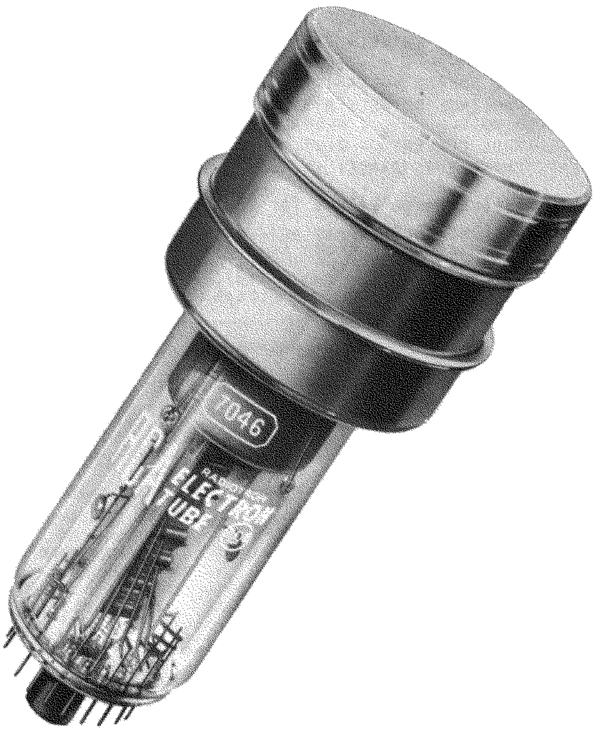
7046

MULTIPLIER PHOTOTUBE

4-7/16" Dia. Curved Circular Semitransparent Photocathode	14-Stage, Head-On, Flat-Faceplate Type Extended S-11 Response Very-Short Time-Resolution Capability	11-1/8" Max. Length 5-1/4" Max. Diameter Thirtyfivar 21-Pin Base

TENTATIVE DATA

RCA-7046 is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and applications involving the measurement of low-level light sources. Its



fast response, high current gain, high peak-current capability, relative freedom from after-pulses, and its very small spread in electron-transit time make it particularly useful for fast coincidence scintillation counting.

The 7046 is capable of delivering pulse currents having magnitudes up to 0.5 ampere without space-charge effects causing appreciable deviation from linearity. Consequently, the need for an associated wide-band amplifier to amplify the output pulse is eliminated in many applications.

The spectral response of the 7046 covers the range from about 2500 to 6500 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4200 angstroms. The 7046, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation. Because of its spectral response, the 7046 is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as thallium-activated sodium iodide.

Design features of the 7046 include a semi-transparent cathode on the curved inner surface of the face end of the bulb; a minimum cathode diameter of 4-7/16 inches; a faceplate of ultra-violet transmitting glass with a flat external surface to facilitate the mounting of flat phosphor crystals in direct contact with the surface; fourteen electrostatically focused multiplying (dynode) stages; two focusing electrodes with external connections for shaping the field which directs the photoelectrons from the cathode onto the first dynode; and an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No.12. The material of which the dynodes are made has stable, high-current-carrying capabilities and permits tube processing to minimize regenerative effects, such as after-pulses.

The internal leads from dynode No.14 and anode to their respective base-pin terminals are short and direct. This arrangement makes possible the use of a load circuit having a short time constant--an essential feature in pulse service.

The curved cathode surface of the 7046 assures very good collection by dynode No.1 of electrons from all parts of the useful cathode area. The curved surface together with the electrode configuration employed in the 7046 provides minimum spread in electron-transit time. As a result, the 7046 has very short time-resolution capability, i.e., in the order of 1 millimicrosecond or less. The 7046 is, therefore, capable of good pulse-height resolution in gamma-ray spectrometry and good time resolution in measurement of short, closely spaced radiation pulses.

The 7046 is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 3,000,000 times when operated with a supply voltage of 2400 volts. The output current of the 7046 is a linear function of the exciting illumination under normal operating conditions.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

The focusing electrodes permit optimizing the magnitude, uniformity, or speed of response in critical applications. The accelerating electrode reduces space charge and thus permits higher peak output current in pulse service than would otherwise be possible.

The various outstanding features of the 7046 commend its use in the design of scintillation counters, and its use in nuclear and "time-of-flight" measurements.

