................................................... Amphenol® No.78SI1T, or equivalent
Magnetic Shield .................................................. Millen® Part No.80801B, or equivalent

TERMINAL DIAGRAM (Bottom View)

- Indicates a change.
### ABSOLUTE-MAXIMUM VALUES

<table>
<thead>
<tr>
<th>DC or Peak AC Supply Voltage</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between anode and cathode</td>
<td>1250 V</td>
</tr>
<tr>
<td>Between dynode No.9 and anode</td>
<td>250 V</td>
</tr>
<tr>
<td>Between consecutive dynodes</td>
<td>250 V</td>
</tr>
<tr>
<td>Between dynode No.1 and cathode</td>
<td>250 V</td>
</tr>
<tr>
<td>Average anode current(e)</td>
<td>0.5 mA</td>
</tr>
<tr>
<td>Ambient temperature(f)</td>
<td>75 °C</td>
</tr>
</tbody>
</table>

### CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage \(E\) across a voltage divider providing 1/10 of \(E\) between cathode and dynode No.1, 1/10 of \(E\) for each succeeding dynode stage, and 1/10 of \(E\) between dynode No.9 and anode.

With \(E = 1000\) V (Except as noted)

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant, (G) at 3400 angstroms</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Cathode radiant, (h) at 3400 angstroms</td>
<td>(-)</td>
<td>0.05</td>
<td>(-)</td>
</tr>
<tr>
<td>Luminous (j)</td>
<td>17.5</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Cathode luminous (k)</td>
<td>(1 \times 10^{-5})</td>
<td>(4 \times 10^{-5})</td>
<td>(-)</td>
</tr>
<tr>
<td>Quantum efficiency at 3200 angstroms</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Current Amplification</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Equivalent Anode-Dark-Current Input (n)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Anode Dark Current at 20 A/(1)m²,(n)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Equivalent Noise Input (g)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>Electron Transit Time (s)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

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

\(b\) Corning No.9741, Corning Glass Works, Corning, New York, or equivalent.

\(c\) 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.

\(e\) 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 1252 lumens per watt.

\(h\) This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 1252 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 2870K and a light input of 10 microlumens is used.

\(j\) Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870K. The value of light flux is 0.01 lumen and 100 volts are applied between cathode and all other electrodes connected as anode.

\(k\) Indicates a change.
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 be
reduced by use of a refrigerant.

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

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

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.

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.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT

R1 through R10 = 20,000 to 1,000,000 ohms

Note 1: Adjustable between approximately 500 and 1250
volts.

Note 2: Capacitors C1 through C3 should be connected at
tube socket for optimum high-frequency performance.

SPECTRAL-SENSITIVITY CHARACTERISTIC
OF PHOTOSENSITIVE DEVICE HAVING S-5 RESPONSE
is shown at the front of this section
DIMENSIONAL OUTLINE

BULB
T9
PHOTO-
CATHODE

15/16 MIN.

BASE
JEDEC No. B11-88

15/16 MAX.

DIA.

3 1/8 MAX.

115/16

± 3/32 MAX.

DIRECTIONS OF INCIDENT RADIATION

PIN No.1

PHOTO-
CATHODE (SEE DETAIL A)

92CM-6264R9

DIMENSIONS IN INCHES

Center line of bulb will not deviate more than 2° in any direction from the perpendicular erected at center of bottom of base.
Equivalent-Noise-Input Characteristic

Volts/Stage = 100  Bandwidth: 1 Hz
Light Source: Tungsten, at 2870°K Interrupted
At 90 Hz To Produce Pulses Alternating
Between Zero and Flux Value Shown For
Any Given Tube Temperature: "On" Period
Of Pulse Equal to "Off" Period; RMS
Signal Current = RMS Noise Current.
External Shield Volts Relative
To Anode Volts = -1000

TUBE TEMPERATURE °C
-175 -150 -125 -100 -75 -50 -25 0 25 50 75

EQUIVALENT NOISE INPUT - LUMENS

92CS-7503R2

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

Volts/Stage = 100
Light source is a tungsten-filament lamp
Operated at a color temperature of 2870°K.

DATA 3
RADIO CORPORATION OF AMERICA
Electronic Components and Devices
Harrison, N. J.
Typical Sensitivity and Current Amplification Characteristics

Supply Voltage \(E\) across voltage divider providing 1/10 of \(E\) between cathode and dynode No. 1, 1/10 of \(E\) for each succeeding dynode stage; and 1/10 of \(E\) between dynode No. 9 and anode.
Typical Effect of Magnetic Field on Anode Current

INCIDENT 0.187" DIA. LIGHT SPOT NORMAL TO AND CENTERED ON PHOTOCATHODE GRILL.
UNIFORM MAGNETIC FIELD PARALLEL TO MAJOR AXIS OF TUBE.
POSITIVE VALUES OF MAGNETIC FLUX ARE FOR LINES OF FORCE TOWARD TUBE BASE.

RELATIVE ANODE CURRENT

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE = 500 V

MAGNETIC FIELD INTENSITY — GAUSSES

Typical Time-Resolution Characteristics

SUPPLY VOLTAGE (E) ACROSS VOLTAGE DIVIDER PROVIDING 1/10 OF E BETWEEN CATHODE AND DYNODE No.1; 1/10 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/10 OF E BETWEEN DYNODE No.9 AND ANODE.
PHOTOCATHODE IS FULLY ILLUMINATED.

TIME — SECONDS

SUPPLY VOLTS (E) BETWEEN ANODE AND CATHODE

DATA 4
RADIO CORPORATION OF AMERICA
Electronic Components and Devices
Harrison, N. J.
Typical Variation of Sensitivity as Tube is Rotated with Respect to Fixed Light Beam

Supply voltage between anode and cathode = constant zero-degree rotational position of tube is established by a collimated light beam perpendicular to and filling the plane of the grill. Tube mounted vertically with allowance made for rotation about major tube axis.

Rotational position (top view) clockwise = (-)
Rotational position (top view) counterclockwise = (+)

Dynode Modulation Characteristics

Anode supply volts (E) = 1000 volts per stage except for dynode-No.6 stage = 100

RADIO CORPORATION OF AMERICA
Electronic Components and Devices
Harrison, N. J.
Typical Variation of Photocathode Sensitivity Along Tube Length

Spot size: 1mm dia., approx.
Variations caused by interception of light by grill as well as surface irregularities have been ignored.

Relative anode current

Distance along cathode from end of cathode nearer base — millimeters

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

Spot size: 1mm dia., approx.
Grill toward observer, base down, cathode width projected normal to plane of grill. Variations caused by interception of light by grill as well as surface irregularities have been ignored.

Relative anode current

Distance along plane of grill from left to right — millimeters
Photomultiplier Tube

9-STAGE, SIDE-ON TYPE

S-5 RESPONSE

For Detection and Measurement of Ultraviolet and Visible Radiation

The 1P28A is the same as the 1P28 except for the following items:

CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a voltage divider providing 1/10 of E between cathode and dynode No. 1; 1/10 of E for each succeeding dynode stage, and 1/10 of E between dynode No. 9 and anode.

With E = 1000 volts

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
</table>
| Luminous | 35  | 200 | 500 | A/Im
| "Red-to-White" Ratio | 7  | -  | -  | %

j Under the following conditions: The light source is a tungsten-filament lamp having a lime-glass envelope. It is operated at a color temperature of 2870 °K and a light input of 10 microlumens is used.

RED-TO-WHITE RATIO

The sensitivity of the 1P28A 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 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.