PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Electron tubes

Part 9 March 1978

Photomultiplier tubes

Photo tubes (diodes)

ELECTRON TUBES

Part 9 **March 1978**

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, sub-assemblies and materials; it is made up of three series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
SEMICONDUCTORS AND INTEGRATED CIRCUITS	RED
COMPONENTS AND MATERIALS	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

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Part 1b	August 1977	ET1b 08-77	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2	May 1976	ET2 05-76	**Microwave products** (This book is valid until Part 2b becomes available.)
Part 2a	November 1977	ET2a 11-77	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 3	January 1975	ET3 01-75	**Special Quality tubes, miscellaneous devices**
Part 4	March 1975	ET4 03-75	**Receiving tubes**
Part 5a	March 1978	ET5a 03-78	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
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Part 7a	March 1977	ET7a 03-77	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	March 1977	ET7b 03-77	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	May 1977	ET8 05-77	**TV picture tubes**
Part 9	March 1978	ET9 03-78	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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Part 1b	May 1977	SC1b 05-77	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes
Part 2	November 1977	SC2 11-77	**Low-frequency and dual transistors**
Part 3	January 1978	SC3 01-78	**High-frequency, switching and field-effect transistors**
Part 4a	June 1976	SC4a 06-76	**Special semiconductors** Transmitting transistors, field-effect transistors, dual transistors, microminiature devices for thick and thin-film circuits
Part 4b	July 1976	SC4b 07-76	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices
Part 5a	November 1976	SC5a 11-76	**Professional analogue integrated circuits**
Part 5b	March 1977	SC5b 03-77	**Consumer integrated circuits** Radio-audio, television
Part 6	October 1977	SC6 10-77	**Digital integrated circuits** LOCMOS HE4000B family
Signetics integrated circuits 1976			Logic, Memories, Interface, Analogue, Microprocessor, Milrel

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	June 1977	CM1 06-77	**Assemblies for industrial use** High noise immunity logic FZ/30-series, counter modules 50-series, NORbits 60-series, 61-series, circuit blocks 90-series, circuit block CSA70(L), PLC modules, input/output devices, hybrid circuits, peripheral devices, ferrite core memory products
Part 2a	October 1977	CM2a 10-77	**Resistors** Fixed resistors, variable resistors, voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC), test switches
Part 2b	February 1978	CM2b 02-78	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3	January 1977	CM3 01-77	**Radio, audio, television** FM tuners, loudspeakers, television tuners and aerial input assemblies, components for black and white television, components for colour television
Part 4a	October 1976	CM4a 10-76	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	December 1976	CM4b 12-76	**Piezoelectric ceramics, permanent magnet materials**
Part 5	July 1975	CM5 07-75	**Ferrite core memory products** Ferroxcube memory cores, matrix planes and stacks, core memory systems
Part 6	April 1977	CM6 04-77	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	September 1971	CM7 09-71	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 8	February 1977	CM8 02-77	**Variable mains transformers**
Part 9	March 1976	CM9 03-76	**Piezoelectric quartz devices**
Part 10	November 1975	CM10 11-75	**Connectors**

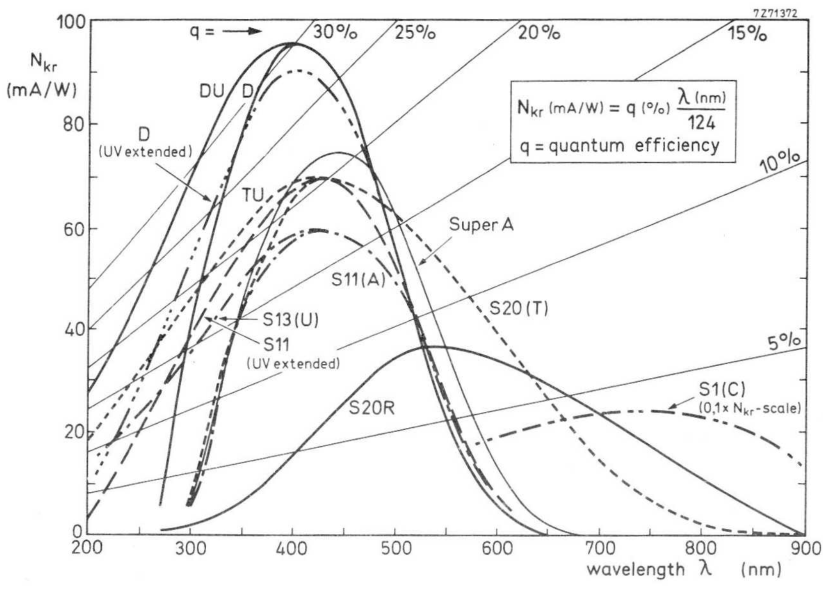
Photomultiplier tubes

SURVEY OF TYPES

photo-cathode dia. mm	tube type	spectral response									socket
		super A	S1 (C)	S20R	S11 (A)	S13 (U)	S20 (T)	TU	D	DU	
14	PM1910				X						FE1004
	PM1918					X					FE1004
	PM1920				X						FE1004
	XP1116		X								FE1004
	XP1117						X				FE1004
23	PM1980				X						FE1114
32	PM2012B								X		FE1012
	PM2013B						X				FE1012
	PM2018B					X					FE1012
	PM2060B	X									FE1012
	XP1011	X									FE1012
	XP1017			X							FE1012
	XP2008	X									FE1012
	XP2010	X									FE1012
	150CVP		X								FE1012
44	PM2202								X		FE2019
	PM2232								X		FE2019
	PM2232B								X		FE1020
	XP1002						X				FE1014
	XP2000								X		FE1014
	XP2020								X		FE1020
	XP2020Q									X	FE1020
	XP2230								X		FE2021
	XP2230B								X		FE1020
	56AVP				X						FE1020
	56CVP		X								FE1020
	56DVP								X		FE1020
	56TUVP							X			FE1020
	56TVP						X				FE1020
61	PM2402								X		FE2019
68	PM2312								X		FE2019
	PM2312B								X		FE1020

Replacement list at the back.

photo-cathode dia. mm	tube type	spectral response									socket
		super A	S1 (C)	S20R	S11 (A)	S13 (U)	S20 (T)	TU	D	DU	
70	XP2030								X		FE1014
110	XP2040				X						FE1020
	XP2040Q				X						FE1020
	XP2041								X		FE1020
	XP2041Q								X		FE1020
	XP2050								X		FE1014
200	60DVP								X		FE1020
	60DVP/H								X		FE1020



Typical spectral sensitivity characteristics.

LIST OF SYMBOLS

Photocathode	k
Secondary emission electrode (dynode) n	S_n
Anode	a
Accelerating electrode	acc
Grid	g
Cathode luminous sensitivity	N_k
Cathode spectral sensitivity	N_{kr}
Luminous anode sensitivity	N_a
Anode spectral sensitivity	N_{ar}
Current amplification (gain)	G
Secondary emission factor of the dynodes	δ
Total supply voltage	V_b
Anode current	I_a
Anode dark current	I_{ao}
Cathode current	I_k
Efficiency	η
Wavelength	λ
Internal connection (do not use)	i.c.
External conductive coating	m

GENERAL OPERATIONAL RECOMMENDATIONS PHOTOMULTIPLIER TUBES

1. GENERAL *

1.1 A **photomultiplier tube** is a photosensitive vacuum device comprising a photoemissive cathode, a photoelectron optical collection system, and one or more stages of electron multiplication using secondary emission electrodes (dynodes) between cathode and anode.

1.2 A **photoemissive cathode** consists of a light-sensitive film (the emission layer) deposited on a substrate.
Two types of cathode may be distinguished:

a. the opaque photocathode;

b. the semi-transparent photocathode.

In the first type, the emission is deposited on a metal surface. In the second, the photocathode is deposited on the inside of the glass window. Although opaque photocathodes can be made more easily, semi-transparent photocathodes are mostly used, since they are mainly placed in front of the tube, which has many advantages for the construction and use of the photomultiplier tubes.

1.3 The **photoelectron optical collection system** (electron-optical input system) is that part of the photomultiplier tube which focuses the photoelectrons onto the first dynode. The quality of the input optics can be measured by the spread in the electron transit times, and by the collection efficiency, i.e. the percentage of electrons emitted by the photocathode that land on the first dynode.
In most tubes the electron-optical input system consists of the photocathode itself and a focusing electrode, connected internally to the first dynode or externally to a suitable voltage between those of the photocathode and the first dynode. In some photomultiplier tubes, such as XP2020, XP2040, XP2041, 56- type family and 60 DVP, an improvement in time characteristics has been obtained by using additional electrodes.

1.4 Several **dynode system constructions** are possible such as linear focused or venetian blind structures.
Examples of materials used for dynodes are Ag-Mg and Cu-Be, of which the latter offers the better stability.
Assuming that all dynodes have the same secondary emission factor, δ, the amplification of the tube is given by:

$$G = \delta^n$$

where n is the number of dynodes.

*) Where applicable reference is made to IEC Publication 306.

1.5 **Spectral response**

The materials used for the photocathode are of great importance to the spectral response. Many substances show photoemission, but often differ greatly in their spectral sensitivity and quantum yield.

1.5.1 The S11 (A-type) and Super A-type tubes are equipped with a semi-transparent caesium antimony photocathode on an MnO_2 layer, evaporated on the inside of a glass window. These types are sensitive to radiation in the visible region of the spectrum and have their maximum sensitivity at approximately 420 nm.

1.5.2 The S13 (U-type) tubes have the same photocathodes as the S11 tubes, but are provided with a fused silica (quartz) window, giving them a sensitivity that extends into the ultraviolet region of the spectrum.

1.5.3 The S1 (C-type) tubes have a semi-transparent caesium-on-silver-oxide photocathode on a glass window.
The sensitivity lies mainly in the red and near infrared regions of the spectrum, with a maximum at approximately 800 nm.

1.5.4 The S20 (T-type) tubes have a tri-alkaline (Sb-Na-K-Cs) semi-transparent photocathode on a glass window. This photocathode has a good sensitivity from the ultraviolet to the near infrared part of the spectrum, with a maximum at approximately 420 nm.

1.5.5 The S20R tubes have a tri-alkaline (Sb-Na-K-Cs) semi-transparent photocathode on a glass window.
The sensitivity extends from the visible into the near infrared part of the spectrum, with a maximum at approximately 550 nm.

1.5.6 The TU-type tubes have the same photocathode as the S20 tubes but are provided with a fused silica (quartz) window, giving them a sensitivity that extends into the ultraviolet region of the spectrum.

1.5.7 The D-type tubes have a bi-alkaline (Sb-K-Cs) semi-transparent photocathode on a glass window.
This photocathode has a high quantum efficiency in the blue region of the spectrum and a low thermionic emission. The maximum sensitivity is at approximately 400 nm.

1.5.8 The DU-type tubes have the same photocathode as the D-type tubes but are provided with a fused silica (quartz) window, giving them a sensitivity that extends into the ultraviolet region of the spectrum.

2. INTERPRETATION OF CHARACTERISTICS

In general the characteristics given in the data sheets are typical values. The "typical value" of a parameter is the median of the frequency distribution of the parameter measured on a large number of tubes.
In some cases maximum or minimum values are stated. These values are defined on test-limits carried out on each tube. Approximate values are given when these values are obtained from batch sample data.
Each tube is accompanied by a test card stating its test results.
The more important parameters are discussed below.

2.1 **Cathode luminous sensitivity**

The cathode luminous sensitivity is defined (IEC) as the quotient of the photocurrent of the cathode by the incident luminous flux, expressed in amperes per lumen.
For this measurement the photomultiplier tube is connected as a diode. The cathode current, I_k, (corrected for dark current) is about 100 nA.
The voltage used should be sufficient to ensure saturation.
The sensitivity is given by: $N_k = \frac{I_k}{\phi}$
where ϕ is the luminous flux, in lumen, of a tungsten filament lamp having a colour temperature of 2856 K.

2.2 **Cathode spectral sensitivity**

The cathode spectral sensitivity is the quotient of the photocurrent of the cathode by the value of the incident monochromatic radiant flux (IEC).

2.3 **Absolute spectral sensitivity**

The absolute spectral sensitivity is the radiant sensitivity for monochromatic radiation of a stated wavelength (IEC).
Measurements of this parameter are carried out with a tungsten filament lamp with a colour temperature of 2856 K and spectral filters. Tolerances of the spectral filters are stated in the tube data. The measuring equipment is calibrated by comparison with substandard light sources.

2.4 **Quantum efficiency**

The quantum efficiency (QE) is the ratio of the number of emitted photoelectrons to the number of incident photons (IEC) and is usually expressed in percent at a given wavelength.
At any given wavelength QE can be easily calculated from the following formula:

$$QE = N_{kr} \cdot \frac{1,24}{\lambda} \cdot 100\ (\%)$$

where N_{kr} is the cathode radiant sensitivity in mA/W at wavelength λ, and λ is the wavelength in nm.
In general the radiant sensitivity is given at the wavelength of maximum response. For other wavelengths the quantum efficiency may be calculated referring to the absolute spectral sensitivity characteristic. This is the relation, usually shown by a graph, between wavelength and absolute spectral sensitivity. Lines of constant quantum efficiency are shown in Fig. 1, page 10.

2.5 **Current amplification (gain) and anode luminous sensitivity**

The current amplification, G, is the ratio of the anode signal current, I_a, to the cathode signal current, I_k, at stated electrode voltages (IEC).

$$G = \frac{I_a}{I_k} .$$

Since the gain is usually very high ($> 10^6$), it is difficult to make this measurement because the cathode signal current has to be made extremely low to prevent the anode current exceeding the stated maximum.

Anode luminous sensitivity

The anode luminous sensitivity, N_a, can be obtained from the cathode luminous sensitivity, N_k, and the gain, G, by:

$$N_a = G \cdot N_k \text{ (A/lm)}.$$

Gain and anode luminous sensitivity measurements are usually taken at several values of applied voltage.

2.6 **Dark current and noise**

2.6.1 **Dark current** is the current flowing in a photoelectric device in the absence of irradiation (IEC).
The major component of the dark current is generally due to thermionic emission of the cathode and depends on the type of cathode and the temperature roughly according to the following table.

type of cathode	dark current emission at 20 °C (electrons $\cdot$ $s^{-1} \cdot cm^{-2}$)	activation energy (eV)	lowest useful temperature (°C)
Ag-O-Cs (S1)	$5 \cdot 10^6$	1	-100
$Sb\text{-}Na_2\text{-}K\text{-}Cs$ (S20R)	10^3	1,3	-40
$Sb\text{-}Na_2\text{-}K\text{-}Cs$ (S20)	300	1,3	-40
$Sb\text{-}Cs_3$ (S11)	100	1,3	-20
Sb-K-Cs (D)	10	1,2	0

At the lowest useful temperature the emission approaches the practical limit of approximately 1 electron.$s^{-1}.cm^{-2}$, due - at least partly - to ambient radioactivity.
When measured at the anode this current increases proportionally with the gain and can also be recorded with an adequate pulse amplifier as random pulses, each corresponding to 1 electron leaving the photocathode; this is then known as the **background noise or dark noise count rate**.
For a given charge threshold, there is generally a certain range of voltage, V_b, where this count rate is more or less constant.
Occasionally, and especially at high voltages, it may be observed that the dark current increases more rapidly than the gain and becomes unstable. Simultaneously the dark noise count rate increases strongly with the applied voltage. This is due to complex field emission phenomena associated with light emission, and related photoelectric emission by the cathode. This behaviour generally tends to improve when the voltage is applied for a long period (some hours).
Another cause for anomalous dark current is retarded fluorescence of the glass if the tube has been exposed (even without voltage applied) to ambient light, especially with blue and UV radiation.
After such an exposure the time required for stabilization can reach 12 h.

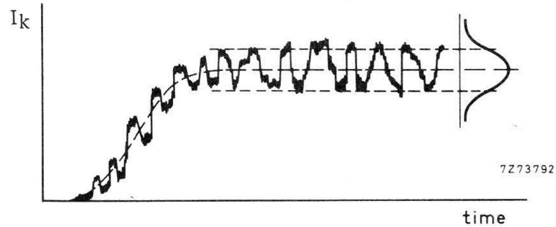
At very low V_b, the major component of the dark current is the - ohmic - leakage current between the pins; this component is proportional to the voltage and increases with dust and high relative humidity.

2.6.2 Shot noise or Schottky effect

If a photocathode under constant illumination gives a photocurrent, I_k, this current will show fluctuations the r.m.s. value of which is given by:

$$\overline{I_k}^2 = 2 \cdot e \cdot I_k \cdot \Delta f$$

in which $e = 1{,}6 \times 10^{-19}$ C, Δf is the bandwidth of the equipment connected to the anode and $\overline{I_k}$ and I_k are expressed in amperes. These fluctuations are directly related to the statistical fluctuations in the emission of photoelectrons.



Noise in photomultipliers.

When the photocurrent and the noise current are amplified by a factor G in the multiplier part of the tube, the anode current will be:

$$I_a = G \,.\, I_k ,$$

and the noise: $$\overline{I_a}^2 = 2 \cdot G \cdot e \cdot I_a \cdot \Delta f \left\{ 1 + \frac{\delta}{\delta_1(\delta - 1)} \right\} .$$

The term $\frac{\delta}{\delta_1(\delta - 1)}$ accounts for a noise contribution in the multiplier part due to statistical fluctuations in the secondary emission, δ being the average electron multiplication per stage and δ_1 being the electron multiplication of the first dynode.

The signal-to-noise ratio of the anode current is given by:

$$\frac{S}{N} = \frac{I_a}{\overline{\overline{I_a}}} = \sqrt{\frac{I_a}{2 \cdot G \cdot e \cdot \Delta f \left\{ 1 + \frac{\delta}{\delta_1(\delta - 1)} \right\}}} .$$

With typical values of $\delta = 4$ and $\delta_1 = 6$ the noise contribution of the multiplier is about 10% on the signal-to-noise ratio.

2.7 Linearity and saturation

The cathode and dynode currents should always be in the region of saturation, i.e. all electrons emitted by an electrode are collected by the next one, so as to guarantee the proportionality between the current and the cathode illumination over the whole operating range. When the tube is operated with a voltage $V_{S1/k}$, within the limiting values, saturation of the cathode is generally assured for cathode currents in the range of 10^{-8} A at room temperature.

Nevertheless for type-D photocathodes, departure from linearity can be observed for cathode currents in the range of 10^{-10} A, especially when operating at low temperatures.
The saturation current of the dynodes is generally reached under normal operating conditions even at the highest permissible luminous flux.
The saturation of the anode is different. The anode current causes a voltage drop across the load resistor. If the anode voltage decreases below a certain value this results in a non-linearity. Moreover, the current may be limited by space charge effects at the highest permissible anode currents.
That limit is reached for anode currents of 10 to 300 mA depending on the type of photomultiplier and on the voltage divider. The electrode currents should never be so high as to be detrimental to the tube's life, or cause excessive fatigue or aging.

2.8 **Time characteristics (IEC)**

2.8.1 The **signal transit time** of a photomultiplier tube is defined as the time interval between the arrival of a delta function light pulse of a stated amplitude at the entrance window of the device and the time at which the output pulse reaches a stated value.
Values given in the data sheet are obtained by measuring the instant at which the illuminating pulse at the cathode becomes maximum and the instant at which the anode pulse attains its maximum.

A **delta function light pulse** is a pulse having finite integrated light flux and infinitesimal duration (width).

2.8.2 The **anode pulse rise time** of a photomultiplier tube is defined as the time required for the amplitude to rise from a stated low percentage to a stated higher percentage of maximum value when a steady state of radiation is instantaneously applied. Normally the 10% and 90% levels are considered.

2.8.3 The **anode pulse duration** at half height (response pulse duration, FWHM) is defined as the time duration between the half amplitude points of the output current pulse when the photocathode receives a delta function light pulse giving rise to a large number of photoelectrons.

2.8.4 The **transit time difference** expresses a systematic relationship between transit time and position of illumination on the photocathode. The reference position is usually the centre of the photocathode.

2.8.5 The **transit time fluctuation** is the standard deviation of the transit time distribution of single electrons leaving the photocathode.

2.8.6 **Remark:** Rise time, pulse duration, and transit time vary as a function of high-tension supply voltage, V_b, approximately as $V_b^{-1/2}$.

2.9 **Stability**

The concept of stability refers to different behaviour of the gain of photomultipliers which may change as a function of current, voltage, time, temperature, and history.
For anode currents between 10 μA and absolute limiting value - which ranges from 100 to 500 μA - slow, irreversible changes of gain are observed. As an indication, for an anode current of 30 μA, a change of gain by a factor of 2 can be observed after about 5000 h for most tube types.

In the specific case of the S1 photocathode there is also a decrease in cathode sensitivity due to caesium desorption effect in the last stages, which requires a lower mean anode current. For anode currents below 1 μA, only reversible changes of gain are generally observed, but these changes may exhibit hysteresis effects with time constants ranging from some seconds to some hours, depending on the anode current. A change of gain in applications such as scintillation counting is very cumbersome because it is associated by a shift of the total absorption peak, strongly degrading the resolution.
According to ANSI-N42-9-1972 of IEEE there are two types of pulse amplitude (height) stability tests :

1. A test of long term **drift** in pulse amplitude measured at a constant count rate.
2. A measure of short-term pulse amplitude **shift** with change in count rate.

In the time stability test, a pulse amplitude analyser, a ^{137}Cs source, and an NaI (Tl) crystal are employed to measure the pulse amplitude. The ^{137}Cs source is located along the major axis of the tube and crystal so that a count rate of about 10^4 c/s is obtained. The entire system is allowed to warm up under operating conditions for a period of 30 minutes to one hour before readings are recorded. Following this period of stabilization, the pulse amplitude is recorded at 1 h intervals for a period of 16 h. The drift rate, D_g, is then calculated, in %, as the mean gain deviation, MGD, of the series of pulse amplitude measurements as follows :

$$D_g = \frac{\sum_{i=1}^{i=n} |p - p_i|}{n} \cdot \frac{100}{p}$$

where p is the mean pulse amplitude averaged over n readings; p_i is the pulse amplitude at the i^{th} reading; and n is the total number of readings.
Typical maximum MGD values for photomultiplier tubes with high-stability Cu-Be dynodes are usually less than 1% when measured under the conditions specified above. Gain stability becomes particularly important when photopeaks produced by nuclear disintegrations of nearly equal energy are being differentiated.

In the count-rate stability test, the photomultiplier tube is first operated at about 10^4 c/s. The count rate is then decreased to approximately 1000 c/s by increasing the source-to-crystal distance. The photopeak position is measured and compared with the last measurement made at a count rate of approximately 10^4 c/s. The count-rate stability is expressed as the % gain shift for the count-rate change. The average anode currents corresponding to a count rate of 10^4 c/s and 10^3 c/s respectively are stated in the notes given with each type.

3. OPERATING NOTES

3.1 The **overall supply voltage** should be well stabilized, since the gain of a photomultiplier tube is strongly dependent on the voltage, expressed by the following relation :

$$\frac{dG}{G} = n \cdot \frac{dV_b}{V_b}.$$

The percentage change in gain is approximately ten times the percentage change in supply voltage. Thus to hold the gain stable within 1%, the power supply must be stabilized to within approximately 0,1%.

When the radiant flux to be measured causes high anode currents, it is possible to replace the resistors of the last 3 or 4 stages in the voltage divider by voltage regulator diodes.

3.2 The **voltage divider** of a photomultiplier tube must be so designed that it does not cause an impermissible shift in the dynode voltage due to variation in incident radiation. The divider current (bleeder current), I_{b1}, must, therefore, be high compared to the anode current.
If this condition is not fulfilled, a high dynode current, accompanied by a high anode current, will seriously decrease the dynode voltages between the last stages. In any case, such variations of the dynode voltages introduce non-linearity of the photomultiplier tube.

3.2.1 In **continuous operation** a first approximation for the relative variation of the gain with a varying illumination of the cathode is:

$$\frac{\Delta G}{G} \approx \frac{I_k}{I_{b1}} \left\{ \delta^n - \frac{\delta^{n+1}}{(n+1)\cdot(\delta-1)} \right\} \approx \frac{I_a}{I_{b1}} \left\{ 1 - \frac{\delta}{(n+1)\cdot(\delta-1)} \right\}.$$

Thus the relative change in gain is approximately proportional to the ratio between the anode current and divider current. For example, to keep the gain stable within 1% when measuring a continuously luminous flux, the divider current should be at least 100 times the anode current.

3.2.2 In **pulsed operation**, as in scintillation counting, two calculations have to be made:
- The divider current should be at least 100 times the averaged integrated anode current $\overline{I_a}$. This is given by:

$$\overline{I_a} = I_a \cdot N \cdot T$$

where: I_a is the anode current pulse amplitude;
N is the anode pulse rate;
T is the anode pulse duration.

- The gain deviation caused by the current pulses must be restricted by decoupling at least the last four divider resistors. Calculations on capacitively stabilized voltage dividers are very complex and will not be dealt with here.
The minimum capacitance needed depends on the peak anode current and the pulse duration.
The value of C_{n+1} can be approximated when assuming that the charge Q_c which C_{n+1} should supply during the anode current pulse is much greater than the charge Q_a carried by the pulse

$$Q_a = \int I_a dT.$$

If the voltage across the last stage must be stable within 1%, that is $\Delta V/V_{S(n)} = 0{,}01$, and if the influence of the voltage divider resistor across the capacitor is neglected, then $Q_c = 100\, Q_a$, whence:

$$C_{n+1} = \frac{Q_c}{V_{S(n)}} = \frac{100 Q_a}{V_{S(n)}} = \frac{100}{V_{S(n)}} \int I_a dT.$$

As the current through the preceding stage is a factor δ lower, its bypass capacitance can be a factor δ smaller:

$$C_n = \frac{C_{n+1}}{\delta}.$$

The use of bypass capacitors gives the high voltage divider current a high time constant. When bursts of pulses occur, that is with short intervals between succeeding pulses, the capacitors will not fully recharge and the pulse effects will add up until the amplitude of the voltage fluctuations has become quite appreciable. In that case the voltage divider current has to be increased.

3.3 General remarks

On no account should the tube be exposed to ambient light when the supply voltage is applied. A luminous flux of less than 10^{-5} lm is sufficient to cause the maximum permissible anode current to be exceeded. To obtain maximum life from the photocathode, the tube should be protected from light as far as possible even when not in use.

After the application of supply voltage, the dark current takes approximately 15 to 30 minutes to fall to a stable value. For this reason it is recommended that the equipment be switched on half an hour before making any measurements requiring a high degree of accuracy.
The dark current may be further reduced by cooling the photocathode.

It is very important to ensure that no condensation occurs on the base or socket of the tube if air cooling is adopted.

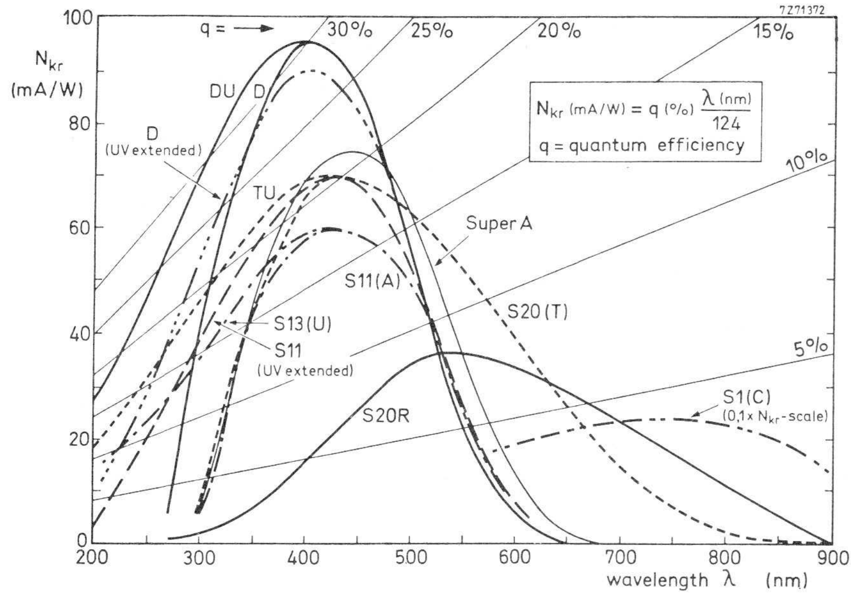


Fig. 1 Typical spectral sensitivity characteristics

The specific curve for each tube type is given in the data sheets.

RATING SYSTEM

As defined by IEC Publication 134

ABSOLUTE MAXIMUM RATING SYSTEM

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

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 variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

10-STAGE PHOTOMULTIPLIER TUBE

The PM1910 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S11 (type A) photocathode. The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements, etc.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S11 (type A)
Useful diameter of the photocathode	> 14 mm
Cathode spectral sensitivity at 437 nm	60 mA/W
Supply voltage for anode spectral sensitivity = 60 kA/W	1400 V
Anode pulse rise time	≈ 2,5 ns
Linearity	
with voltage divider A (Fig. 2)	≈ 30 mA
with voltage divider B (Fig. 3)	≈ 80 mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-concave
Refractive index at 550 nm	1,52

Photocathode

Semi-transparent, head-on	
Material	Sb – Cs
Useful diameter	> 14 mm
Spectral sensitivity characteristic (Fig. 5)	S11 (type A)
Maximum spectral sensitivity at	420 ± 30 nm
Spectral sensitivity at 437 ± 5nm (Fig. 5)	typ. 60 mA/W > 40 mA/W

Data based on pre-production tubes.

Multiplier system

Number of stages	10
Dynode structure	linear focused
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 2 pF
anode to all	≈ 4 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of: 0,3 mT perpendicular to axis a; 0,2 mT parallel to axis a; see Fig. 1.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding 15 mm beyond the photocathode.

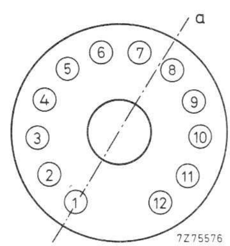


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

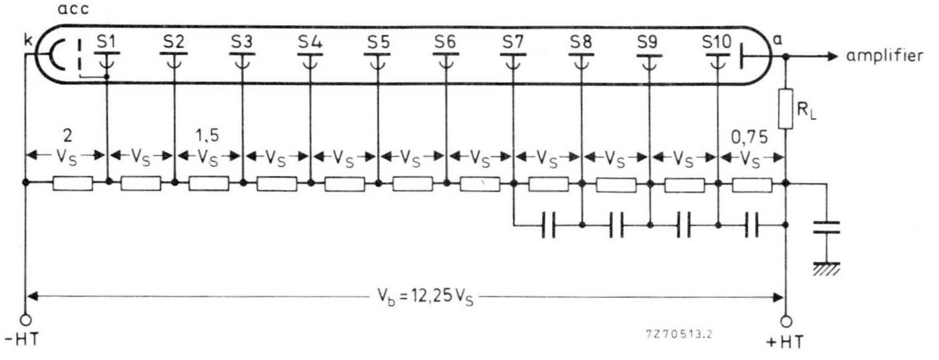


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

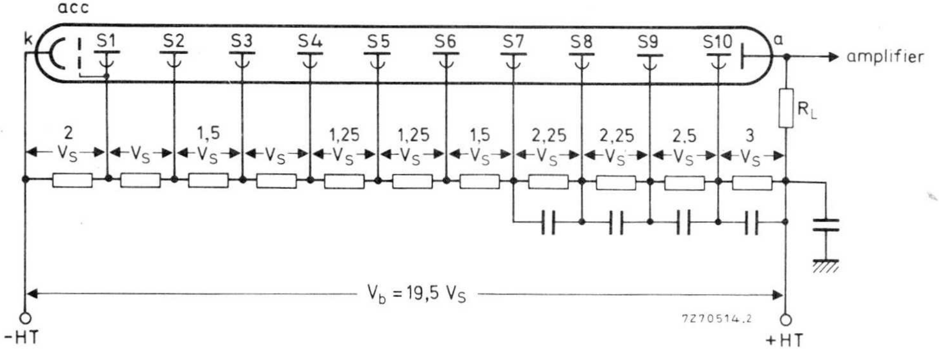


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

	note		
With voltage divider A (Fig. 2)	1		
Supply voltage for an anode spectral sensitivity N_{ar} = 60 kA/W at 437 nm (Fig. 7)		< typ.	1700 V 1400 V
Anode dark current at N_{ar} = 60 kA/W (Fig. 7)	2,3	< typ.	20 nA 2 nA
Pulse amplitude resolution for ^{137}Cs at N_{ar} = 12 kA/W	4	≈	7,6 %
Anode current linear within 2% at V_b = 1600 V		up to ≈	30 mA
With voltage divider B (Fig. 3)	1		
Anode spectral sensitivity at V_b = 1700 V (Fig. 7)		≈	40 kA/W
Anode pulse rise time at V_b = 1700 V	5	≈	2,5 ns
Anode pulse duration at half height at V_b = 1700 V	5	≈	4 ns
Signal transit time at V_b = 1700 V	5	≈	23 ns
Anode current linear within 2% at V_b = 1700 V		up to ≈	80 mA

LIMITING VALUES (absolute maximum rating system)

	note		
Supply voltage	6	max.	1900 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	7	max. min.	350 V 100 V
Voltage between consecutive dynodes		max.	250 V
Voltage between anode and final dynode	8	max. min.	300 V 30 V
Ambient temperature range operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

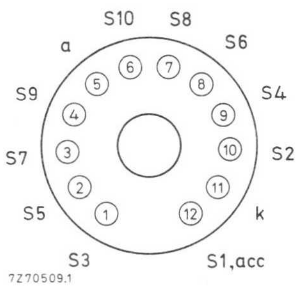
Notes see page 5.

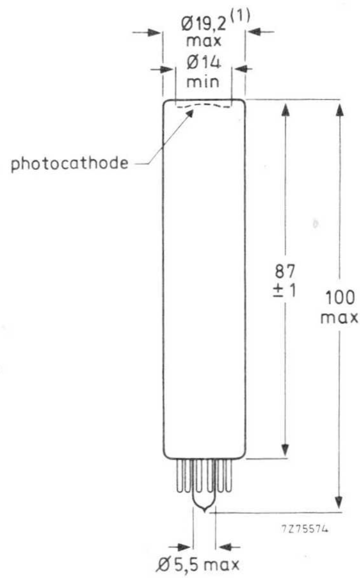
Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ ohm.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$¼ h).
4. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 1118 or equivalent) with a diameter of 12 mm and a height of 12 mm. The count rate used is $\approx 10^4$ c/s.
5. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of $\approx$ 600 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm





(1) The tube can be inserted into a cylindrical gauge of $19,3^{+0,1}_{-0}$ mm diameter and a length of 90 ± 1 mm.

Fig. 4.

Base	12-pin all glass
Net mass	21 g

ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56134

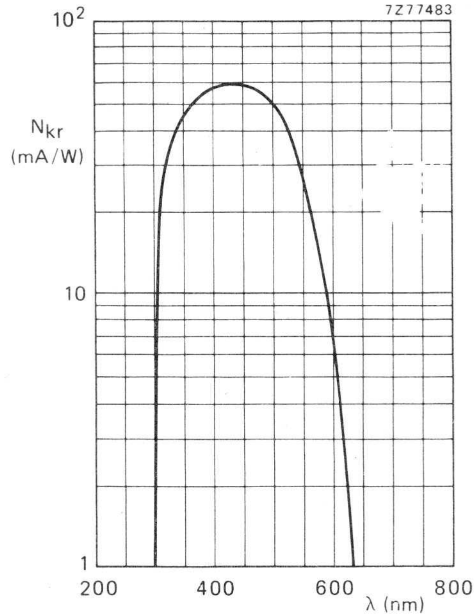


Fig. 5 Spectral sensitivity characteristic.

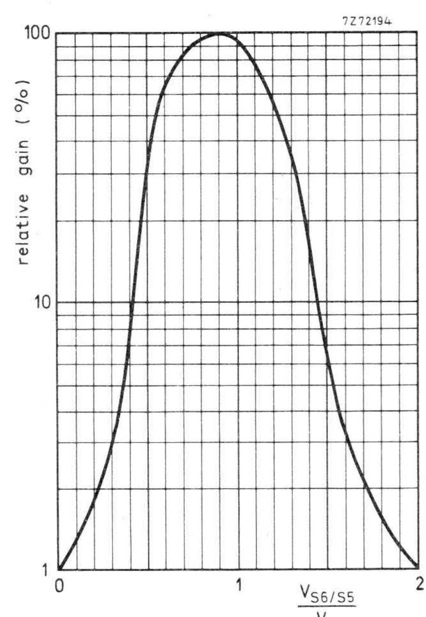


Fig. 6 Relative gain as a function of the voltage between S_6 and S_5, normalized to V_S. $V_{S7/S5}$ constant.

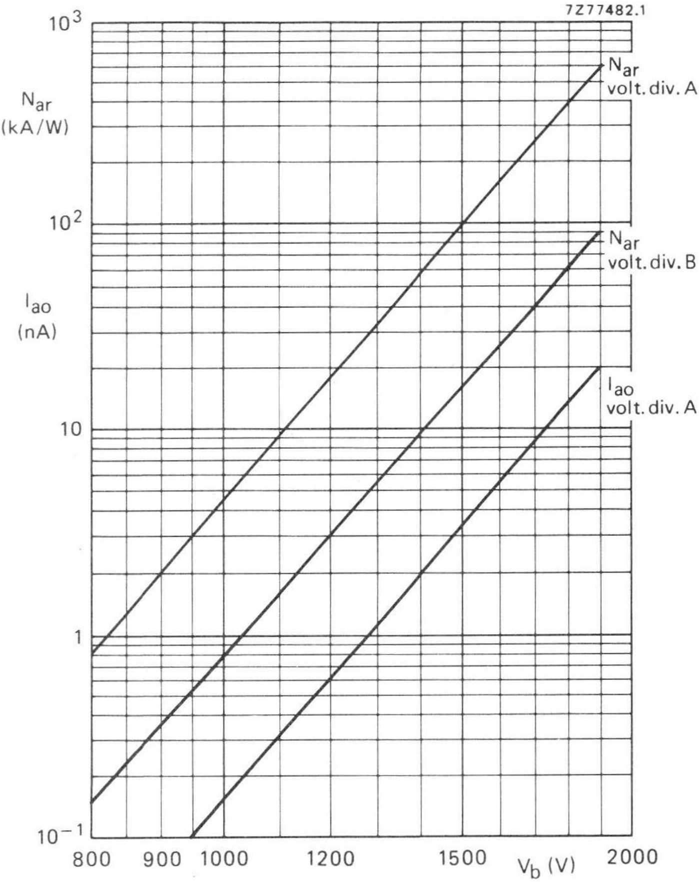


Fig. 7 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM1918 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S13 (type U) photocathode. The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements, etc.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S13 (type U)
Useful diameter of the photocathode	> 14 mm
Cathode spectral sensitivity at 437 nm	60 mA/W
Supply voltage for an anode spectral sensitivity = 60 kA/W at 437 nm	1400 V
Anode pulse rise time	≈ 2,7 ns
Linearity with voltage divider A with voltage divider B	 ≈ 30 mA ≈ 80 mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	fused silica
Shape	plano-plano
Refractive index at 250 nm at 400 nm	 1,50 1,47

Photocathode

Semi-transparent head-on	
Material	Sb-Cs
Useful diameter	> 14 mm
Spectral sensitivity characteristic (Fig. 5)	S13 (type U)
Maximum spectral sensitivity at	420 ± 30 nm
Luminous sensitivity	≈ 60 μA/lm
Spectral sensitivity at 437 ± 5 nm (Fig. 5)	typ. 60 mA/W > 40 mA/W

Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	2 pF
anode to all	≈	4 pF

Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of : 0,3 mT perpendicular to axis a; 0,2 mT parallel to axis a, see Fig. 1.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding 15 mm beyond the photocathode.

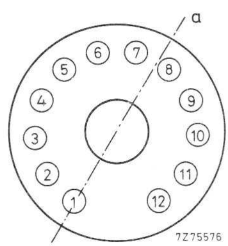


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

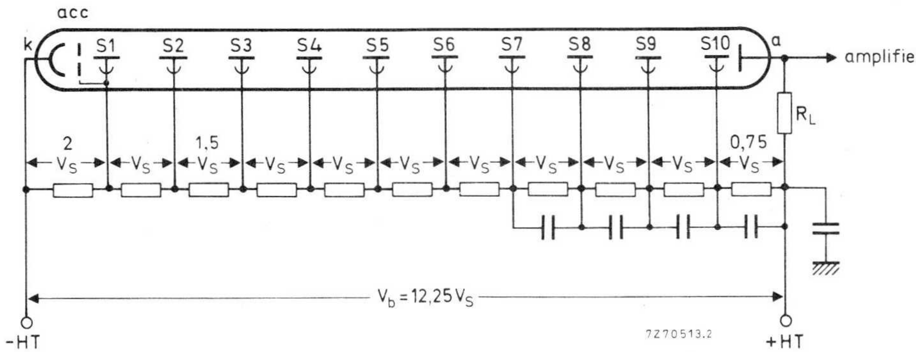


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

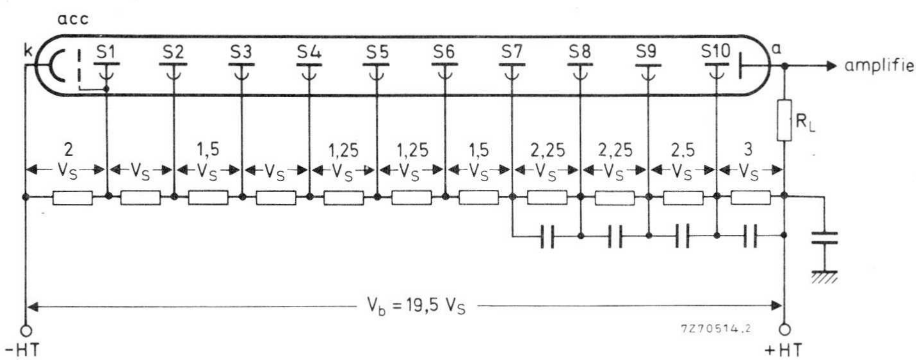


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

	note		
With voltage divider A (Fig. 2)	1		
Supply voltage for an anode spectral sensitivity N_{ar} = 60 kA/W at 437 nm (Fig. 7)		< typ.	1700 V 1400 V
Anode dark current at N_{ar} = 60 kA/W (Fig. 7)	2,3	< typ.	20 nA 2 nA
Anode current linear within 2% at V_b = 1600 V		up to ≈	30 mA
With voltage divider B (Fig. 3)	1		
Anode spectral sensitivity at V_b = 1700 V (Fig. 7)		≈	40 kA/W
Anode pulse rise time at V_b = 1700 V	4	≈	2,7 ns
Anode pulse duration at half height at V_b = 1700 V	4	≈	4,5 ns
Signal transit time at V_b = 1700 V	4	≈	25 ns
Anode current linear within 2% at V_b = 1700 V		up to ≈	80 mA

LIMITING VALUES (absolute maximum rating system)

Supply voltage	5	max.	1900 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	6	max. min.	350 V 100 V
Voltage between consecutive dynodes		max.	250 V
Voltage between anode and final dynode	7	max. min.	300 V 30 V
Ambient temperature range			
operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $>10^{15}$ ohm.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈¼ h).
4. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
5. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of ≈ 600 kA/W, whichever is lower.
6. Minimum value to obtain good collection in the input optics.
7. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm

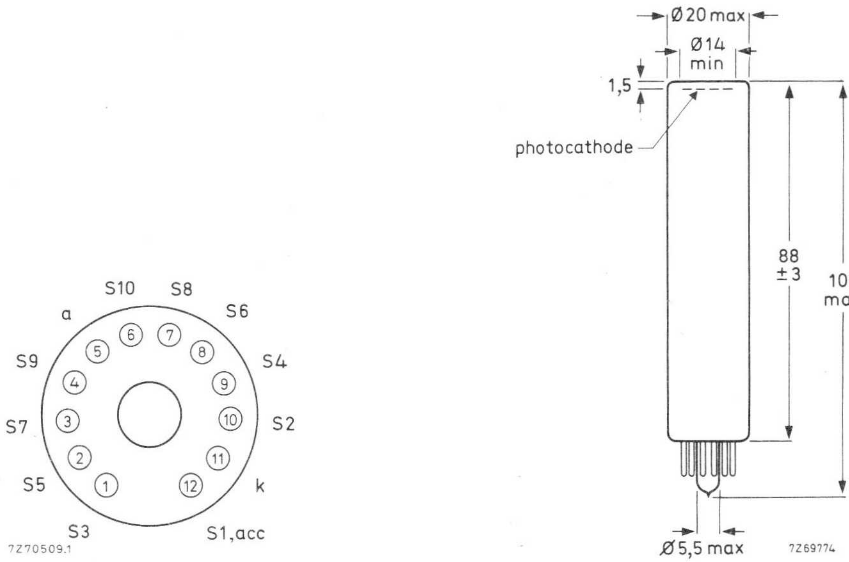


Fig. 4.

Base	12-pin all-glass
Net mass	20 g

ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56134

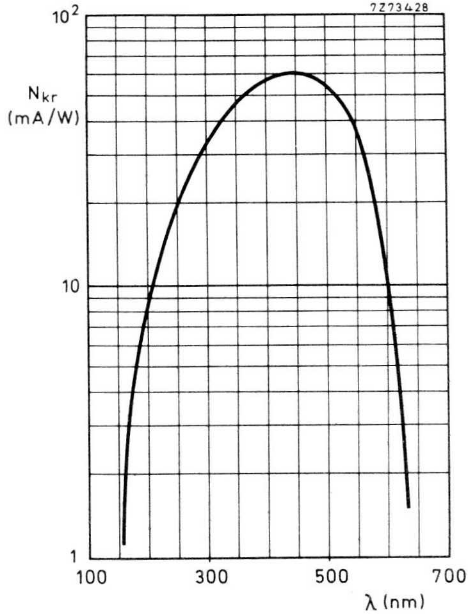


Fig. 5 Spectral sensitivity characteristic.