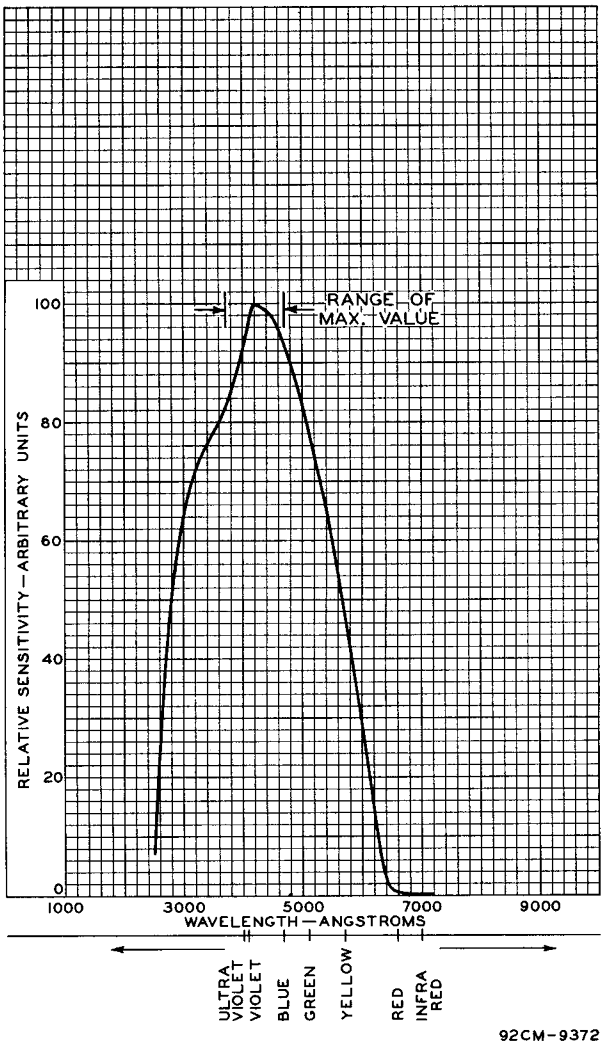


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7046. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

DATA

General:

Spectral Response. . . . . . . .Extended S-11 (See Fig.1)
Wavelength of Maximum Response . . . 4200 ± 500 angstroms
Faceplate, with flat external surface . . . . Ultraviolet Transmitting Glass
Cathode, Semitransparent:
  Shape. . . . . .Curved Circular
Window:
  Area . . . . 15.5 sq. in.
  Minimum diameter . . . . 4-7/16 in.
  Index of refraction. 1.468
Direct Interelectrode Capacitances (Approx.):
  Anode to dynode No.14. . . . . 2.4 μμf
  Anode to all other electrodes. . . . 5 μμf
  Dynode No.14 to all other electrodes 7 μμf
Maximum Overall Length . . . . 11-1/8"
Seated Length. . . . . 9-3/4" ± 1/4"
Envelope . . . . See *Dimensional Outline*
Cathode Terminal . . . . Metal Flange
Base . . . . Small-Button Thirtyfivar 21-Pin (JETEC No.E21-40)
Mounting Position. . . . . .Any
Weight (Approx.) . . . . 1 lb. 14 oz.

Maximum Ratings, *Absolute Values:*

DC ANODE-SUPPLY VOLTAGE.	3400 max.	volts
DC SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE.	400 max.	volts
DC SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES.	400 max.	volts
DC SUPPLY VOLTAGE BETWEEN GRID No.3 AND DYNODE No.13	500 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE.	1500 max.	volts
DC SUPPLY VOLTAGE BETWEEN GRID No.2 AND ANODE.	2300 max.	volts
DC GRID-No.1 SUPPLY VOLTAGE.	1200 max.	volts
DC SUPPLY VOLTAGE BETWEEN DYNODE No.1 AND GRID No.2.	400 max.	volts
AVERAGE ANODE CURRENT●	2 max.	ma
AMBIENT TEMPERATURE RANGE.	-125 to +75	°C

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across a voltage divider providing electrode voltages shown in Table I

With E = 2800 volts (except as noted), and with Grid-No.3, Grid-No.1, and Dynode-No.1 Voltages Adjusted to Give Maximum Gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	-	0.140	-	amp/μw
Cathode Radiant, at 4200 angstroms . .	-	0.046	-	μa/μw
Luminous:#				
At 0 cps.	40	180	1500	amp/lumen
With dynode No.14 as output electrode† . . .	-	108	-	amp/lumen
Cathode Luminous:				
With tungsten light source▲	40	60	-	μa/lumen
With blue light source (See Fig.2)**	4	-	-	μa
Current Amplification	-	3×10^6	-	
Equivalent Anode-Dark-Current Input‡■ . .	-	2×10^{-9}	1.2×10^{-8}	lumen
	-	26×10^{-5}♪	156×10^{-5}♪	watt
Equivalent Noise Input★	-	1×10^{-11}	-	lumen
	-	13×10^{-7}♪	-	watt
Greatest Transit-Time Spread:				
Within a circle centered on tube face and having a diameter of—				
3 inches.	-	0.5	-	milliμsec
4 inches.	-	4	-	milliμsec

With E = 3400 volts (except as noted), and with Grid-No.3, Grid-No.1, and Dynode-No.1 Voltages Adjusted to Give Maximum Gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms.	-	0.91	-	amp/μw
Cathode Radiant, at 4200 angstroms . . .	-	0.046	-	μa/μw

Luminous:#				
At 0 cps	–	1200	–	amp/lumen
With dynode No.14 as output electrode†.	–	800	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲.	40	60	–	µa/lumen
With blue light source (See Fig.2)**	4	–	–	µa
Current Amplification. .	–	20×10^6	–	

TABLE 1

VOLTAGE TO BE PROVIDED BY DIVIDER	
Between	**3.8% of Supply Voltage (E) Multiplied By**
Cathode and Grid No.1	2 approx.*
Cathode and Grid No.2	11.5
Grid No.2 and Dynode No.1	1 approx.*
Grid No.2 and Dynode No.2	2
Dynode No.2 and Dynode No.3	1
Dynode No.3 and Dynode No.4	1
Dynode No.4 and Dynode No.5	1
Dynode No.5 and Dynode No.6	1
Dynode No.6 and Dynode No.7	1
Dynode No.7 and Dynode No.8	1
Dynode No.8 and Dynode No.9	1
Dynode No.9 and Dynode No.10	1
Dynode No.10 and Dynode No.11	1
Dynode No.11 and Dynode No.12	1
Dynode No.12 and Dynode No.13	1
Dynode No.13 and Dynode No.14	1
Dynode No.14 and Anode	1
Anode and Cathode	26.5

* Adjusted to Give Maximum Gain.

● Averaged over any interval of 30 seconds maximum.

\# Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.14 as the output electrode. With this arrangement, the load is connected in the dynode-No.14 circuit and the anode serves only as collector. This type of operation is suitable only for small output signals or for applications where linearity is not required.

▲ Under the following conditions: The light source is a tungsten-filament lamp 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 together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

♦ Measured at 4200 angstroms.

✣ Measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give a luminous sensitivity of 500 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 2800 volts, 25°C tube temperature, tungsten light source 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. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

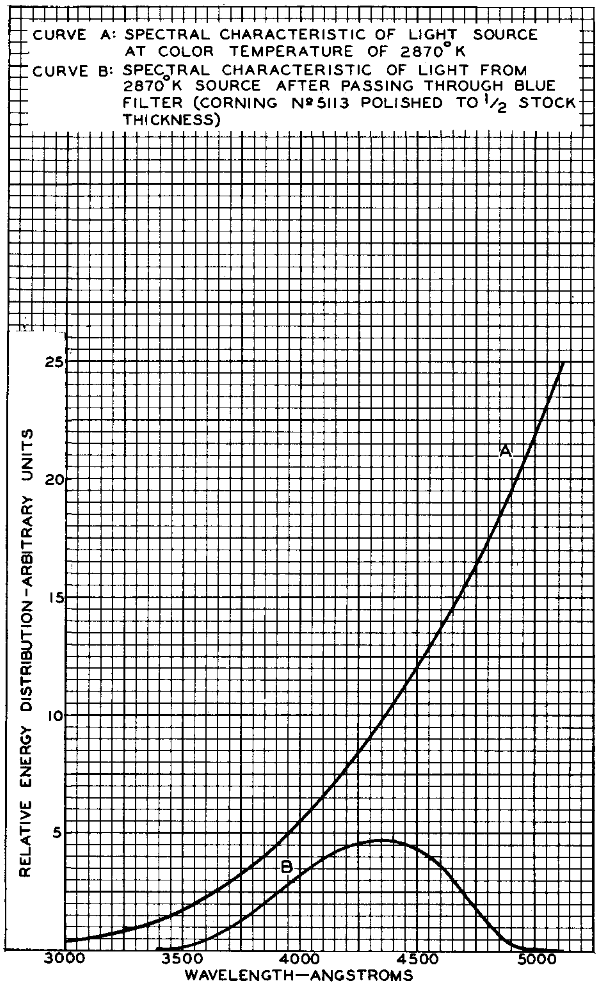


Fig.2 - Spectral Characteristic of 2870°K Light Source, and Spectral Characteristic of Light from 2870°K after Passing through Indicated Filter.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Transit-Time Spread. The increase in width of the output pulse over that of the input pulse. Pulse width is measured at 50% of the pulse height.

GENERAL CONSIDERATIONS

The 7046 is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 7046 multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated curved cathode are directed by fixed electrostatic fields provided by grids No.1 and No.2 to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode