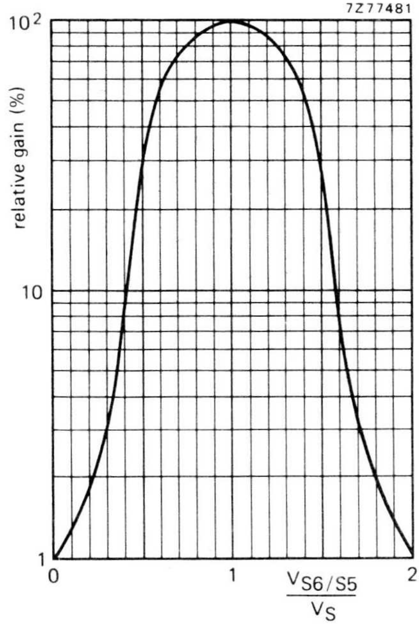


Fig. 6 Relative gain as a function of the voltage between S6 and S5, normalized to V_S.
$V_{S7/S6}$ constant.

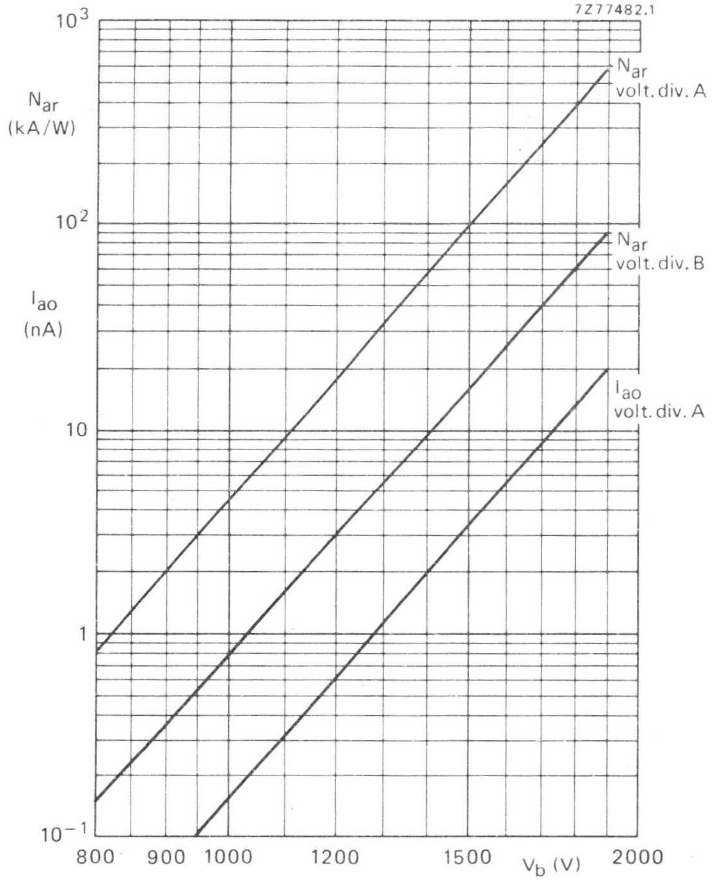


Fig. 7 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

6-STAGE PHOTOMULTIPLIER TUBE

The PM1920 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S11 (type A) photocathode. The tube is intended for use in optical measurements with relatively high luminous fluxes where it offers a good sensitivity combined with a wide bandwidth and a good signal to noise ratio. Its construction makes it particularly suitable for industrial applications under limited dimensional conditions.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		S11 (type A)
Useful diameter of the photocathode	>	14 mm
Cathode spectral sensitivity at 437 nm		60 mA/W
Supply voltage for an anode spectral sensitivity = 0,2 kA/W		700 V
Anode pulse rise time (with voltage divider B)	≈	2 ns
Linearity		
with voltage divider A	up to ≈	30 mA
with voltage divider B	up to ≈	80 mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material		lime glass
Shape		plano-concave
Refractive index at 550 nm		1,52

Photocathode

Semi-transparent, head-on		
Material		Sb-Cs
Useful diameter	>	14 mm
Spectral sensitivity characteristic (Fig. 5)		S11 (type A)
Maximum spectral sensitivity at		420 ± 30 nm
Luminous sensitivity	≈	60 μA/lm
Spectral sensitivity at 437 ± 5 nm	typ.	60 mA/W
	>	40 mA/W

Multiplier system

Number of stages		6
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	2 pF
anode to all	≈	4 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux of:

0,3 mT perpendicular to axis a,

0,2 mT parallel to axis a; see Fig. 1.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding 15 mm beyond the photocathode.

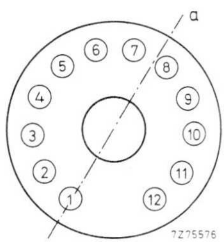


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

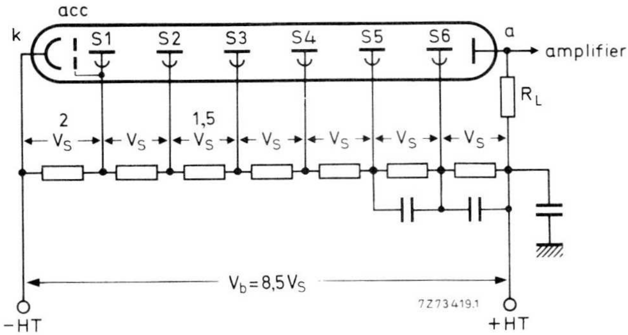


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

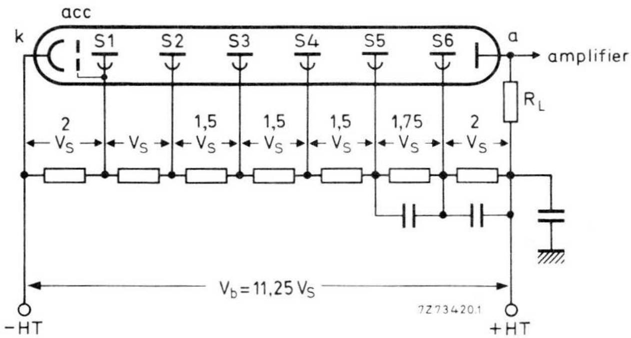


Fig. 3 Voltage divider B. Typical value of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

	note		
With voltage divider A (Fig. 2)	1		
Supply voltage for anode spectral sensitivity N_{ar} = 0,2 kA/W (Fig. 6)		<	1200 V
		typ.	700 V
Anode dark current at N_{ar} = 0,2 kA/W (Fig. 6)	2,3	<	5 nA
		typ.	0,5 nA
Anode current linear within 2% at V_b = 1100 V		up to ≈	30 mA
With voltage divider B (Fig. 3)	1		
Anode spectral sensitivity at V_b = 1200 V (Fig. 6)		≈	0,5 kA/W
Anode pulse rise time at V_b = 1200 V	4	≈	2 ns
Anode pulse duration at half height at V_b = 1200 V	4	≈	3,2 ns
Signal transit time at V_b = 1200 V	4	≈	16 ns
Anode current linear within 2% at V_b = 1200 V		up to ≈	80 mA

LIMITING VALUES (absolute maximum rating system)

	note		
Supply voltage		max.	1300 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	5	max.	350 V
		min.	100 V
Voltage between anode and final dynode	6	max.	300 V
		min.	30 V
Voltage between consecutive dynodes		max.	250 V
Ambient temperature range			
operational (for short periods of time)		max.	+80 °C
		min.	−30 °C
continuous operation and storage		max.	+50 °C
		min.	−30 °C

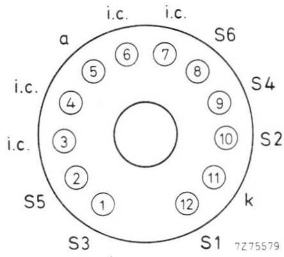
Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $>10^{15}$ ohm.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$¼ h).
4. Measured with a pulsed light source, with a pulse duration (FWHM) of $<$ 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
5. Minimum value to obtain good collection in the input optics.
6. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm



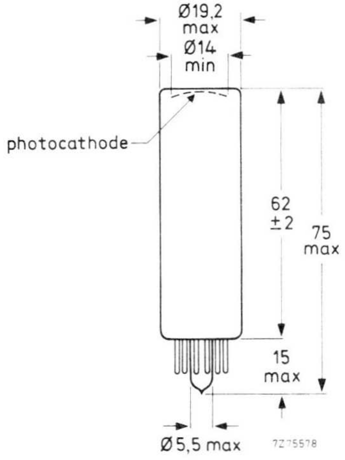


Fig. 4.

Base	12-pin all glass
Net mass	16 g

ACCESSORIES

Socket	FE 1004
Mu-metal shield	type 56134

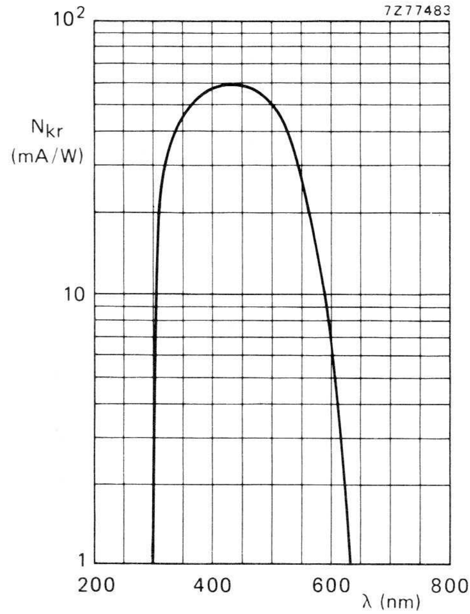


Fig. 5 Spectral sensitivity characteristic.

DEVELOPMENT SAMPLE DATA

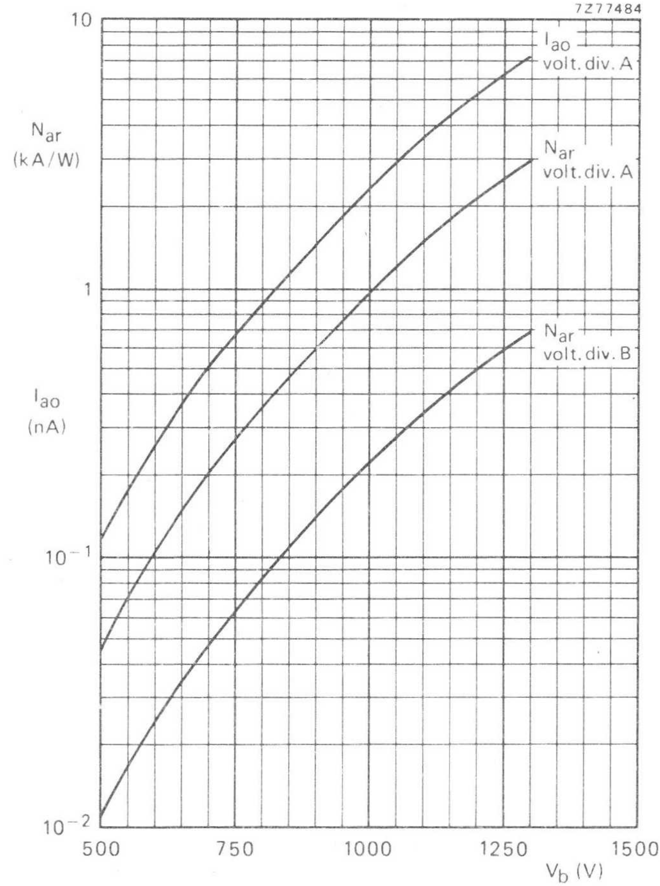


Fig. 6 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM1980 is a 23 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparant S11 (type A) photocathode. The tube is intended for use in applications such as high energy physics, scintillation counting and laboratory and industrial photometry.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		S11 (type A)	
Useful diameter of the photocathode	>	23	mm
Cathode spectral sensitivity at 437 nm		70	mA/W
Supply voltage for an anode spectral sensitivity of 60 kA/W at 437 nm		1400	V
Anode pulse rise time	≈	2,5	ns
Pulse amplitude resolution for ^{137}Cs	≈	7,6	%
Linearity			
with voltage divider A	≈	30	mA
with voltage divider B	≈	80	mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime glass		
Shape	plano-concave		
Refractive index at 550 nm		1,52	

Photocathode

Semi-transparent, head-on

Material	Sb-Cs		
Useful diameter	>	23	mm
Spectral sensitivity characteristic (Fig. 5)	S11 (type A)		
Maximum sensitivity at		420 ± 30	nm
Luminous sensitivity		75	μA/lm
Spectral sensitivity at 437 ± 5 nm (Fig. 5)	typ.	70	mA/W
	>	40	mA/W

Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	2 pF
anode to all	≈	4 pF

Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of:
0,15 mT perpendicular to axis a;
0,1 mT parallel to axis a (see Fig. 1).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding 15 mm beyond the photocathode.

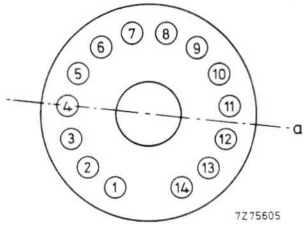


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

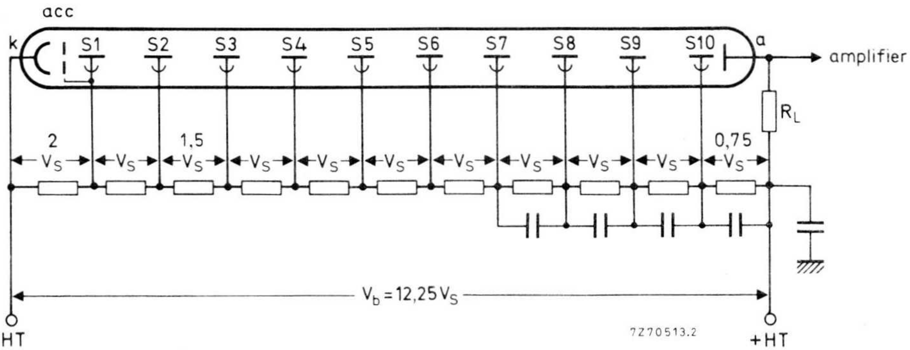


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

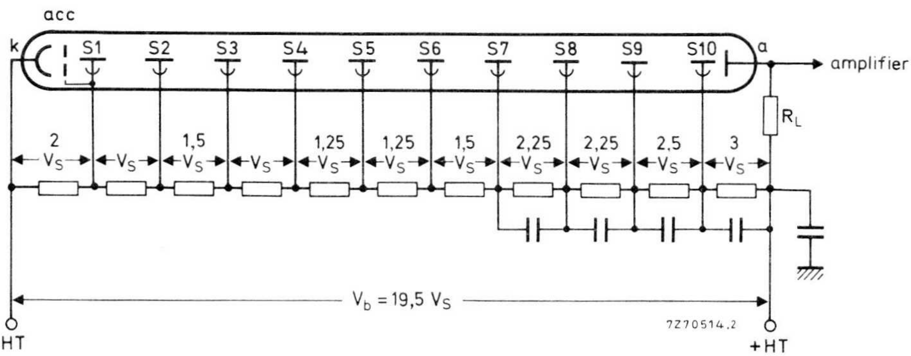


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS*

	notes		
With voltage divider A (Fig. 2)	1		
Supply voltage for an anode spectral sensitivity of 60 kA/W (Fig. 7)		< typ.	1700 V 1400 V
Anode dark current at 60 kA/W (Fig. 7)	2,3	< typ.	20 nA 2 nA
Pulse amplitude resolution for ^{137}Cs at 12 kA/W	4	≈	7,6 %
Anode current linear within 2% at V_b = 1600 V	up to	≈	30 mA
With voltage divider B (Fig. 3)	1		
Anode spectral sensitivity at V_b = 1700 V (Fig. 7)	5	≈	40 kA/W
Anode pulse rise time at V_b = 1700 V	5	≈	2,5 ns
Anode pulse duration at half height at V_b = 1700 V	5	≈	3,5 ns
Signal transit time at V_b = 1700 V	5	≈	24 ns
Anode current linear within 2% at V_b = 1700 V	up to	≈	80 mA

LIMITING VALUES (Absolute maximum rating system)

	notes		
Supply voltage	6	max.	1900 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	7	max. min.	350 V 100 V
Voltage between consecutive dynodes		max.	250 V
Voltage between anode and final dynode	8	max. min.	300 V 30 V
Ambient temperature range			
operational (for short periods of time)		max. min.	+ 80 °C −30 °C
storage and continuous operation		max. min.	+ 50 °C −30 °C

* All spectral sensitivities refer to a wavelength of 437 nm.

Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A it is necessary to increase the inter dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization of the tube in darkness ($\approx$ ¼ h).
4. Pulse amplitude resolution for ^{137}Cs is measured with a NaI(Tl) cylindrical scintillator (Quartz et Silice ser.no.1162 or equivalent) with a diameter of 22 mm and a height of 6 mm. The count rate used is $\approx 10^4$ c/s.
5. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm

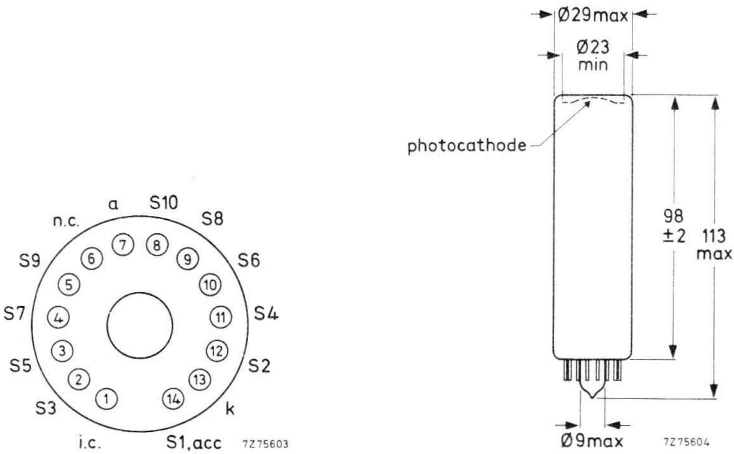


Fig. 4.

Base	14-pin all-glass
Net mass	36 g

ACCESSORIES

Socket	type FE1114
Mu-metal shield	type 56127

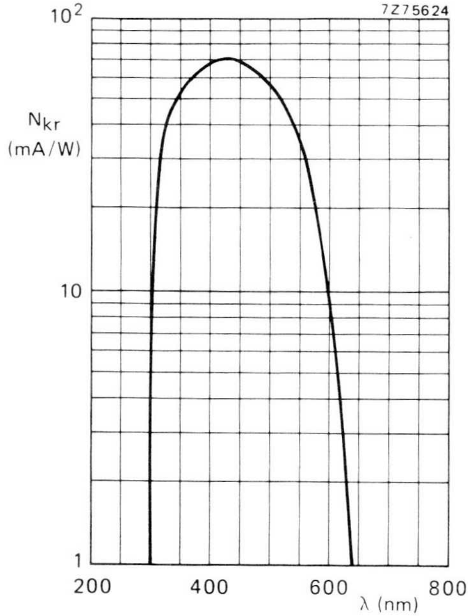


Fig. 5 Spectral sensitivity characteristic.

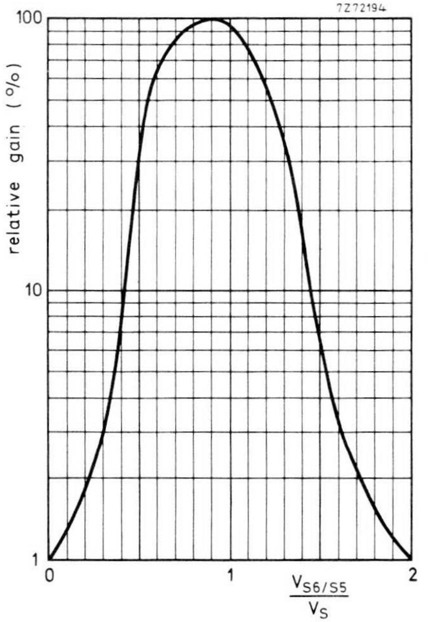


Fig. 6 Relative gain as a function of the voltage between S_6 and S_5, normalized to V_S. $V_{S7/S5}$ constant.

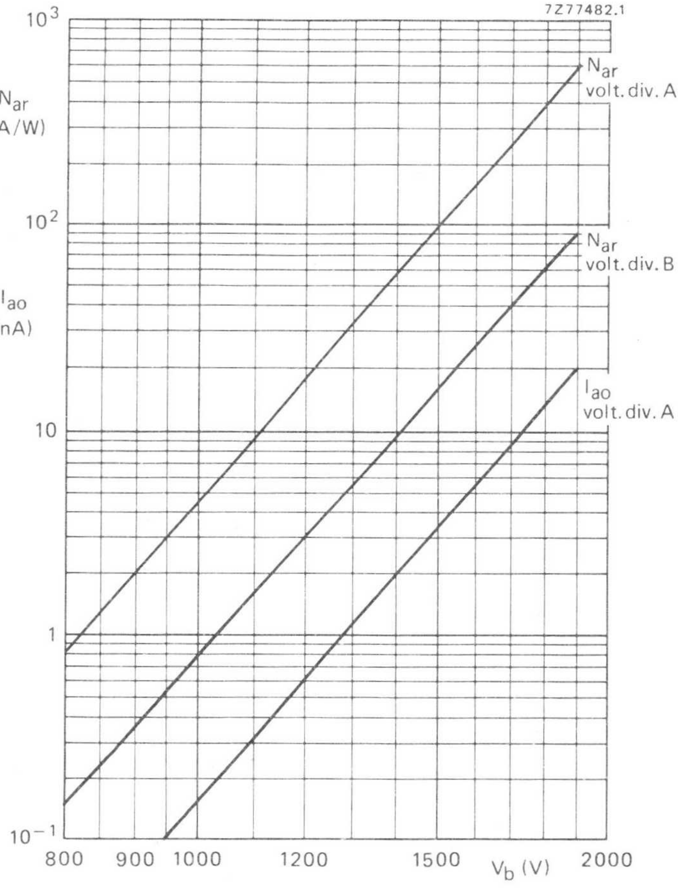


Fig. 7 Anode luminous sensitivity N_a, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM2012B is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in X-ray and γ-spectrometry and for all applications requiring a low background noise and/or dark current. Its Cu-Be dynode system offers a high stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode at 401 nm			77	mA/W
Supply voltage for an anode spectral sensitivity = 60 kA/W			1350	V
Pulse amplitude resolution for ^{57}Co at N_a = 10 kA/W		≈	11,2	%
for ^{55}Fe at N_a = 60 kA/W		≈	42	%
Peak-to-valley ratio for ^{55}Fe at N_a = 60 kA/W		≈	34	
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Mean anode sensitivity deviation		≈	1	%
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	200	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Shape	plano-plano		
Material	lime glass		
Refractive index at 550 nm		1,52	

Photocathode (note 1)

Semi-transparent, head-on	Sb-K-Cs		
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig.3)	type D		
Maximum sensitivity at		400 ± 30	nm
Spectral sensitivity at 401 ± 3 nm	typ	77	mA/W
	>	60	mA/W

Electron optical input system

This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

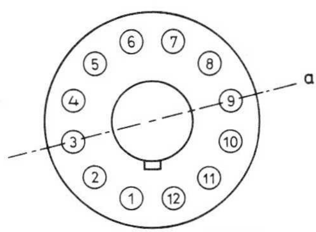
Multiplier system

Number of stages		10
Dynode structure	linear focused	
Dynode material	Cu-Be	
Capacitances		
Anode to all	≈	5 pF
Anode to final dynode	≈	3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):
- at a magnetic flux density of 0,6 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,35 mT perpendicular to axis a (see Fig. below);
- at a magnetic flux density of 0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

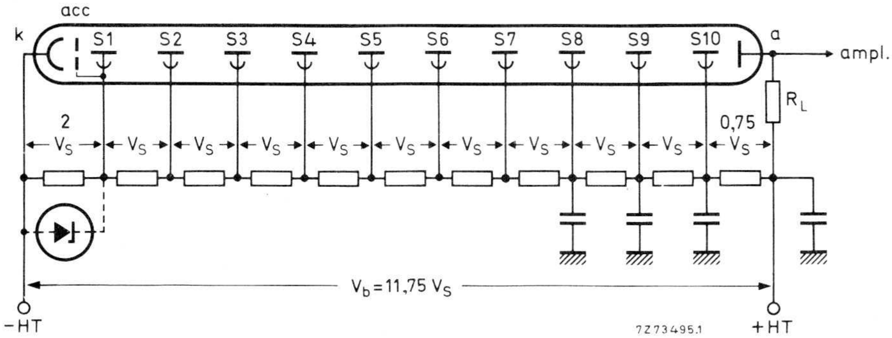


Fig. 1 Voltage divider A (note 6).

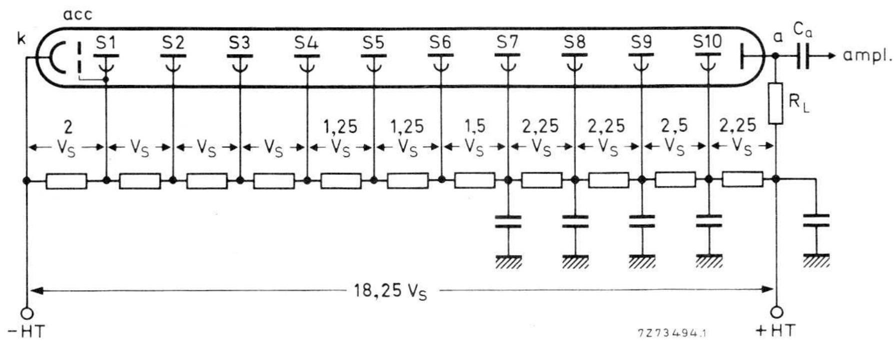


Fig.2 Voltage divider B.

k = cathode

acc = accelerating electrode

S_n = dynode no.n

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

	note			
With voltage divider A (Fig.1)	2			
Supply voltage for an anode spectral sensitivity of 60 kA/W at 401 ± 3 nm (Fig.5)			<	1600 V
			typ	1350 V
for an anode spectral sensitivity of 300 kA/W at 401 ± 3 nm (Fig.5)			≈	1650 V
Anode dark current at an anode spectral sensitivity of 60 kA/W	3,4		<	20 nA
			typ	1 nA
Pulse amplitude resolution for ^{137}Cs at N_a = 10 kA/W	5,6		≈	7,2 %
Pulse amplitude resolution for ^{57}Co at N_a = 10 kA/W	5,6		≈	11,2 %
Pulse amplitude resolution for ^{55}Fe at N_a = 60 kA/W	6,7		≈	42 %
Peak-to-valley ratio for ^{55}Fe at N_a = 60 kA/W	6,7		≈	34
Anode current linear within 2% at V_b = 1700 V		up to	≈	100 mA
Mean anode sensitivity deviation	6,13			
long term (16 h)			≈	1 %
after change of count rate			≈	1 %
With voltage divider B (Fig.2)	2			
Anode spectral sensitivity at V_b = 1700 V (Fig.5)			≈	50 kA/W
Anode pulse rise time at V_b = 1700 V	8		≈	2,5 ns
Anode pulse duration at half-height at V_b = 1700 V	8		≈	6 ns
Signal transit time at V_b = 1700 V	8		≈	26 ns
Anode current linear within 2% at V_b = 1700 V		up to	≈	200 mA

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	9	max	1800 V
Continuous anode current		max	0,2 mA
Voltage between first dynode and photocathode	10	max	500 V
		min	150 V
Voltage between consecutive dynodes		max	300 V
Voltage between anode and final dynode	11	max	300 V
		min	30 V
Ambient temperature range			
Operational (for short periods of time)	12	max	+80 °C
		min	−30 °C
Continuous operation and storage		max	+50 °C
		min	−30 °C

Notes see page 5.

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at $-30\ ^oC$. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.

2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

3. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ 1/4 h).

5. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^3$ c/s.

6. For optimum peak amplitude resolution it is recommended that the voltage between the first dynode and the photocathode be maintained at $\approx$ 200 V, e.g. by means of a voltage regulator diode.

7. Pulse amplitude resolution for ^{55}Fe is measured with an NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s, see also note 6.

8. Measured with a pulsed-light source, with a pulse duration (FWHM) of $<$ 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

9. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.

10. Minimum value to obtain good collection in the input optics.

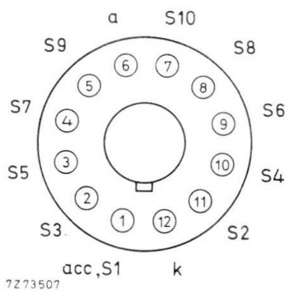
11. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

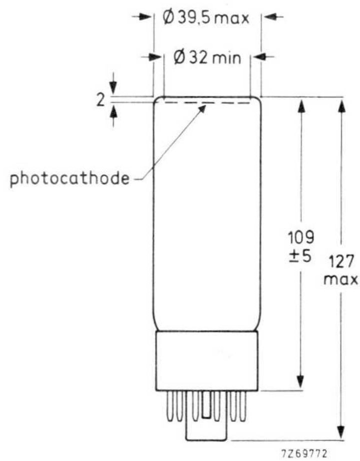
12. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.

13. The mean pulse amplitude deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an anode current of $\approx$ 300 nA.
    Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an anode current of $\approx$ 300 nA and $\approx$ 30 nA respectively. See also note 6.
    Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.

MECHANICAL DATA

Dimensions in mm





Net mass:	80 g
Base:	12-pin (JEDEC B12--43)

ACCESSORIES

Socket:	type FE1012
Mu-metal shield:	type 56127

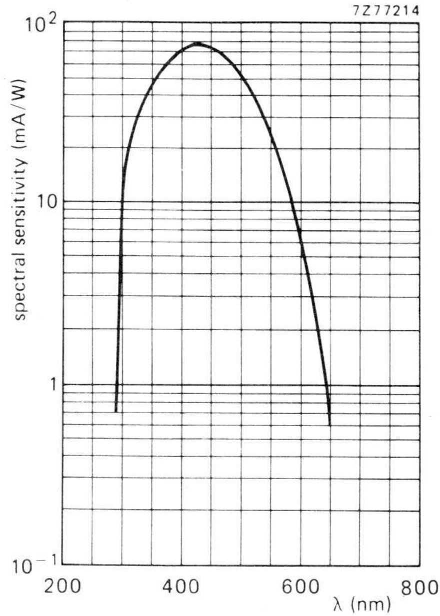


Fig.3
Spectral sensitivity characteristic.

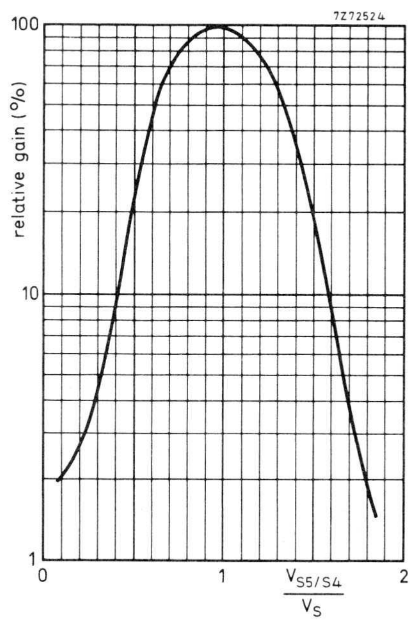


Fig.4
Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S, $V_{S6/S4}$ constant.

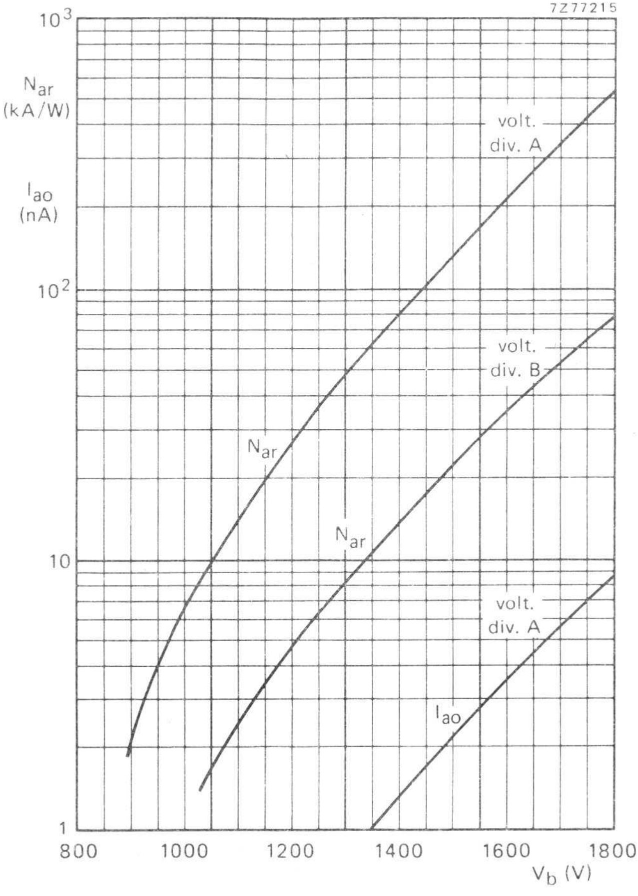


Fig.5
Anode spectral sensitivity, N_{ar}, and anode dark current, I_{ao}, as a function of supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM2013B is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent trialkaline S20 (type T) photocathode. The tube is intended for use in low light level measurements in the entire part of the visible spectrum. Its Cu-Be dynode multiplier system offers a high stability which makes it especially suitable for industrial applications, such as laser reading.

QUICK REFERENCE DATA

Spectral sensitivity characteristic			S20 (type T)
Useful diameter of the photocathode		>	32 mm
Cathode spectral sensitivity at 698 nm			20 mA/W
Supply voltage for an anode luminous sensitivity of 60 A/lm			1250 V
Anode pulse rise time (with voltage divider B)		≈	2,5 ns
Linearity with voltage divider A	up to	≈	100 mA
Linearity with voltage divider B	up to	≈	200 mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window (frosted)

Material	borosilicate
Shape	plano-plano
Refractive index at 550 nm	1,48

Photocathode

Semi-transparent, head-on	
Material	Sb-Na-K-Cs
Useful diameter	> 32 mm
Spectral sensitivity characteristic (Fig. 5)	S20 (type T)
Maximum spectral sensitivity at	420 ± 30 nm

Data based on pre-production tubes.

Photocathode (continued)

Luminous sensitivity	≈	200 μA/lm
Spectral sensitivity		
at 698 ± 7 nm	typ.	20 mA/W
	>	10 mA/W
at 629 ± 3 nm	≈	40 mA/W

Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	3 pF
anode to all	≈	5 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of:
0,6 mT in the direction of the longitudinal axis;
0,35 mT perpendicular to axis a (see Fig. 1);
0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

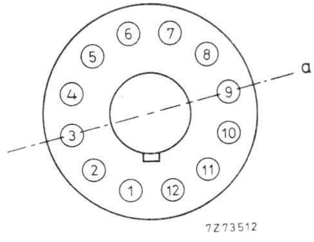


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

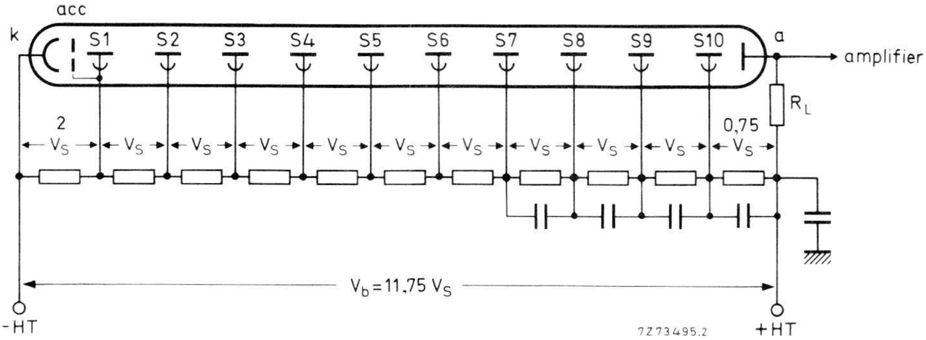


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

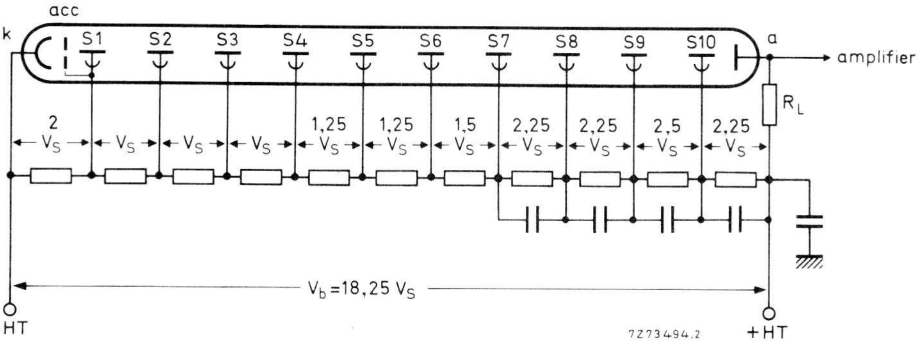


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

	note			
With voltage divider A (Fig. 2)	1			
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 7)		typ.	1250	V
		<	1600	V
Anode dark current at N_a = 60 A/lm (Fig. 7)	2,3	typ.	2	nA
		<	50	nA
Anode current linear within 2% at V_b = 1700 V up to		≈	100	mA
Mean anode sensitivity deviation at V_b = 1000 V long term (16 h)	4	≈	1	%
With voltage divider B (Fig. 3)	1			
Anode luminous sensitivity at V_b = 1700 V (Fig. 7)		≈	90	A/lm
Anode pulse rise time at V_b = 1700 V	5	≈	2,5	ns
Anode pulse duration at half height at V_b = 1700 V	5	≈	6	ns
Signal transit time at V_b = 1700 V	5	≈	26	ns
Anode current linear within 2% at V_b = 1700 V up to		≈	200	mA

LIMITING VALUES (absolute maximum rating system)

	note			
Supply voltage	6	max.	1800	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	7	max.	500	V
		min.	150	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	8	max.	300	V
		min.	30	V
Ambient temperature range	9			
operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
continuous operation and storage		max.	+50	°C
		min.	−30	°C

Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ ohm.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$¼ h).
4. The mean anode sensitivity deviation measurement is carried out with light pulses at a count rate of $\approx 10^4$ c/s, resulting in an average anode current of 0,3 μA. See also *General Operational Recommendations Photomultiplier Tubes.*
5. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode luminous sensitivity of $\approx$ 600 A/lm, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
9. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb.

MECHANICAL DATA

Dimensions in mm

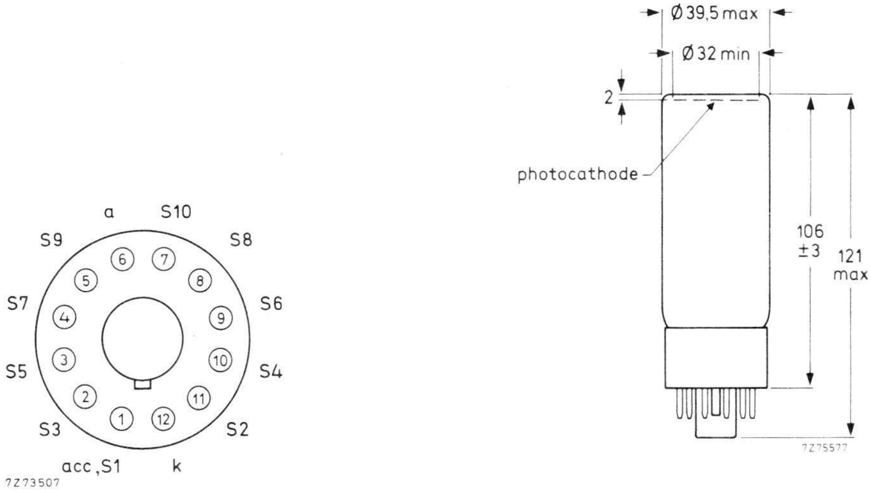


Fig. 4.

Remark

In order to improve the anode sensitivity over the entire cathode area the external surface of the window has been frosted.

Base	12-pin (JEDEC B12-43)
Net mass	81 g

ACCESSORIES

Socket	type FE1012
Mu-metal shield	type 56127

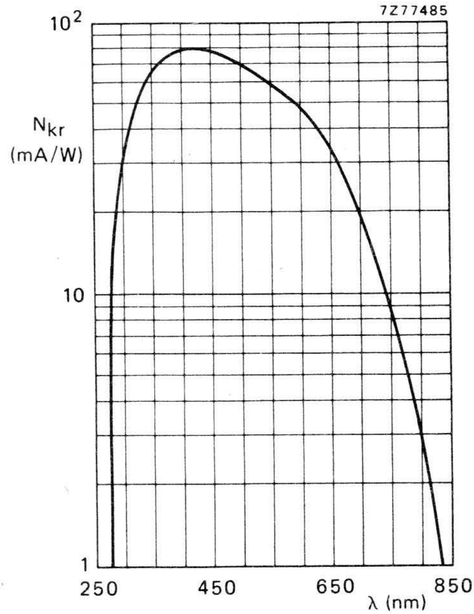


Fig. 5 Spectral sensitivity characteristic.

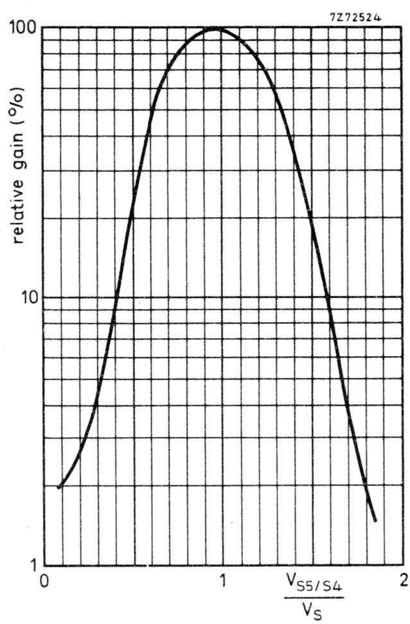


Fig. 6 Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S. $V_{S6/S4}$ constant.

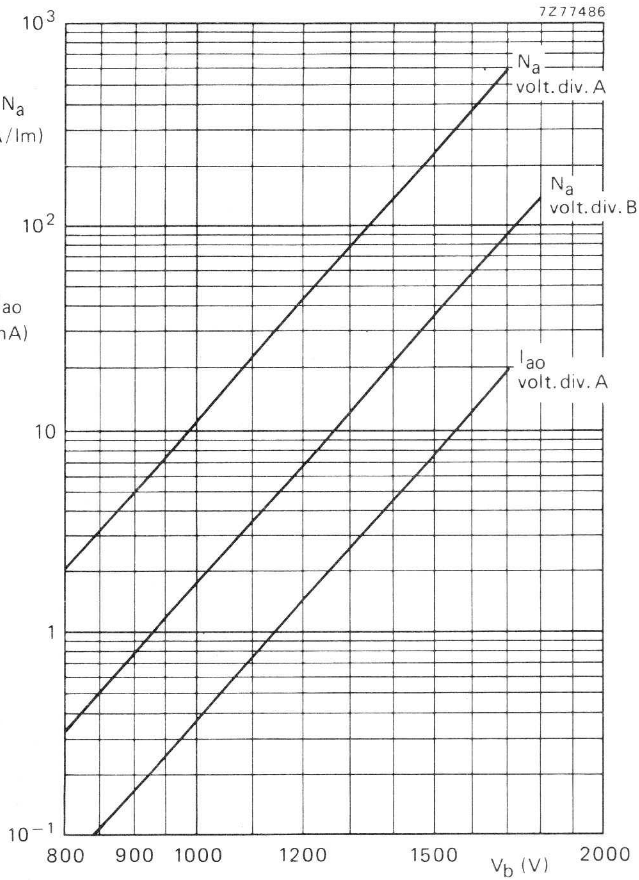


Fig. 7 Anode luminous sensitivity N_a, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM2018 B is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S13 (type U) photocathode. The tube is intended for use in applications where a high sensitivity in the ultraviolet region of the spectrum is required, such as spectrophotometry.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		S13 (type U)
Useful diameter of the photocathode	>	32 mm
Cathode spectral sensitivity at 437 nm		75 mA/W
Supply voltage		
for an anode spectral sensitivity of 60 kA/W at 437 nm		1350 V
Anode pulse rise time (with voltage divider B)	≈	2,5 ns
Linearity		
with voltage divider A	up to ≈	100 mA
with voltage divider B	up to ≈	200 mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material		fused silica
Shape		plano-plano
Refractive index		
at 250 nm		1,50
at 400 nm		1,47

Photocathode

Semi-transparent, head-on		
Material		Sb-Cs
Useful diameter	>	32 mm
Spectral sensitivity characteristic (Fig. 5)		S13 (type U)
Maximum spectral sensitivity at		400 ± 30 nm
Spectral sensitivity at 437 ± 5 nm	typ.	75 mA/W
	>	40 mA/W
Luminous sensitivity	≈	85 μA/lm

Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	3 pF
anode to all	≈	5 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of:

0,6 mT in the direction of the longitudinal axis;
0,35 mT perpendicular to axis a (see Fig. 1);
0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

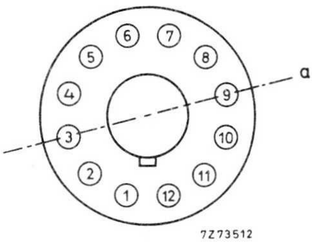


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

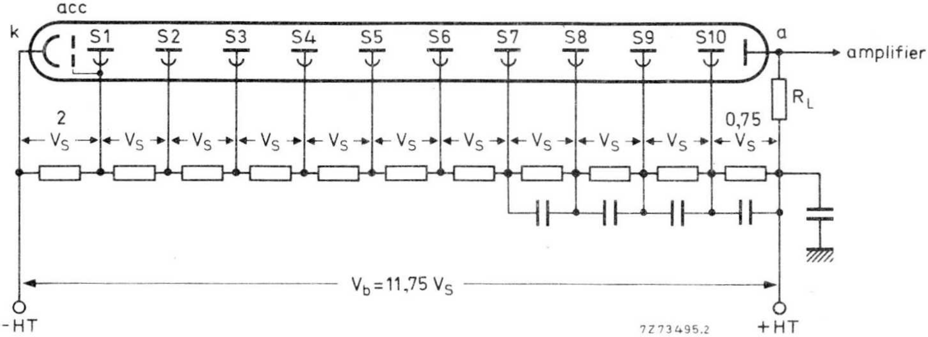


Fig. 2 Voltage divider A. Typical value of capacitors: 10 nF, k = cathode, acc = accelerating electrode, S_n = dynode no., a = anode, R_L = load resistor.