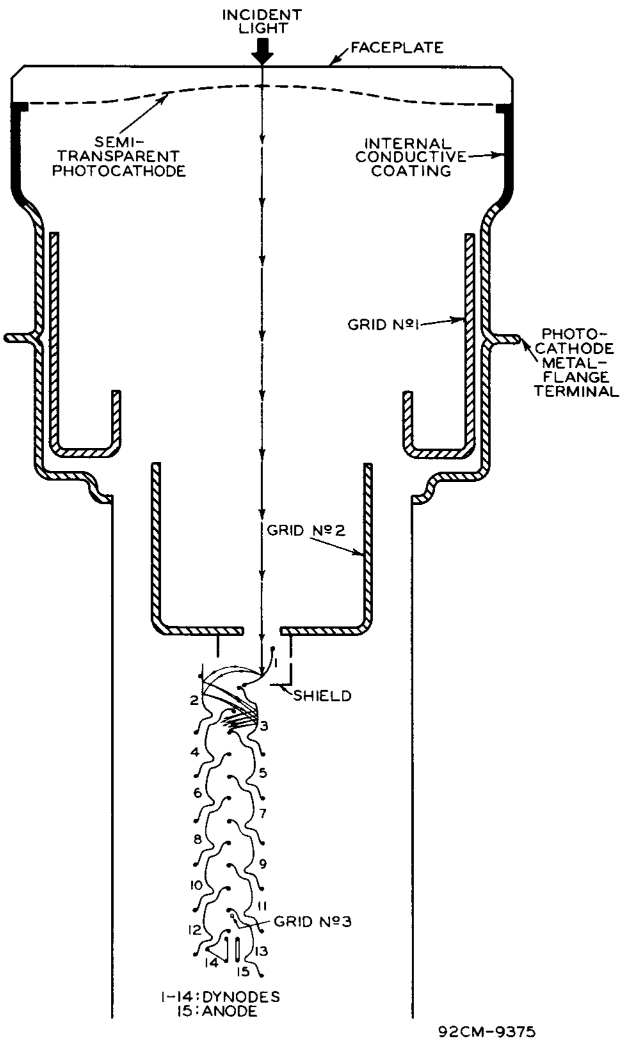


Fig.3 - Schematic Arrangement of Type 7046 Structure.

where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.14) are collected by the anode and constitute the current utilized in the output circuit.

The anode consists of a grating which allows the electrons from dynode No.13 to pass through it to dynode No.14. Spacing between dynode No.14 and anode creates a collecting field such that all the electrons emitted by dynode No.14 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 7046 can be coupled to any practical load impedance.

The shield which is adjacent to dynode No.1 shields dynode No.1 and the cathode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the cathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the faceplate end of the envelope is connected to the cathode and to the metal portion of the envelope, and serves to direct the electrons from the cathode toward dynode No.1.

The focusing electrodes (grid No.1 and grid No.2) shape the fields which direct photoelectrons from the cathode onto dynode No.1. For consideration of the operating voltage applied to the focusing electrodes, see INSTALLATION AND APPLICATION.

The accelerating electrode (grid No.3) serves to minimize the effect of space charge in the region of dynode No.12. For consideration of the operating potential of dynode No.12 with respect to dynode No.13, see INSTALLATION and APPLICATION.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7046 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a tube temperature may cause the volatile cathode surface to evaporate with consequent decrease in the life and sensitivity of the tube.

Terminal Connections. The *base pins* of the 7046 fit the thirtyfivar 35-contact socket, such as Alden Part No.435SBA, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident light falls on the face end of the tube. Connection to the *metal flange* is made by a spring-finger ring, bearing against the edge of the flange.

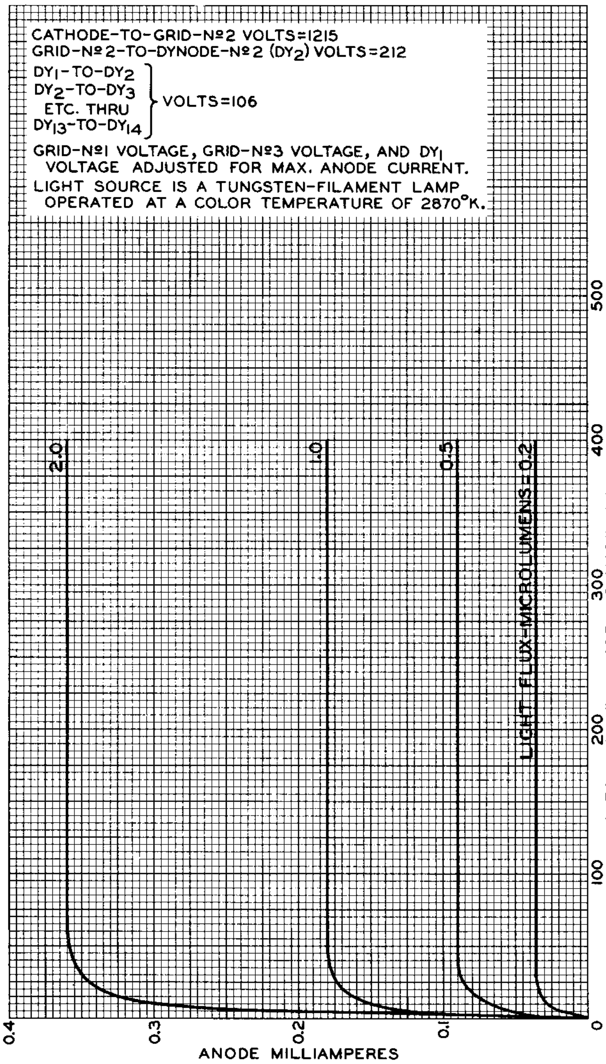


Fig.4 - Average Anode Characteristics of Type 7046.

In general, *supply voltages* for the electrodes of the 7046 may be provided as shown in Table 1. The voltage distribution shown in Table 1 gives the highest current amplification consistent with best collection of photoelectrons. The operating voltage between dynode No.14 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig.4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltages between dynode No.14 and anode reduces the dark current. As a result, the operating stability of the 7046 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No.14 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

For operation involving high-current pulses, the overall supply voltage should be reapportioned so that the voltages applied between dynodes near the anode are increased. Successive interdynode voltages should not be more than 5/4 of the preceding interdynode stage.