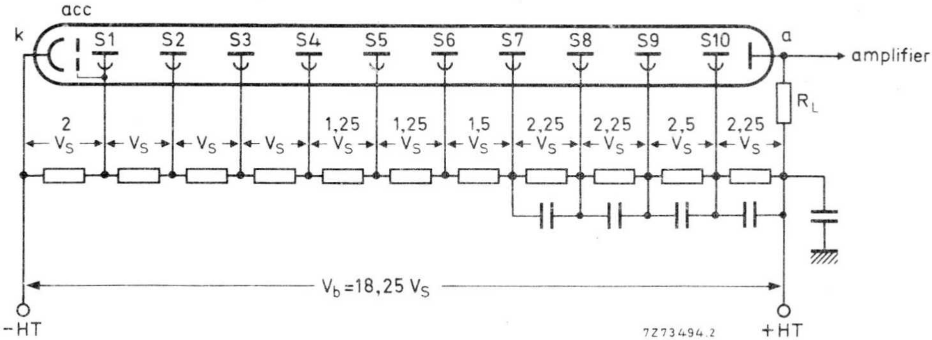


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF, k = cathode, acc = accelerating electrode, S_n = dynode no., a = anode, R_L = load resistor.

TYPICAL CHARACTERISTICS

	note		
With voltage divider A (Fig. 2)	1		
Supply voltage for an anode spectral sensitivity N_{ar} = 60 kA/W at 437 nm (Fig. 7)		< typ.	1600 V 1350 V
Anode dark current at an anode spectral sensitivity N_{ar} = 60 kA/W	2,3	< typ.	50 nA 5 nA
Anode current linear within 2% at V_b = 1700 V		up to ≈	100 mA
With voltage divider B (Fig. 3)	1		
Anode spectral sensitivity at V_b = 1700 V (Fig. 7)		≈	50 kA/W
Anode pulse rise time at V_b = 1700 V	4	≈	2,5 ns
Anode pulse duration at half-height at V_b = 1700 V	4	≈	6 ns
Signal transit time at V_b = 1700 V	4	≈	26 ns
Anode current linear within 2% at V_b = 1700 V		up to ≈	200 mA

LIMITING VALUES (absolute maximum rating system)

	note		
Supply voltage	5	max.	1800 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	6	max. min.	500 V 150 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	7	max. min.	300 V 30 V
Ambient temperature range			
operational (for short periods of time)	8	max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

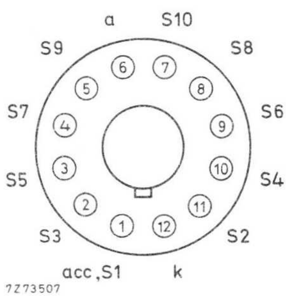
Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ 1/4 h).
4. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b{}^{-1/2}$.
5. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.
6. Minimum value to obtain good collection in the input optics.
7. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
8. This range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm



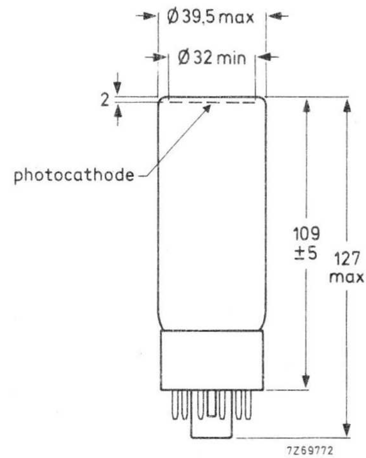


Fig. 4.

Base	12-pin (JEDEC B12–43)
Net mass	78 g

ACCESSORIES

Socket	type FE1012
Mu-metal shield	type 56127

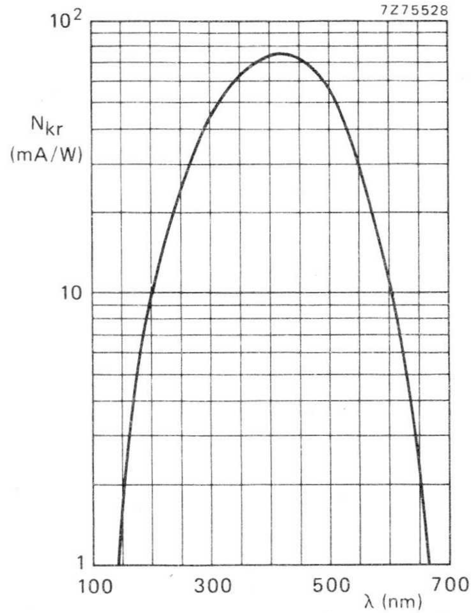


Fig. 5 Spectral sensitivity characteristic.

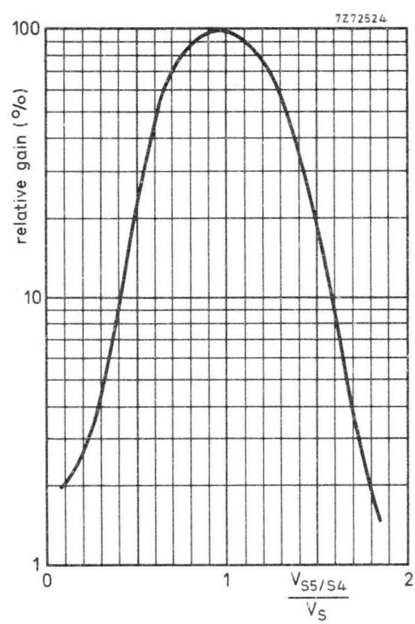


Fig. 6 Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S, $V_{S6/S4}$ constant.

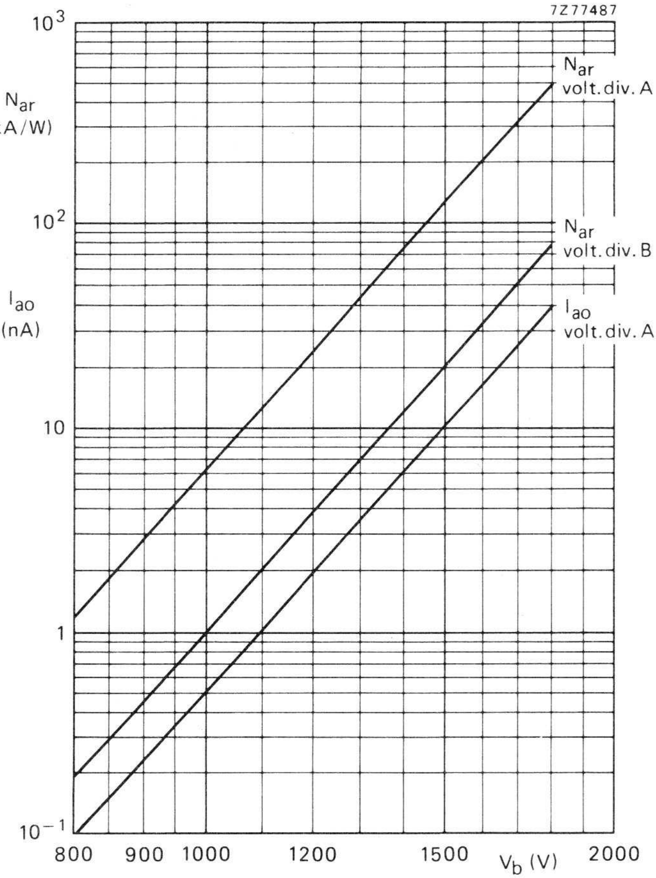


Fig. 7 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM2060B is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent Super A photocathode. The tube is intended for use in applications such as scintillation counting, laboratory and industrial photometry. Its Cu-Be dynode system offers a high stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		Super A
Useful diameter of the photocathode		> 32 mm
Spectral sensitivity of the photocathode at 437 nm		≈ 70 mA/W
Supply voltage for luminous sensitivity N_a = 60 A/lm		1180 V
Pulse amplitude resolution for ^{137}Cs		≈ 8 %
Mean anode sensitivity deviation		≈ 1 %
Anode pulse rise time (with voltage divider B)		≈ 2,5 ns
Linearity		
with voltage divider A	up to	≈ 100 mA
with voltage divider B	up to	≈ 200 mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Shape	plano-plano
Material	lime glass
Refractive index at 550 nm	1,52

Photocathode

Semi-transparent, head-on	
Material	Sb-Cs
Useful diameter	> 32 mm
Spectral sensitivity characteristic (Fig. 3)	type Super A
Maximum sensitivity at	420 ± 30 nm
Luminous sensitivity	typ 80 μA/lm
	> 40 μA/lm
Spectral sensitivity at 437 ± 5 nm	≈ 70 mA/W

Electron optical input system

This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

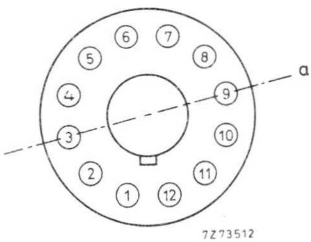
Multiplier system

Number of stages	10
Dynode structure	linear focused
Dynode material	Cu-Be
Capacitances	
Anode to all	≈ 5 pF
Anode to final dynode	≈ 3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):
- at a magnetic flux density of 0,6 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,35 mT perpendicular to axis a (see Fig. below);
- at a magnetic flux density of 0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a with respect to base pins (bottom view).

DEVELOPMENT SAMPLE DATA

RECOMMENDED CIRCUITS

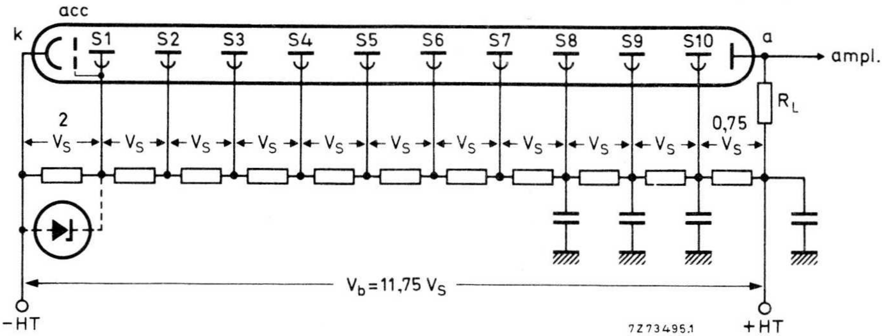


Fig. 1 Voltage-divider A (note 4).

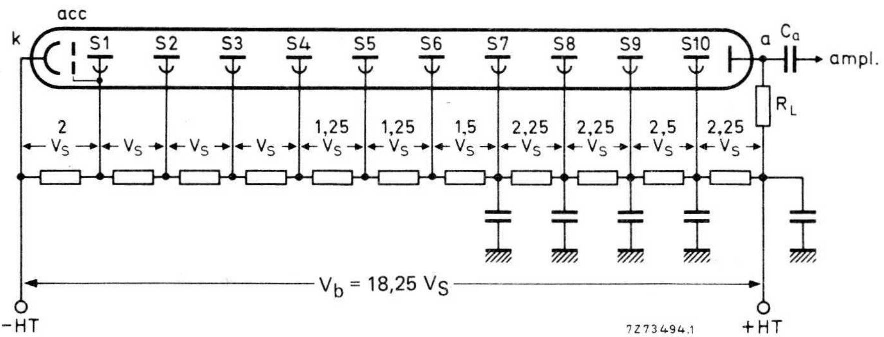


Fig. 2 Voltage divider B.

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

	notes (see page 5)		
With voltage divider A (Fig. 1)	1		
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)		< typ	1500 V 1180 V
Anode dark current at an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)	2,3	< typ	50 nA 5 nA
Pulse amplitude resolution for ^{137}Cs at N_a = 10 A/lm	4	≈	8 %
Mean anode sensitivity deviation at V_b = 1200 V	5		
long term		≈	1 %
after change of count rate		≈	1 %
Anode current linear within 2% at V_b = 1700 V		up to ≈	100 mA
With voltage divider B (Fig. 2)			
Anode luminous sensitivity at V_b = 1700 V (Fig. 5)		≈	150 A/lm
Anode pulse rise time at V_b = 1700 V	6	≈	2,5 ns
Anode pulse duration at half height at V_b = 1700 V	6	≈	6 ns
Signal transit time at V_b = 1700 V	6	≈	26 ns
Anode current linear within 2% at V_b = 1700 V		up to ≈	200 mA

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	7	max	1800 V
Continuous anode current		max	0,2 mA
Voltage between first dynode and photocathode	8	max min	500 V 150 V
Voltage between consecutive dynodes		max	300 V
Voltage between anode and final dynode	9	max min	300 V 30 V
Ambient temperature range			
Operational (for short periods of time)	10	max min	+80 °C −30 °C
Continuous operating and storage		max min	+50 °C −30 °C

Notes

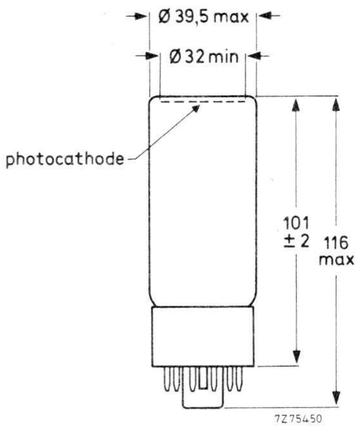
1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ 1/4 h).
4. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^4$ c/s.
For optimum peak amplitude resolution it is recommended that the voltage between first dynode and photocathode be maintained at $\approx$ 200 V, e.g. by means of a voltage regulator diode.
5. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the scintillator count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 100 nA.
Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 300 nA and $\approx$ 30 nA respectively.
Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
6. Measured with a pulsed-light source, with a pulse duration (FWHM) of $<$ 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
7. Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
10. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

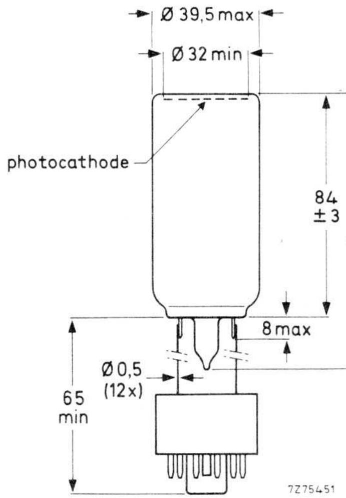
Dimensions in mm

The standard type PM2060B is dimensioned as per drawing below. A special version, PM2060FLB, features flying leads of Ni wire 0,5 mm ϕ soldered to a 12-pin base (JEDEC B12-43); base connections are identical to PM2060B.

PM2060B



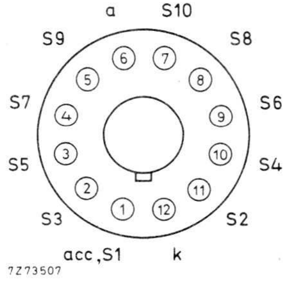
PM2060FLB



Net mass: 75 g
Base: 12-pin (JEDEC B12-43)

ACCESSORIES

Socket: type FE1012
Mu-metal shield: type 56127



DEVELOPMENT SAMPLE DATA

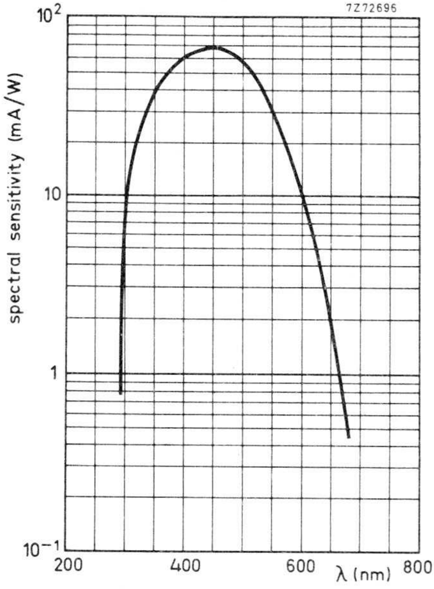


Fig. 3 Spectral sensitivity characteristic.

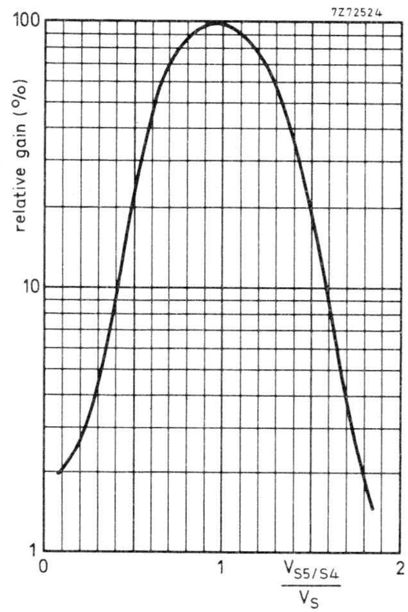


Fig. 4 Relative gain as a function of the voltage between S5 and S4, normalized to V_S, $V_{S6/S4}$ constant.

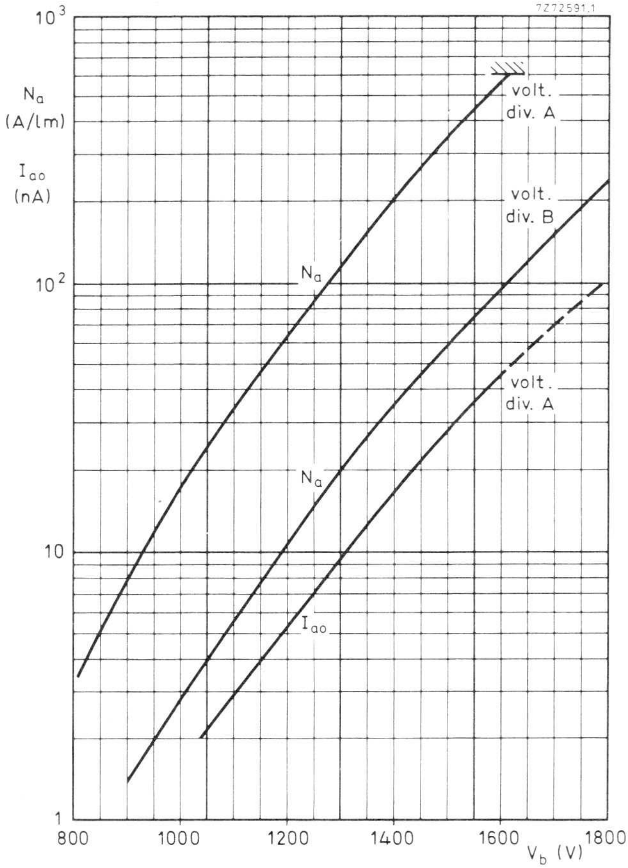


Fig. 5 Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The PM2202 is a 44 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in applications such as scintillation counting, laboratory and industrial photometry. Its Cu-Be dynode system offers a high stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Cathode spectral sensitivity at 401 nm			75	mA/W
Supply voltage for an anode spectral sensitivity of 60 kA/W at 401 nm			1400	V
Anode pulse rise time		≈	3,5	ns
Pulse amplitude resolution (^{137}Cs)		≈	7,4	%
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	200	mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime-glass		
Shape	plano-plano		
Refractive index at 550 nm		1,52	

Photocathode *

Semi-transparent, head-on			
Material	Sb-K-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 8)	type D		
Maximum spectral sensitivity at		400 ± 30	nm
Spectral sensitivity at 401 ± 3 nm	typ.	75	mA/W
	>	60	mA/W

* The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.

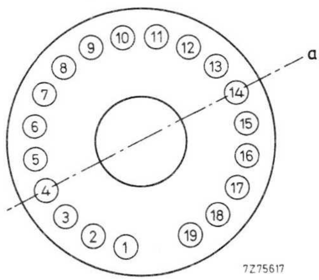
Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	3 pF
anode to all	≈	5 pF

Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved (at V_b = 1200 V, voltage divider A) at a magnetic flux density of:
0,2 mT perpendicular to axis a (see Fig. 1);
0,1 mT parallel with axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding more than 15 mm beyond the photocathode.



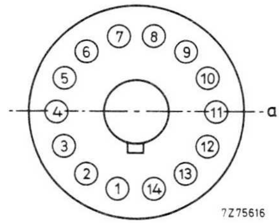


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

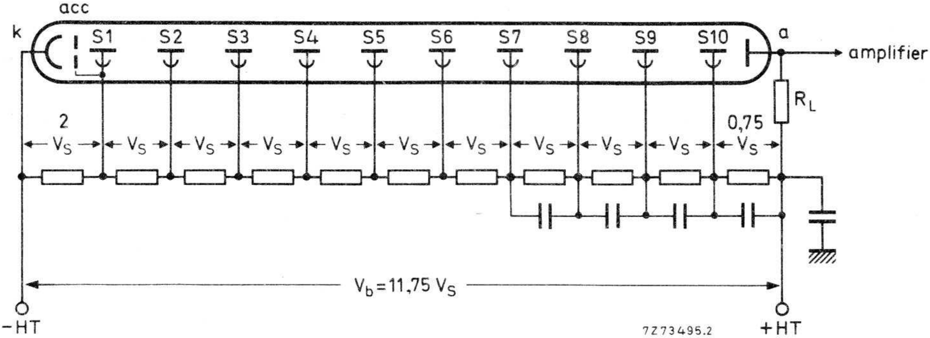


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

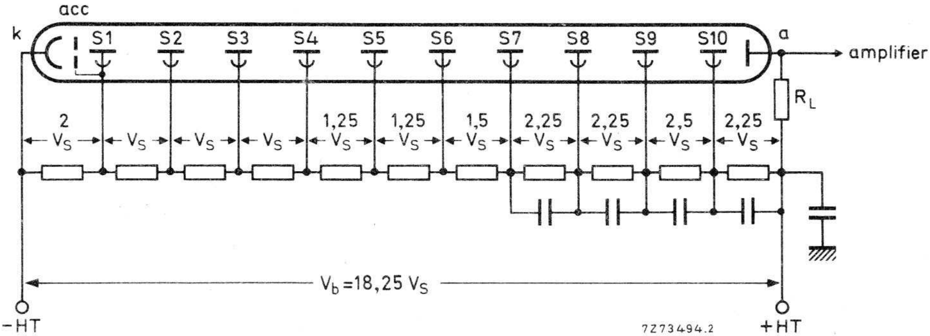


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS *

	notes				
With voltage divider A (Fig. 2)	1				
Supply voltage for an anode spectral sensitivity of 60 kA/W (Fig. 10)			<	1700	V
			typ.	1400	V
Anode dark current at an anode spectral sensitivity of 60 kA/W	2,3		<	30	nA
			typ.	3	nA
Pulse amplitude resolution for ^{137}Cs at an anode spectral sensitivity of 12 kA/W	4		≈	7,4	%
Anode current linear within 2% at V_b = 1700 V		up to	≈	100	mA
Mean anode sensitivity deviation	10				
long term (16 h)			≈	1	%
after change of count rate			≈	1	%
versus temp. between 0 and + 40 °C at 450 nm			≈	0,2	%/°C
With voltage divider B (Fig. 3)	1				
Anode spectral sensitivity at V_b = 1700 V (Fig. 10)			≈	40	kA/W
Anode pulse rise time at V_b = 1700 V	5		≈	3,5	ns
Anode pulse duration at half-height at V_b = 1700 V	5		≈	7	ns
Signal transit time at V_b = 1700 V	5		≈	35	ns
Anode current linear within 2% at V_b = 1700 V		up to	≈	200	mA

LIMITING VALUES (absolute maximum rating system)

	notes			
Supply voltage	6	max.	1800	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	7	max.	600	V
		min.	150	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	8	max.	300	V
		min.	30	V
Ambient temperature range				
operational (for short periods of time)	9	max.	+ 80	°C
		min.	−30	°C
continuous operation and storage		max.	+ 50	°C
		min.	−30	°C

* All spectral sensitivities refer to a wavelength of 401 nm.

Notes see page 5.

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
4. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no. 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count rate used is $\approx 10^4$ c/s.
5. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
9. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
10. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 300 nA and $\approx$ 30 nA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.

MECHANICAL DATA

Dimensions in mm

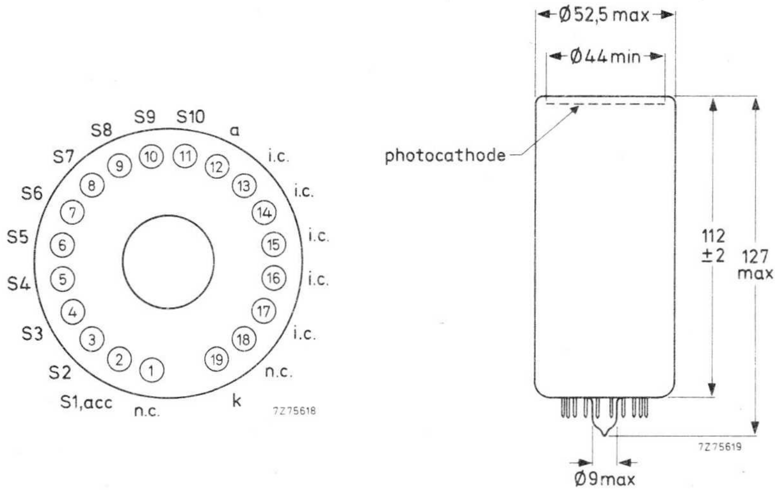


Fig. 4 PM2202.

Base	19-pin all-glass
Net mass	110 g

ACCESSORIES

Socket	type FE2019
Mu-metal shield	type 56130

MECHANICAL DATA (continued)

Dimensions in mm

Type PM2202B is dimensioned as per Fig. 5. A special version, PM2202FLB (Fig. 6) features flying leads of Ni wire 0,5 mm ϕ soldered to a 14-pin base (JEDEC B14-38); base connections are for both types according to Fig. 7.

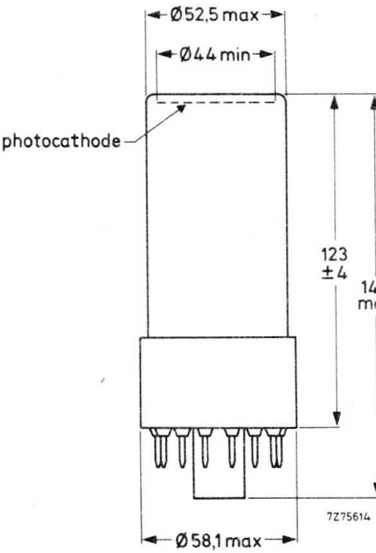


Fig. 5 PM2202B.

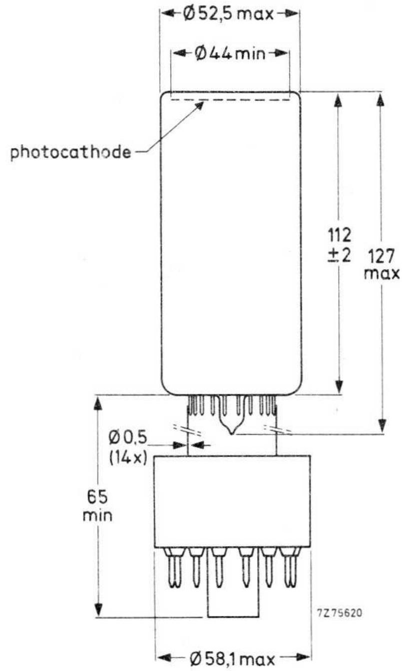


Fig. 6 PM2202FLB.

Base	14-pin (JEDEC B14-38)
Net mass	153 g

ACCESSORIES

Socket	type FE1014
Mu-metal shield	type 56130

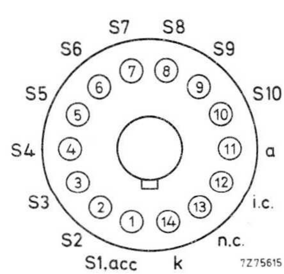


Fig. 7 Base connections.

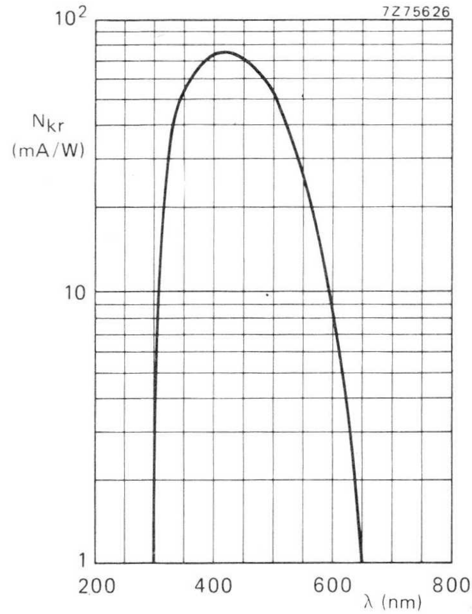


Fig. 8 Spectral sensitivity characteristic.

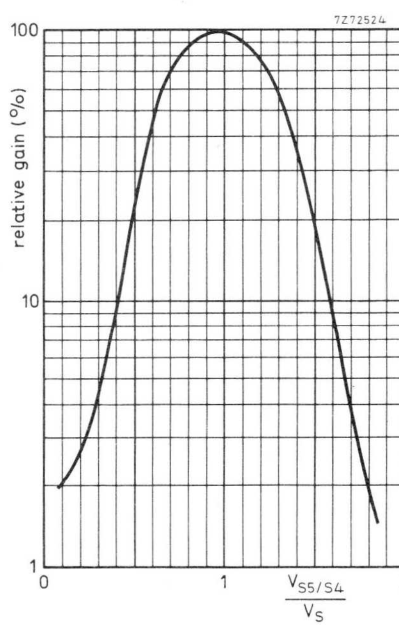


Fig. 9 Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S. $V_{S6/S4}$ constant.

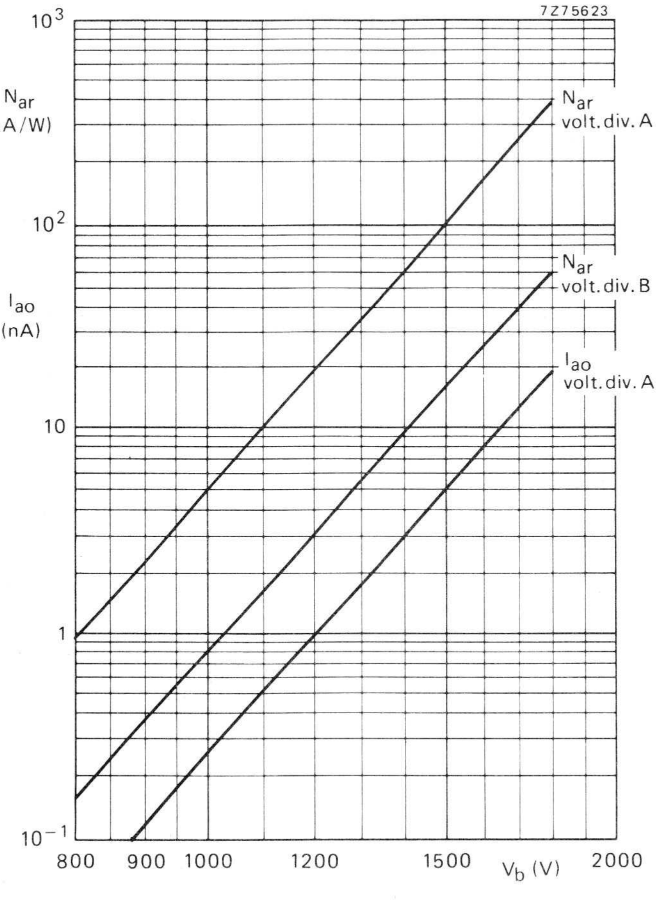


Fig. 10 Anode luminous sensitivity N_a, and anode dark current I_{ao} as a function of the supply voltage V_b.

12-STAGE PHOTOMULTIPLIER TUBE

The PM2232 is a 44 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparent bialkaline type D photocathode. The tube features a high cathode sensitivity and a good linearity combined with good time characteristics. It is intended for use in high energy physics experiments where a large number of tubes is needed. The PM2232B is provided with a 20-pin plastic base and is plug-in interchangeable with type XP2230B, and unilaterally interchangeable with the 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 401 nm			25	%
Cathode spectral sensitivity at 401 nm			80	mA/W
Supply voltage for a gain of 3×10^7			1900	V
Pulse amplitude resolution for ^{137}Cs		≈	7,3	%
Anode pulse rise time (with voltage divider B)		≈	2,2	ns
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	250	mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime-glass		
Shape	plano-concave		
Refractive index at 550 nm		1,52	

Photocathode (note 1)

Semi-transparent, head-on

Material	Sb-K-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 6)	type D		
Maximum spectral sensitivity at		400 ± 30	nm
Quantum efficiency at 401 nm		25	%
Spectral sensitivity at 401 ± 3 nm	typ.	80	mA/W
	>	65	mA/W

Note see page 4.

Multiplier system

Number of stages	12
Dynode structure	linear focused
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved (at V_b = 1400 V, voltage divider A) at a magnetic flux density of:
0,2 mT perpendicular to axis a (see Fig. 1);
0,1 mT parallel with axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

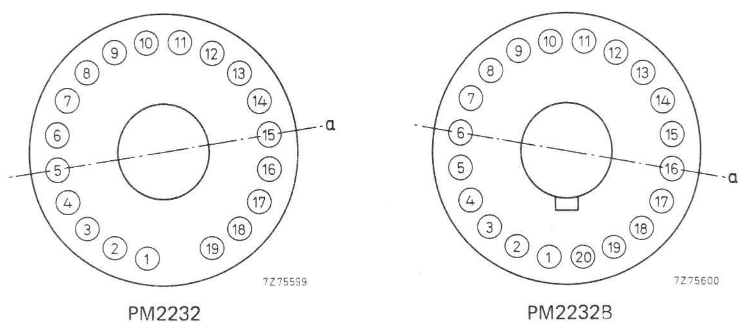


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

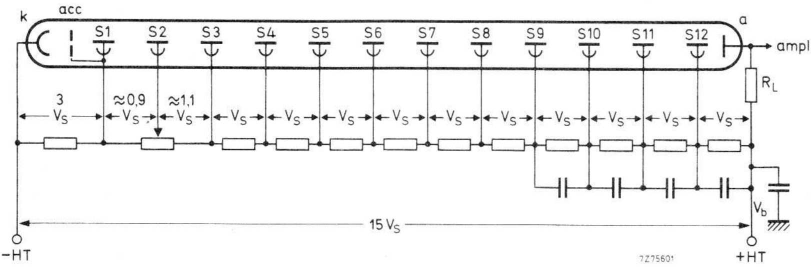


Fig. 2 Voltage divider A. Typical values of capacitors: 1 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

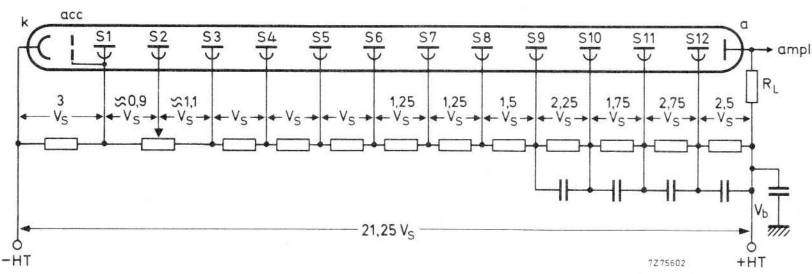


Fig. 3 Voltage divider B. Typical values of capacitors: 1 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS	notes			
With voltage divider A (Fig. 2)	2			
Supply voltage for a gain of 3×10^7 (Fig. 7)			$<$ typ.	2400 V 1900 V
Anode dark current at a gain of 3×10^7 (Fig. 7)	3,4		$<$ typ.	40 nA 10 nA
Background noise at a gain of 3×10^7	5		$\approx$	1200 c/s
Pulse amplitude resolution for ^{137}Cs at an anode spectral sensitivity of 12 kA/W at 401 nm	6		$\approx$	7,3 %
Anode current linear within 2% at V_b = 1900 V		up to	$\approx$	100 mA
With voltage divider B (Fig. 3)	2			
Gain at V_b = 2000 V (Fig. 7)			$\approx$	7×10^6
Anode pulse rise time at V_b = 2000 V	7		$\approx$	2,2 ns
Anode pulse duration at half height at V_b = 2000 V	7		$\approx$	3,5 ns
Signal transit time at V_b = 2000 V	7		$\approx$	35 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2000 V			$\approx$	0,7 ns
Anode current linear within 2% at V_b = 2000 V		up to	$\approx$	250 mA

LIMITING VALUES (absolute maximum rating system)

Supply voltage	8	max.	2500 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	9	max. min.	800 V 300 V
Voltage between consecutive dynodes		max.	400 V
Voltage between anode and final dynode	10	max. min.	600 V 80 V
Ambient temperature range			
operational (for short periods of time)	11	max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

Notes see page 5.

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
5. After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7. After a 30 min. stabilization period noise pulses with a threshold of $4{,}8 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded.
6. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no.: 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count-rate used is $\approx 10^4$ c/s.
7. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

   Non-inductive resistors of 50 Ω are connected in the base of type PM2232B to S_{11} and S_{12}. See also *General Operational Recommendations Photomultiplier Tubes.*
8. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm

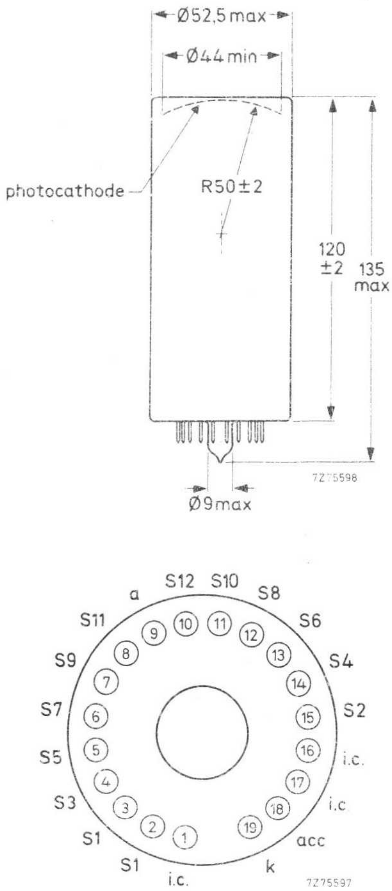


Fig. 4 PM2232.

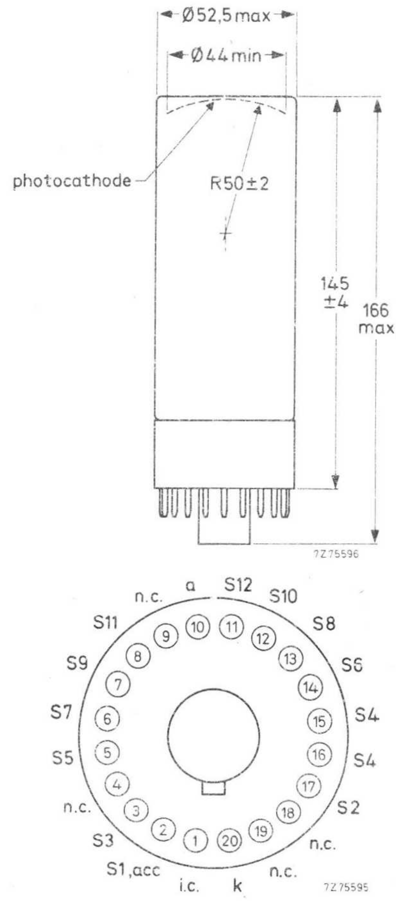


Fig. 5 PM2232B.

Base	19-pin all glass	Base	20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass	125 g	Net mass	162 g

ACCESSORIES

Socket
- for PM2232 — type FE2019
- for PM2232B — type FE1020

Mu-metal shield — type 56130

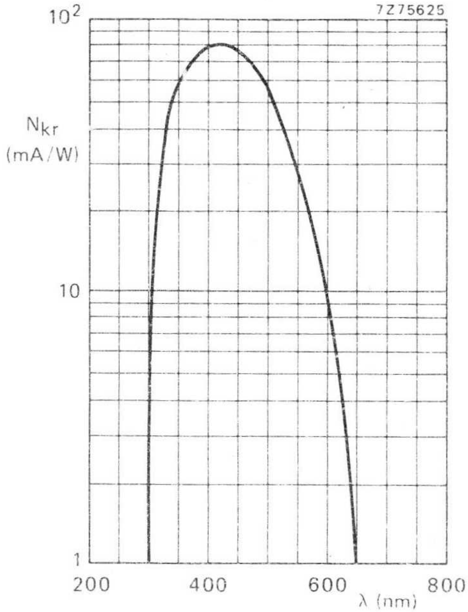


Fig. 6 Spectral sensitivity characteristic.

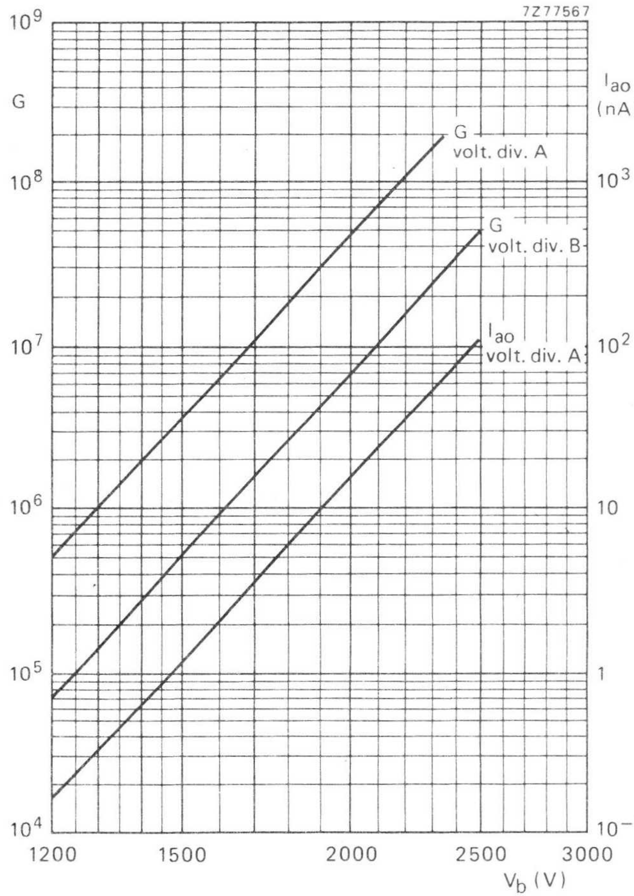


Fig. 7 Gain G, and anode dark current, I_{ao}, as a function of supply voltage V_b.

12-STAGE PHOTOMULTIPLIER TUBE

The PM2312 is a 68 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparant bialkaline type D photocathode. The tube is intended for use in nuclear physics where the number of photons to be detected is very low and where good time characteristics and a good linearity are required (coincidence measurements, Cerenkov counters).
The PM2312B is provided with a 20-pin plastic base.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	68	mm
Quantum efficiency at 401 nm			26	%
Cathode spectral sensitivity at 401 nm			85	mA/W
Supply voltage for a gain of 3×10^7			2000	V
Pulse amplitude resolution for ^{137}Cs		≈	8,5	%
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	250	mA

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	borosilicate		
Shape	plano-concave		
Refractive index at 550 nm		1,48	

Photocathode (note 1)

Semi-transparent, head on			
Material	Sb-K-Cs		
Useful diameter	>	68	mm
Spectral sensitivity characteristic (Fig. 6)	type D		
Maximum spectral sensitivity at	400 ± 30		nm
Quantum efficiency at 401 nm		26	%
Spectral sensitivity at 401 ± 3 nm	typ.	85	mA/W
	>	65	mA/W

Note
See page 5.

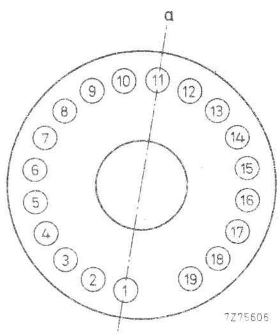
Multiplier system

Number of stages	12
Dynode structure	linear focused
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

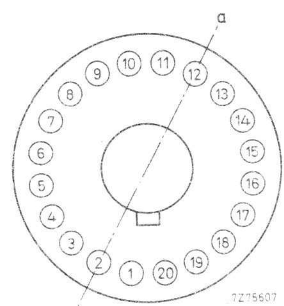
Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved (at V_b = 1500 V, voltage divider A) at a magnetic flux density of:
0,2 mT perpendicular to axis a (see Fig. 1);
0,1 mT parallel with axis a

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



PM2312



PM2312B

Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

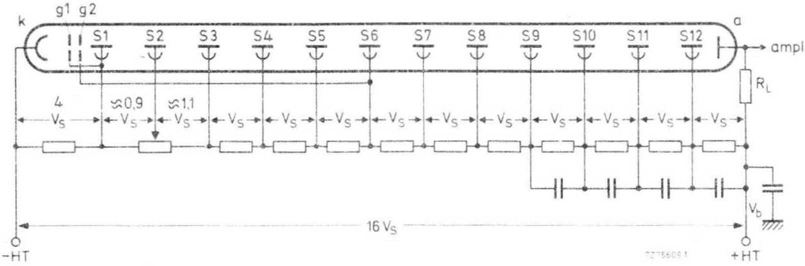


Fig. 2 Voltage divider A. Typical value of capacitors: 1 nF; k = cathode; g_1, g_2 = accelerating electrodes; S_n = dynode no.; a = anode; R_L = load resistor.

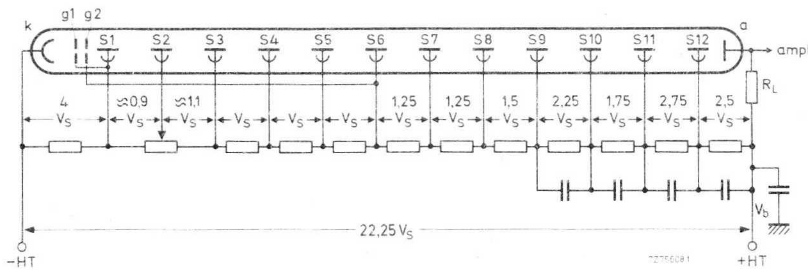


Fig. 3 Voltage divider B. Typical value of capacitors: 1 nF; k = cathode; g_1, g_2 = accelerating electrodes; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

	notes			
With voltage divider A (Fig. 2)	2			
Supply voltage for a gain of 3×10^7 (Fig. 7)		typ.	2000	V
		<	2500	V
Anode dark current at a gain of 3×10^7 (Fig. 7)	3,4	typ.	25	nA
		<	250	nA
Background noise at a gain of 3×10^7 (Fig. 7)	5	≈	2000	c/s
Pulse amplitude resolution for ^{137}Cs at an anode spectral sensitivity of 12 kA/W	6	≈	8,5	%
Anode current linear within 2% at V_b = 2000 V	up to	≈	100	mA
With voltage divider B (Fig. 3)	2			
Gain at V_b = 2000 V (Fig. 7)		≈	6×10^6	
Anode pulse rise time at V_b = 2000 V	7	≈	2,5	ns
Anode pulse duration at half height at V_b = 2000 V	7	≈	3,5	ns
Signal transit time at V_b = 2000 V	7	≈	35	ns
Signal transit time difference between the centre of the photocathode and 30 mm from the centre at V_b = 1800 V		≈	0,7	ns
Anode current linear within 2% at V_b = 2000 V	up to	≈	250	mA

LIMITING VALUES (absolute maximum rating system)

Supply voltage	8	max.	2500	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	9	max.	700	V
		min.	300	V
Voltage between consecutive dynodes		max.	400	V
Voltage between g_2 and photocathode (g_2 normally connected to S6)		max.	1500	V
Voltage between anode and final dynode	10	max.	600	V
		min.	80	V
Ambient temperature range	11			
operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
continuous operation and storage		max.	+50	°C
		min.	−30	°C

Notes see page 5.

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B′ are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity.
   Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ Ω.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ 1/4 h).
5. After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7 . After a 30 min stabilization period noise pulses with a threshold of $4{,}8 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded (Fig. 7).
6. Pulse amplitude resolution for ^{137}Cs is measured with a NaI(Tl) cylindrical scintillator (Quartz et Silice ser. no. 4170 or equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is ≈ 10^4 c/s.
7. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
   The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
   The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

   Non-inductive resistors of 50 Ω are connected in the base of type PM2312B to S_{11} and S_{12}.
   See also *General Operational Recommendations Photomultiplier Tubes.*
8. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage, the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm

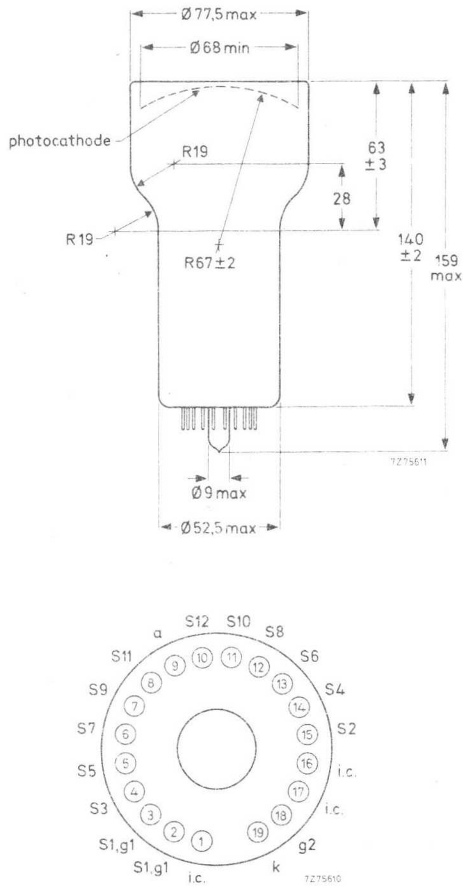


Fig. 4 PM2312.

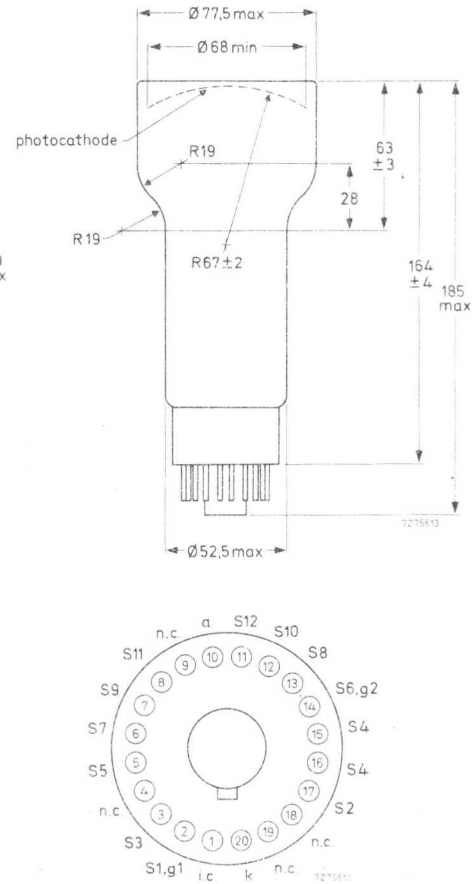


Fig. 5 PM2312B.

Base	19-pin all-glass
Net mass	215 g

Base*	20-pin IEC 67-1-42a, Jedec B20-102
Net mass	252 g

ACCESSORIES

Socket	
for PM 2312	type FE2019
for PM 2312B	type FE1020
Mu-metal shield	type 56135

* This tube can be inserted in sockets, wired for type XP2020 or 56AVP-family tubes.

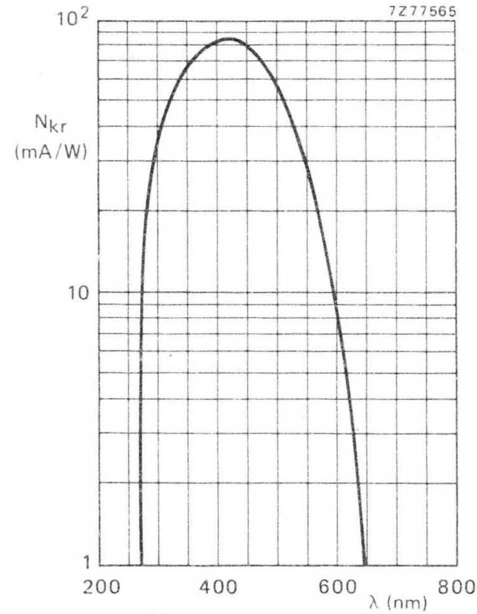


Fig. 6 Spectral sensitivity characteristic.

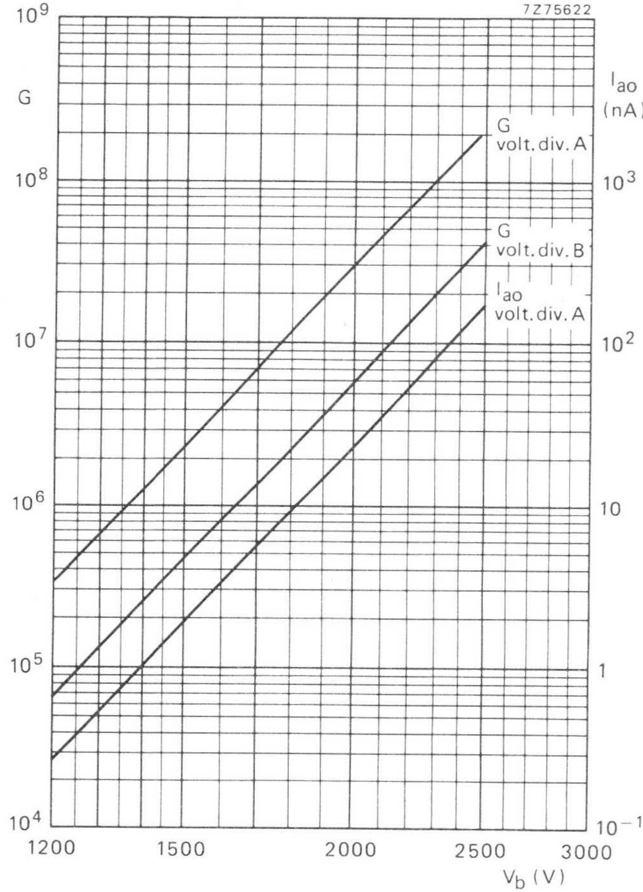


Fig. 7 Gain G, and anode dark current I_{ao} as a function of the supply voltage V_b.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

The PM2402 is a 61 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in nuclear physics where a very good pulse amplitude resolution is required. The tube offers a high cathode sensitivity and, combined with a very low dark current and high stability, its excellent collection from each point of the photocathode makes it very suitable for scintillation detection in nuclear medicine, e.g. gamma cameras.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 61 mm
Cathode spectral sensitivity at 401 nm	90 mA/W
Supply voltage for an anode spectral sensitivity of 12 kA/W	1250 V
Anode dark current at an anode spectral sensitivity of 12 kA/W	0,5 nA
Pulse amplitude resolution (^{137}Cs)	≈ 7 %
Mean anode sensitivity deviation	≈ 1 %

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-plano
Refractive index at 550 nm	1,52

Photocathode *

Semi-transparent, head-on

Material	Sb-K-Cs
Useful diameter	> 61 mm
Spectral sensitivity characteristic (Fig. 3)	type D

* The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.

Photocathode (continued)

Maximum spectral sensitivity at	400 ± 30 nm
Quantum efficiency at 401 nm	28 %
Spectral sensitivity at 401 ± 3 nm	typ. 90 mA/W > 65 mA/W

Multiplier system

Number of stages	10
Dynode structure	venetian blind
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 7 pF
anode to all	≈ 8,5 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1500 V) at a magnetic flux density of 0,35 mT perpendicular to the tube axis.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

RECOMMENDED CIRCUIT

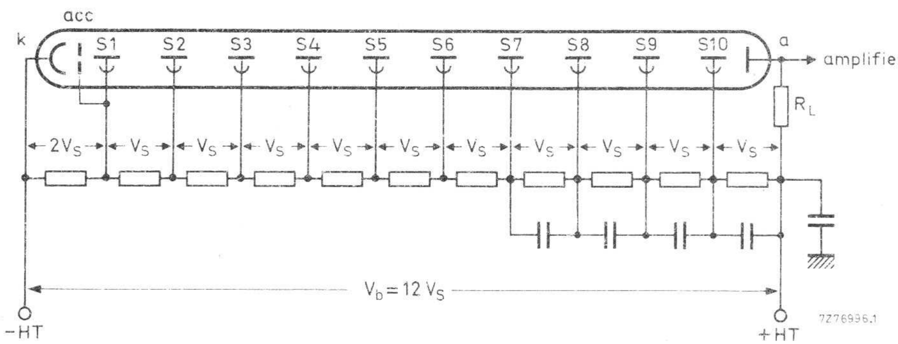


Fig. 1 Voltage divider type A. For obtaining the best energy resolution the accelerating electrode should be connected to S1. Typical values of capacitors; 10 nF, k = cathode; acc = accelerating electrode; Sn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS (with voltage divider A, Fig. 1), see also note 1

	note		
Supply voltage for an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 4)		< typ.	1450 V 1250 V
Anode spectral sensitivity at V_b = 1500 V and 401 nm (Fig. 4)		≈	40 kA/W
Anode dark current at an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 4)	2	< typ.	5 nA 0,5 nA
Pulse amplitude resolution for ^{137}Cs at N_{ar} = 12 kA/W	3	≈	7 % *
Pulse amplitude resolution for ^{57}Co at N_{ar} = 12 kA/W	3	≈	9,7 % *
Pulse amplitude resolution for ^{55}Fe at N_{ar} = 60 kA/W	4	≈	42 %
Peak to valley ratio for ^{55}Fe at N_{ar} = 60 kA/W	4	≈	35
Mean anode sensitivity deviation	5		
long term (16 h)		≈	1 %
after change of count rate		≈	1 %
versus temperature between 20 °C and 60 °C at 450 nm		≈	0,1% per °C
Anode current linear within 2% at V_b = 1500 V		up to ≈	10 mA
Anode pulse rise time at V_b = 1500 V	6	≈	10 ns
Anode pulse duration at half height at V_b = 1500 V	6	≈	20 ns
Signal transit at V_b = 1500 V	6	≈	46 ns

LIMITING VALUES (absolute maximum rating system)

	note		
Supply voltage	7	max.	2000 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	8	max. min.	500 V 150 V
Voltage between accelerating electrode and photocathode		max.	500 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	9	max.	300 V
Ambient temperature range			
operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

DEVELOPMENT SAMPLE DATA

* Measured with a ϕ44 x 50 mm NaI (Tl) scintillator.

Notes

1. Whenever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $>10^{15}$ ohm.
2. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$¼ h).
3. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count rate used is $\approx 10^4$ c/s.
4. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
5. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long-term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s, corresponding to an anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance from the scintillator such that the count rate can be changed from $\approx 10^4$ c/s to $\approx 10^3$ c/s, corresponding to anode currents of $\approx$ 300 nA and $\approx$ 30 nA respectively. Both tests are carried out according to ANSI-N42-9-1972 of IEEE recommendations.
6. Measured with a pulsed light source, with a pulse duration (FWHM) of $<$ 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
7. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of $\approx$ 300 kA/W, whichever is lower.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

DEVELOPMENT SAMPLE DATA

MECHANICAL DATA

Dimensions in mm

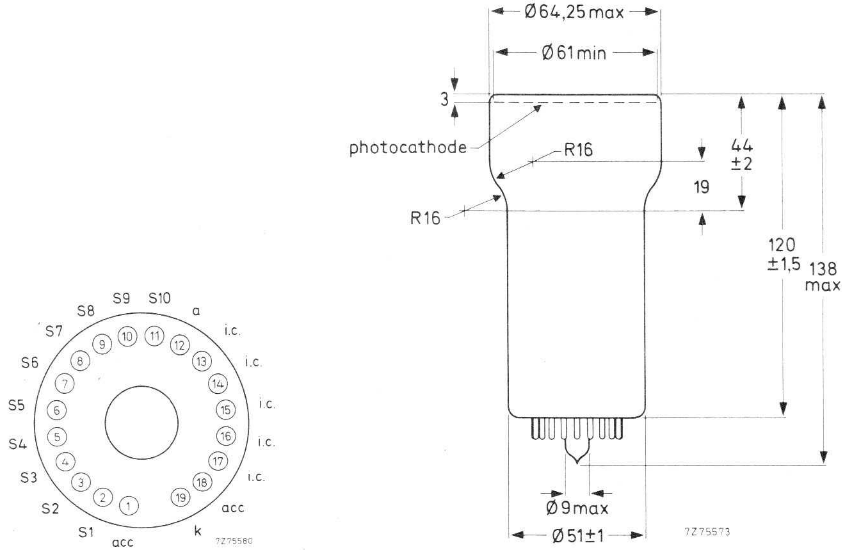


Fig. 2.

Base	19-pin all-glass
Net mass	150 g

ACCESSORIES

Socket	type FE2019
Mu-metal shield	type 56131

The PM2402B is supplied with a plastic base on request. This version fits the socket FE1014.
Base connections of the PM2402B are identical to those of the XP2030.

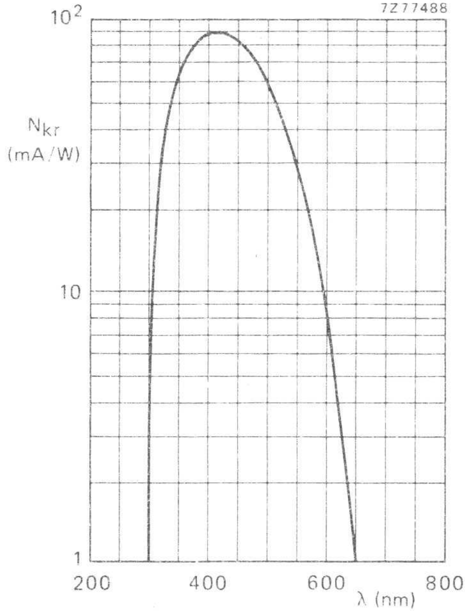


Fig. 3 Spectral sensitivity characteristic.

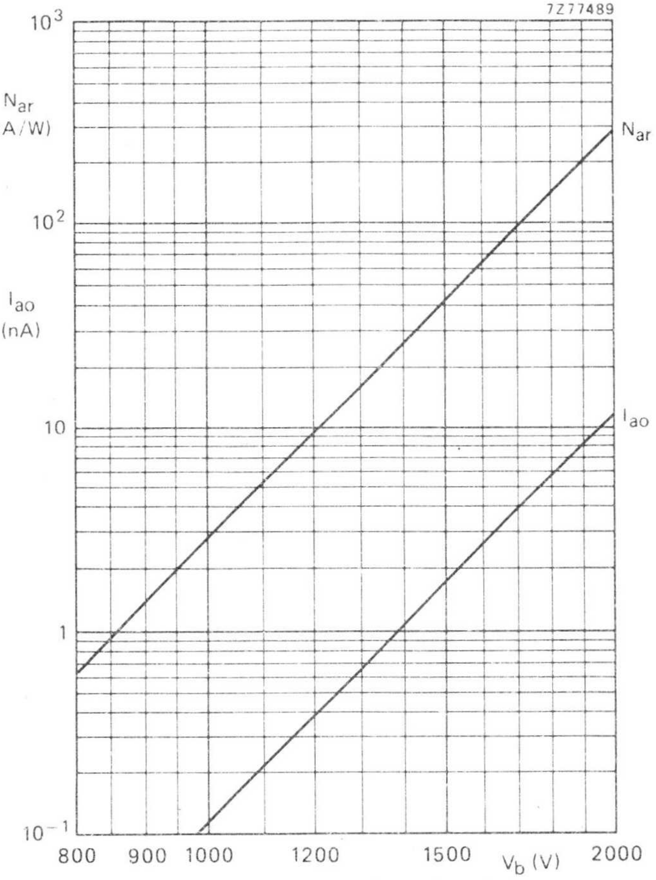


Fig. 4 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

DEVELOPMENT SAMPLE DATA

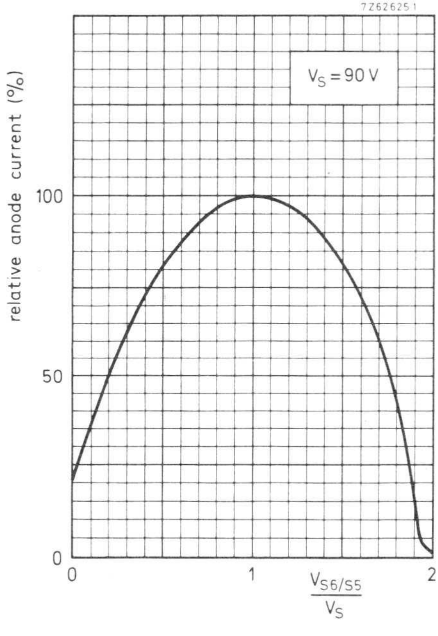


Fig. 5 Relative anode current as a function of the voltage between S6 and S5, normalized to V_S, $V_{S7/S5}$ constant.

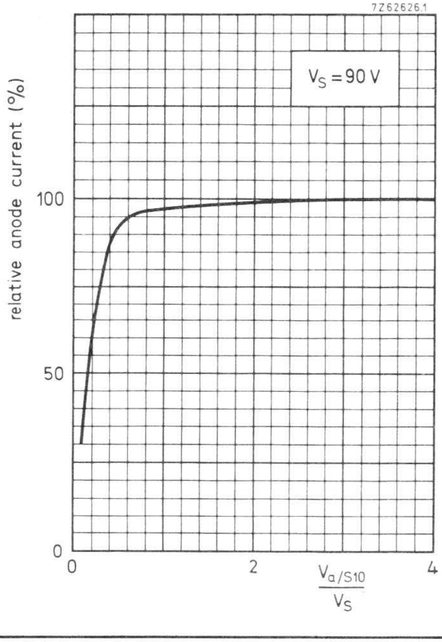


Fig. 6 Relative anode current as a function of the voltage between anode and last dynode, normalized to V_S.

10-STAGE PHOTOMULTIPLIER TUBE

The XP1002 is a 44 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent trialkaline S20 (type T) photocathode. The tube is intended for use in low light level measurements in the entire visible part of the spectrum. Its Cu-Be dynode multiplier system offers a high stability which makes it especially suitable for industrial applications, such as laser reading.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		S20 (type T)		
Useful diameter of the photocathode		>	44	mm
Spectral sensitivity of the photocathode at 698 nm			16	mA/W
at 632, 8 nm		≈	30	mA/W
Supply voltage for an anode luminous sensitivity = 60 A/lm			1460	V
Mean anode sensitivity deviation		≈	1	%
Anode pulse rise time (with voltage divider B)		≈	4	ns
Linearity, with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	100	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Shape	plano-plano		

Photocathode

Semi-transparent head-on			
Material	Sb-Na-K-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 3)	S20 (type T)		
Maximum spectral sensitivity at		420 ± 30	nm
Luminous sensitivity	typ.	165	μA/lm
	>	110	μA/lm
Spectral sensitivity at 698 ± 7 nm		16	mA/W
at 629 ± 3 nm	≈	30	mA/W

Electron optical input system

This system consists of : the photocathode, k ; a metallized part of the glass envelope internally connected to the photocathode ; an accelerating electrode, acc.

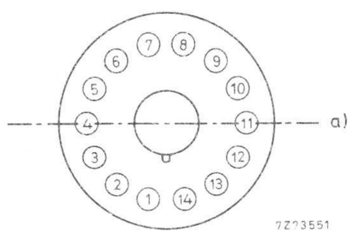
Multiplier system

Number of stages	10		
Dynode structure	linear focused		
Dynode material	Cu-Be		
Capacitances			
Anode to all	≈	5	pF
Anode to final dynode	≈	3	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A) :
- at a magnetic flux density of 0, 2 mT perpendicular to axis a);
- at a magnetic flux density of 0, 1 mT parallel to axis a). (see Fig. below.)

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

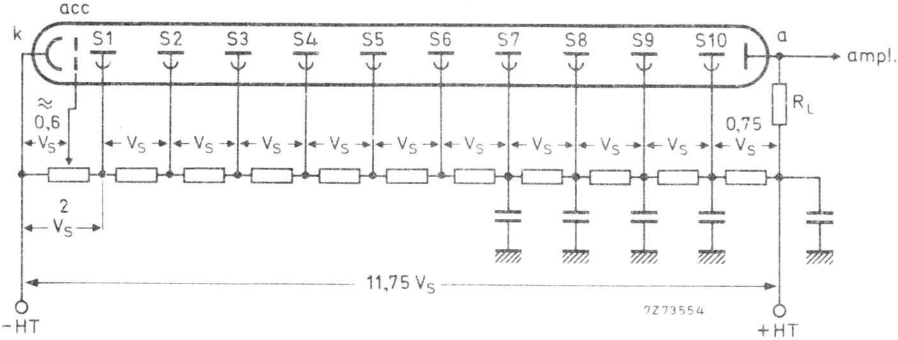


Fig. 1 Voltage divider A

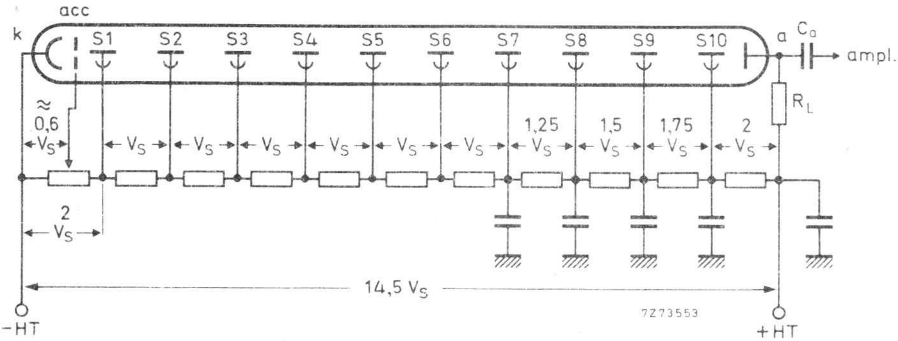


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	[1]			
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)		typ. <	1460 1650	V V
Anode dark current at N_a = 60 A/lm (Fig. 5)	[2][3]	typ. <	3 50	nA nA
Anode current linear within 2% at V_b = 1700 V up to		≈	30	mA
Mean anode sensitivity deviation at V_b = 1200 V, long term (16 h)	[4]	≈	1	%
With voltage divider B (Fig. 2)	[1]			
Anode luminous sensitivity at V_b = 1700 V (Fig. 5)		≈	75	A/lm
Anode pulse rise time at V_b = 1700 V	[5]	≈	4	ns
Anode pulse duration at half height at V_b = 1700 V	[5]	≈	12	ns
Signal transit time at V_b = 1700 V	[5]	≈	38	ns
Anode current linear within 2% at V_b = 1700 V up to		≈	100	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[6]	max.	1800	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	[7]	max. min.	500 120	V V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	[8]	max. min.	300 30	V V
Ambient temperature range	[9]			
Operational (for short periods of time)		max. min.	+80 −30	°C °C
Continuous operation and storage		max. min.	+50 −30	°C °C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively.
Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) The mean anode sensitivity deviation measurement is carried out with light pulses at a count rate of 10^4 c/s resulting in an average anode current of 0,1 μA. See also "General Operational Recommendations Photomultiplier Tubes".

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

6) Total HT supply voltage, or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.

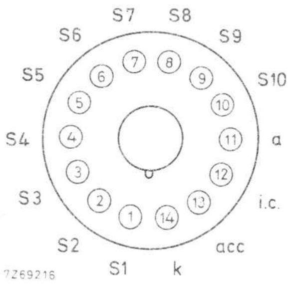
7) Minimum value to obtain good collection in the input optics.

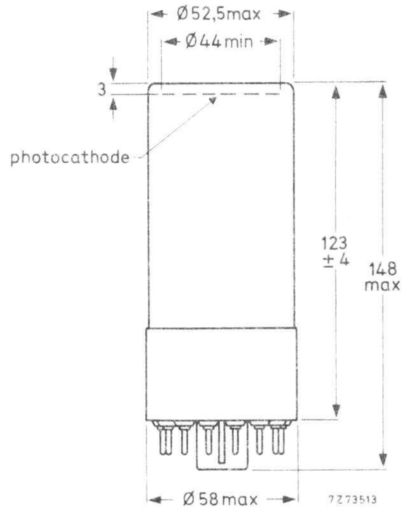
8) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

9) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass : 150 g

Base : 14-pin (IEC 67-I-16a; JEDEC B14-38)

ACCESSORIES

→ Socket : type FE1014

Mu-metal shield : type 56128

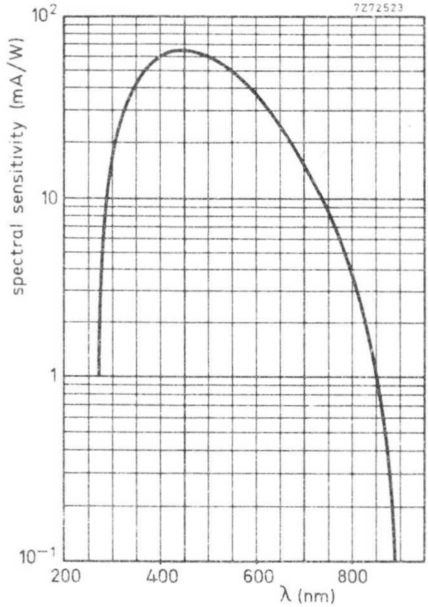


Fig. 3

Spectral sensitivity characteristic

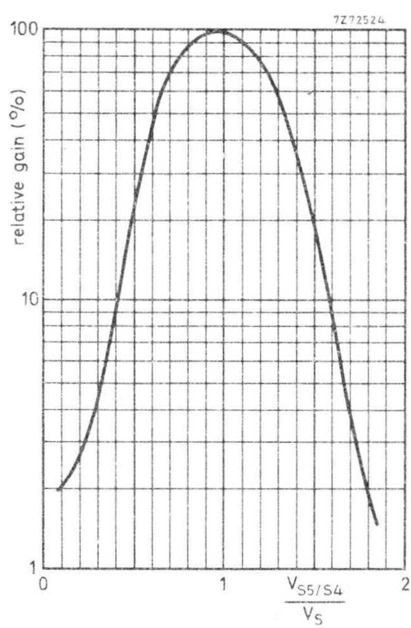


Fig. 4

Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S
$V_{S6/S4}$ constant

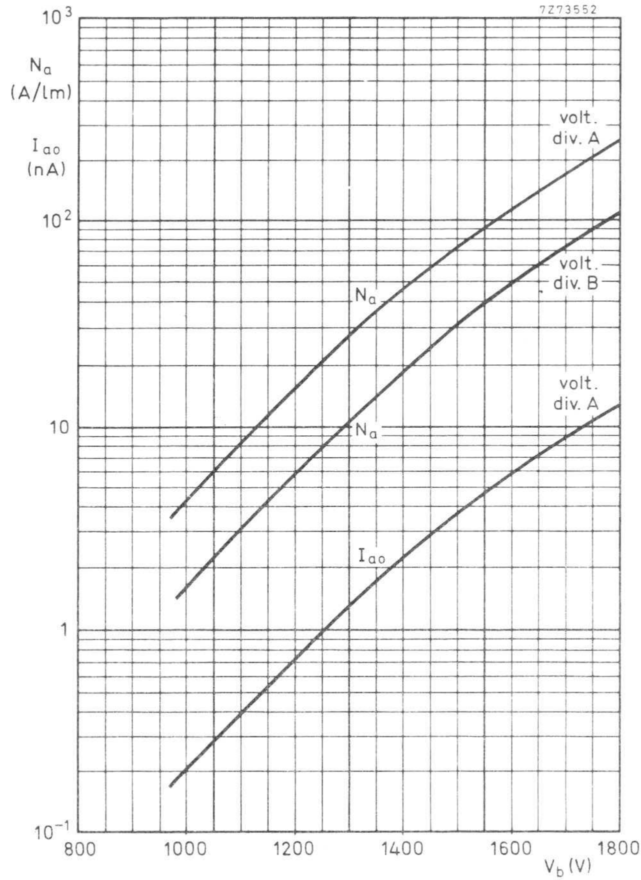


Fig. 5
Anode luminous sensitivity, Na, and anode dark current, I_{ao}, as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The XP1011 is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent Super A photocathode. The rugged construction of the tube makes it particularly suitable for applications such as scintillation counting and optical measurements under severe operating conditions.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			Super A	
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode at 437 nm			80	mA/W
Supply voltage for a luminous sensitivity = 60 A/lm			1500	V
Pulse amplitude resolution for ^{137}Cs		≈	8	%
Anode pulse rise time (with voltage divider B)		≈	3,5	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	100	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes"

GENERAL CHARACTERISTICS

Window

Shape			plano-plano	
Material			borosilicate	
Refractive index at 550 nm			1,48	

Photocathode

Semi-transparent, head-on				
Material			Sb-Cs	
Useful diameter		>	32	mm
Spectral sensitivity characteristic (Fig. 3)			type Super A	
Maximum spectral sensitivity at			420 ±30	nm
Luminous sensitivity	1)	typ.	90	μA/lm
		>	40	μA/lm

Note see page 2.

Spectral sensitivity at 437 ± 5 nm	2)		80	mA/W

Electron optical input system

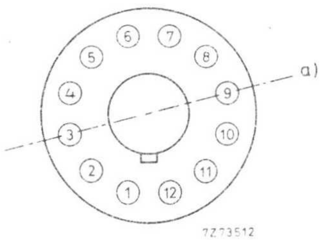
This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc ; internally connected to S1.

Multiplier system

Number of stages			10	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Anode to all	C_a	≈	5	pF
Anode to final dynode	$C_{a/S10}$	≈	3	pF

Magnetic field see Fig. 4

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Dynode axis with respect to base pins (bottom view).

[1]) Cathode luminous sensitivity is measured with a tungsten filament lamp of colour temperature 2856 ± 5 K.

[2]) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

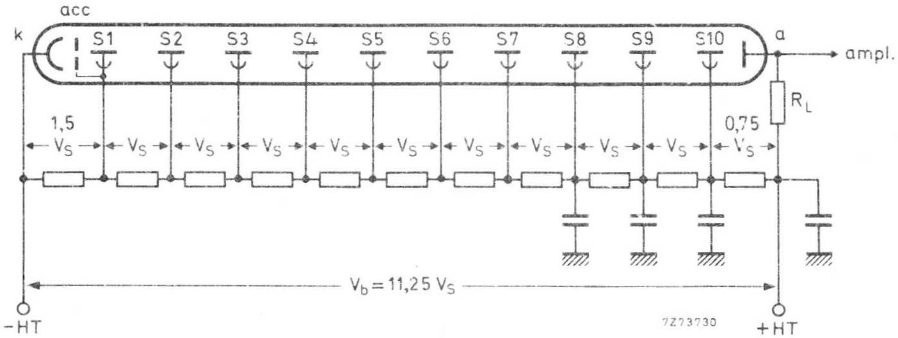


Fig. 1 Voltage divider A

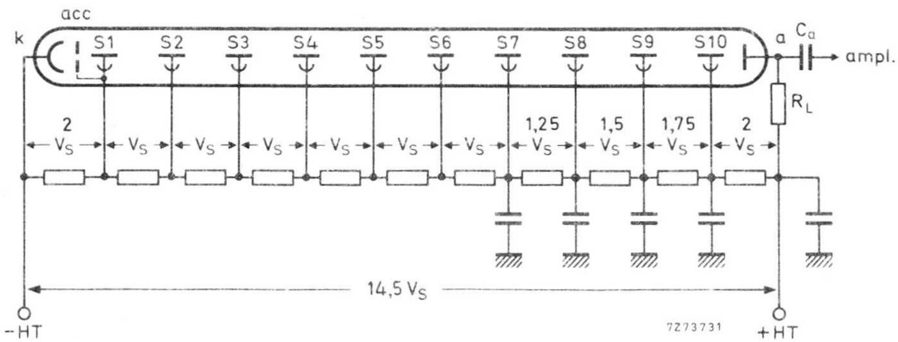


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)		<	1700	V
		typ.	1500	V
Anode dark current at an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)	2) 3)	<	50	nA
		typ.	15	nA
Pulse amplitude resolution for ^{137}Cs at V_b = 1200 V	4)	≈	8	%
Anode current linear within 2% at V_b = 1700 V up to		≈	30	mA
With voltage divider B (Fig. 2)	1)			
Anode luminous sensitivity at V_b = 1700 V (Fig. 4)		≈	45	A/lm
Anode pulse rise time at V_b = 1700 V	5)	≈	3,5	ns
Anode pulse duration at half height at V_b = 1700 V	5)	≈	6	ns
Signal transit time at V_b = 1700 V	5)	≈	34	ns
Anode current linear within 2% at V_b = 1700 V up to		≈	100	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	6)	max.	1800	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	7)	max.	500	V
		min.	120	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	8)	max.	300	V
		min.	30	V
Ambient temperature range	10)			
Operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively.
Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive strip connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$1/4 h).

4) Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm.
The count rate used is $\approx 10^4$ c/s.

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

6) Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.

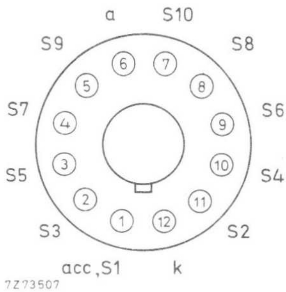
7) Minimum value to obtain good collection in the input optics.

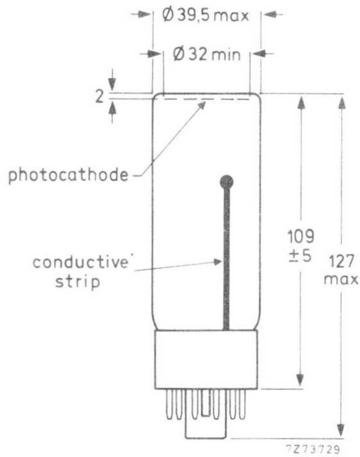
8) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

9) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass : approx. 80 g

Base : 12-pin (JEDEC B12-43)

ACCESSORIES

→ Socket : type FE1012

Mu-metal shield : type 56127

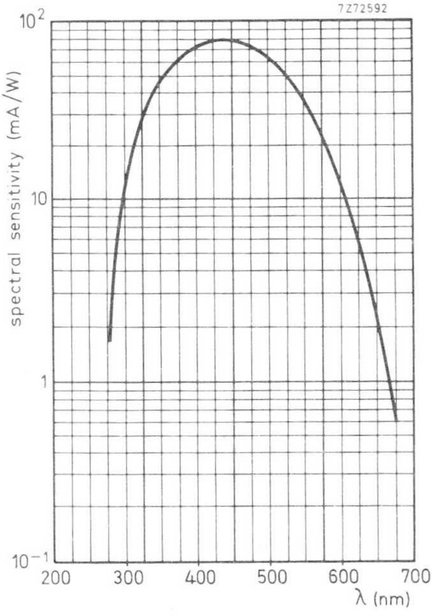


Fig. 3
Spectral sensitivity characteristic

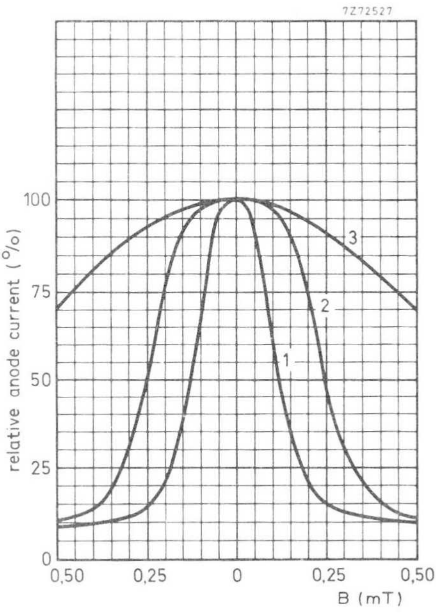


Fig. 4
Relative anode current as a function of the flux density B

1. B ⊥ tube axis, // axis a)
2. B ⊥ tube axis, ⊥ axis a)
3. B // tube axis

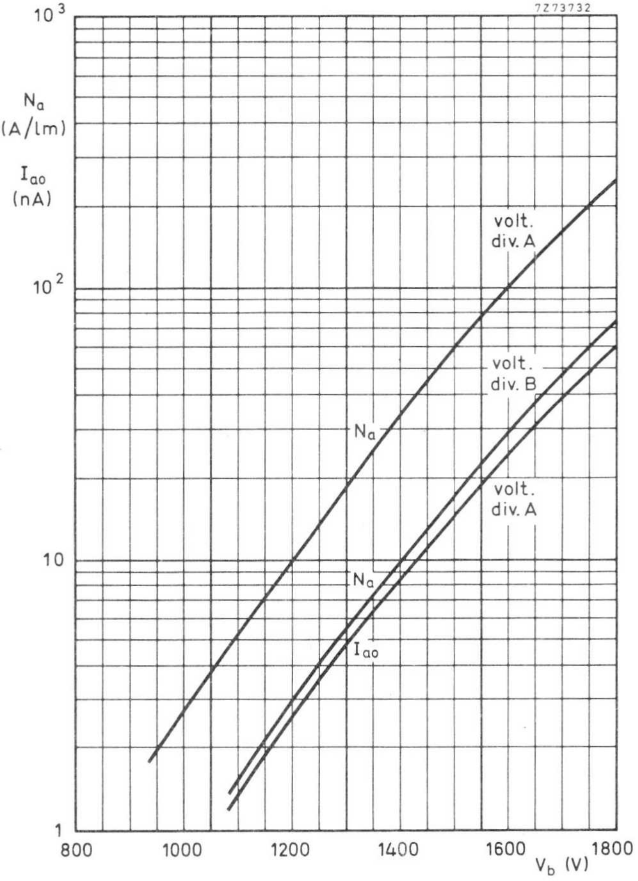


Fig. 5
Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b.

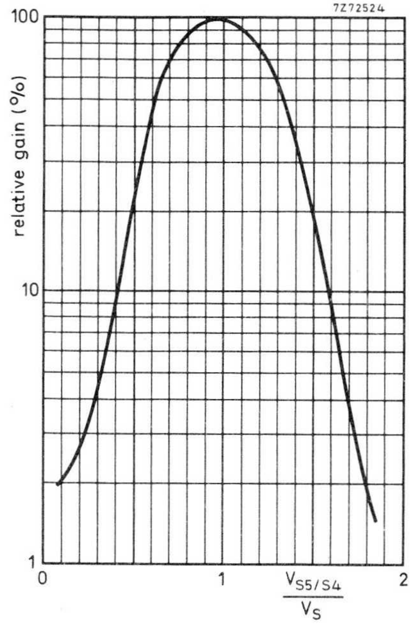


Fig. 6
Relative gain as a function of the voltage between S5 and S4, normalized to V_S
$V_{S6/S4}$ constant.

10-STAGE PHOTOMULTIPLIER TUBE

The XP1017 is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent trialkaline S20R (extended red) photocathode.
The tube is intended for use in applications where a high sensitivity in the red and near-infrared part of the spectrum is needed.

QUICK REFERENCE DATA

Spectral sensitivity characteristics			S20R	
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode	at 550 nm	≈	35	mA/W
	at 698 nm	≈	23	mA/W
	at 858 nm		6,5	mA/W
Supply voltage for anode luminous sensitivity = 60 A/lm			1470	V
Anode pulse rise time (with voltage divider B)		≈	3,5	ns
Linearity				
with voltage divider A		up to ≈	30	mA
with voltage divider B		up to ≈	100	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window (frosted)

Material	borosilicate
Shape	plano-plano
Refractive index at 550 nm	1,48

Photocathode

Semi-transparent, head-on			
Material		Sb-Na-K-Cs	
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig. 3)		S20R	
Maximum sensitivity at		550 ± 50	nm
Luminous sensitivity	typ.	210	μA/lm
	>	150	μA/lm
Spectral sensitivity at 858 ± 8 nm	typ.	6,5	mA/W
	>	1,5	mA/W
at 550 nm	≈	35	mA/W
at 698 nm	≈	23	mA/W
at 903 nm	≈	1,2	mA/W

Electron optical input system

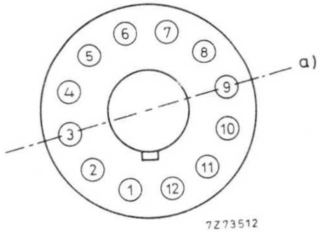
This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

Multiplier system

Number of stages			10	
Dynode structure			linear focused	
Dynode material			Cu-Be	
Capacitances				
Anode to all	C_a	≈	5	pF
Anode to final dynode	$C_{a/S10}$	≈	3	pF

Magnetic field See fig. 4.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

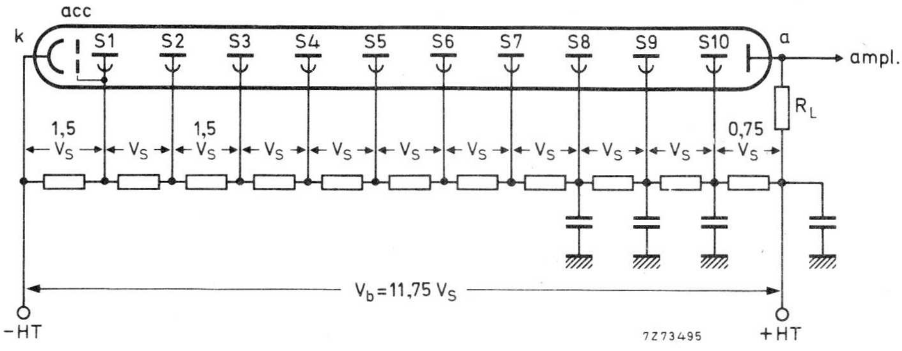


Fig. 1 Voltage divider A

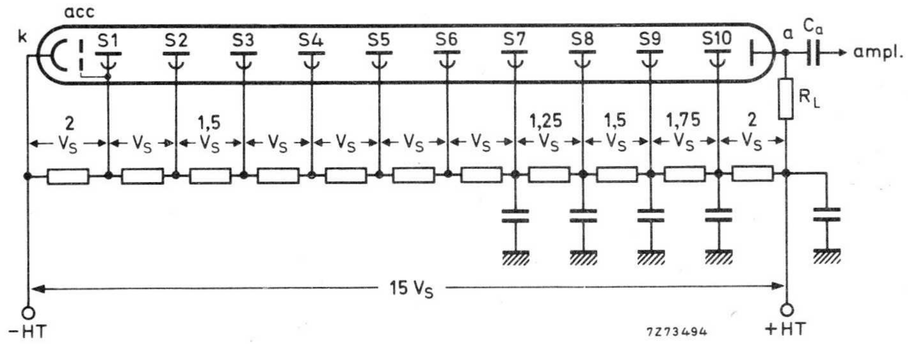


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical values of capacitors; 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1) [1]

Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)	< typ.	1650 1470	V V
Supply voltage for a gain $G = 10^6$	≈	1800	V
Anode dark current at N_a = 60 A/lm (Fig. 5) [2] [3]	< typ.	50 2	nA nA
Anode current linear within 2% at V_b = 1700 V up to	≈	30	mA

With voltage divider B (Fig. 2) [1]

Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)	≈	1730	V
Anode pulse rise time at V_b = 1700 V [4]	≈	3,5	ns
Anode pulse duration at half height at V_b = 1700 V [4]	≈	6	ns
Signal transit time at V_b = 1700 V [4]	≈	34	ns
Anode current linear within 2% at V_b = 1700 V up to	≈	100	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage [5]	max.	1900	V
Continuous anode current	max.	0,2	mA
Voltage between first dynode and photocathode [6]	max. min.	500 120	V V
Voltage between consecutive dynodes	max.	300	V
Voltage between anode and final dynode [7]	max. min.	300 30	V V
Ambient temperature range			
Operational (for short periods of time) [8]	max. min.	+80 −30	°C °C
Continuous operation and storage	max. min.	+50 −30	°C °C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of <1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

5) Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.