Two *focusing electrodes* are provided to optimize the magnitude, uniformity, or speed of the response. In applications where an increased

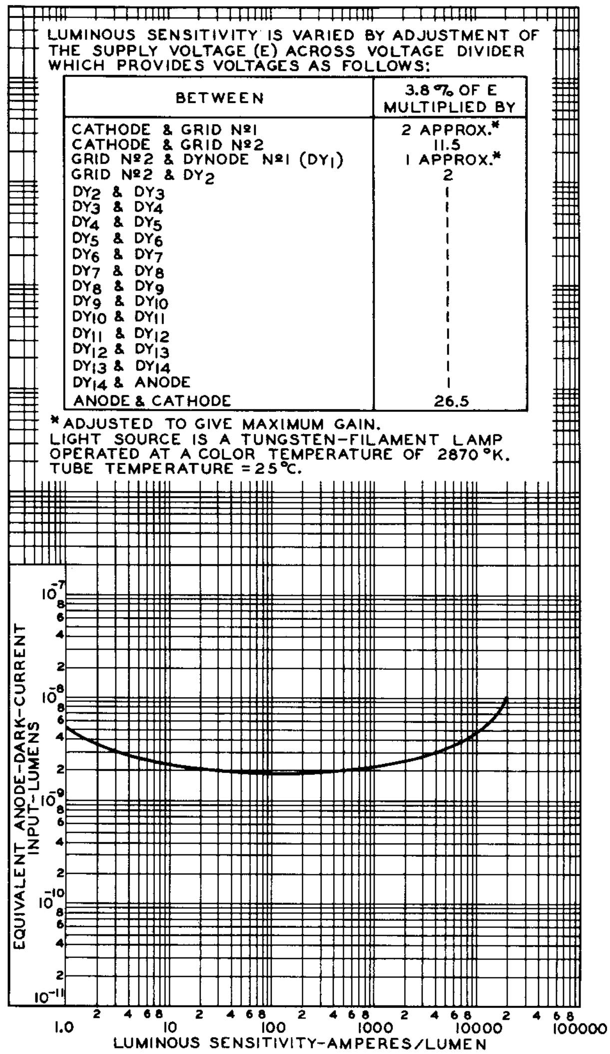


Fig.5 - Typical Anode-Dark-Current Characteristic of Type 7046.

number of collected photoelectrons is the primary consideration, the grid-No.1 voltage should be adjusted for maximum anode current while the cathode is uniformly flooded with light.

The *accelerating electrode*, when operated at a suitable potential with respect to dynode No.13, serves to minimize the effect of space charge in the region of dynode No.12. Provision should be made to adjust the accelerating-electrode voltage over a range extending from the value at which dynode No.13 operates to that at which the anode operates. The adjustment may be accomplished by means of a high-resistance potentiometer connected between the voltage-divider tap for dynode No.13 and the anode end of the voltage divider. Since the accelerating electrode draws at most only negligible current, the potentiometer can have sufficiently high resistance so that it will not substantially affect the voltage distribution at the taps of the shunted section of the divider. Within the specified adjustment range, it will be found that the accelerating-electrode voltage may be adjusted to obtain either maximum gain or maximum peak output current. In general, the adjustment to apply the highest voltage to the accelerating electrode will permit the highest peak current with some sacrifice in gain.

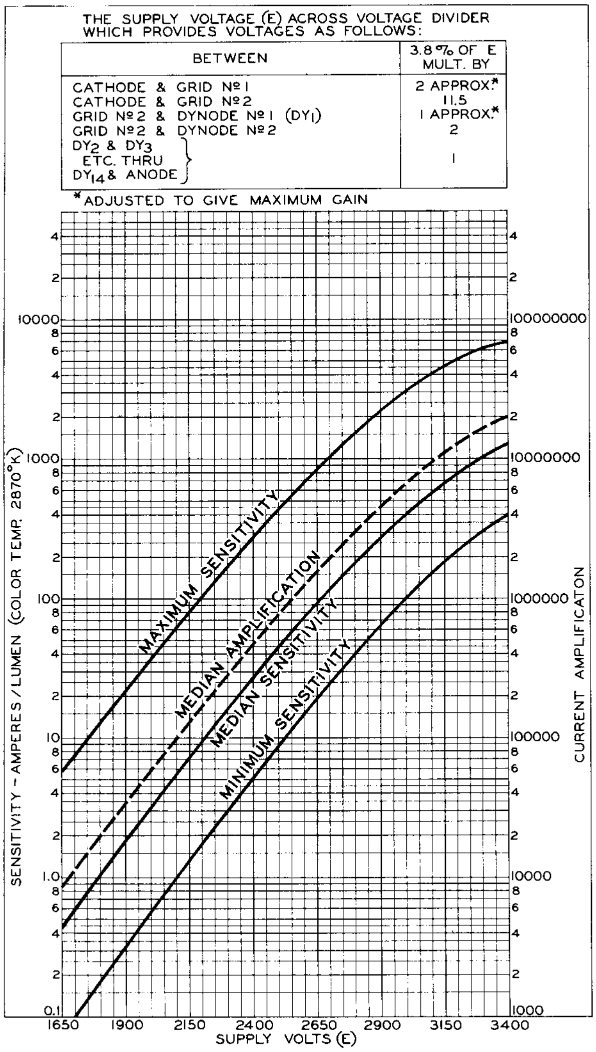


Fig.6 - Characteristics of Type 7046.