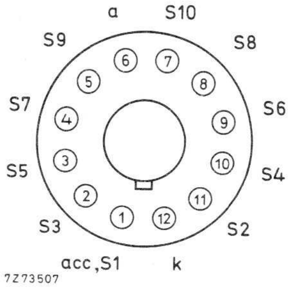
6) Minimum value to obtain good collection in the input optics.

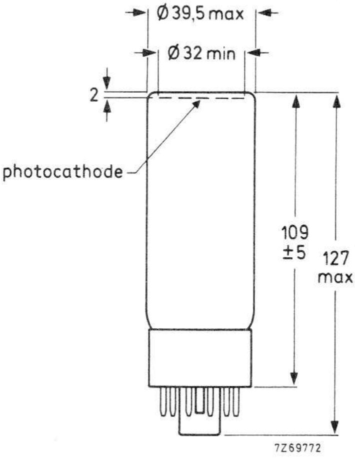
7) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

8) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass : 80 g

Base : 12-pin (JEDEC B12-43)

ACCESSORIES

→ Socket : type FE1012

Mu-metal shield : type 56127

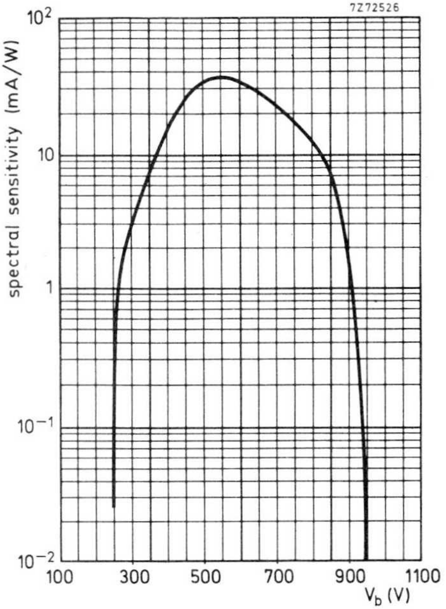


Fig. 3
Spectral sensitivity characteristic

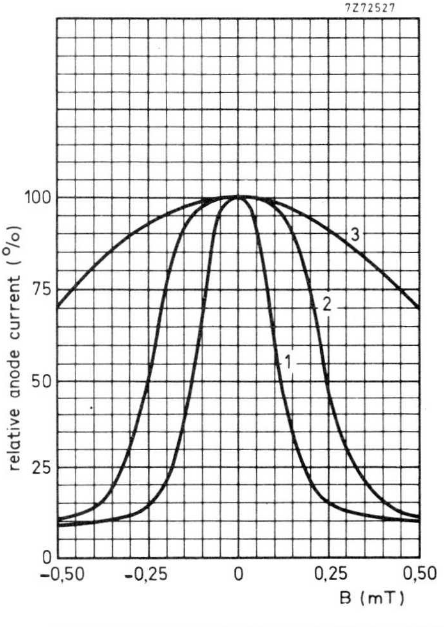


Fig. 4
Relative anode current as a function of the magnetic flux density B

1. B ⊥ tube axis, // axis a
2. B ⊥ tube axis, ⊥ axis a
3. B // tube axis

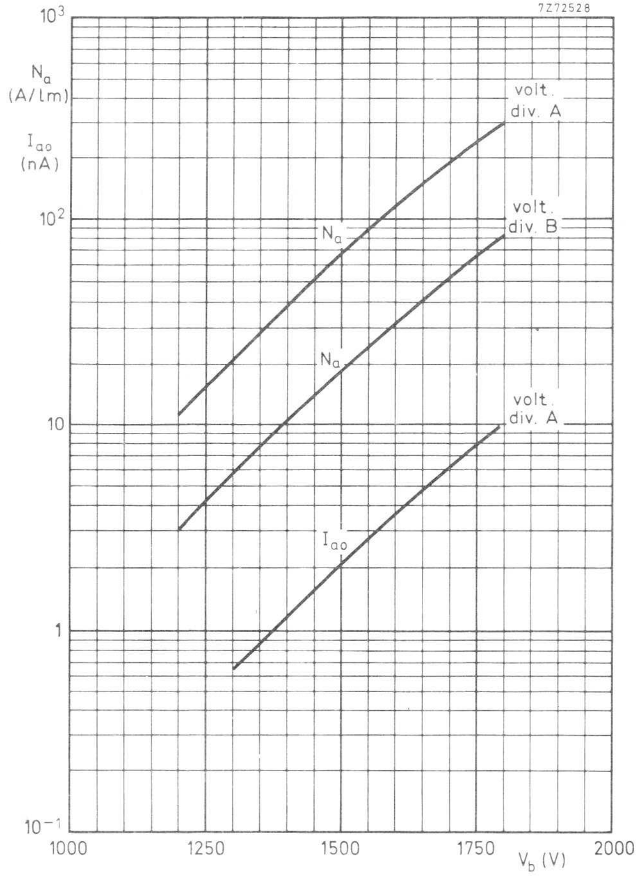


Fig. 5
Anode luminous sensitivity, Na, and anode dark current, I_{ao}, as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The XP1116 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S1 (type C) photocathode.
The tube is intended for use in optical measurements where a good sensitivity in the visible and near-infrared part of the spectrum is needed. Its rugged construction makes it particularly suitable for industrial applications under limited dimensional conditions.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			S1 (type C)	
Useful diameter of the photocathode		>	14	mm
Spectral sensitivity of the photocathode at 903 nm			1,6	mA/W
Supply voltage for an anode luminous sensitivity N_a = 10 A/lm			1650	V
Anode pulse rise time (with voltage divider B)		≈	3,5	ns
Linearity				
with voltage divider A	up to	≈	10	mA
with voltage divider B	up to	≈	30	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate		
Shape	plano-plano		
Refractive index at 550 nm	1,48		

Photocathode

Semi-transparent, head-on			
Material	Ag-O-Cs		
Useful diameter	>	14	mm
Spectral sensitivity characteristic (Fig. 3)	S1 (type C)		
Maximum spectral sensitivity at		800 ± 100	nm

Luminous sensitivity	1)	typ.	20 μA/lm
		>	15 μA/lm
Spectral sensitivity at 903 ± 8 nm	2)		1,6 mA/W
at 1060 ± 10 nm		≈	0,12 mA/W

Electron optical input system

This consists of : the photocathode, k; a metallized part of the glass envelope internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

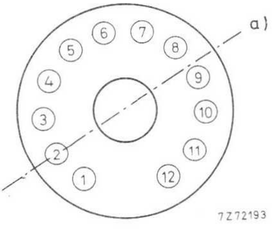
Multiplier system

Number of stages			10
Dynode structure			linear focused
Dynode material			Ag-Mg
Capacitances			
Anode to all	C_a	≈	3 pF
Anode to final dynode	$C_{a/S10}$	≈	1,9 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):
- at a magnetic flux density of 0,3 mT perpendicular to axis a);
- at a magnetic flux density of 0,2 mT parallel to axis a). (See Fig. below.)

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Dynode plane with respect to base pins (bottom view).

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

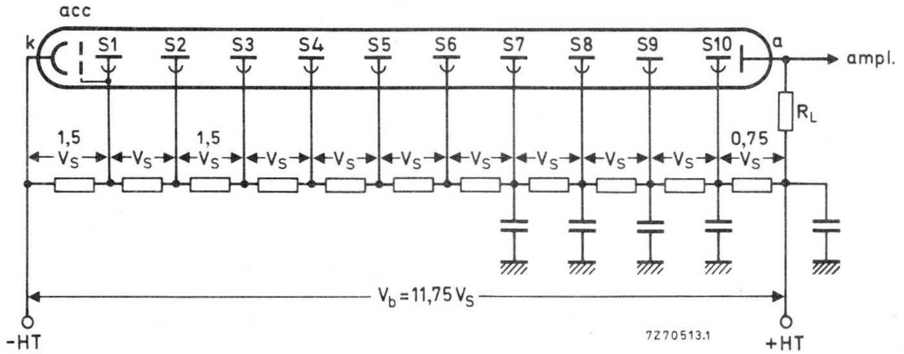


Fig. 1 Voltage divider A

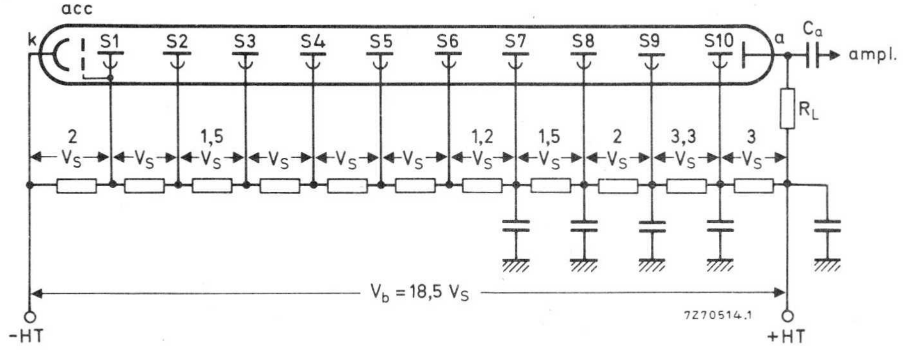


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistance

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for an anode luminous sensitivity N_a = 10 A/lm (Fig. 5)		typ. <	1650 1800	V V
Anode dark current at N_a = 10 A/lm (Fig. 5)	2)3)	typ. <	5 10	µA µA
Anode current linear within 2% at V_b = 1800 V up to		≈	10	mA
With voltage divider B (Fig. 2)	1)			
Anode luminous sensitivity at V_b = 1800 V		≈	2,5	A/lm
Anode pulse rise time at V_b = 1800 V	4)	≈	3,5	ns
Anode pulse duration at half height at V_b = 1800 V	4)	≈	6	ns
Signal transit time at V_b = 1800 V	4)	≈	30	ns
Anode current linear within 2% at V_b = 1800 V up to		≈	30	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	1900	V
Continuous anode current	6)	max.	10	µA
Voltage between first dynode and photocathode	7)	max. min.	350 100	V V
Voltage between consecutive dynodes		max.	200	V
Voltage between anode and final dynode		max. min.	300 30	V V
Ambient temperature range Operational (for short periods of time)		max. min.	+50 −30	°C °C
Continuous operation and storage		max. min.	+50 −30	°C °C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at -HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The shrink sleeve or the mu-metal shield around the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current for S1 (type C) photocathodes is measured at a temperature of 20 ^{o}C. The dark current varies sharply with temperature. See also note 6.

4) Measured with a pulsed-light source, with a pulse duration of < 1 ns; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum and the instant at which the anode pulse attains its maximum. Rise time, pulse duration, and transit time vary as a function of the HT supply voltage V_b, approximately at $V_b^{-1/2}$.

5) Total HT supply voltage, or the voltage at which the tube has an anode luminous sensitivity of 30 A/lm, whichever is lower.

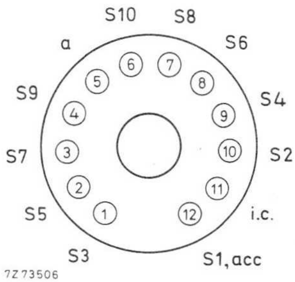
6) As the dark current increases by a factor of 2 for every 7 ^{o}C increase in temperature, the anode sensitivity should be limited so that the continuous anode current limit is not exceeded.

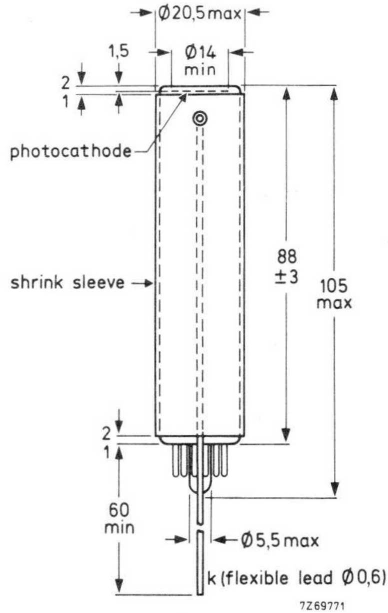
7) Minimum value to obtain good collection in the input optics.

8) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm





Net mass : 25 g

Base : 12-pin all-glass

ACCESSORIES

Socket : type FE 1004

Mu-metal shield : type 56134

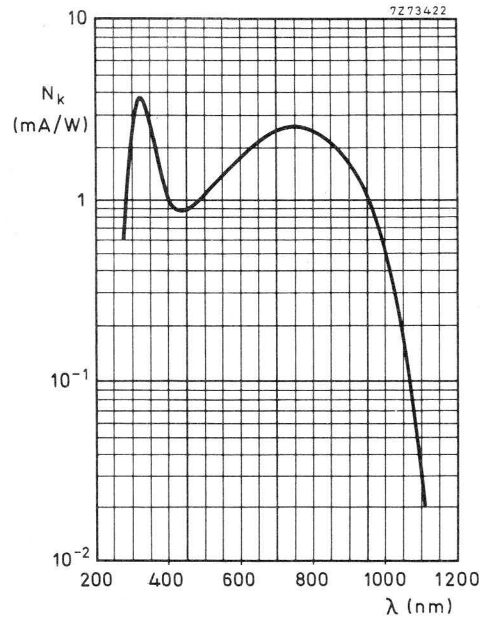


Fig. 3

Spectral sensitivity characteristic

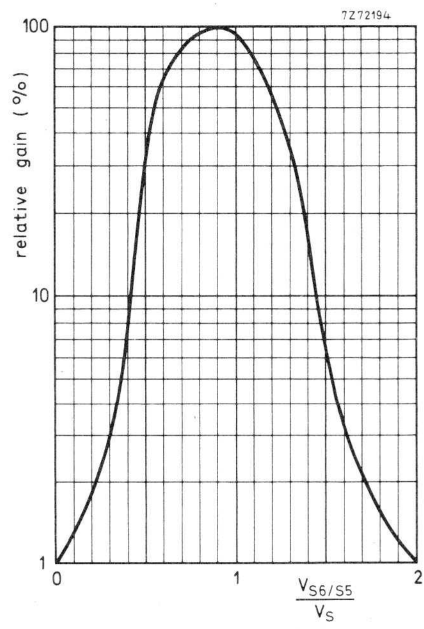


Fig. 4

Relative gain as a function of the voltage between S6 and S5, normalized to V_S

$V_{S7/S5}$ constant

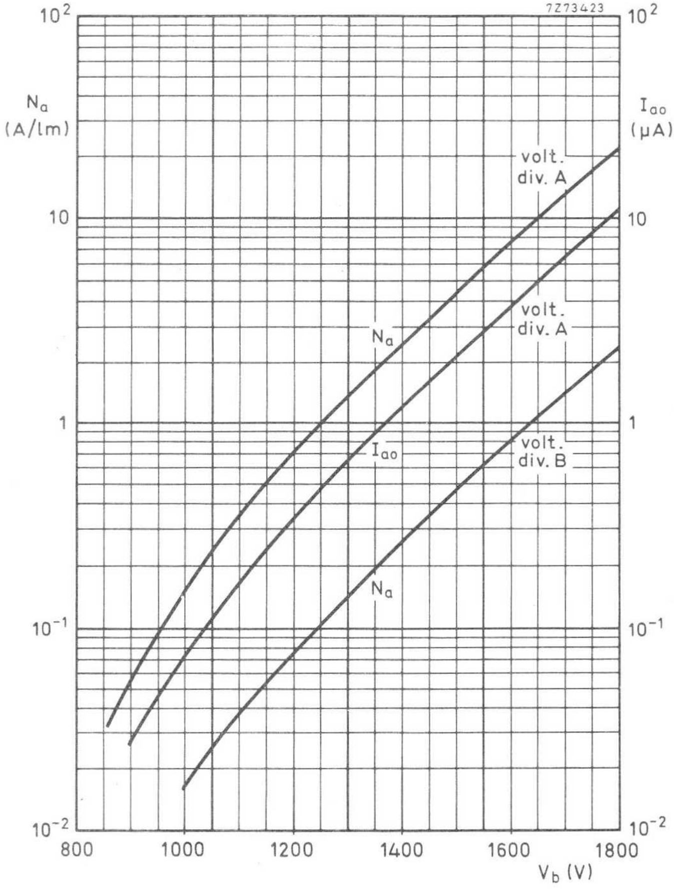


Fig. 5

Anode luminous sensitivity, N_a, and dark current, I_{ao}, as a function of supply voltage.

9-STAGE PHOTOMULTIPLIER TUBE

The XP1117 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S20 (type T) photocathode.
The tube is intended for use in optical measurements where a good sensitivity in the entire visible spectrum is needed.
Its rugged construction makes it particularly suitable for industrial applications under limited dimensional conditions.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			S20 (type T)	
Useful diameter of the photocathode		>	14	mm
Spectral sensitivity of the photocathode at 698 nm			13	mA/W
Supply voltage for an anode luminous sensitivity N_a = 30 A/lm			1520	V
Anode pulse rise time (with voltage divider B)		≈	3,5	ns
Linearity				
with voltage divider A	up to	≈	10	mA
with voltage divider B	up to	≈	30	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material		borosilicate	
Shape		plano-plano	
Refractive index at 550 nm		1,48	

Photocathode

Semi-transparent, head-on			
Material		Sb-Na-K-Cs	
Useful diameter	>	14	mm
Spectral sensitivity characteristic (Fig. 3)		S20 (type T)	
Maximum spectral sensitivity at		420 ± 30	nm
Luminous sensitivity	typ.	140	μA/lm
	>	100	μA/lm
Spectral sensitivity at 698 ± 7 nm		13	mA/W

Electron optical input system

This consists of: the photocathode, k; a metallized part of the envelope internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

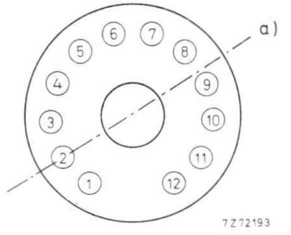
Multiplier system

Number of stages		9	
Dynode structure		linear focused	
Dynode material		Ag-Mg	
Capacitances			
Anode to all	≈	3	pF
Anode to final dynode	≈	1,9	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):
- at a magnetic flux density of 0,3 mT perpendicular to axis a);
- at a magnetic flux density of 0,2 mT parallel to axis a). (see Fig. below.)

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

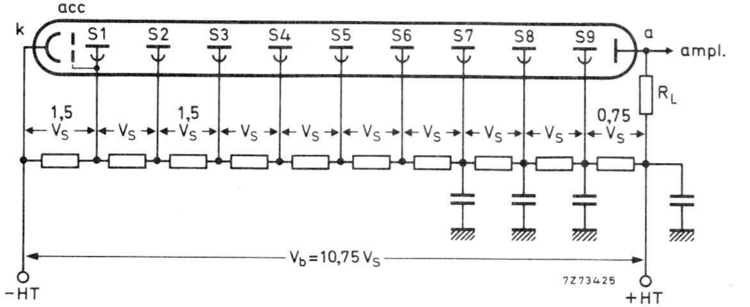


Fig. 1 Voltage divider A

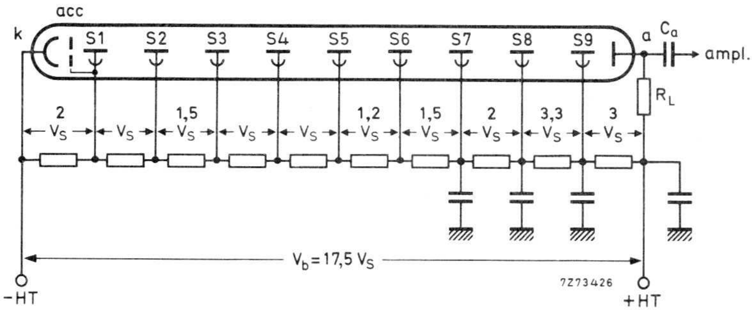


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1) [1]

Supply voltage for an anode luminous sensitivity N_a = 30 A/lm (Fig. 5)		typ.	1520	V
		<	1800	V
Anode dark current at N_a = 30 A/lm (Fig. 5)	[2] [3]	typ.	10	nA
		<	100	nA
Anode current linear within 2% at V_b = 1800 V up to		≈	10	mA

With voltage divider B (Fig. 2) [1]

Anode luminous sensitivity at V_b = 1800 V (Fig. 5)		≈	15	A/lm
Anode pulse rise time at V_b = 1800 V	[4]	≈	3,5	ns
Anode pulse duration at half height at V_b = 1800 V	[4]	≈	6	ns
Signal transit time at V_b = 1800 V	[4]	≈	28	ns
Anode current linear within 2% at V_b = 1800 V up to		≈	30	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[5]	max.	1900	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	[6]	max.	350	V
		min.	100	V
Voltage between consecutive dynodes		max.	200	V
Voltage between anode and final dynode	[7]	max.	300	V
		min.	30	V
Ambient temperature range				
Operational (for short periods of time)		max.	+70	°C
		min.	−50	°C
Continuous operation and storage		max.	+50	°C
		min.	−50	°C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The shrink sleeve or the mu-metal shield around the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

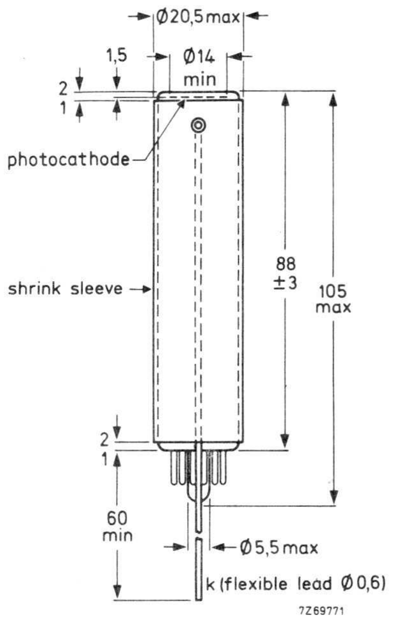
5) Total HT supply voltage, or the voltage at which the tube has an anode sensitivity of 500 A/lm, whichever is lower.

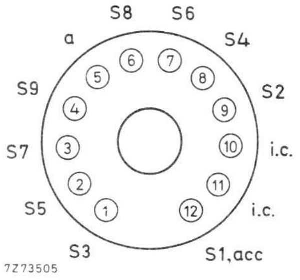
6) Minimum value to obtain good collection in the input optics.

7) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

Dimensions in mm





Net mass : 25 g

Base : 12-pin all glass

ACCESSORIES

Socket : type FE1004

Mu-metal shield : type 56134

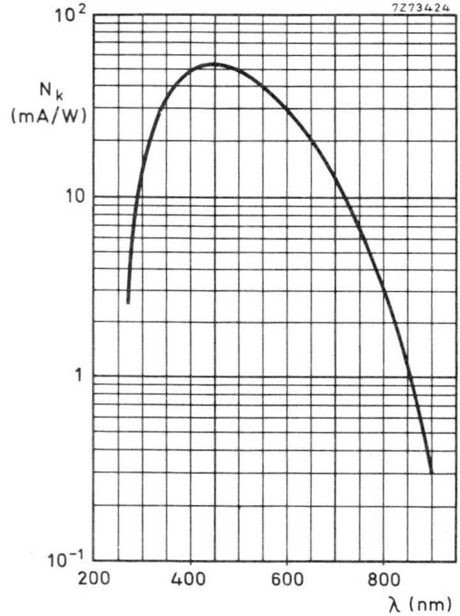


Fig. 3

Spectral sensitivity characteristic

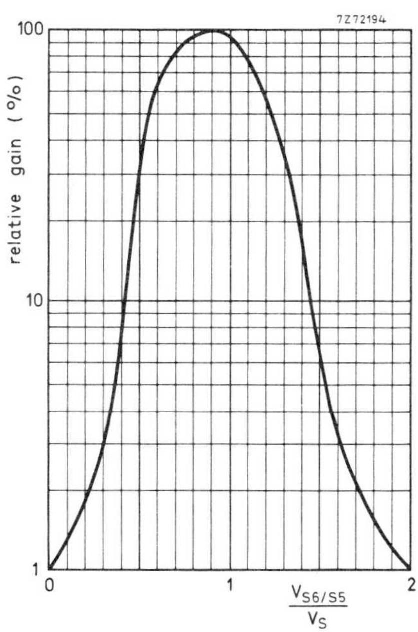


Fig. 4

Relative gain as a function of the voltage between S_6 and S_5, normalized to V_S
$V_{S7/S5}$ constant

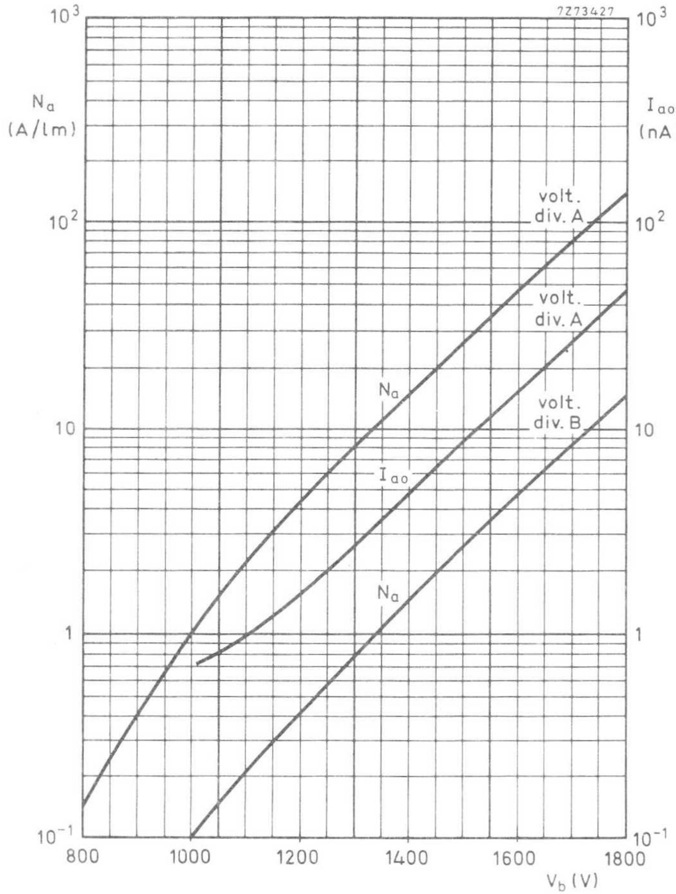


Fig. 5

Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

The XP2000 is a 44 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in nuclear physics where a very good pulse amplitude resolution is required. The tube offers a high cathode sensitivity and, combined with a very low dark current and high stability, its excellent collection from each point of the photocathode makes it very suitable for scintillation detection in nuclear medicine, e.g. gamma cameras.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 44 mm
Cathode spectral sensitivity at 401 nm	85 mA/W
Supply voltage for an anode spectral sensitivity of 12 kA/W	1250 V
Anode dark current at an anode spectral sensitivity of 12 kA/W	0,5 nA
Pulse amplitude resolution (^{137}Cs)	≈ 7 %
Mean anode sensitivity deviation	≈ 1 %

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-plano
Refractive index at 550 nm	1,52

Photocathode *

Semi-transparent, head-on	
Material	Sb-K-Cs
Useful diameter	> 44 mm
Spectral sensitivity characteristic (Fig. 4)	type D

* The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.

Photocathode (continued)

Maximum spectral sensitivity at	400 ± 30 nm
Quantum efficiency at 401 nm	26,5 %
Spectral sensitivity at 401 ± 3 nm	typ. 85 mA/W > 60 mA/W

Multiplier system

Number of stages	10
Dynode structure	venetian blind
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 7 pF
anode to all	≈ 8,5 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1500 V) at a magnetic flux density of 0,4 mT perpendicular to the tube axis.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

RECOMMENDED CIRCUIT

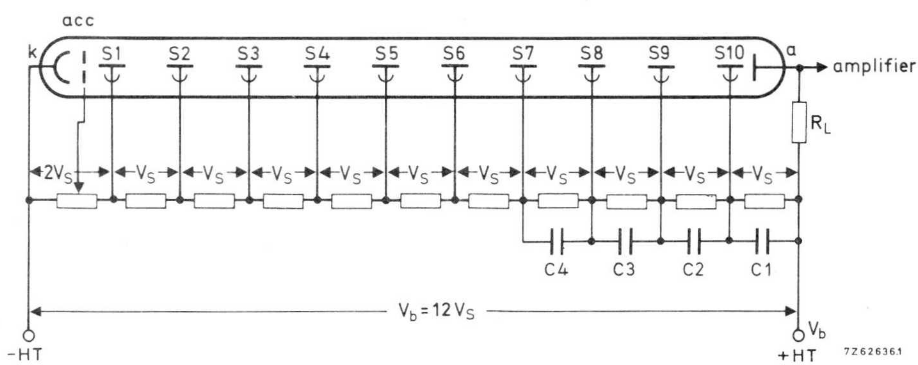


Fig. 1 Voltage divider type A. For obtaining the best energy resolution the accelerating electrode should be connected to S1. Typical values of capacitors: 10 nF, k = cathode; acc = accelerating electrode; Sn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS (with voltage divider A, Fig. 1), see also note 1

	note			
Supply voltage for an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 5)		< typ.	1450 1250	V V
Anode spectral sensitivity at V_b = 1500 V, at 401 nm (Fig. 5)		≈	40	kA/W
Anode dark current at an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 5)	2	< typ.	5 0,5	nA nA
Pulse amplitude resolution for ^{137}Cs at N_{ar} = 12 kA/W	3	≈	7	%
Pulse amplitude resolution for ^{57}Co at N_{ar} = 12 kA/W	3	≈	9,9	%
Pulse amplitude resolution for ^{55}Fe at N_{ar} = 60 kA/W	4	≈	42	%
Peak to valley ratio for ^{55}Fe at N_{ar} = 60 kA/W	4	≈	35	
Mean anode sensitivity deviation	5			
long term (16 h)		≈	1	%
after change of count rate		≈	1	%
versus temperature between 20 °C and 60 °C at 450 nm		≈	0,1% per	°C
Anode current linear within 2% at V_b = 1500 V		up to ≈	10	mA
Anode pulse rise time at V_b = 1500 V	6	≈	10	ns
Anode pulse duration at half height at V_b = 1500 V	6	≈	20	ns
Signal transit time at V_b = 1500 V	6	≈	46	ns

LIMITING VALUES (absolute maximum rating system)

Supply voltage	7	max.	2000	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	8	max. min.	500 150	V V
Voltage between accelerating electrode and photocathode		max.	500	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	9	max.	300	V
Ambient temperature range operational (for short periods of time)	10	max. min.	+80 −30	°C °C
continuous operation and storage		max. min.	+50 −30	°C °C

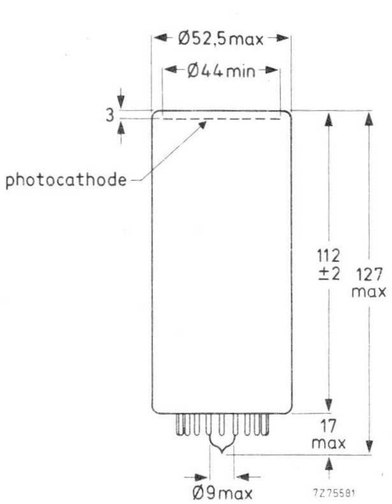
Notes see page 4.

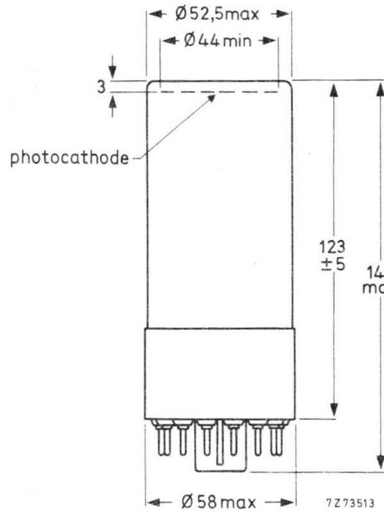
Notes

1. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $>10^{15}$ ohm.
2. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈¼ h).
3. Pulse amplitude resolution for ^{137} Cs and ^{57} Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count rate used is $\approx 10^4$ c/s.
4. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
5. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long-term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s, corresponding to an anode current of ≈ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance from the scintillator such that the count rate can be changed from $\approx 10^4$ c/s to $\approx 10^3$ c/s, corresponding to anode currents of ≈ 300 nA and ≈ 30 nA respectively. Both tests are carried out according to ANSI-N42-9-1972 of IEEE recommendations.
6. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
7. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of ≈ 300 kA/W, whichever is lower.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
10. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





from series no.
10001 on

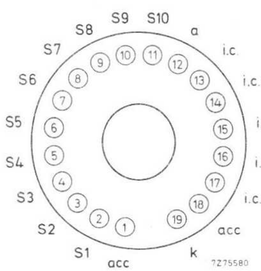


Fig. 2.

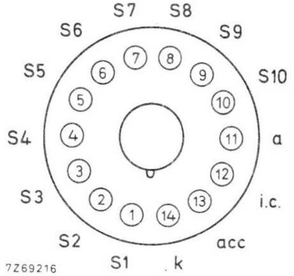


Fig. 3.

Base	19-pin all-glass
Net mass	130 g

To be ordered under type no. XP2000 UB

Base	14-pin IEC 67-1-16a (Jedec B14-38)
Net mass	173 g

To be ordered under type no. XP2000

ACCESSORIES

Socket

for version of Fig. 2	type FE2019
for version of Fig. 3	type FE1014
Mu-metal shield	type 56130

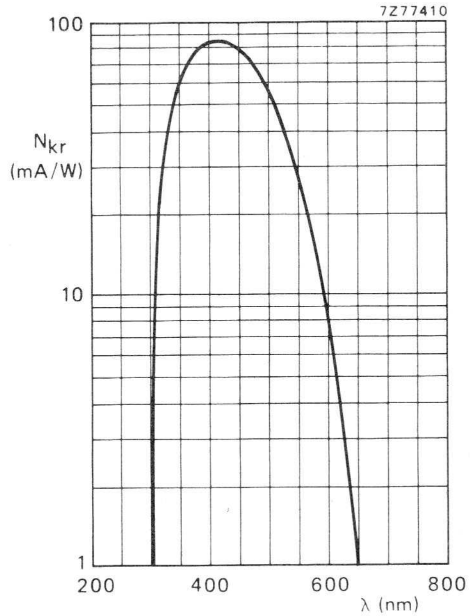


Fig. 4 Spectral sensitivity characteristic.

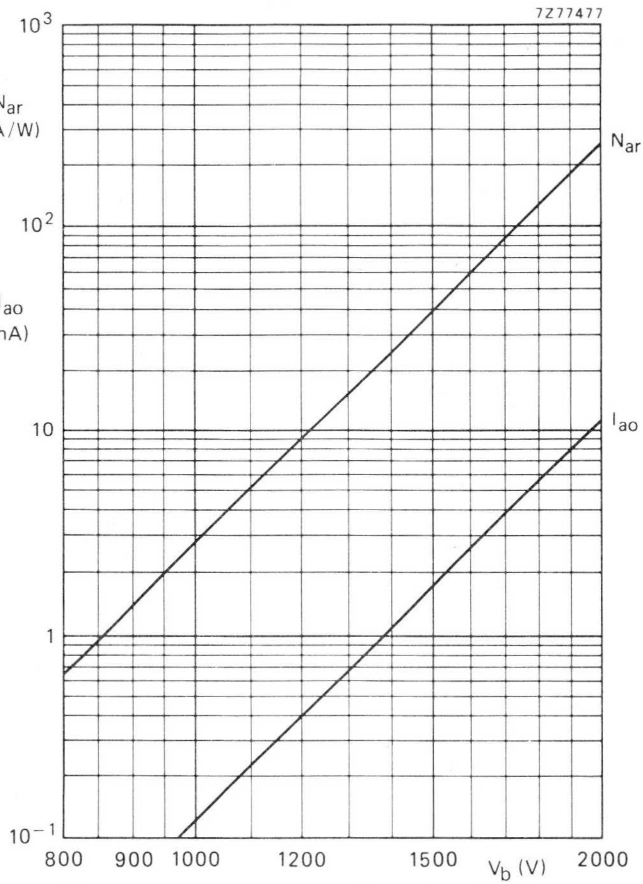


Fig. 5 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

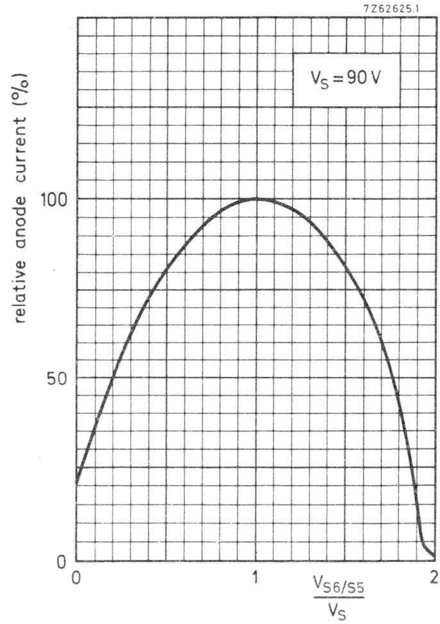


Fig. 6 Relative anode current as a function of the voltage between S6 and S5, normalized to V_S, $V_{S7/S5}$ constant.

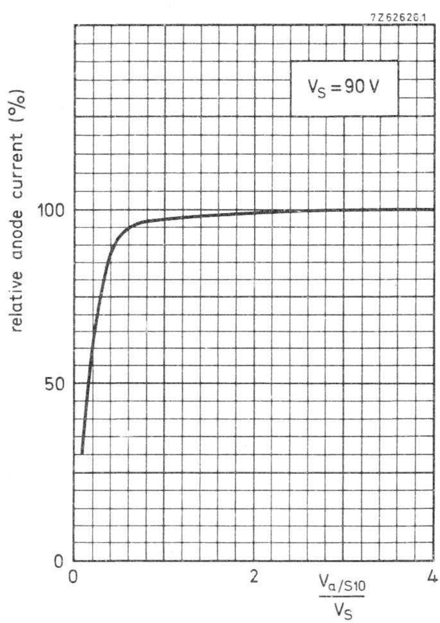


Fig. 7 Relative anode current as a function of the voltage between anode and last dynode, normalized to V_S.

10-STAGE PHOTOMULTIPLIER TUBE

The XP2008 is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent Super A photocathode. The tube is intended for use in applications such as scintillation counting, laboratory and industrial photometry. Its Cu-Be dynode system offers a high stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		Super A	
Useful diameter of the photocathode	>	32	mm
Spectral sensitivity of the photocathode at 437 nm	≈	70	mA/W
Supply voltage for luminous sensitivity N_a = 60 A/lm		1180	V
Pulse amplitude resolution for ^{137}Cs	≈	8	%
Mean anode sensitivity deviation	≈	1	%
Anode pulse rise time (with voltage divider B)	≈	2,5	ns
Linearity			
with voltage divider A	up to ≈	100	mA
with voltage divider B	up to ≈	200	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Shape	plano-plano		
Material	lime glass		
Refractive index at 550 nm		1,52	

Photocathode

Semi-transparent, head-on			
Material	Sb-Cs		
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig. 3)	type Super A		
Maximum sensitivity at		420 ± 30	nm
Luminous sensitivity	typ	80	µA/lm
	>	40	µA/lm
Spectral sensitivity at 437 ± 5 nm	≈	70	mA/W

Electron optical input system

This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S 1.

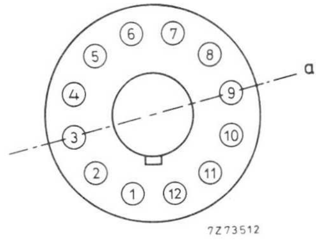
Multiplier system

Number of stages		10
Dynode structure		linear focused
Dynode material		Cu-Be
Capacitances		
Anode to all	$\approx$	5 pF
Anode to final dynode	$\approx$	3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):
- at a magnetic flux density of 0,6 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,35 mT perpendicular to axis a (see Fig. below);
- at a magnetic flux density of 0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

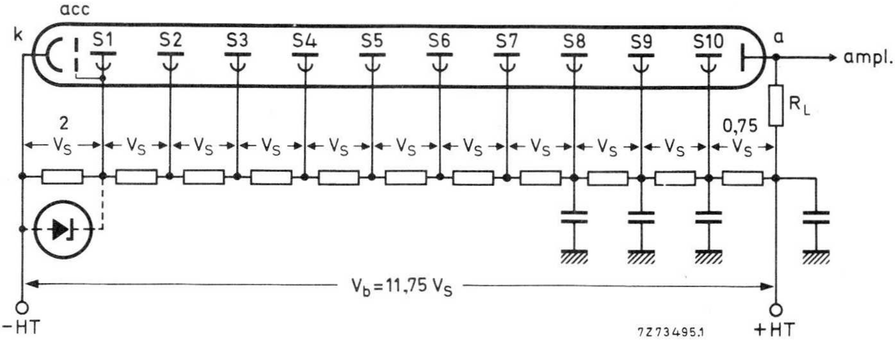


Fig. 1 Voltage-divider A (note 4)

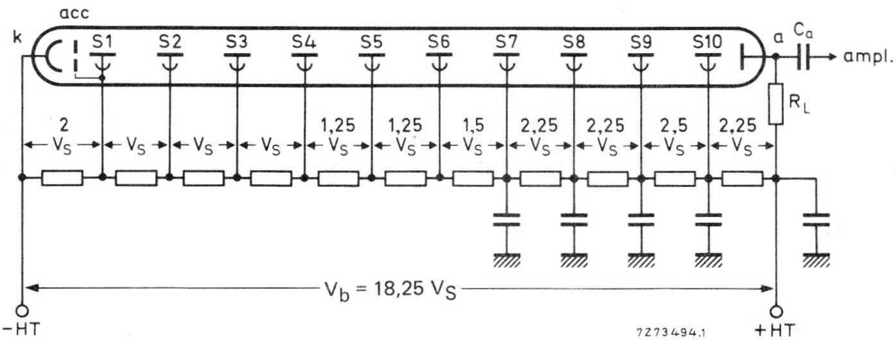


Fig. 2 Voltage divider B.

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

	note			
With voltage divider A (Fig. 1)	1			
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)		< typ	1500 1180	V V
Anode dark current at an anode luminous sensitivity N_a = 60 A/lm (Fig. 5)	2,3	< typ	50 5	nA nA
Pulse amplitude resolution for ^{137}Cs at N_a = 10 A/lm	4	≈	8	%
Mean anode sensitivity deviation at V_b = 1200 V	5			
long term		≈	1	%
after change of count rate		≈	1	%
Anode current linear within 2% at V_b = 1700 V		up to ≈	100	mA
With voltage divider B (Fig. 2)				
Anode luminous sensitivity at V_b = 1700 V (Fig. 5)		≈	150	A/lm
Anode pulse rise time at V_b = 1700 V	6	≈	2,5	ns
Anode pulse duration at half height at V_b = 1700 V	6	≈	6	ns
Signal transit time at V_b = 1700 V	6	≈	26	ns
Anode current linear within 2% at V_b = 1700 V		up to ≈	200	mA

LIMITING VALUES (Absolute maximum rating system)

	note			
Supply voltage	7	max	1800	V
Continuous anode current		max	0,2	mA
Voltage between first dynode and photocathode	8	max min	500 150	V V
Voltage between consecutive dynodes		max	300	V
Voltage between anode and final dynode	9	max min	300 30	V V
Ambient temperature range				
Operational (for short periods of time)	10	max min	+80 −30	°C °C
Continuous operating and storage		max min	+50 −30	°C °C

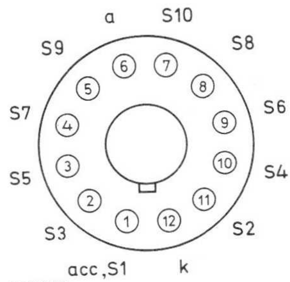
Notes see page 5.