A very small *dark current* is observed when voltage is applied to the electrodes of the 7046 in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or 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. Dark current may be kept at a minimum by storing tubes in light-proof containers.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output

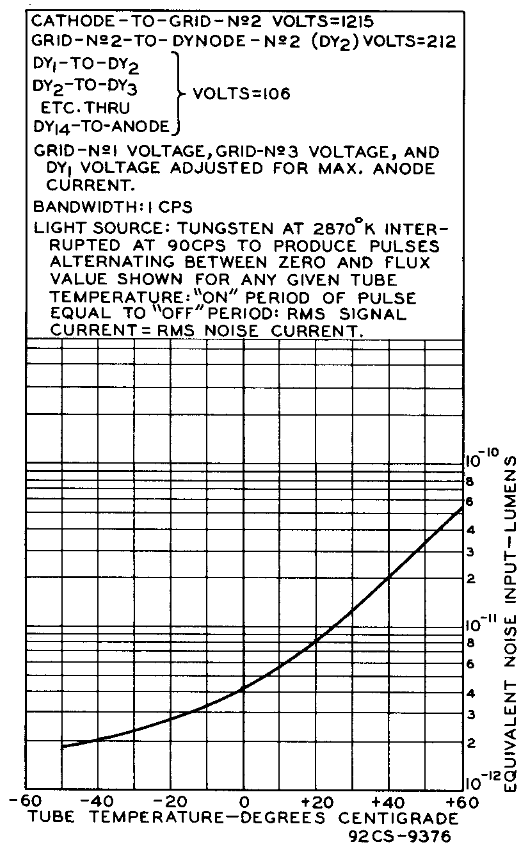


Fig.7 - Equivalent-Noise-Input Characteristic of Type 7046.

to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.5 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7046, and the curves in Fig.6 which show luminous sensitivity as a function of the supply voltage. The voltage between dynode No.14 and the anode should be kept as low as will permit operation at a point just giving anode-current saturation. This point on the anode characteristic curves, shown in Fig.4, occurs in the approximate range of 50 to 100 volts.

In applications involving low-light level *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 2300 to 3200 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 3200 volts, regenerative phenomena usually contribute to the noise.

The noise spectrum of the 7046 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 7046 is recommended. The resulting reduction in thermionic emission from the cathode lowers the detection threshold to give improved operation. The curve in Fig.7 shows the equivalent noise input as a function of the temperature of the 7046.

Exposing the 7046 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 7046 is dependent on the magnitude of the anode current and its duration. When the 7046 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 7046 usually recovers a substantial percentage of such less in sensitivity.

The use of an average anode current well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 100 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the *nth* power, where *n* is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for the equipment designer to provide adequate adjustment of the supply voltage so that the amplification of individual tubes can be adjusted to the desired design value. The voltage-adjustment range required to take care

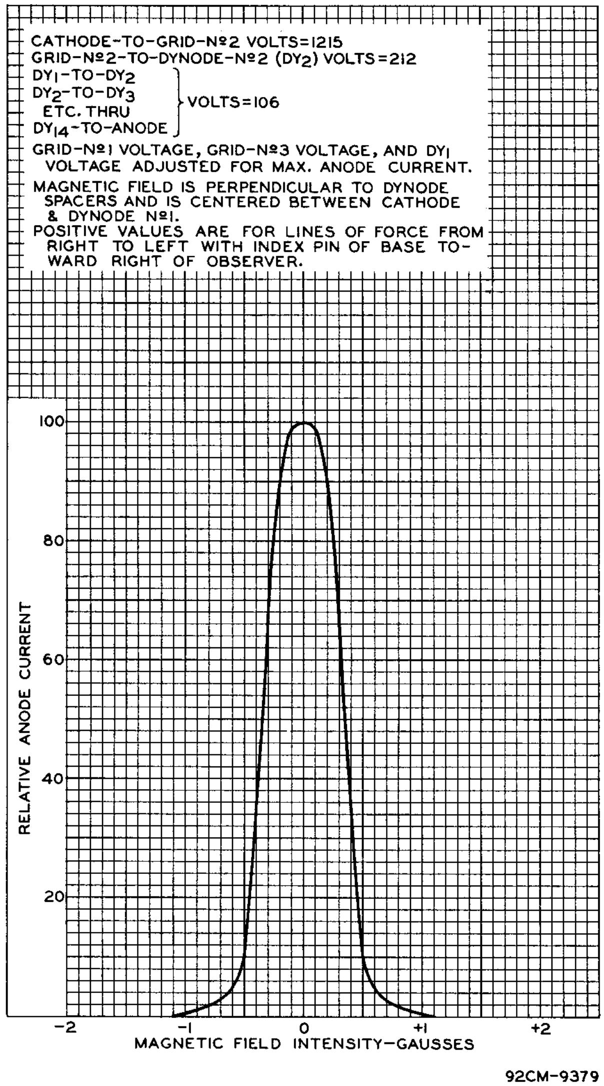


Fig.8 - Effect of Magnetic Field on Anode Current of Type 7046.

of variations between individual tubes may be determined from Fig.6 for low-light-level service. For example, if a sensitivity design value of 200 amperes per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of about 3180 volts, and on the "maximum" sensitivity curve to a supply voltage of 2340 volts. Therefore, provision should be made to adjust the supply voltage over the range from 2340 to 3180 volts.