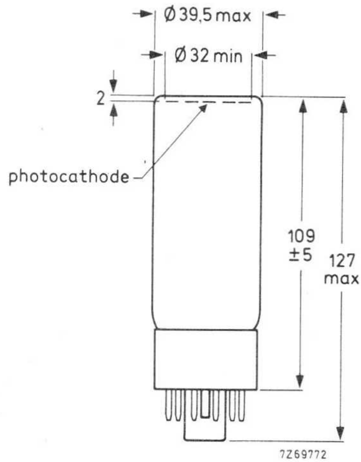
Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).
4. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^4$ c/s.
   For optimum peak amplitude resolution it is recommended that the voltage between first dynode and photocathode be maintained at ≈ 200 V, e.g. by means of a voltage regulator diode.
5. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the scintillator count rate is $\approx 10^4$ c/s corresponding to an average anode current of ≈ 100 nA.
   Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of ≈ 100 nA and ≈ 10 nA respectively.
   Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
6. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
7. Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
10. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass:	80 g
Base:	12-pin (JEDEC B12-43)

ACCESSORIES

→ Socket:	type FE1012
Mu-metal shield:	type 56127

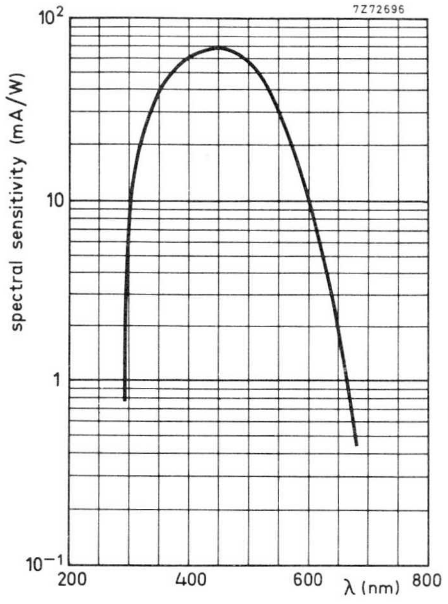


Fig. 3 Spectral sensitivity characteristic.

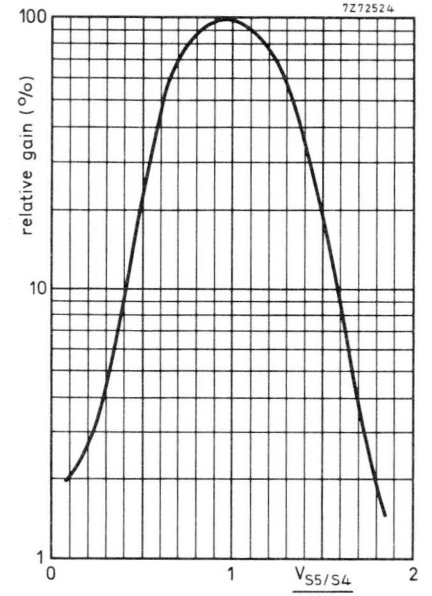


Fig. 4 Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S, $V_{S6/S4}$ constant.

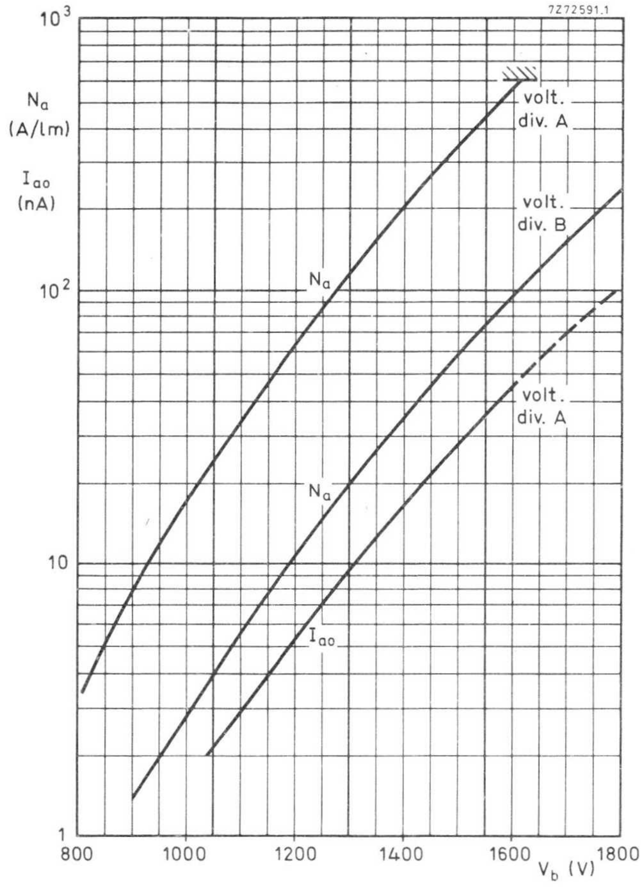


Fig. 5 Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b.

10-STAGE PHOTOMULTIPLIER TUBE

The XP2010 is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent Super A photocathode. The tube is intended for use in X-ray and γ-spectrometry. Its Cu-Be dynode system offers a high stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		Super A		
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode at 437 nm		≈	80	mA/W
Supply voltage for anode luminous sensitivity N_a = 60 A/lm			1180	V
Pulse amplitude resolution for ^{55}Fe at N_a = 60 A/lm		≈	45	%
Mean anode sensitivity deviation		≈	1	%
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	200	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Shape	plano-plano		
Material	lime glass		
Refractive index at 550 nm		1,52	

Photocathode

Semi-transparent, head-on			
Material	Sb-Cs		
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig.3)	type Super A		
Maximum sensitivity at		420 ± 30	nm
Luminous sensitivity	typ	90	μA/lm
	>	70	μA/lm
Spectral sensitivity at 437 ± 5 nm	≈	80	mA/W

Electron optical input system

This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

Multiplier system

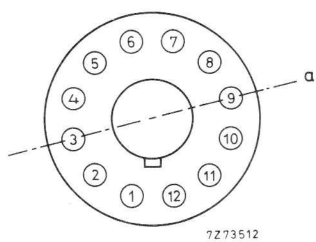
Number of stages		10
Dynode structure	linear focused	
Dynode material	Cu-Be	
Capacitances		
Anode to all	≈	5 pF
Anode to final dynode	≈	3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1200 V, voltage divider A):

– at a magnetic flux density of 0,6 mT in the direction of the longitudinal axis;
– at a magnetic flux density of 0,35 mT perpendicular to axis a (see Fig. below);
– at a magnetic flux density of 0,15 mT parallel to axis a.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

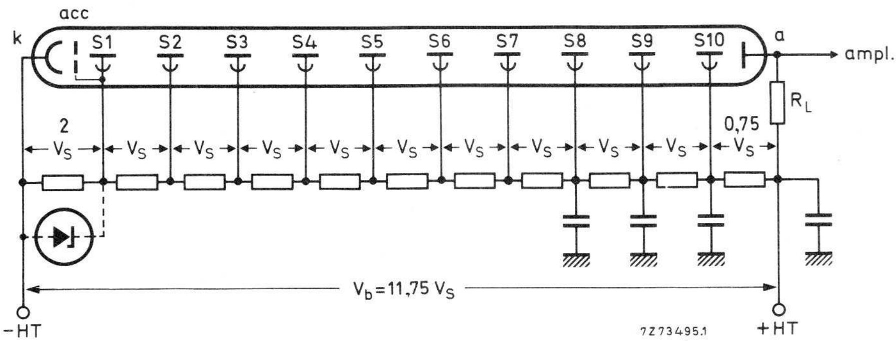


Fig.1 Voltage divider A. (note 5)

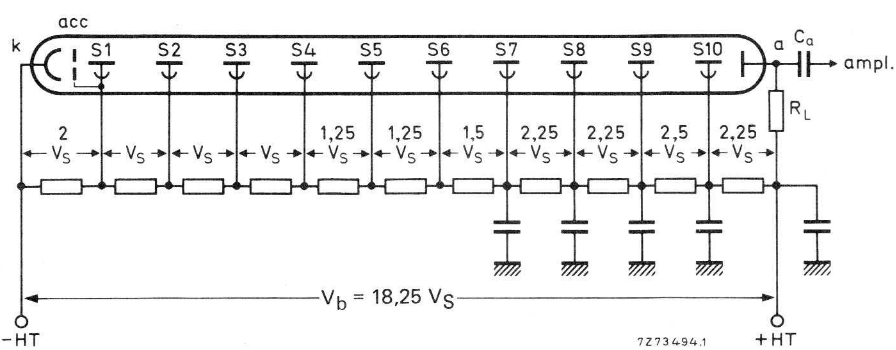


Fig.2 Voltage divider B.

k = cathode
acc = accelerating electrode
S_n = dynode no.n
a = anode
R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

	note				
With voltage divider A (Fig.1)	1				
Supply voltage for an anode luminous sensitivity N_a = 60 A/lm (Fig.5)			< typ	1500 1180	V V
Anode dark current at an anode luminous sensitivity N_a = 60 A/lm (Fig.5)	2,3		< typ	25 2	nA nA
Pulse amplitude resolution for ^{55}Fe at an anode luminous sensitivity N_a = 60 A/lm	4		≈	45	%
Peak to valley ratio for ^{55}Fe at N_a = 60 A/lm	4		≈	30	
Pulse amplitude resolution for ^{137}Cs at N_a = 10 A/lm	5		≈	7,5	%
Mean anode sensitivity deviation at V_b = 1200 V	6				
long term			≈	1	%
after change of count rate			≈	1	%
Anode current linear within 2% at V_b = 1700 V		up to	≈	100	mA
With voltage divider B (Fig.2)	1				
Anode luminous sensitivity at V_b = 1700 V (Fig.5)			≈	150	A/lm
Anode pulse rise time at V_b = 1700 V	7		≈	2,5	ns
Anode pulse duration at half height at V_b = 1700 V	7		≈	6	ns
Signal transit time at V_b = 1700 V	7		≈	26	ns
Anode current linear within 2% at V_b = 1700 V		up to	≈	200	mA

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	8	max	1800	V
Continuous anode current		max	0,2	mA
Voltage between first dynode and photocathode	9	max min	500 150	V V
Voltage between consecutive dynodes		max	300	V
Voltage between anode and final dynode	10	max min	300 30	V V
Ambient temperature range				
Operational (for short periods of time)	11	max min	+80 −30	°C °C
Continuous operation and storage		max min	+50 −30	°C °C

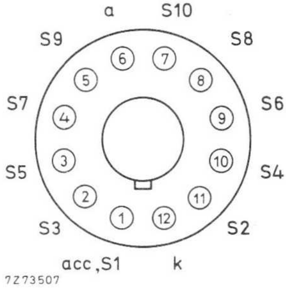
Notes see page 5.

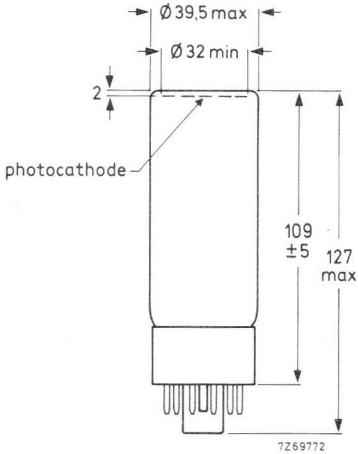
Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage.
   The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ 1/4 h).
4. Pulse amplitude resolution for ^{55}Fe is measured with an NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window.
   The count rate used is $\approx 2 \times 10^3$ c/s.
5. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^4$ c/s.
   For optimum peak amplitude resolution it is recommended that the voltage between first dynode and photocathode be maintained at $\approx$ 200 V, e.g. by means of a voltage regulator diode.
6. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the scintillator count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 100 nA. Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 100 nA and $\approx$ 10 nA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
7. Measured with a pulsed-light source, with a pulse duration (FWHM) of $<$ 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
8. Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass:	80 g
Base:	12-pin (JEDEC B12–43)

ACCESSORIES

→ Socket:	type FE1012
Mu-metal shield:	type 56127

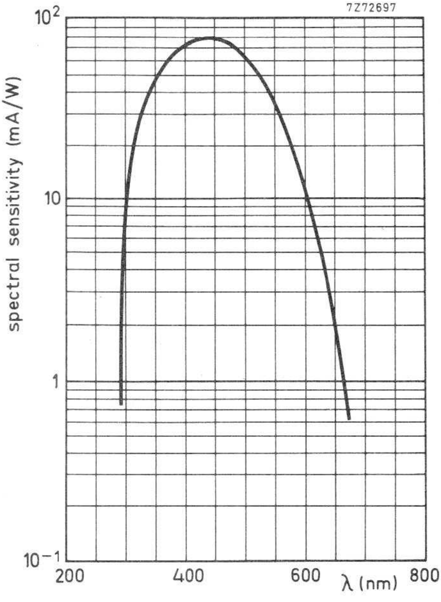


Fig.3 Spectral sensitivity characteristic.

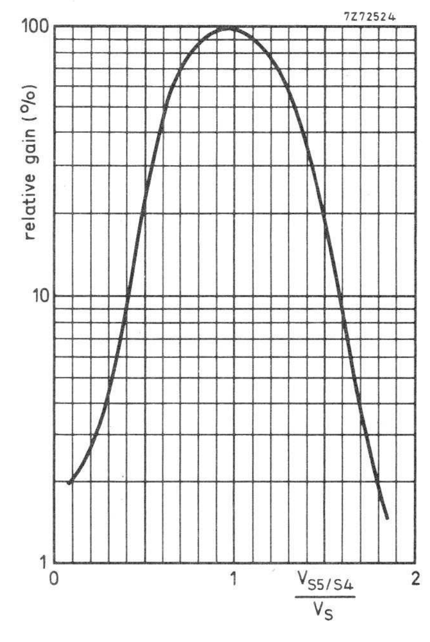


Fig. 4 Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S, $V_{S6/S4}$ constant.

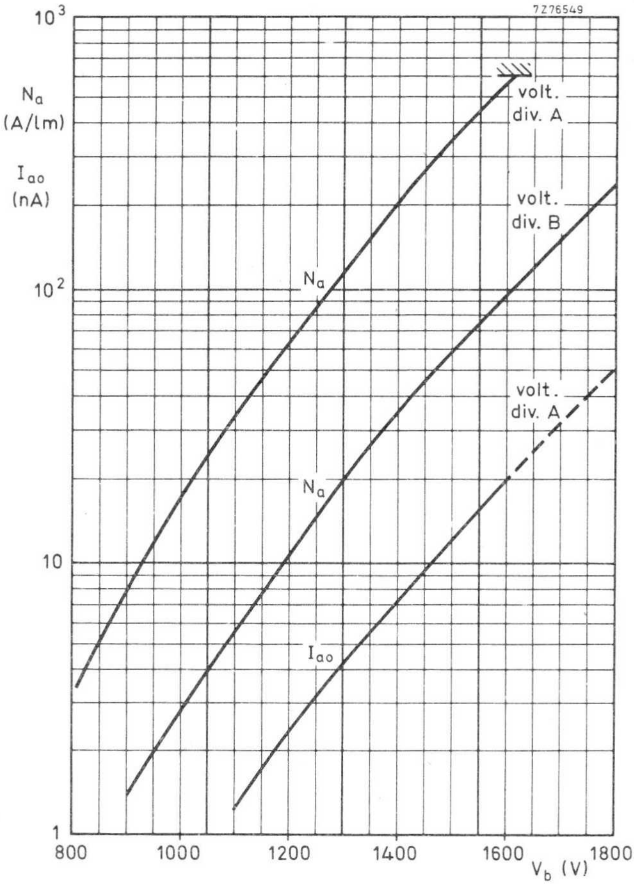


Fig.5 Anode luminous sensitivity, N_a and anode dark current, I_{ao}, as a function of supply voltage V_b.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2020 is a 44 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparent type D photocathode. The tube is intended for use in nuclear physics where the number of photons to be detected is very low. The tube features a high cathode sensitivity and a good linearity combined with very low background noise and extremely good time characteristics. It is especially useful in high-energy physics experiments where ultimate time characteristics are needed, such as coincidence measurements, Cerenkov detection, etc.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 401 nm				
XP2020			26	%
XP2020Q			25	%
Spectral sensitivity of the photocathode at 401 nm				
XP2020			85	mA/W
XP2020Q			80	mA/W
Supply voltage for a gain of 3×10^7			2200	V
Pulse amplitude resolution for ^{137}Cs		≈	7,5	%
Anode pulse rise time (with voltage divider B′)		≈	1,5	ns
Linearity, with voltage divider B	up to	≈	280	mA
Signal transit time fluctuation		≈	0,25	ns

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material		
XP2020	borosilicate	
XP2020Q	fused silica	
Shape	plano-concave	
Refractive index		
XP2020, at 550 nm	1,48	
XP2020Q, at 400 nm	1,47	
XP2020Q, at 250 nm	1,50	

Photocathode (note 1)

Semi-transparent, head-on

Material	Sb-K-Cs		
Useful diameter	>	44	mm

Note, see page 6.

	XP2020	XP2020Q	
Spectral sensitivity characteristic	type D (Fig. 6)	type DU (Fig. 7)	
Maximum spectral sensitivity at	400 ± 30	400 ± 30	nm
Quantum efficiency at 401 nm	26	25	%
Spectral sensitivity at 401 ± 3 nm	typ. 85	typ. 80	mA/W
	> 60	> 60	mA/W

Multiplier system

Number of stages	12	
Dynode structure	linear focused	
Dynode material	Ag-Mg	
Capacitances		
Grid 1 to k + S_1 + acc + g_2 + S_5	≈ 20	pF
Anode to final dynode	≈ 4	pF
Anode to all	≈ 7	pF

Magnetic field

See Fig. 13.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

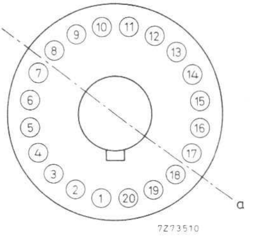


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

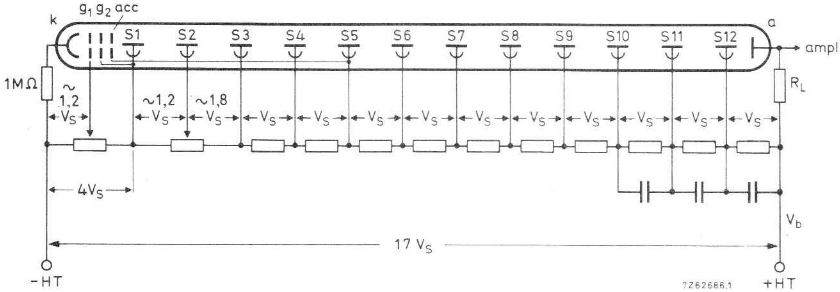


Fig. 2 Voltage divider type A.

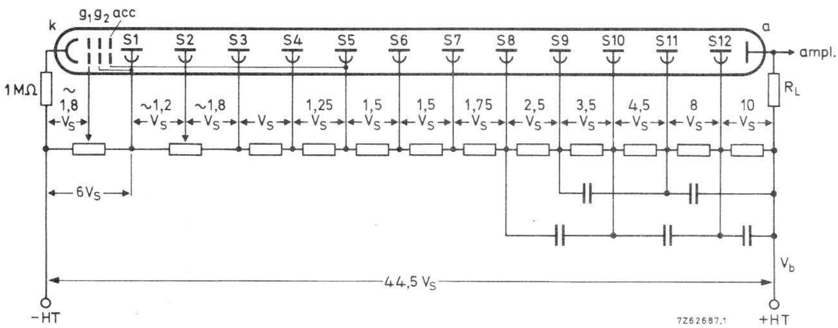


Fig. 3 Voltage divider type B.

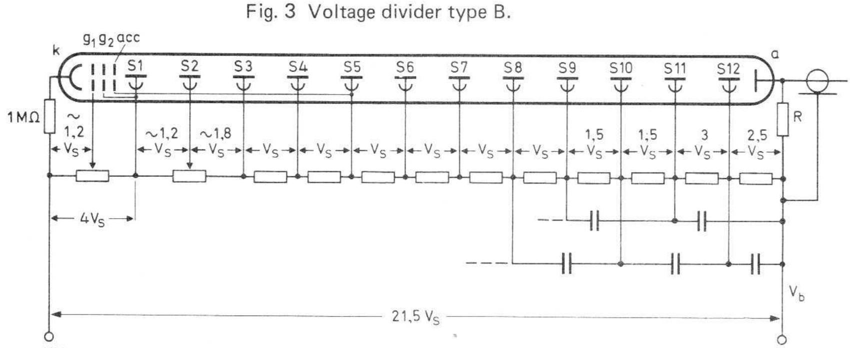


Fig. 4 Voltage divider type B′.

k	= cathode
g_1, g_2	= focusing electrodes
acc	= accelerating electrode
S_n	= dynode no. n
a	= anode
R_L	= load resistor

R = This resistor connects the anode when the output cable is not terminated. Recommended value: 10 kΩ.

The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.
Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

	note			
With voltage divider A (Fig. 2)	2			
Supply voltage for a gain of 3×10^7 (Fig. 8)			typ.	2200 V
			$<$	2600 V
Anode dark current at a gain of 3×10^7 (Fig. 8)	3,4		typ.	7 nA
			$<$	100 nA
Background noise at a gain of 3×10^7 (Fig. 11)	5		typ.	900 c/s
			$<$	2500 c/s
Pulse amplitude resolution for ^{55}Fe at V_b = 1500 V	6		$\approx$	43 %
Peak to valley ratio for ^{55}Fe at $G = 3 \times 10^7$			$\approx$	34
Pulse amplitude resolution for ^{137}Cs at V_b = 1500 V	6		$\approx$	7,5 %
Anode pulse rise time at V_b = 2000 V	7,13		$\approx$	1,6 ns
Anode pulse duration at half height at V_b = 2000 V	7,13		$\approx$	3,7 ns
Signal transit time at V_b = 2000 V	7,13		$\approx$	28 ns
Anode current linear within 2% at V_b = 2000 V		up to	$\approx$	25 mA
Obtainable peak anode current			$\approx$	100 mA
With voltage divider B (Fig. 3)	2			
Gain at V_b = 2800 V			$\approx$	2×10^6
Anode pulse rise time at V_b = 2800 V	7,13		$\approx$	1,7 ns
Anode pulse duration at half height at V_b = 2800 V	7,13		$\approx$	2,7 ns
Signal transit time at V_b = 2800 V	7,13		$\approx$	31 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2800 V			$\approx$	0,25 ns
Anode current linear within 2% at V_b = 2800 V		up to	$\approx$	280 mA
Obtainable peak anode current			$\approx$	0,5 to 1 A
With voltage divider B' (Fig. 4)	2			
Gain at V_b = 2500 V			$\approx$	2×10^7
Anode pulse rise time at V_b = 2500 V	7,13		$\approx$	1,5 ns
Anode pulse duration at half height at V_b = 2500 V	7,13		$\approx$	2,4 ns
Signal transit time at V_b = 2500 V	7,13		$\approx$	30 ns
Signal transit time fluctuation at V_b = 2500 V	12,13		$\approx$	0,25 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2500 V			$\approx$	0,25 ns
Anode current linear within 2% at V_b = 2500 V		up to	$\approx$	70 mA
Obtainable peak anode current			$\approx$	250 mA

Notes see page 6.

LIMITING VALUES (Absolute maximum rating system)	note			
Supply voltage	8	max.	3000	V
Continuous anode current		max.	0,2	mA
Voltage between focusing electrode, g_1 and photocathode	9	max.	300	V
Voltage between first dynode and photocathode		max.	800	V
		min.	300	V
Voltage between consecutive dynodes (except S_{11} and S_{12})		max.	400	V
Voltage between dynodes S_{11} and S_{12}	13	max.	600	V
Voltage between anode and final dynode	10	max.	700	V
		min.	80	V
Ambient temperature range	11			
operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
continuous operation and storage		max.	+50	°C
		min.	−30	°C

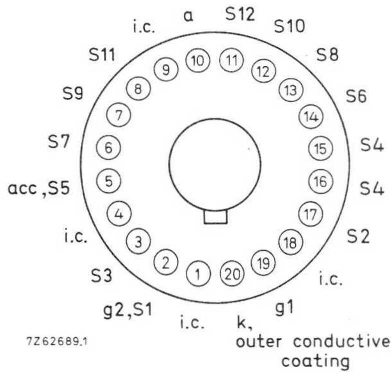
Notes see page 6.

Notes to pages 1, 4 and 5

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B′ are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this should be kept at cathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ ¼ h).
5. After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7. After a 30 min. stabilization period noise pulses with a threshold of $4{,}25 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded (Fig. 9).
6. Pulse amplitude resolution for ^{55}Fe is measured with a NaI (Tl) cylindrical scintillator with a diameter of 19 mm and a height of 3 mm. The count rate is $\approx 10^3$ c/s. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator with a diameter of 44 mm and a height of 50 mm. The count rate is $\approx 10^4$ c/s.
7. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
8. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.
12. Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.
13. Non-inductive resistors of 50 Ω are incorporated in the base connected to S_{11} and S_{12}. See also *General Operational Recommendations Photomultiplier Tubes.*

MECHANICAL DATA

Dimensions in mm



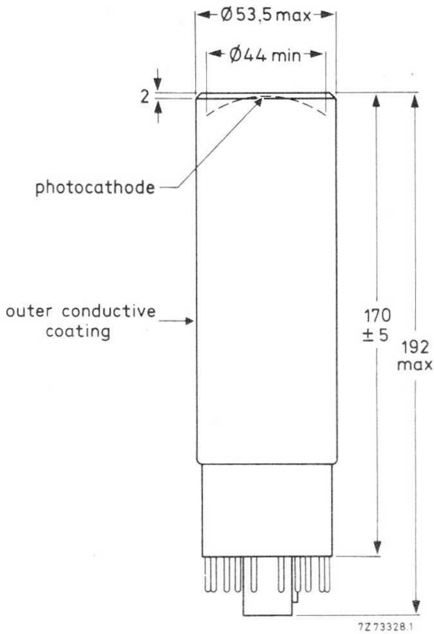


Fig. 5.

The base connections of the XP2020 are such that the tube is unilaterally interchangeable with the 56AVP-family tubes.

Base	20-pin (JEDEC B20-102)
Net mass	240 g

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56130

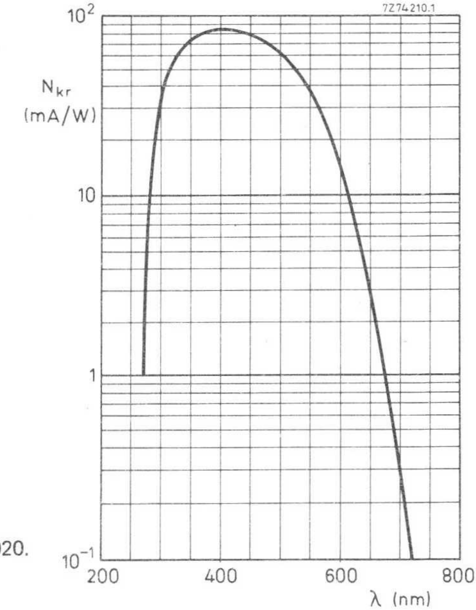


Fig. 6 Spectral sensitivity characteristic XP2020.

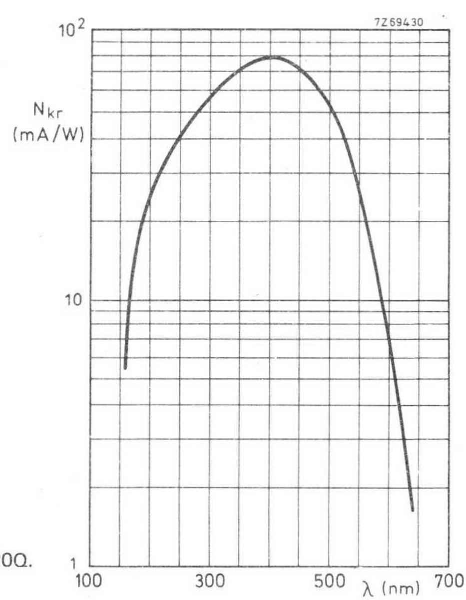


Fig. 7 Spectral sensitivity characteristic XP2020Q.

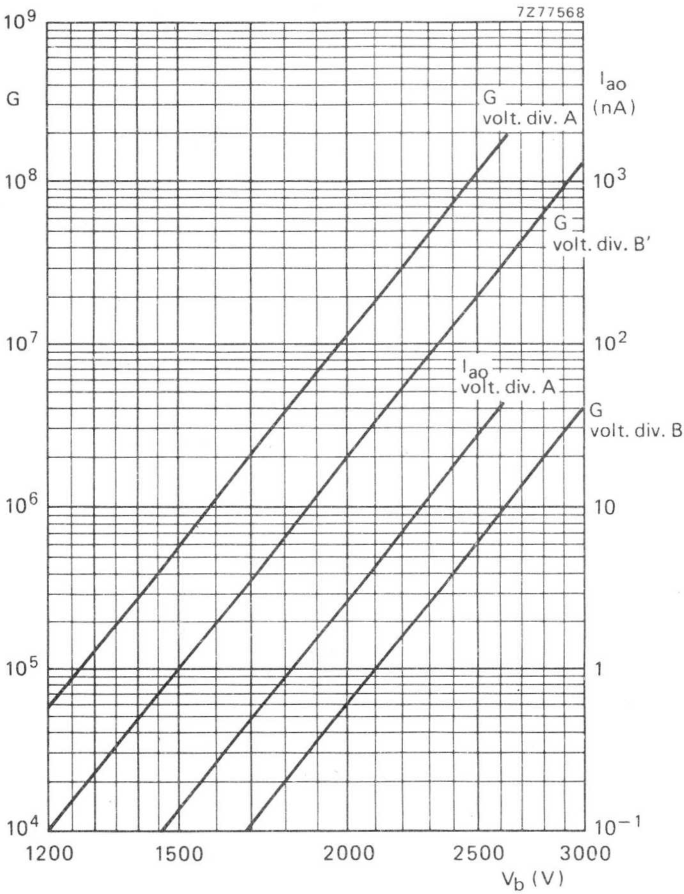


Fig. 8 Gain, G, and anode dark current, I_{ao}, as a function of supply voltage V_b.

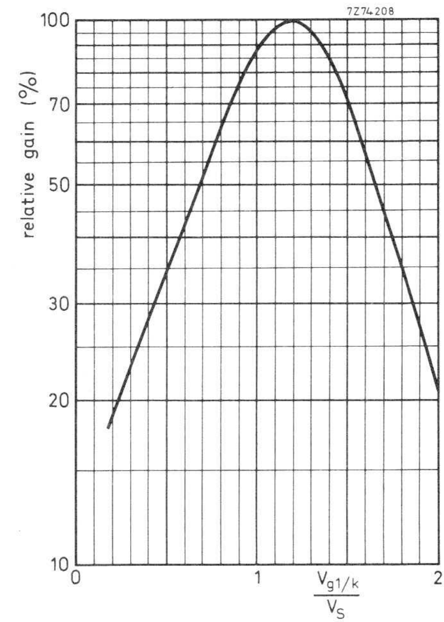


Fig. 9 Relative gain as a function of the voltage between grid 1 and cathode, normalized to V_S. $V_{S1/k}$ constant.

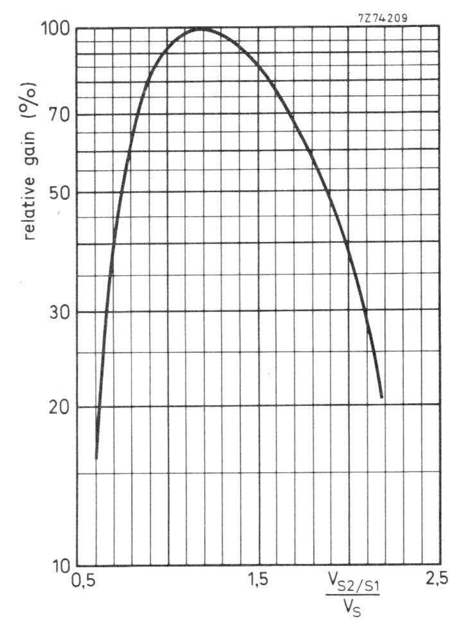


Fig. 10 Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S. $V_{S3/S1}$ constant.

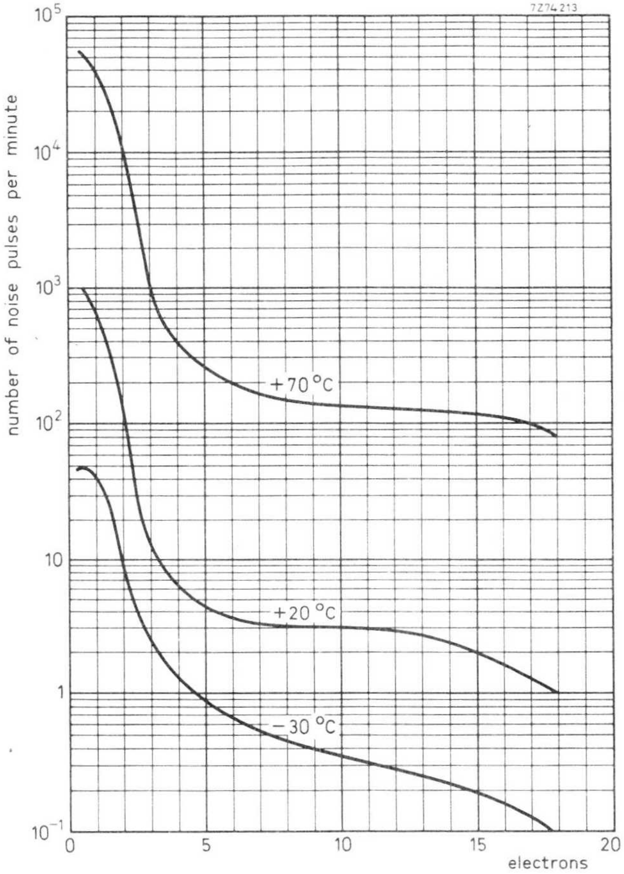


Fig. 11 Typical background spectrum from 0,1 to 18 equivalent photoelectrons, at a gain of 3 x 10^7 with voltage divider A.

→

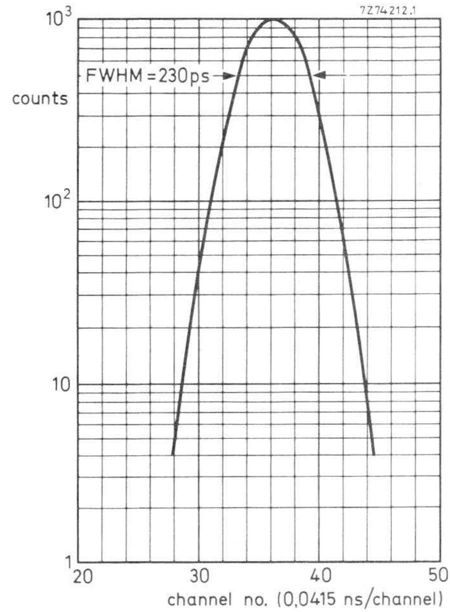


Fig. 12 Time resolution for 2 tubes XP2020 in coincidence. Measuring conditions:
Number of photoelectrons ≈ 1500
Supply voltage 2500 V
Constant fraction operation
Dynamic energy region 20%.

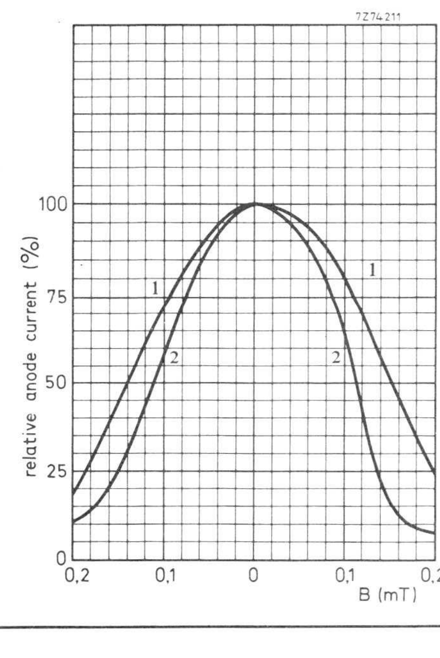


Fig. 13 Relative anode current as a function of the magnetic flux density B.
1. ⊥ axis a
2. // axis a

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

The XP2030 is a 70 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in nuclear physics where a very good pulse amplitude resolution is required. The tube offers a high cathode sensitivity and, combined with a very low dark current and high stability, its excellent collection from each point of the photocathode makes it very suitable for scintillation detection in nuclear medicine, e.g. gamma cameras.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D	
Useful diameter of the photocathode	>	70	mm
Cathode spectral sensitivity at 401 nm		105	mA/W
Supply voltage for an anode spectral sensitivity = 12 kA/W		1250	V
Anode dark current at an anode spectral sensitivity = 12 kA/W		0,5	nA
Pulse amplitude resolution (^{137}Cs)	≈	7,2	%
Mean anode sensitivity deviation	≈	1	%

To be read in conjunction with *General Operational Recommendations Photomultiplier Tubes.*

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-plano
Refractive index at 550 nm	1,52

Photocathode *

Semi-transparent, head-on

Material	Sb-K-Cs
Useful diameter	> 70 mm
Spectral sensitivity characteristic (Fig. 4)	type D

* The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.

Photocathode (continued)

Maximum spectral sensitivity at	400 ± 30 nm
Quantum efficiency at 401 nm	32 %
Spectral sensitivity at 401 ± 3 nm	typ. 105 mA/W > 65 mA/W

Multiplier system

Number of stages	10
Dynode structure	venetian blind
Dynode material	Cu-Be
Capacitances	
anode to final dynode	≈ 7 pF
anode to all	≈ 8,5 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1500 V) at a magnetic flux density of 0,3 mT perpendicular to the tube axis.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

RECOMMENDED CIRCUIT

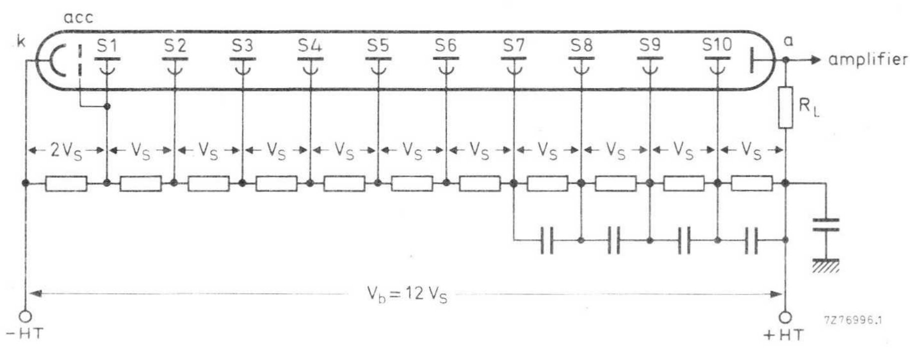


Fig. 1 Voltage divider type A. For obtaining the best energy resolution the accelerating electrode should be connected to S1. Typical values of capacitors: 10 nF, k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS (with voltage divider A, Fig. 1), see also note 1

	note			
Supply voltage for an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 5)			< typ.	1450 V 1250 V
Anode spectral sensitivity at V_b = 1500 V and 401 nm (Fig. 5)			≈	**40** kA/W
Anode dark current at an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 5)	2		< typ.	5 nA 0,5 nA
Pulse amplitude resolution for ^{137}Cs at N_{ar} = 12 kA/W	3		≈	7,2 %
Pulse amplitude resolution for ^{57}Co at N_{ar} = 12 kA/W	3		≈	10,7 %
Mean anode sensitivity deviation	4			
long term (16 h)			≈	1 %
after change of count rate			≈	1 %
versus temperature between 20 °C and 60 °C at 450 nm			≈	0,1% per °C
Anode current linear within 2% at V_b = 1500 V		up to	≈	10 mA
Anode pulse rise time at V_b = 1500 V	5		≈	11 ns
Anode pulse duration at half height at V_b = 1500 V	5		≈	22 ns
Signal transit time at V_b = 1500 V	5		≈	54 ns

LIMITING VALUES (absolute maximum rating system)

	note		
Supply voltage	6	max.	2000 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	7	max. min.	500 V 150 V
Voltage between accelerating electrode and photocathode		max.	500 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	8	max.	300 V
Ambient temperature range	9		
operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

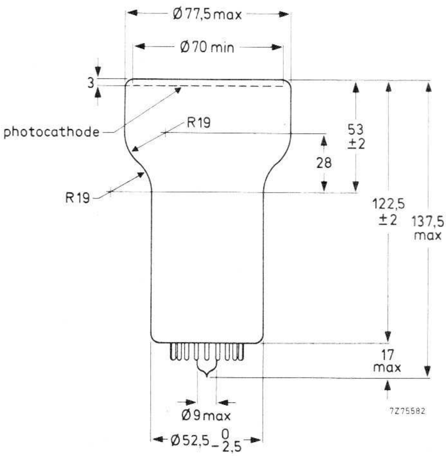
Notes see page 4.

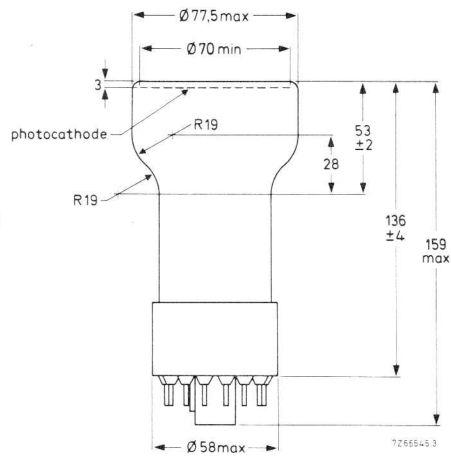
Notes

1. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ ohm.
2. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
3. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4170 or equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is $\approx 10^4$ c/s.
4. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long-term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s, corresponding to an anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance from the scintillator such that the count rate can be changed from $\approx 10^4$ c/s to $\approx 10^3$ c/s, corresponding to anode currents of $\approx$ 300 nA and $\approx$ 30 nA respectively. Both tests are carried out according to ANSI-N42-9-1972 of IEEE recommendations.
5. Measured with a pulsed light source, with a pulse duration (FWHM) of $<$ 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of $\approx$ 300 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
9. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





from series no.
10 001 on

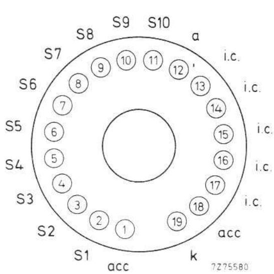


Fig. 2.

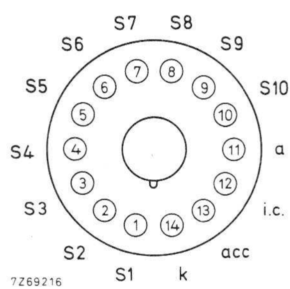


Fig. 3.

Base	19-pin all-glass
Net mass	165 g

To be ordered under type no. XP2030 UB

Base	14-pin IEC 67-1-16a (Jedec B14-38)
Net mass	208 g

To be ordered under type no. XP2030

ACCESSORIES

Socket

for versions of Fig. 2	type FE2019
for versions of Fig. 3	type FE1014
Mu-metal shield	type 56135

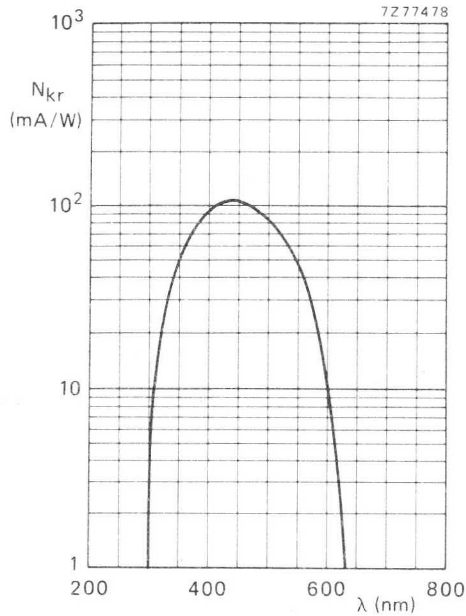


Fig. 4 Spectral sensitivity characteristic.

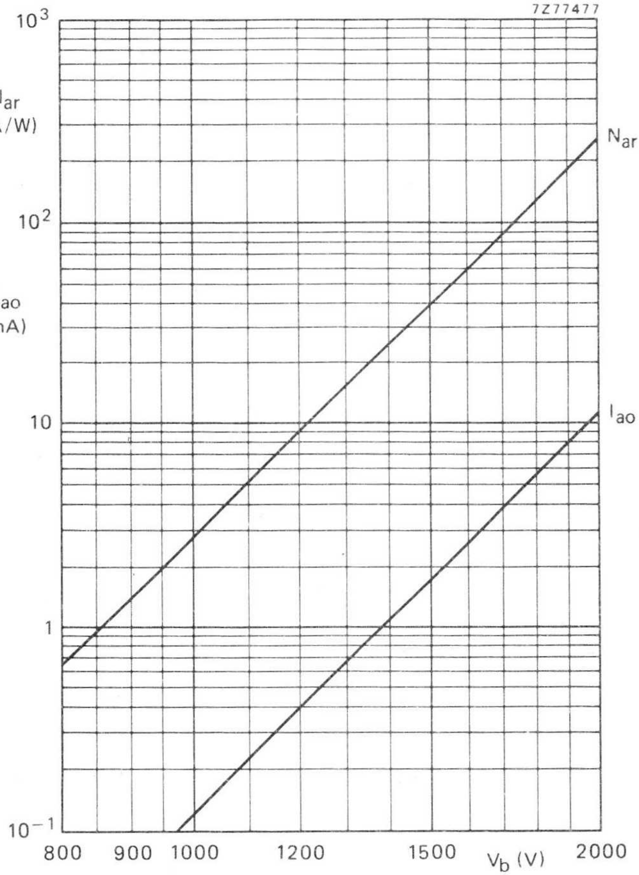


Fig. 5 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

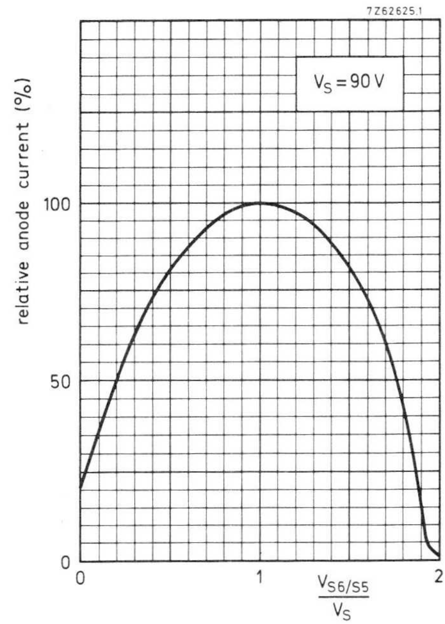


Fig. 6 Relative anode current as a function of the voltage between S6 and S5, normalized to V_S, $V_{S7/S5}$ constant.

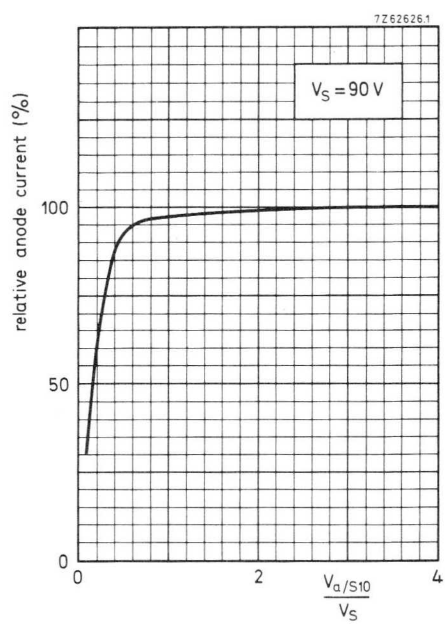


Fig. 7 Relative anode current as a function of the voltage between anode and last dynode, normalized to V_S.

14-STAGE PHOTOMULTIPLIER TUBE

The XP2040 (XP2040Q) is a 110 mm (useful diameter) head-on photomultiplier tube with a concave-convex window and a semi-transparent S11 (type A) photocathode.
The tube is intended for use in nuclear physics where the number of photons to be detected is very low or where good time characteristics are required (coincidence measurements, Cerenkov counters).
A plano-concave plastic adapter supplied with tube type XP2040 enables transmission from 300 nm. The XP2040Q is supplied with a plano-concave quartz adapter enabling transmission at a wavelength of 200 nm and higher.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			S11 (type A) extended ultraviolet	
Useful diameter of the photocathode		>	110	mm
Supply voltage for a gain of 3×10^7			2000	V
Cathode spectral sensitivity at 437 nm			70	mA/W
Anode pulse rise time (with voltage divider B')		≈	2	ns
Linearity,				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Glass: Ultraviolet transmitting (type Schott 8337 or equivalent) [1]		
Shape	concave-convex	
Radius of curvature	183 ± 5	mm
Refractive index at 550 nm	1,48	

[1]) This glass window must be protected from humidity.

Photocathode

Semi-transparent, head on

Useful diameter		>	110	mm
Spectral sensitivity characteristic (Fig. 4)			S11 (type A) extended ultraviolet	
Material			Sb-Cs	
Maximum spectral sensitivity at			420 ± 30	nm
Luminous sensitivity		typ.	70	µA/lm
		>	45	µA/lm
Spectral sensitivity at 437 ± 5 nm		≈	70	mA/W

Multiplier system

Number of stages			14	
Dynode structure			linear focused	
Dynode material			Cu-Be	
Capacitances				
Grid no. 1 to k+g_2+acc+S1	$C_{g1/k, g2, acc, S1}$	≈	70	pF
Anode to final dynode	$C_{a/S14}$	≈	5	pF
Anode to all	C_a	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1900 V, voltage divider A):
- at a magnetic flux density of 0, 15 mT in the direction of the longitudinal axis ;
- at a magnetic flux density of 0, 13 mT perpendicular to axis a) (see Fig. below).
- at a magnetic flux density of 0, 05 mT parallel to axis a)

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

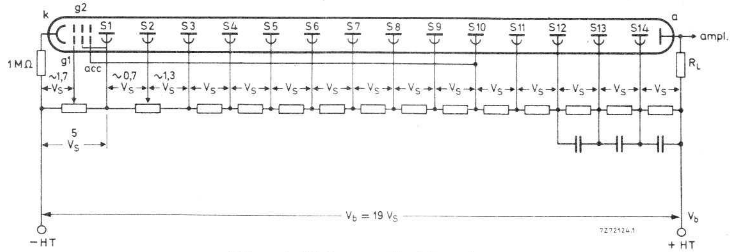


Fig. 1 Voltage divider A

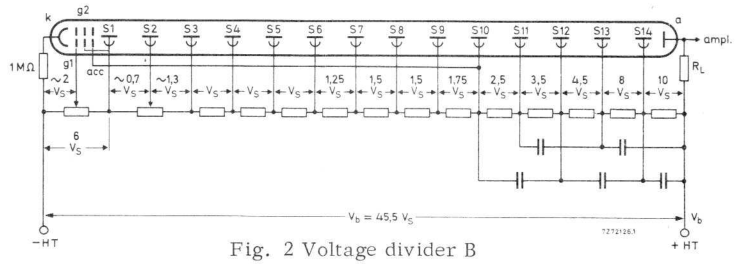


Fig. 2 Voltage divider B

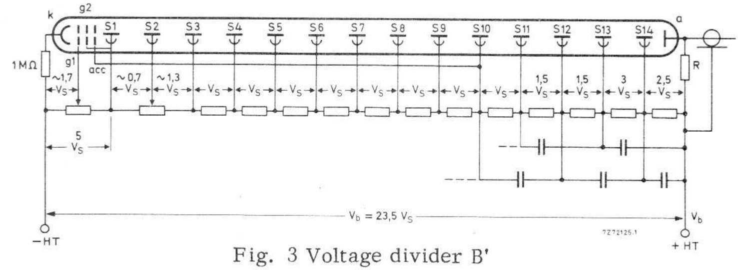


Fig. 3 Voltage divider B'

k = cathode
g_1, g_2 = focusing electrodes
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

R = This resistor serves to connect the anode when the output cable is not terminated. Recommended value 10 kΩ.

The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

The voltage between k and g1 should be adjusted at about 1,7 V_S for voltage dividers A and B' or at about 2 V_S for voltage divider B.

The voltage between S_1 and S_2 should be adjusted at about 0,7 V_S.
Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

Supply voltage for a gain G of 3×10^7, Fig. 6	1)	<	2700	V
		typ.	2000	V
Anode dark current at $G = 3 \times 10^7$, Fig. 6	1) 2)	<	4	μA
		typ.	0,2	μA
Anode pulse rise time at V_b = 2200 V	3) 4)	≈	2,5	ns
Anode pulse width at half height at V_b = 2200 V	3)	≈	5	ns
Signal transit time at V_b = 2200 V	3)	≈	46	ns
Anode current linear within 2%, at V_b = 2200 V up to		≈	30	mA
Obtainable peak anode current		≈	200	mA

With voltage divider B (Fig. 2) 5)

Gain at V_b = 2800 V, Fig. 6		≈	1×10^7	
Anode pulse rise time at V_b = 2800 V	3) 4)	≈	2,1	ns
Anode pulse width at half height at V_b = 2800 V	3)	≈	3	ns
Signal transit time at V_b = 2800 V	3)	≈	49	ns
Signal transit time difference between the centre of the photocathode and 50 mm from the centre, at V_b = 2800 V		≈	1	ns
Anode current linear within 2%, at V_b = 2800 V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1,0	A

With voltage divider B' (Fig. 3) 5)

Gain at V_b = 2500 V, Fig. 6		≈	5×10^7	
Anode pulse rise time at V_b = 2500 V	3) 4)	≈	2	ns
Anode pulse width at half height at V_b = 2500 V	3)	≈	3	ns
Signal transit time at V_b = 2500 V	3)	≈	46	ns
Signal transit time difference between the centre of the photocathode and 50 mm from the centre, at V_b = 2500 V		≈	1	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	80	mA
Obtainable peak anode current		≈	500	mA

Notes see page 5.

Notes to page 4

1) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at -HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended to keep the metal envelope at cathode potential. This implies safety precautions to protect the user.

2) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈1/4 h).

3) Measured with a pulsed light source with a pulse duration of < 1 ns ; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse width, and transit time vary as a function of the HT supply voltage V_b, approximately as $V_b^{-1/2}$.

4) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier tubes".

5) Divider circuits B and B' are examples of "progressive dividers", each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally advisable to keep the increase in voltage between one stage and the next to less than a factor 2.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[1]	max.	3000	V
Continuous anode current	[5]	max.	0, 2	mA
Voltage between first dynode and photocathode	[2]	max.	800	V
		min.	400	V
Voltage between focusing electrode g_1 and photocathode		max.	300	V
Voltage between accelerating electrode and photocathode		max.	18	V_S
		min.	14	V_S
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	[3]	max.	500	V
		min.	80	V
Ambient temperature range	[4]			
Operational (for short periods of time)		max.	+80	^oC
		min.	-30	^oC
Continuous operation and storage		max.	+50	^oC
		min.	-30	^oC

[1]) Total HT supply voltage, or the voltage at which the tube circuited in voltage divider "A" has a gain of 3×10^8 , whichever is lower.

[2]) Minimum value to obtain good collection in the input optics.

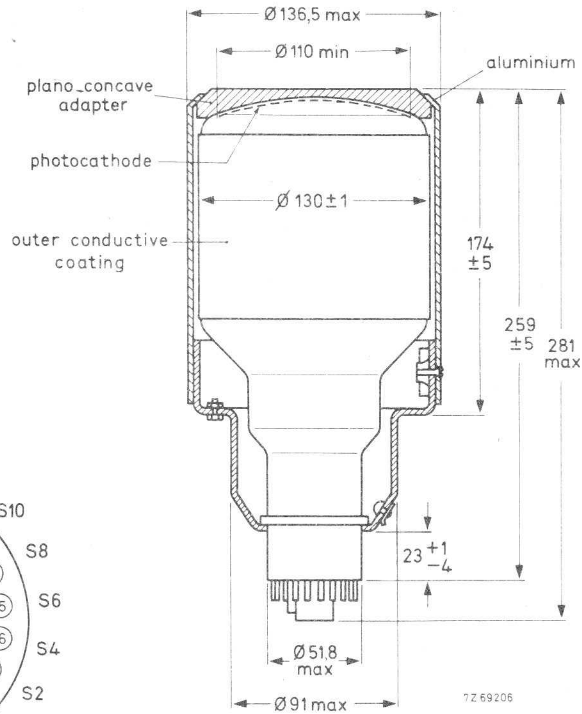
[3]) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

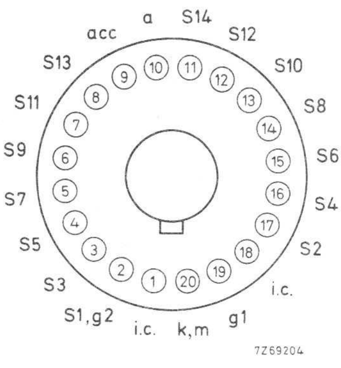
[4]) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

[5]) For applications requiring a high stability a value of $< 10\ \mu A$ is recommended.

MECHANICAL DATA

Dimensions in mm





Base : 20-pin (JEDEC B20-102)

Net mass : 1340 g

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56133

The XP2040 may be used with the base assembly S5630/03, consisting of two magnetic shields, a voltage divider, a mechanical system with provisions for mounting the photomultiplier tube and a scintillator. Details available on request.

Optical coupling silicone grease is supplied with each tube. This grease should be applied to the adapter - photomultiplier interface before operation.

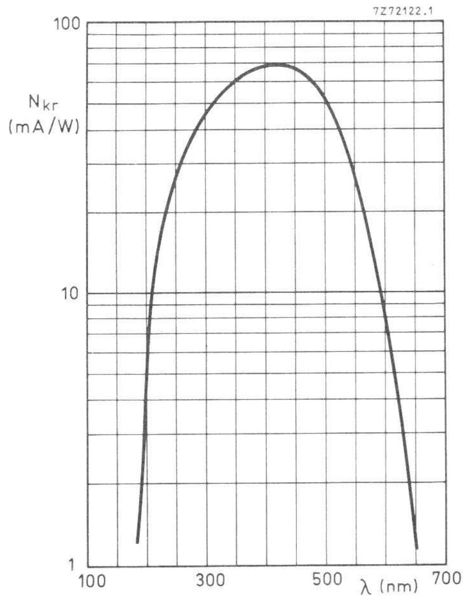


Fig. 4

Spectral sensitivity characteristic
(without adapter, or with quartz adapter).

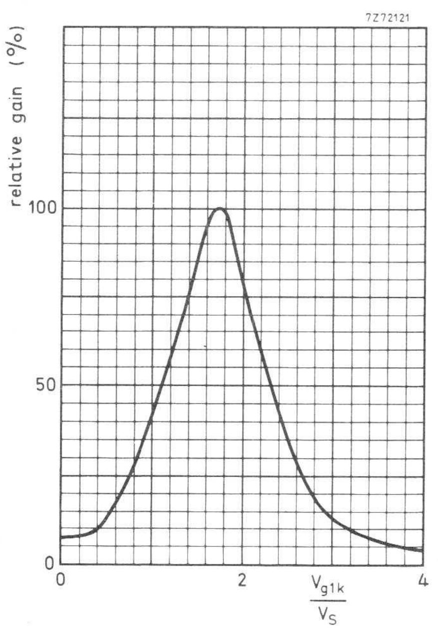


Fig. 5

Relative gain as a function of the voltage between focusing electrode g_1 and photocathode k, normalized to V_S.

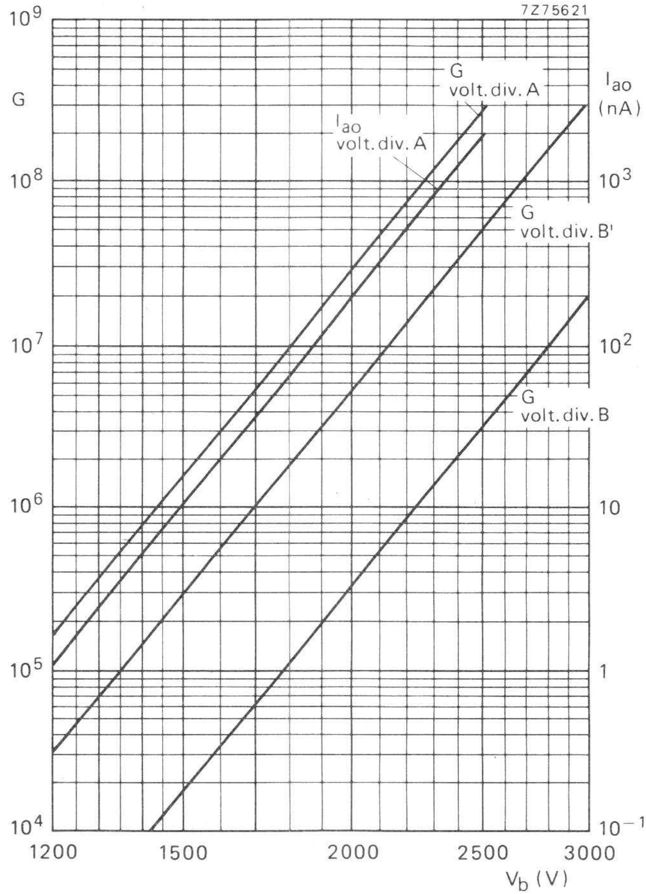


Fig. 6

Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b.

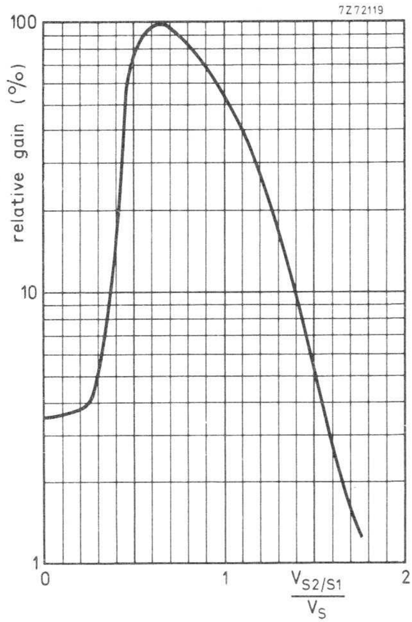


Fig. 7

Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S, $V_{S3/S1}$ constant.

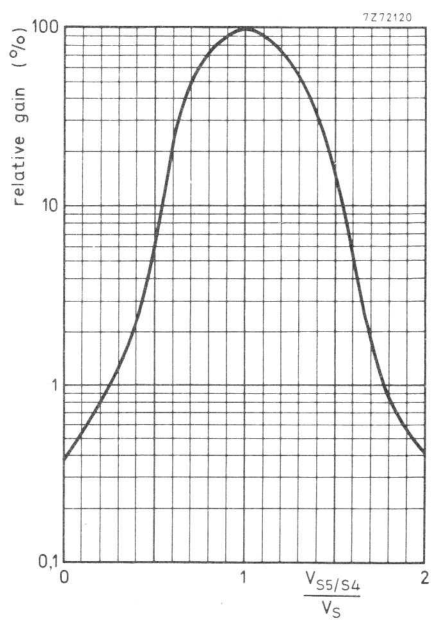


Fig. 8

Relative gain as a function of the voltage between S_5 and S_4 normalized to V_S, $V_{S6/S4}$ constant.

14-STAGE PHOTOMULTIPLIER TUBE

The XP2041 (XP2041Q) is a 110 mm (useful diameter) head-on photomultiplier tube with a concave-convex window and a semi-transparent bialkaline type D photocathode.
The tube is intended for use in nuclear physics where the number of photons to be detected is very low or where good time characteristics are required (coincidence measurements, Cerenkov counters).
A plano-concave plastic adapter supplied with tube type XP2041 enables transmission from 300 nm. The XP2041Q is supplied with a plano-concave quartz adapter enabling transmission at a wavelength of 200 nm and higher.

QUICK REFERENCE DATA

Spectral sensitivity characteristic			type D extended ultraviolet	
Useful diameter of the photocathode		>	110	mm
Supply voltage for a gain of 3×10^7			2200	V
Quantum efficiency at 401 nm			26	%
Cathode spectral sensitivity at 401 nm			85	mA/W
Anode pulse rise time (with voltage divider B')		≈	2	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	220	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier tubes".

GENERAL CHARACTERISTICS

Window

Glass : Ultraviolet transmitting (type Schott 8337 or equivalent) [1]

Shape	concave-convex	
Radius of curvature	183 ± 5	mm
Refractive index at 550 nm	1,48	

[1]) This glass window must be protected from humidity.

Photocathode

Semi-transparent, head-on			
Useful diameter	>	110	mm
Spectral sensitivity characteristic (Fig. 4)		type D extended ultraviolet	
Material		bi-alkaline Sb-K-Cs	
Maximum spectral sensitivity at		400 ± 30	nm
Spectral sensitivity at 401 ± 3 nm	typ.	85	mA/W
	>	65	mA/W

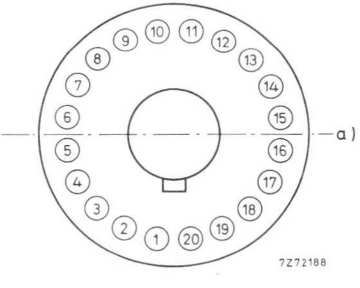
Multiplier system

Number of stages			14	
Dynode structure			linear focused	
Dynode material			Cu-Be	
Capacitances				
Grid no. 1 to k+g_2+acc+S1	$C_{g1/k, g2, acc, S1}$	≈	70	pF
Anode to final dynode	$C_{a/S14}$	≈	5	pF
Anode to all	C_a	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1900 V, voltage divider A):
- at a magnetic flux density of 0,15 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,13 mT perpendicular to axis a);
- at a magnetic flux density of 0,05 mT parallel to axis a) (see Fig. below)

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding >15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

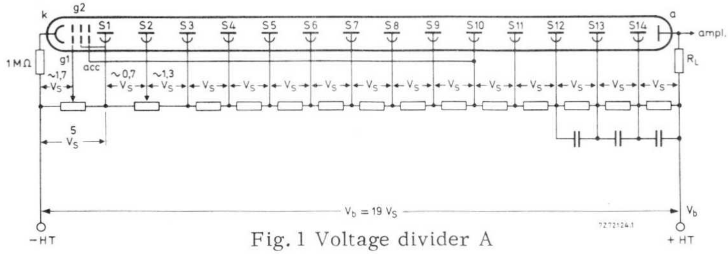


Fig. 1 Voltage divider A

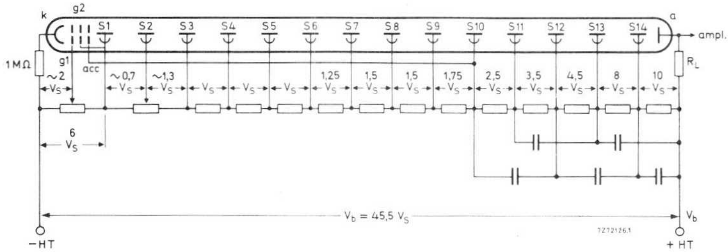


Fig. 2 Voltage divider B

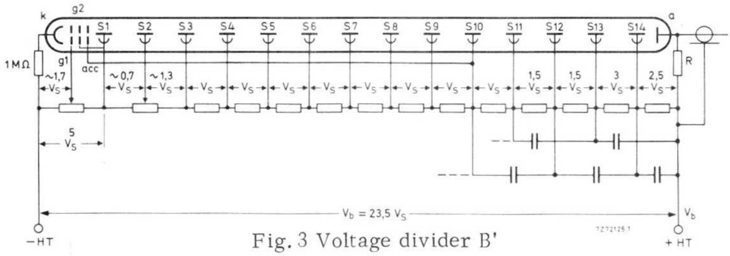


Fig. 3 Voltage divider B'

k = cathode
g_1, g_2 = focusing electrodes
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

The voltage between k and g_1 should be adjusted at about 1,7 V_S for voltage dividers A and B' or at about $2V_S$ for voltage divider B.

R = This resistor serves to connect the anode when the output cable is not terminated. Recommended value : 10 kΩ.

The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

The voltage between S1 and S2 should be adjusted at about 0,7 V_S.
Typical value of capacitors : 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

Supply voltage for a gain G of 3×10^7, Fig. 6	1)	<	2700	V
		typ.	2200	V
Anode dark current at G = 3×10^7, Fig. 6	1) 2)	<	600	nA
		typ.	30	nA
Anode pulse rise time at V_b = 2200 V	3) 4)	≈	2,5	ns
Anode pulse width at half height at V_b = 2200 V	3)	≈	5	ns
Signal transit time at V_b = 2200 V	3)	≈	46	ns
Anode current linear within 2%, at V_b = 2200 V up to		≈	30	mA
Obtainable peak anode current		≈	200	mA

With voltage divider B (Fig. 2) 5)

Gain at V_b = 2800 V. Fig. 6		≈	4×10^6	
Anode pulse rise time at V_b = 2800 V	3) 4)	≈	2,1	ns
Anode pulse width at half height at V_b = 2800 V	3)	≈	3	ns
Signal transit time at V_b = 2800 V	3)	≈	49	ns
Signal transit time difference between the centre of the photocathode and 50 mm from the centre at V_b = 2800 V		≈	1	ns
Anode current linear within 2%, at V_b = 2800 V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1,0	A

With voltage divider B' (Fig. 3) 5)

Gain at V_b = 2500 V, Fig. 6		≈	2×10^7	
Anode pulse rise time at V_b = 2500 V	3) 4)	≈	2	ns
Anode pulse width at half height at Vb = 2500 V	3)	≈	3	ns
Signal transit time at V_b = 2500 V	3)	≈	46	ns
Signal transit time difference between the centre of the photocathode and 50 mm from the centre at V_b = 2500 V		≈	1	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	80	mA
Obtainable peak anode current		≈	500	mA

Notes see page 5.

Notes to page 4

1) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at -HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended to keep the metal envelope at cathode potential. This implies safety precautions to protect the user.

2) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

3) Measured with a pulsed light source with a pulse duration of < 1 ns; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse width, and transit time vary as a function of the HT supply voltage V_b, approximately as $V_b^{-1/2}$.

4) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier tubes"

5) Divider circuits B and B' are examples of "progressive dividers", each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally advisable to keep the increase in voltage between one stage and the next to less than a factor 2.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	3000	V
Continuous anode current	5)	max.	0, 2	mA
Voltage between first dynode and photocathode	2)	max.	800	V
		min.	400	V
Voltage between focusing electrode g_1 and photocathode		max.	300	V
Voltage between accelerating electrode and photocathode		max.	18	V_S
		min.	14	V_S
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	3)	max.	500	V
		min.	80	V
Ambient temperature range	4)			
Operational (for short periods of time)		max.	+80	°C
		min.	-30	°C
continuous operation and storage		max.	+50	°C
		min.	-30	°C

1) Total HT supply voltage, or the voltage at which the tube circuited in voltage divider "A" has a gain of 3×10^8, whichever is lower.

2) Minimum value to obtain good collection in the input optics.

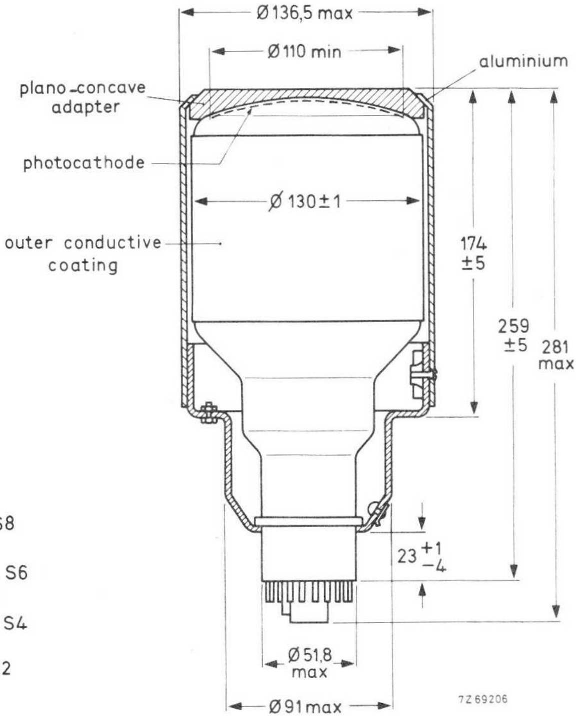
3) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

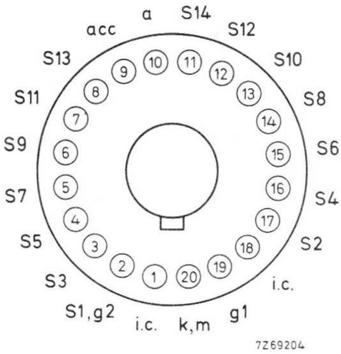
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

5) For applications requiring a high stability a value of $< 10\,\mu A$ is recommended.

MECHANICAL DATA

Dimensions in mm





Base : 20-pin (JEDEC B20-102)

Net mass : 1340 g

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56133

The XP2041 may be used with the base assembly S5630/03, consisting of two magnetic shields, a voltage divider, a mechanical system with provisions for mounting the photomultiplier tube and a scintillator. Details are available on request.

Optical coupling silicone grease is supplied with each tube. The grease should be applied to the adapter-photomultiplier interface before operation.

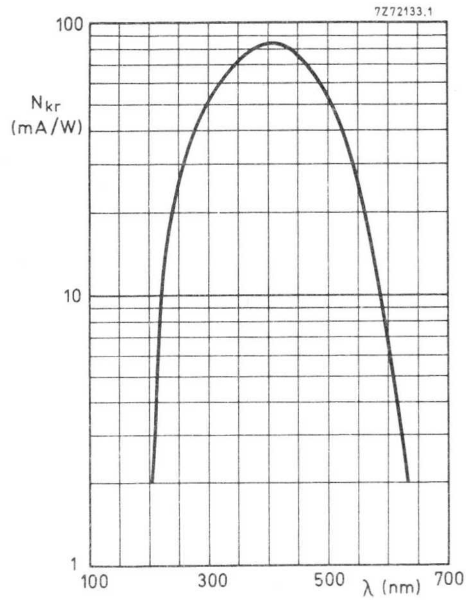


Fig. 4

Spectral sensitivity characteristic
(without adapter or with quartz adapter).

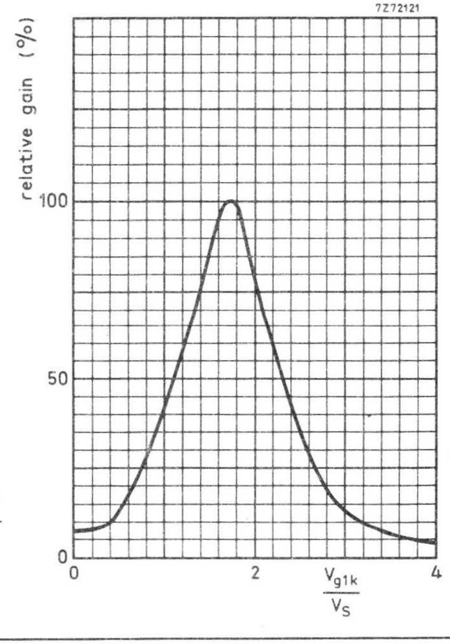


Fig. 5

Relative gain as a function of the voltage between focusing electrode g_1 and photocathode, normalized to V_S.

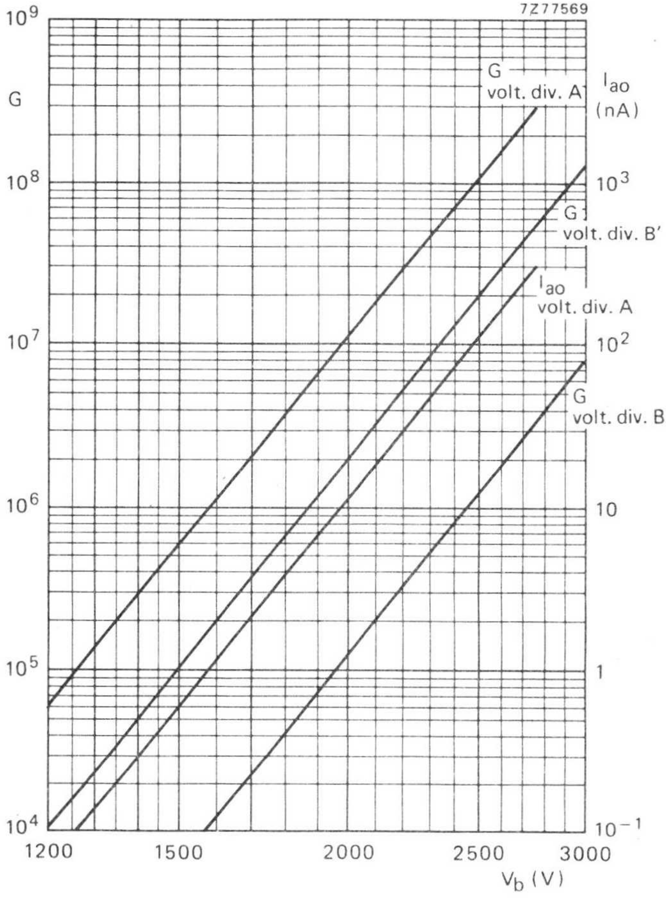


Fig. 6

Gain, G, and anode dark current, I_{ao}, as a function of supply voltage V_b.

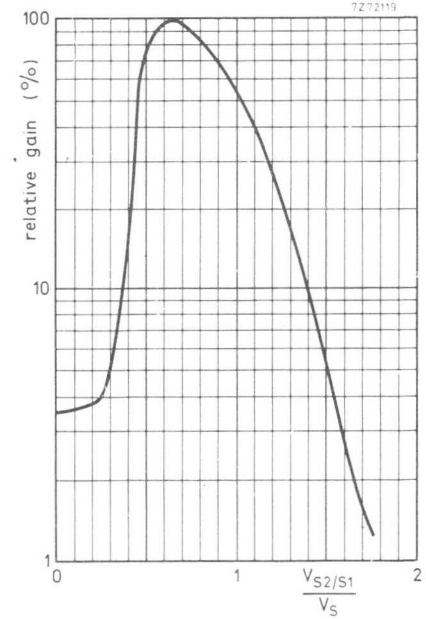


Fig. 7

Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S.

$V_{S3/S1}$ constant.

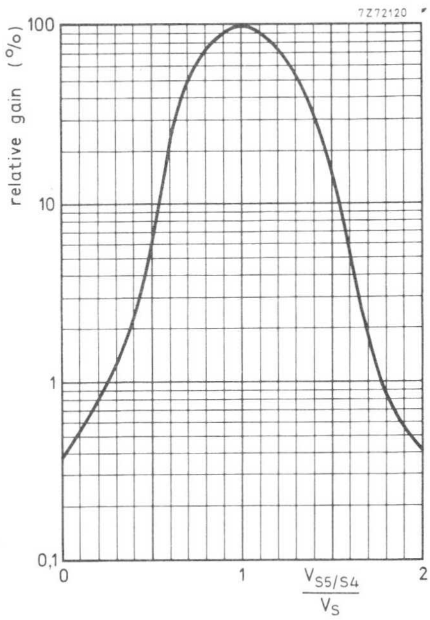


Fig. 8

Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S.

$V_{S6/S4}$ constant.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

The XP2050 is a 110 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent bialkaline type D photocathode. The tube is intended especially for scintillation counting in different fields, such as gamma spectrometry or high energy physics (large dimensional Cerenkov counters).

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D		
Useful diameter of the photocathode	>	110	mm
Quantum efficiency at 401 nm		95	mA/W
Supply voltage for an anode spectral sensitivity of 12 kA/W at 401 nm		1270	V
Pulse amplitude resolution (^{137}Cs)	≈	7,5	%
Mean anode sensitivity deviation	≈	1	%

To be read in conjunction with *General Operational Recommendations Photomultiplier tubes.*

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-plano
Refractive index at 550 nm	1,48

Photocathode *

Semi-transparent, head-on

Material	Sb-K-Cs
Useful diameter	> 110 mm
Spectral sensitivity characteristic (Fig. 4)	type D

* The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.

Photocathode (continued)

Maximum spectral sensitivity at			400 ± 30 nm
Quantum efficiency at 401 ± 3 nm			29 %
Spectral sensitivity at 401 ± 3 nm	N_{kr}	typ.	95 mA/W
		>	65 mA/W

Multiplier system

Number of stages		10
Dynode structure		venetian blind
Dynode material		Cu-Be
Capacitances		
anode to final dynode	≈	7 pF
anode to all	≈	8,5 pF

Magnetic field

When the cathode is illuminated uniformly the anode current is halved (at V_b = 1500 V) at a magnetic flux density of 0,2 mT perpendicular to the tube axis.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

RECOMMENDED CIRCUITS

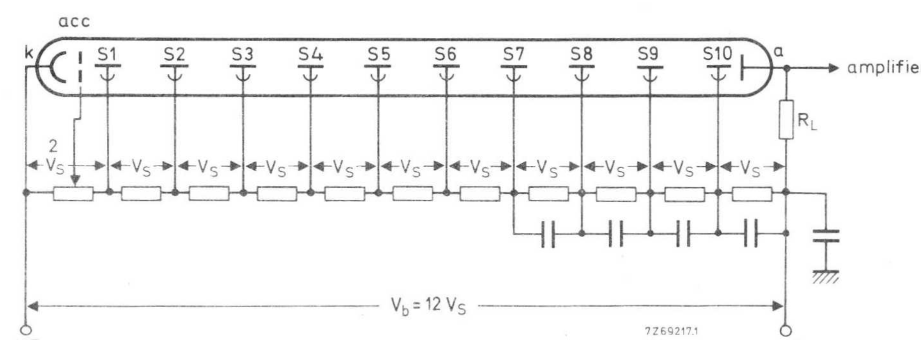


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

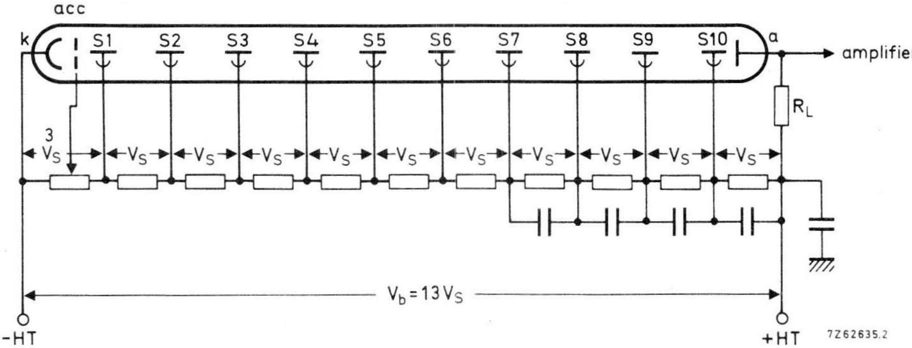


Fig. 2 Voltage divider A–1. Typical values of capacitors: 10 nF; k = cathode; acc = accelerating electrode; S_n = dynode no.; a = anode; R_L = load resistor.

The accelerating electrode potential should be adjusted for optimum pulse amplitude resolution.

TYPICAL CHARACTERISTICS	note				
With voltage divider A (Fig. 1)	1				
Supply voltage for an anode spectral sensitivity N_{ar} = 12 kA/W at 401 nm (Fig. 5)			<	1500	V
			typ.	1270	V
Anode spectral sensitivity at V_b = 1500 V			≈	35	kA/W
Anode dark current at N_{ar} = 12 kA/W at 401 nm	2		<	5	nA
			typ.	0,5	nA
Anode current linear within 2% at V_b = 1500 V		up to	≈	10	mA
With voltage divider A–1 (Fig. 2)					
Anode spectral sensitivity at V_b = 1500 V and 401 nm (Fig. 5)			≈	25	kA/W
Pulse amplitude resolution for ^{137}Cs at N_{ar} = 12 kA/W	3		≈	7,5	%
Anode current linear within 2% at V_b = 1500 V		up to	≈	10	mA
Mean anode sensitivity deviation	4				
long term (16 h)			≈	1	%
after change of count rate			≈	1	%
Anode pulse rise time at V_b = 1500 V	5		≈	16	ns
Anode pulse width at half height at V_b = 1500 V	5		≈	40	ns
Signal transit time at V_b = 1500 V	5		≈	90	ns

Notes see page 4.

LIMITING VALUES (absolute maximum rating system)

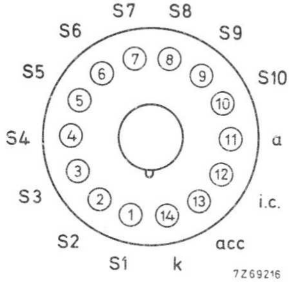
	note		
Supply voltage	6	max.	2000 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	7	max. min.	500 V 150 V
Voltage between accelerating electrode and photocathode		max.	500 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	8	max.	300 V
Ambient temperature range	9		
operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

Notes

1. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ ohm.
2. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
3. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 4170 or equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is $\approx 10^4$ c/s.
4. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long-term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s, corresponding to an anode current of $\approx$ 300 nA. Mean anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance from the scintillator such that the count rate can be changed from $\approx 10^4$ c/s to $\approx 10^3$ c/s, corresponding to anode currents of $\approx$ 300 nA and $\approx$ 30 nA respectively. Both tests are carried out according to ANSI-N42-9-1972 of IEEE recommendations.
5. Measured with a pulsed light source, with a pulse duration (FWHM) of $<$ 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of $\approx$ 300 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
9. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm



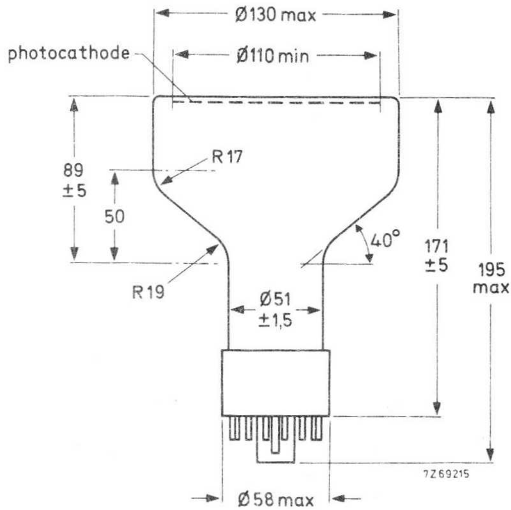


Fig. 3.

Base: IEC 67–I–16a (Jedec B14–38)

Net mass: 460 g

ACCESSORIES

Socket	type FE1014
Mu-metal shield	type 56133

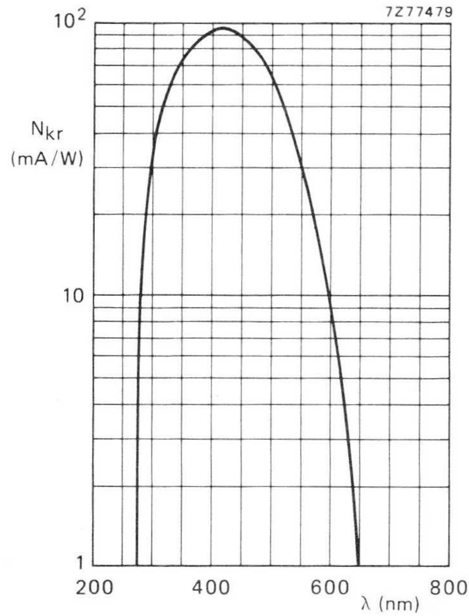


Fig. 4 Spectral sensitivity characteristic.

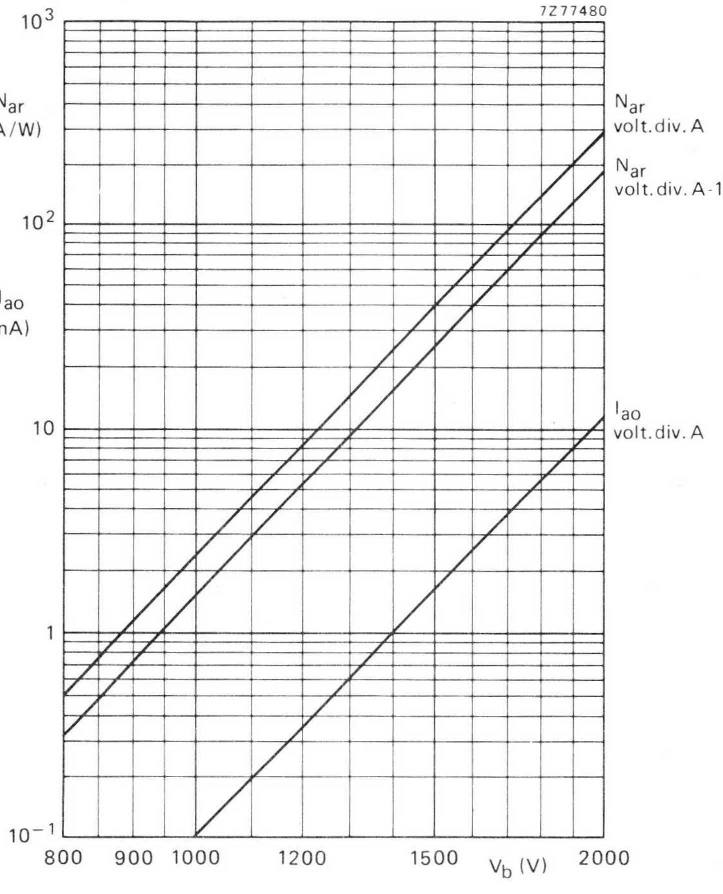


Fig. 5 Anode spectral sensitivity N_{ar}, and anode dark current I_{ao} as a function of the supply voltage V_b.

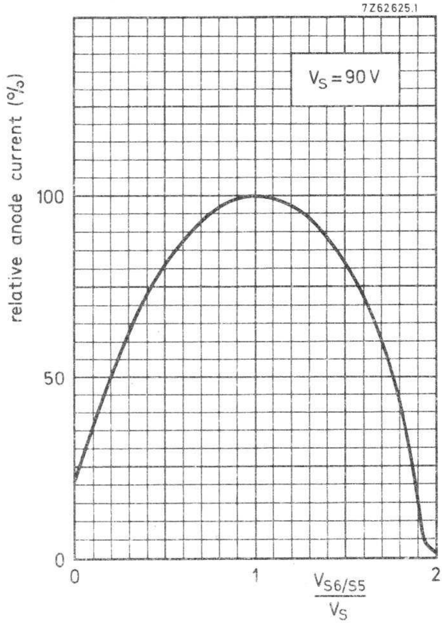


Fig. 6 Relative anode current as a function of the voltage between dynodes S6 and S5, normalized to V_S. $V_{S7/S5}$ constant.

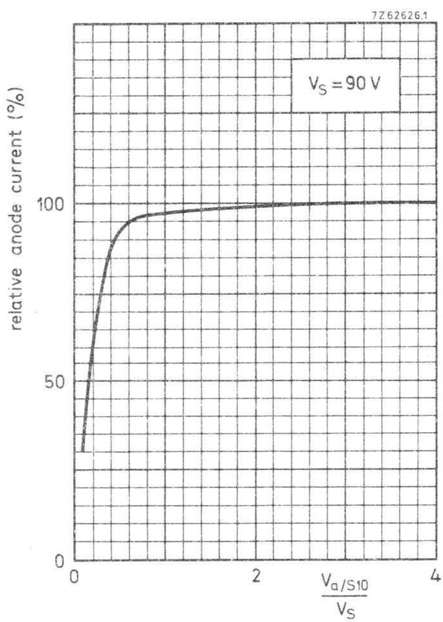


Fig. 7 Relative anode current as a function of the voltage between anode and final dynode.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2230 is a 44mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparent bialkaline type D photocathode.
The tube is intended for use in nuclear physics where the number of photons to be detected is very low. The tube features a high cathode sensitivity and a good linearity combined with very low background noise and very good time characteristics. It is especially useful in high-energy physics experiments such as coincidence measurements, Cerenkov detection etc.