Electrostatic shielding of the 7046 is not required. The metallic coating on the inner side of the face end of the envelope together with the metal portion of the envelope act as an electrostatic shield to prevent the envelope wall from charging to a positive potential.

With certain orientations of the 7046, it will be observed that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig.8 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current. When grid No.1 is operated at a potential near that of the cathode, the effect of the magnetic field will be increased. For orientations of the 7046 other than that indicated in Fig.8, the effect of the magnetic field is less pronounced. When the magnetic field is parallel to the axis of the tube, the effect is least.

To prevent such decrease in response of the tube, magnetic shielding must be provided. A suitable shield may be obtained from James Millen Mfg. Co., Malden, Mass. by ordering Part No.80805P. In general, it is recommended that the shield be connected to cathode potential. When connected to anode potential, this shielding should be spaced sufficiently from the envelope or otherwise insulated to prevent voltage breakdown between the shield and the metal portion of the envelope.

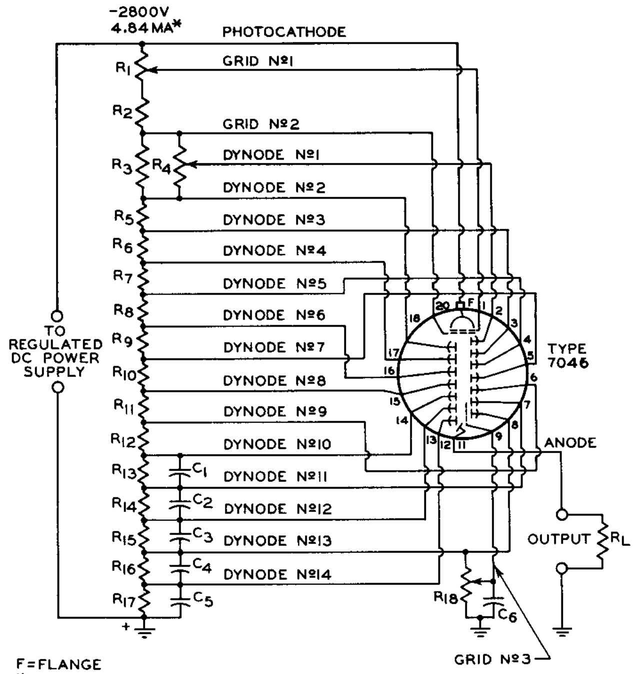
It is to be noted that the use of an external magnetic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safe-guards to prevent personnel from coming in contact with the high potential of the shield.*

Magnetization of the metal portion of the envelope will result in reduced or nonuniform collection of photoelectrons and hence a reduction in sensitivity. The tube may be demagnetized by subjecting it to an ac magnetic field which is gradually reduced in intensity.

Adequate *light and ultraviolet-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 7046. Although the metallic coating on the inner side wall of the face end of the envelope serves to reduce the amount of extraneous radiation reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous radiation.

Whenever frequency response is important, the leads from the 7046 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each electrode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the



F=FLANGE
*FOR -3400V, CURRENT IS 5.88 MA.

92CS-9373

C_1 = 25 μμf, disk ceramic, 600 volts (dc working)
C_2 = 50 μμf, disk ceramic, 600 volts (dc working)
C_3 = 100 μμf, disk ceramic, 600 volts (dc working)
C_4 = 250 μμf, disk ceramic, 600 volts (dc working)
C_5 = 500 μμf, disk ceramic, 600 volts (dc working)
C_6 = 100 μμf, disk ceramic, 600 volts (dc working)
R_1 = 50000 ohms, 2 watts, adjustable
R_2 = 200000 ohms, 10 watts
R_3 = 43000 ohms, 2 watts, adjustable
R_4 = 1 megohm, .2 watts, adjustable
R_5 through R_{17} = 22000 ohms, 1 watt
R_{18} = 10 megohms, 2 watts, adjustable
R_L = Value will depend upon magnitude of peak pulse voltage desired.

Note: Capacitors C_1 through C_6 should be connected at tube socket.

Fig.9 - Voltage-Divider Arrangement for Type 7046.

current in the divider should be several times the maximum value of anode current. The value should also be adequate to prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Inasmuch as the gain of the 7046 is critically dependent on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum tube regulator circuit of the mu-bridge type.

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.

A typical voltage-divider arrangement for use with the 7046 is shown in Fig.9.

The high voltages at which the 7046 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 7046, 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.

REFERENCES

Ralph W. Engstrom, *"Multiplier Phototube Characteristics; Application to Low Light Levels"*, Journal of the Optical Society of America, Vol.37, pp.420-431, June, 1947.

G. A. Morton and K. W. Robinson, *"A Coincidence Scintilation Counter,"* Nucleonics, Vol.4, No.2, pp.25-29, February, 1949.

W. H. Jordan and P. R. Bell *"Scintillation Counters,"* Nucleonics, Vol.5, No.4,October, 1949.

H. H. Goldsmith, *"Bibliography on Radiation Detection,"* Nucleonics, Vol.4, No.5, May, 1949.

"Properties of Scintillation Materials," Nucleonics, Vol.6, No.5, pp.70-72, May, 1950.

F. S. Johnson, K. Watanabe, and R. Tousey, *"Fluorescent Sensitized Photomultipliers for Heterochromatic Photometry in the Ultraviolet,"* Journal of the Optical Society of America, Vol.41, No.10, pp.702-708, October, 1951.

R. T. Wright, *"Scintillation Response of Phosphors at Low Particle Energies"*, Physical Review, Vol.96, pp. 569-570, November 1, 1954.

C. J. Borkowski and R. L. Clark, *"Gamma-Ray Energy Resolution with NaI-TlI Scintillation Spectrometers"*, The Review of Scientific Instruments, Vol.24, No.11, pp.1046-1050, November, 1953.

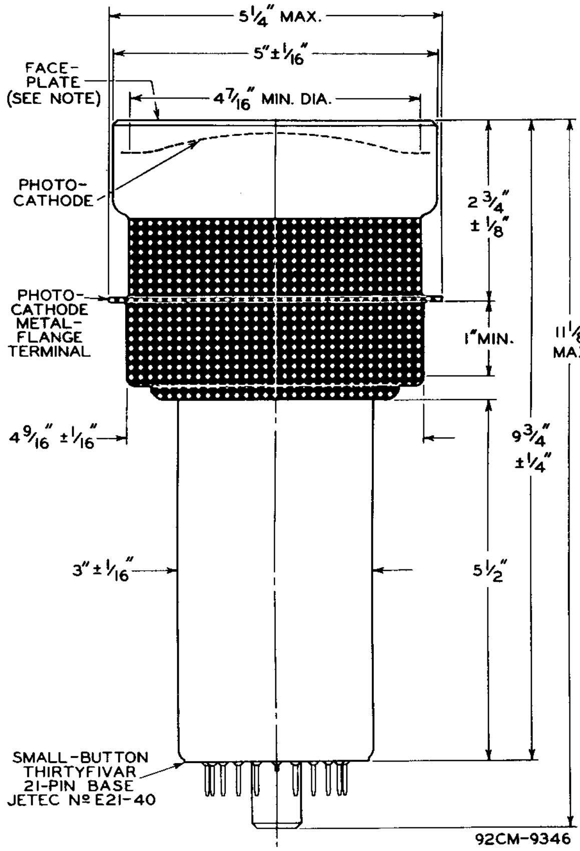
R. K. Swank and W. L. Buck, *"Decay Times of Some Organic Scintillators"*, The Review of Scientific Instruments, Vol.26, pp.15-16, January, 1955.

R. F. Post and N. S. Shiren, *"Performance of Pulsed Photo-Multiplier Scintillation Counters"*, Physical Review, Vo.78, p.81, April, 1950.

W. Widmaier, R. W. Engstrom, and R. G. Stoudenheimer, *"A New High-Gain Multiplier Phototube For Scintillation Counting"*. IRE Transactions of the Professional Group On Nuclear Science, Vol.NS-3, No.4, November, 1956.

W. Widmaier, and R. W. Engstrom, *"Variation of the Conductivity of the Semitransparent Cesium-Antimony Photocathode"*, RCA Review, Vol.XVI, No.1, March 1955.

DIMENSIONAL OUTLINE



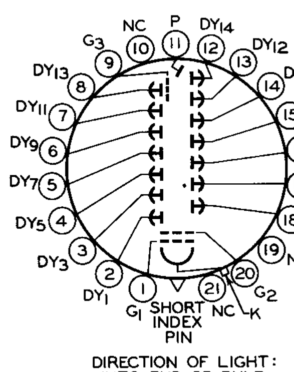
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 4-7/16" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.015" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS

Bottom View

PIN 1: GRID No.1
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: DYNODE No.13
PIN 9: GRID No.3 (Accelerating Electrode)
PIN 10: NO CONNECTION
PIN 11: ANODE



21-A

PIN 12: DYNODE No.14
PIN 13: DYNODE No.12
PIN 14: DYNODE No.10
PIN 15: DYNODE No.8
PIN 16: DYNODE No.6
PIN 17: DYNODE No.4
PIN 18: DYNODE No.2
PIN 19: NO CONNECTION
PIN 20: GRID No.2
PIN 21: NO CONNECTION
METAL FLANGE: CATHODE