The XP2230B is provided with a 20-pin plastic base. This version may be used as a plug-in replacement for the 56DVP.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 401 nm			28	%
Spectral sensitivity of the photocathode at 401 nm			90	mA/W
Supply voltage for a gain $G = 3 \times 10^7$			2300	V
Background noise		≈	600	c/s
Pulse amplitude resolution for ^{137}Cs		≈	7,5	%
Anode pulse rise time (with voltage divider B')		≈	1,6	ns
Linearity (with voltage divider B)	up to	≈	280	mA
Signal transit time fluctuation at V_b = 2500 V		≈	0,35	ns

To be read in conjunction with "General Operational Recommendations Photomultiplier tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-concave
Refractive index at 550 nm	1,48

Photocathode [1]

Semi-transparent, head-on

Material		Sb-K-Cs		
Useful diameter		>	44	mm
Spectral sensitivity characteristic (Fig. 4)		type D		
Maximum spectral sensitivity at			400 ± 30	nm
Quantum efficiency at 401 nm			28	%
Spectral sensitivity at 401 ± 3 nm [2]		typ.	90	mA/W
		>	65	mA/W

Electron optical input system

This consists of : the photocathode, k, and the accelerating electrode, acc, for type XP2230B internally connected to S1.

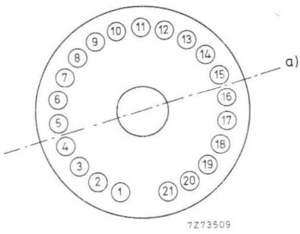
Multiplier system

Number of stages			12	
Dynode structure		linear focused		
Dynode material			Ag-Mg	
Capacitances				
Anode to all	C_a	≈	6	pF
Anode to final dynode	$C_{a/S12}$	≈	4	pF

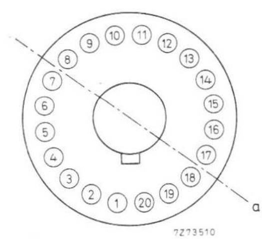
Magnetic field

See Fig. 9

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



XP2230



XP2230B

Axis a) with respect to base pins (bottom view)

Notes see page 5.

RECOMMENDED CIRCUITS

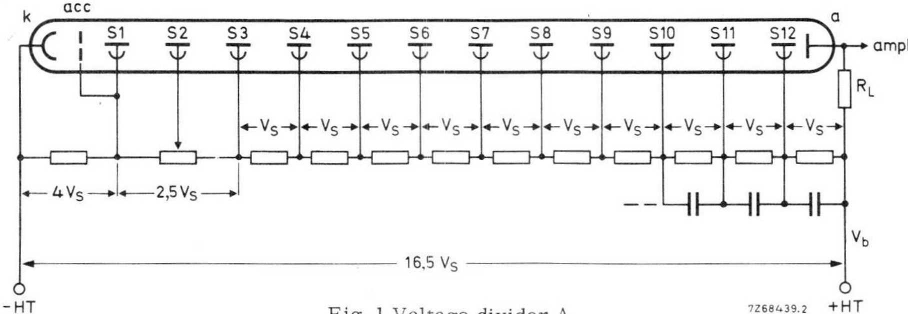


Fig. 1 Voltage divider A

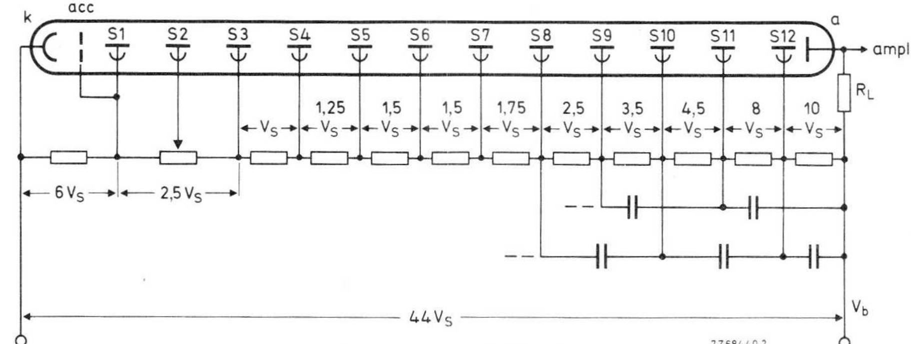


Fig. 2 Voltage divider B

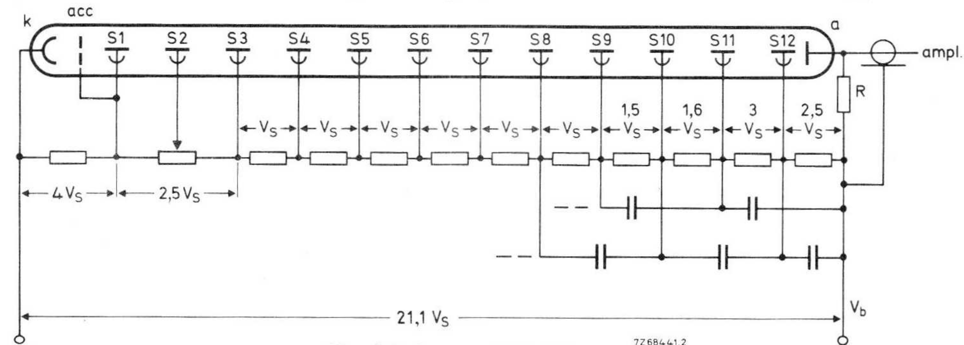


Fig. 3 Voltage divider B'

k = cathode

acc = accelerating electrode

S_n = dynode no. n

R_L = load resistor

a = anode

R = This resistor serves to connect the anode when the output cable is not terminated.
Recommended value: 10 kΩ

Typical value of capacitors: 1 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1) [3]

Supply voltage for a gain $G = 3 \times 10^7$ (Fig. 6)		typ.	2300	V
		<	2600	V
Anode dark current at $G = 3 \times 10^7$ (Fig. 6)	4) 5)	typ.	7	nA
		<	25	nA
Background noise at $G = 3 \times 10^7$ (Fig. 5)	6)	≈	600	c/s
Pulse amplitude resolution for ^{137}Cs at $V_b = 1200$ V	7)	≈	7,5	%
Anode pulse rise time at $V_b = 2000$ V	8)	≈	1,8	ns
Anode pulse duration at half height at $V_b = 2000$ V	8)	≈	3,8	ns
Signal transit time at $V_b = 2000$ V	8)	≈	28	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2000$ V	8)	≈	0,6	ns
Anode current linear within 2% at $V_b = 2000$ V up to		≈	25	mA
Obtainable peak anode current		≈	100	mA

With voltage divider B (Fig. 2) [3]

Gain G at $V_b = 3000$ V (Fig. 6)		≈	5×10^6	
Anode pulse rise time at $V_b = 3000$ V	8)	≈	1,6	ns
Anode pulse duration at half height at $V_b = 3000$ V	8)	≈	3	ns
Signal transit time at $V_b = 3000$ V	8)	≈	31	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 3000$ V	8)	≈	0,65	ns
Anode current linear within 2% at $V_b = 3000$ V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1	A

With voltage divider B' (Fig. 3) [3]

Gain G at $V_b = 2500$ V (Fig. 6)		≈	2×10^7	
Anode pulse rise time at $V_b = 2500$ V	8)	≈	1,6	ns
Anode pulse duration at half height at $V_b = 2500$ V	8)	≈	2,7	ns
Signal transit time at $V_b = 2500$ V	8)	≈	28	ns
Signal transit time fluctuation at $V_b = 2500$ V	9)	≈	0,35	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2500$ V	8)	≈	0,6	ns

Anode current linear within 2% at V_b = 2500 V up to	≈	70	mA
Obtainable peak anode current	≈	250	mA

[1]) The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,01 nA at −80 °C.
If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.

[2]) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

[3]) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuits B and B' are examples of progressive dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

[4]) Wherever possible, the photomultiplier power supply should be arranged so that the photocathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautious to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

[5]) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ 1/4 h).

[6]) After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7.
After a 30 min stabilization period noise pulses with a threshold of $4,25 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded. (See Fig. 5).

[7]) Pulse amplitude resolution for ^{137}Cs is measured with a NaI(Tl) cylindrical scintillator with a diameter of 44 mm and a height of 50 mm. The count rate is $\approx 10^3$ c/s.

[8]) Measured with a pulsed-light source with a pulse duration of < 1 ns; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum.
Rise time, pulse duration, and transit time vary as a function of the HT supply voltage, V_b, approximately as $V_b^{-\frac{1}{2}}$.

[9]) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[10]	max.	3000	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	[11]	max.	800	V
		min.	300	V
Voltage between consecutive dynodes (except S12 and S11)		max.	400	V
Voltage between dynode S12 and dynode S11		max.	600	V
Voltage between anode and final dynode	[12]	max.	700	V
		min.	80	V
Ambient temperature range				
XP2230				
Operational (for short periods of time)		max.	+80	°C
		min.	-80	°C
Continuous operation and storage		max.	+50	°C
		min.	-80	°C
XP2230B				
Operational (for short periods of time)	[13]	max.	+80	°C
		min.	-30	°C
Continuous operation and storage		max.	+50	°C
		min.	-30	°C

[10] Total supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.

[11] Minimum value to obtain good collection in the input optics.

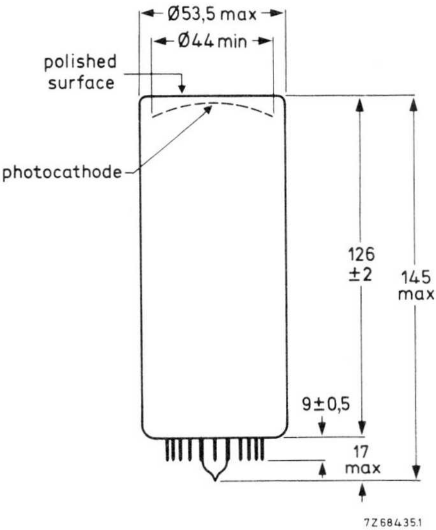
[12] When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

[13] This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

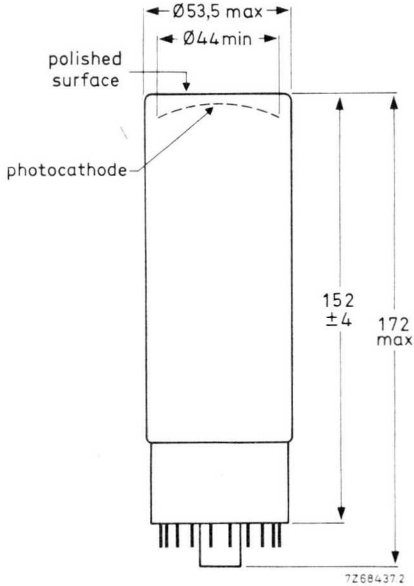
MECHANICAL DATA

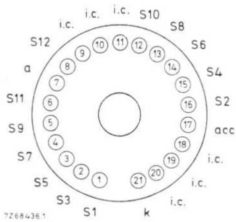
Dimensions in mm

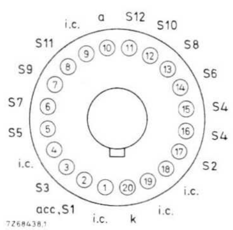
XP2230



XP2230B







Base: 21-pin all-glass

Base: 20-pin (IEC 67-I-42a, JEDEC B20-102)

Net mass: 160 g

190 g

ACCESSORIES

Socket: for XP2230 type FE2021

for XP2230B type FE1020

Mu-metal shield: type 56128 or type 56130

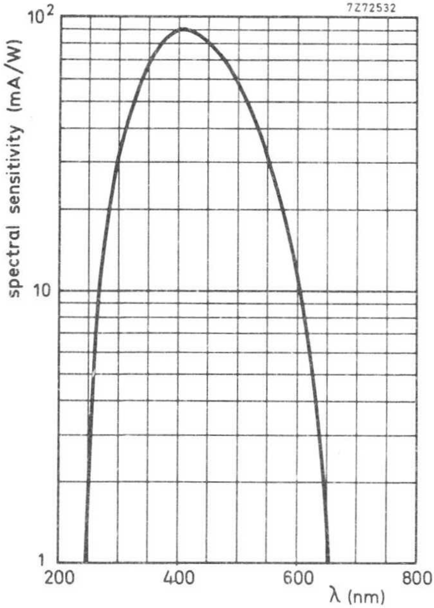


Fig. 4
Spectral sensitivity characteristic.

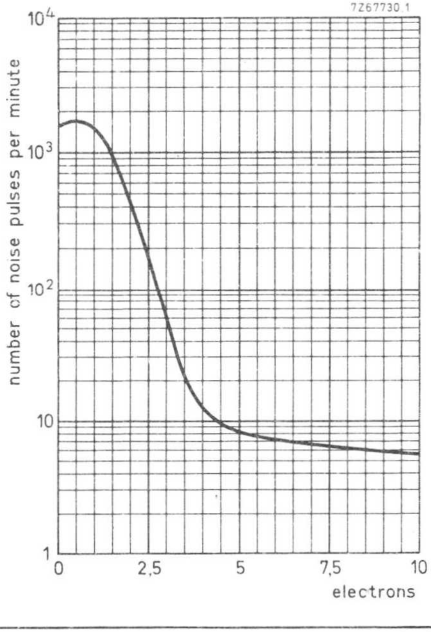


Fig. 5
Typical background spectrum from 0,1 to 10 equivalent photoelectrons, at a gain of 3×10^7, voltage divider A.

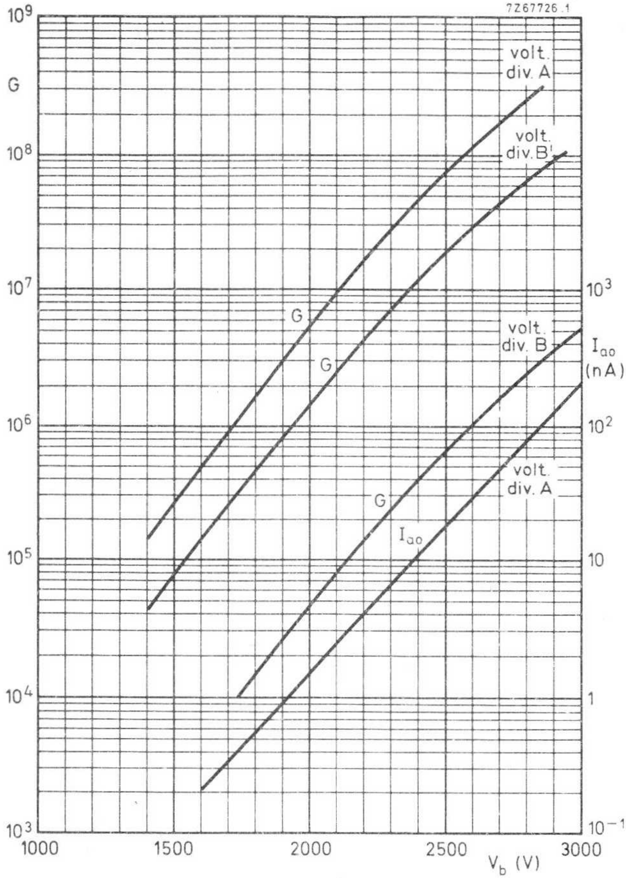


Fig. 6

Gain G, and anode dark current, I_{ao}, as a function of supply voltage V_b.

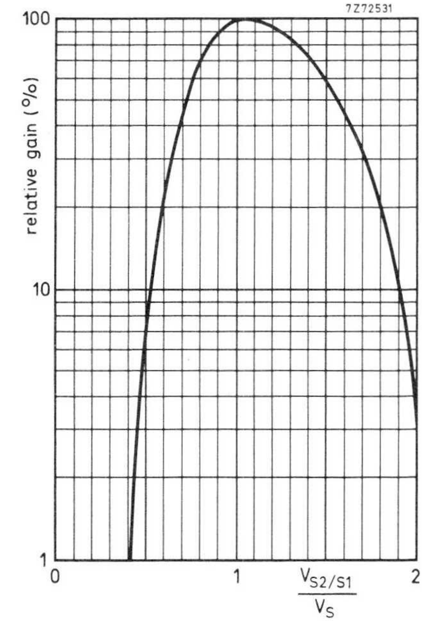


Fig. 7
Relative gain as a function of the voltage between dynodes S_2 and S_1, normalized to V_S.
$V_{S3/S1}$ constant.

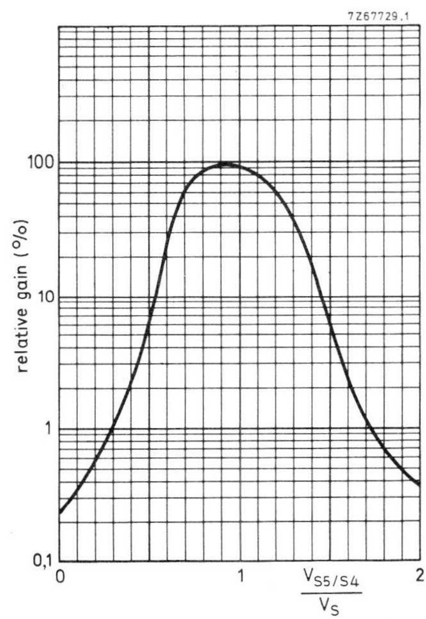


Fig. 8
Relative gain as a function of the voltage between dynodes S_5 and S_4, normalized to V_S.
$V_{S6/S4}$ constant.

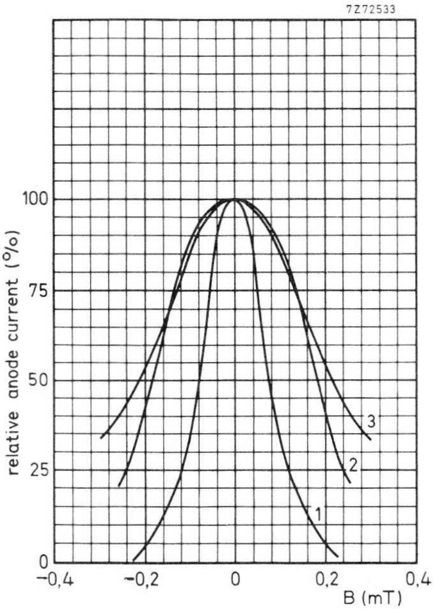


Fig. 9
Relative anode current as a function of the magnetic flux density B.
Voltage divider A, V_b = 2300 V.

1 B // axis a)
2 B ⊥ axis a)
3 B // tube axis

14-STAGE PHOTOMULTIPLIER TUBE

The 56AVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave window and a semi-transparent S11 (type A) photocathode. The tube is intended for use in nuclear physics where good time characteristics are required (coincidence measurements, Cerenkov counters, etc).

The 56AVP can be used in a special mounting assembly S5630/01 consisting of two magnetic shields, scintillator holder, voltage divider and mechanical housing.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		S11	(type A)	
Useful diameter of photocathode		>	44	mm
Spectral sensitivity of the photocathode at 437 nm			60	mA/W
Supply voltage for a gain of 3×10^7			1800	V
Anode pulse rise time (with voltage divider B')		≈	2,1	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-concave
Refractive index at 550 nm	1,48

Photocathode

Semi-transparent, head-on			
Material		SbCs	
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)		S11 (type A)	
Maximum sensitivity at		420 ± 30	nm
Luminous sensitivity	typ.	60	μA/lm
	>	45	μA/lm
Spectral sensitivity at 437 ± 5 nm		60	mA/W

Electron optical input system

This system consists of : the photocathode; the focusing electrode g_1; the accelerating electrode acc, internally connected to S_1.

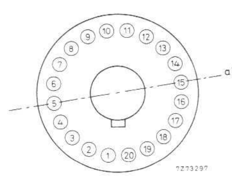
Multiplier system

Number of stages			14	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Grid no. 1 to k + S_1 + acc	$C_{g1/k, S1, acc}$	≈	25	pF
Anode to all	C_a	≈	9,5	pF
Anode to final dynode	$C_{a/S14}$	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b= 1800V, voltage divider A):
- at a magnetic flux density of 0,2 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,1 mT perpendicular to axis a) (see Fig. below);
- at a magnetic flux density of 0,05 mT parallel to axis a).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

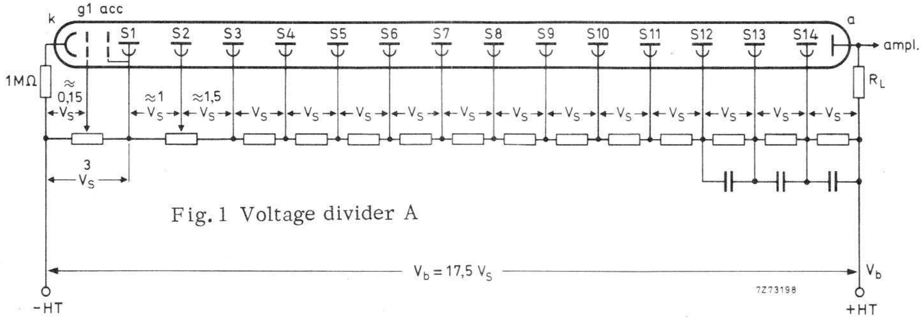


Fig. 1 Voltage divider A

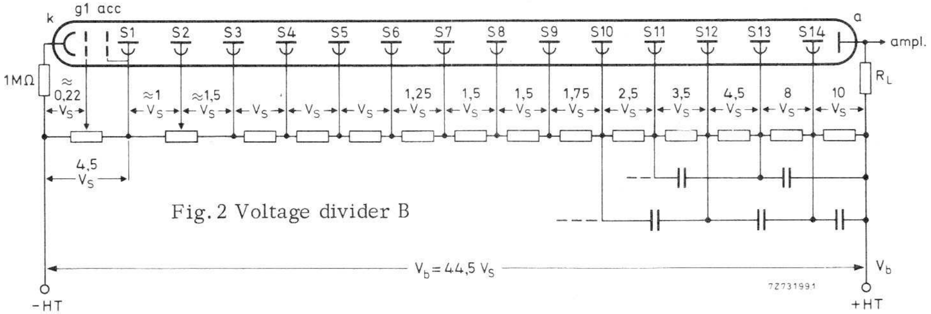


Fig. 2 Voltage divider B

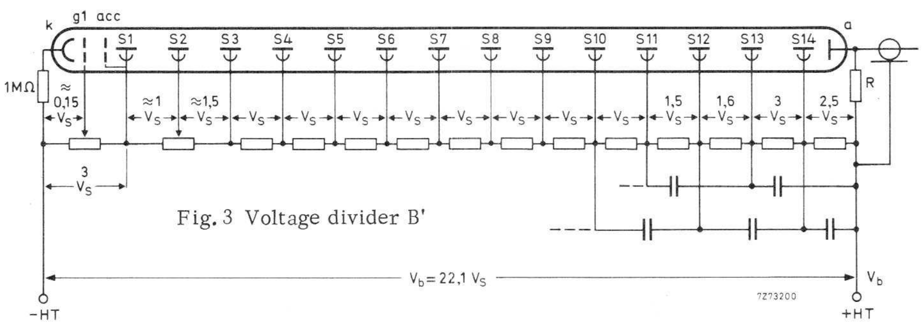


Fig. 3 Voltage divider B'

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

R = This resistor connects the anode when the output cable is not terminated. Recommended value: 10 kΩ.

The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for a gain of 3×10^7 (Fig. 6)		<	2300	V
		typ.	1800	V
Anode dark current at $G = 3 \times 10^7$ (Fig. 6)	2) 3)	<	1500	nA
		typ.	20	nA
Anode pulse rise time at V_b = 1800 V	4) 5)	≈	2,3	ns
Anode pulse duration at half height at V_b = 1800 V	4) 5)	≈	4,5	ns
Signal transit time at V_b = 1800 V	4) 5)	≈	46	ns
Anode current linear within 2%, at V_b = 1800 V up to		≈	30	mA
Obtainable peak anode current		≈	100	mA
With voltage divider B (Fig. 2)	1)			
Gain at V_b = 2500 V (Fig. 6)		≈	$1,2 \times 10^7$	
Anode pulse rise time at V_b = 2500 V	4) 5)	≈	2,6	ns
Anode pulse duration at half height at V_b = 2500 V	4) 5)	≈	3,9	ns
Signal transit time at V_b = 2500 V	4) 5)	≈	48	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2500 V		≈	0,8	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1,0	A
With voltage divider B' (Fig. 3)	1)			
Gain at V_b = 2200 V (Fig. 6)		≈	8×10^7	
Anode pulse rise time at V_b = 2200 V	4) 5)	≈	2,1	ns
Anode pulse duration at half height at V_b = 2200 V	4) 5)	≈	3,5	ns
Signal transit time at V_b = 2200 V	4) 5)	≈	44	ns
Signal transit time fluctuation at V_b = 2200 V	6)	≈	0,5	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2200 V		≈	0,5	ns
Anode current linear within 2%, at V_b = 2200 V up to		≈	80	mA
Obtainable peak anode current		≈	300	mA

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuits B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended to keep the increase in voltage between one stage and the next less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at – HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\,\Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of <1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

5) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier Tubes".

6) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[1]	max.	2500	V
Continuous anode current	[5]	max.	0,2	mA
Voltage between first dynode and photocathode	[2]	max.	800	V
		min.	250	V
Voltage between focusing electrode g_1 and photocathode		max.	100	V
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	[3]	max.	500	V
		min.	80	V
Ambient temperature range	[4]			
Operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

[1] Total HT supply voltage or the voltage at which the tube has a gain of 2×10^8, whichever is lower.

[2] Minimum value to obtain good collection in the input optics

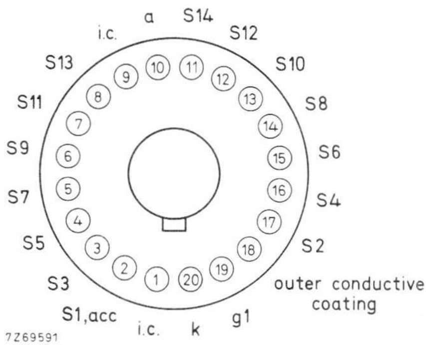
[3] When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

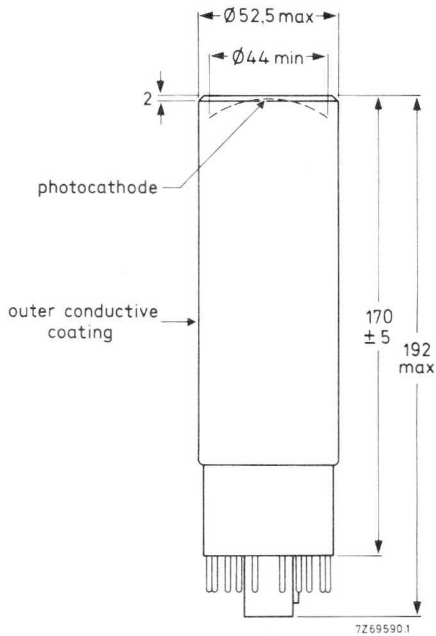
[4] This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

[5] For applications requiring a high stability a value of < 10 μA is recommended.

MECHANICAL DATA

Dimensions in mm





Net mass: 235 g

Base: 20-pin (JEDEC B20-102)

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56130

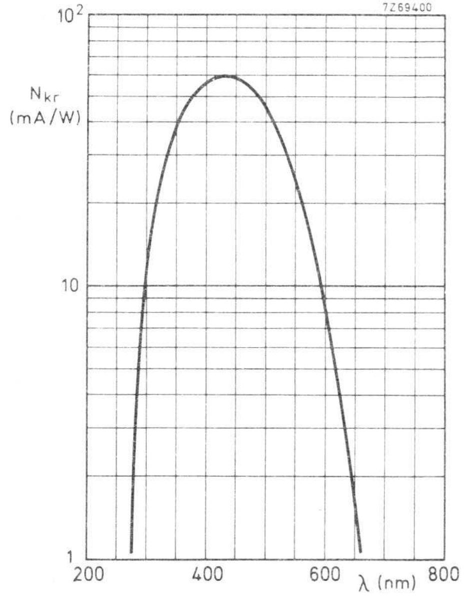


Fig. 4

Spectral sensitivity characteristic

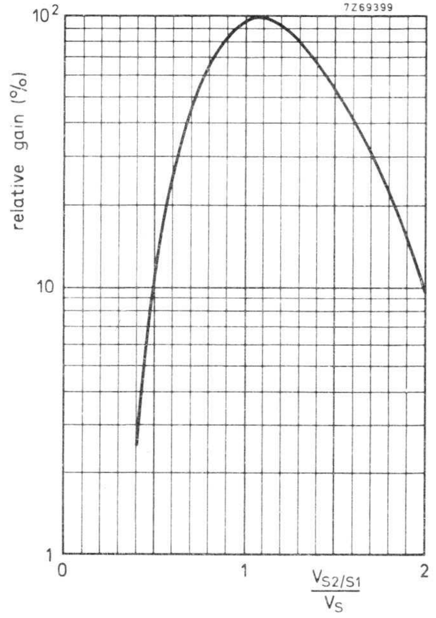


Fig. 5

Relative gain as a function of the voltage between S2 and S1, normalized to V_S
$V_{S3/S1}$ constant

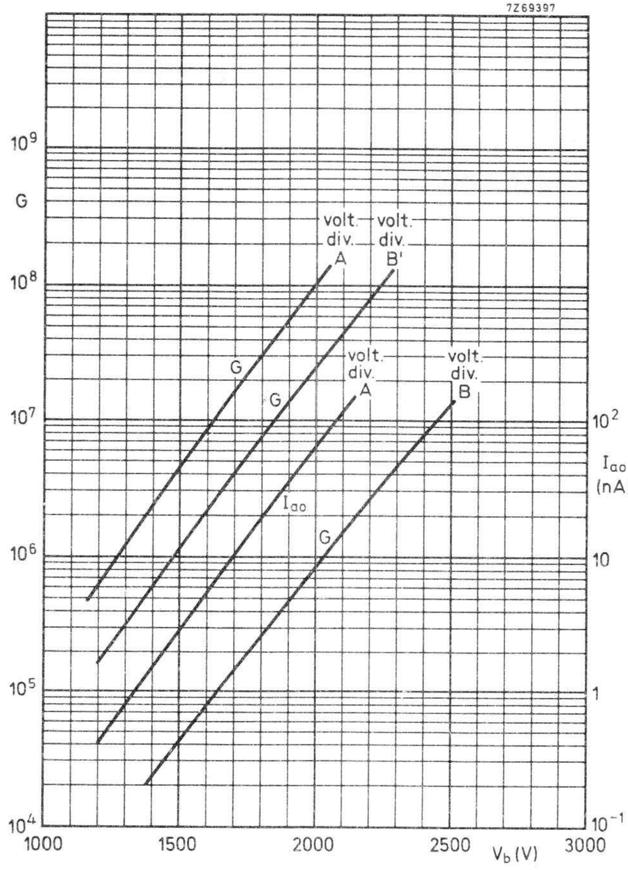


Fig. 6

Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b

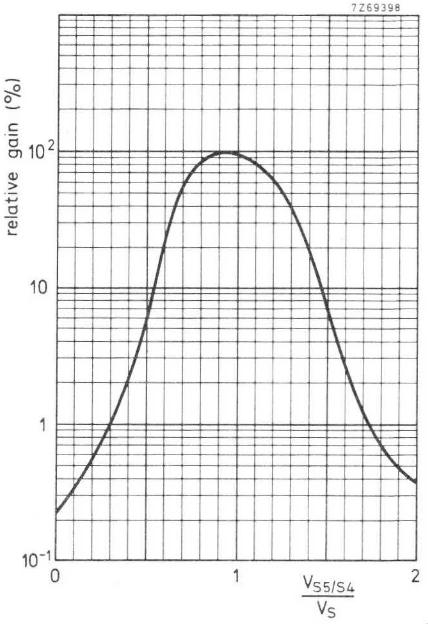


Fig. 7

Relative gain as a function of the voltage between S5 and S4 normalized to V_S
$V_{S6/S4}$ constant

10-STAGE PHOTOMULTIPLIER TUBE

The 56CVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave window and a semi-transparent S1 (type C) photocathode. The tube is intended for use in optical experiments such as laser detection and pollution monitoring, where a high sensitivity in the red and infrared region is required combined with good time characteristics.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			S1 (type C)	
Useful diameter of the photocathode		>	44	mm
Spectral sensitivity of the photocathode at 903 nm			1,4	mA/W
Cathode luminous sensitivity			20	μA/lm
Supply voltage for an anode sensitivity of 10 A/lm			1800	V
Anode pulse rise time (with voltage divider B')		≈	2,1	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-concave
Refractive index at 550 nm	1,48

Photocathode

Semi-transparent, head-on			
Material	Ag-O-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)	S1 (type C)		
Maximum spectral sensitivity at		800 ± 100	nm
Luminous sensitivity	typ.	20	μA/lm
	>	15	μA/lm
Spectral sensitivity at 903 ± 8 nm		1,4	mA/W
at 1060 ± 10 nm	≈	0,1	mA/W

Electron optical input system

This system consists of: the photocathode; the focusing electrode g_1; the accelerating electrode acc, internally connected to S_1.

Multiplier system

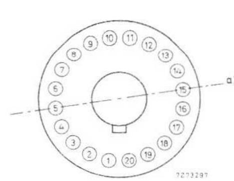
Number of stages			10	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Grid no. 1 to $k + S_1$ + acc	$C_{g1/k, S1, acc}$	≈	25	pF
Anode to all	C_a	≈	9,5	pF
Anode to final dynode	$C_{a/S10}$	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1800 V, voltage divider A):

- at a magnetic field density 0,2 mT in the direction of the longitudinal axis;
- at a magnetic field density 0,1 mT perpendicular to axis a) (see Fig. below);
- at a magnetic field density 0,05 mT parallel to axis a).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

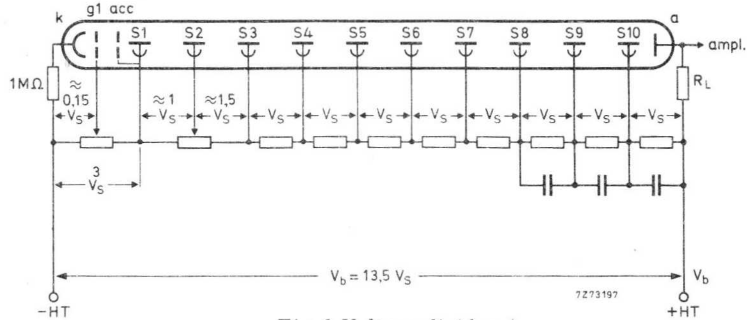


Fig. 1 Voltage divider A

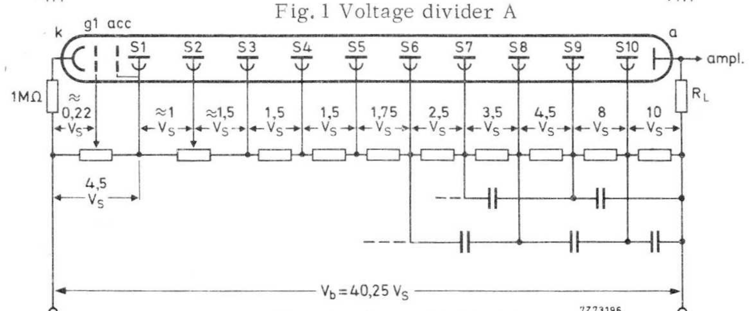


Fig. 2 Voltage divider B

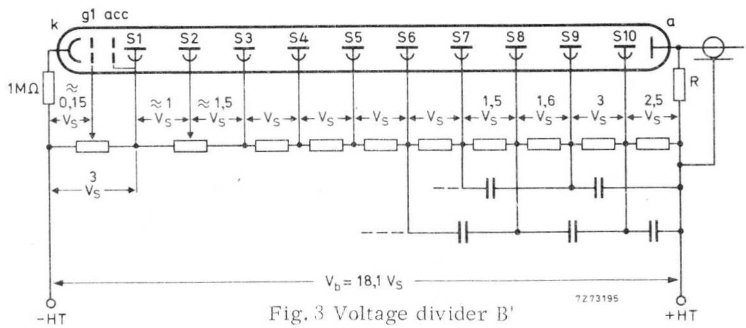


Fig. 3 Voltage divider B'

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

R = This resistor connects the anode when the output cable is not terminated. Recommended value: 10 kΩ

The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for an anode sensitivity N_a = 10 A/lm		typ. <	1800 2500	V V
Anode dark current at N_a = 10 A/lm (Fig. 6)	2)3)	typ. <	4 20	µA µA
Anode pulse rise time at V_b = 1800 V	4)5)	≈	2,3	ns
Anode pulse duration at half height at V_b = 1800 V	4)5)	≈	4,2	ns
Signal transit time at V_b = 1800 V	4)5)	≈	32	ns
Anode current linear within 2% at V_b = 1800 V up to		≈	30	mA
Obtainable peak anode current		≈	100	mA
With voltage divider B (Fig. 2)	1)			
Anode sensitivity at V_b = 2500 V		≈	1,5	A/lm
Anode pulse rise time at V_b = 2500 V	4)5)	≈	2,4	ns
Anode pulse duration at half height at V_b = 2500 V	4)5)	≈	3,3	ns
Signal transit time at V_b = 2500 V	4)5)	≈	34	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2500 V	4)5)	≈	0,8	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	280	mA
Obtainable peak anode current			0,5 to 1	A
With voltage divider B' (Fig. 3)	1)			
Anode sensitivity at V_b = 2200 V		≈	12	A/lm
Anode pulse rise time at V_b = 2200 V	4)5)	≈	2,1	ns
Anode pulse duration at half height at V_b = 2200 V	4)5)	≈	3	ns
Signal transit time at V_b = 2200 V	4)5)	≈	32	ns
Signal transit time fluctuation at V_b = 2200 V		≈	0,5	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2200 V	6) 4)5)	≈	0,5	ns
Anode current linear within 2%, at V_b = 2200 V up to		≈	80	mA
Obtainable peak anode current		≈	300	mA

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuits B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended to keep the increase in voltage between one stage and the next less than a factor 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at − HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user.
The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}$ Ω.

3) Dark current of S1 (type C) cathodes is measured at a temperature of 20 °C. The dark current varies sharply with temperature. See also note 5 on page 6.

4) Measured with a pulsed light source with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of the HT supply voltage V_b, approximately as $V_b^{-1/2}$.

5) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S10. See also "General Operational Recommendations Photomultiplier tubes".

6) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	3000	V
Continuous anode current	5)	max.	20	µA
Voltage between first dynode and photocathode	2)	max.	800	V
		min.	250	V
Voltage between focusing electrode g_1 and photocathode		max.	100	V
Voltage between consecutive dynodes		max.	600	V
Voltage between anode and final dynode	3)	max.	750	V
		min.	80	V
Ambient temperature range	4)5)			
Operational (for short periods of time)		max.	+50	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

1) Total HT supply voltage, or the voltage at which the tube has an anode sensitivity of 60 A/lm, whichever is lower.

2) Minimum value to obtain good collection in the input optics.

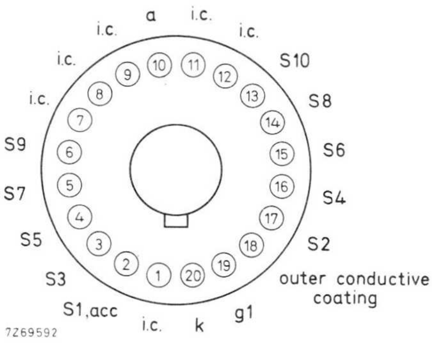
3) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

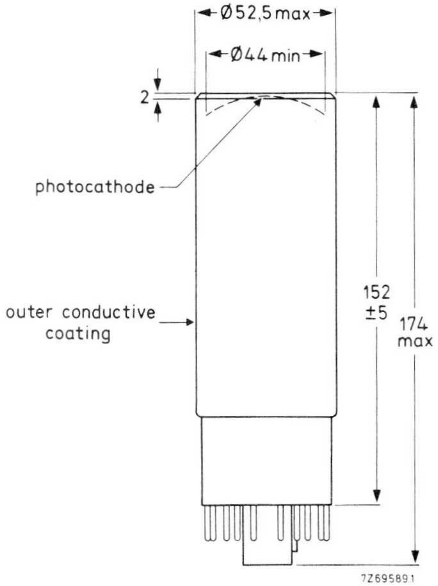
4) The lower temperature limit is set by stresses in the sealing layer of the base to the glass bulb.
When low temperature operation is contemplated the manufacturer should be consulted.

5) As the dark current increases by a factor 2 for every 7 °C increase in temperature, the anode sensitivity should be limited so that the continuous anode current limit is not exceeded.

MECHANICAL DATA

Dimensions in mm





Net mass : 210 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket type FE1020

Mu-metal shield type 56130

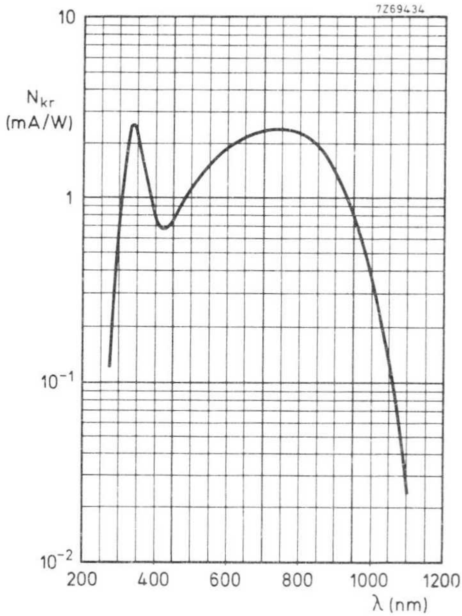


Fig. 4
Spectral sensitivity characteristic

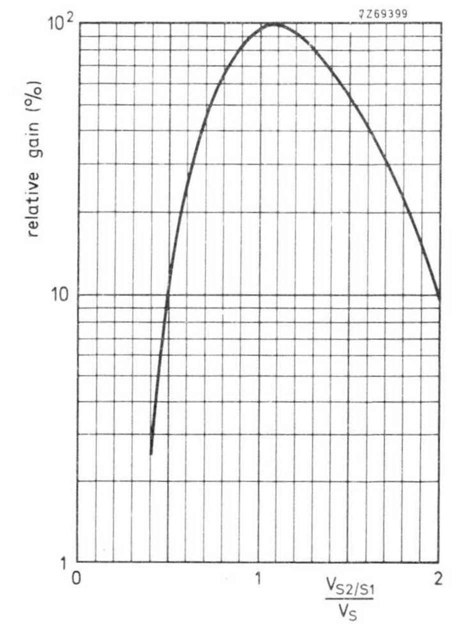


Fig. 5
Relative gain as a function of the voltage between S2 and S1, normalized to V_S
$V_{S3/S1}$ constant.

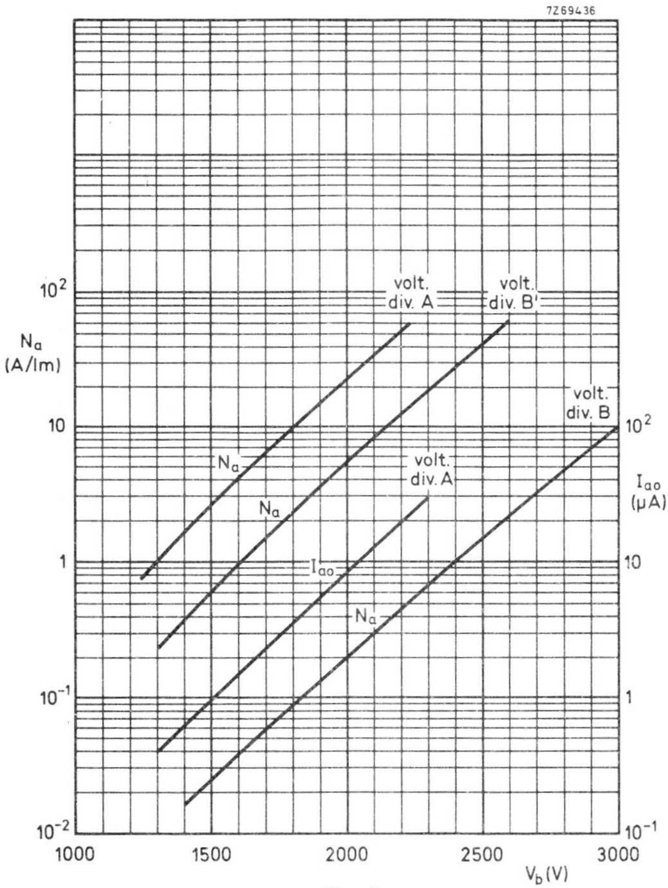


Fig. 6
Anode sensitivity, N_a, and anode dark current I_{ao}, as a function of supply voltage V_b

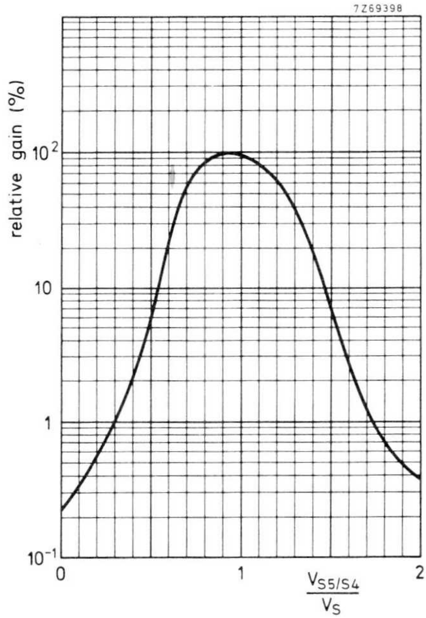


Fig. 7
Relative gain as a function of the voltage between S5 and S4 normalized to V_S
$V_{S6/S4}$ constant.

14-STAGE PHOTOMULTIPLIER TUBE

The 56DVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave window and a semi-transparent bialkaline type D photocathode. The tube is intended for use in nuclear physics where the number of photons to be detected is very low. The tube features a high cathode sensitivity and a very good collection efficiency combined with low background noise and good time characteristics, and is especially useful in experiments such as coincidence measurements, Cerenkov counting etc. A special version, the 56DVP/03, features a background noise level below 1000 c/s. For coincidence measurements, pairs of tubes with equal anode sensitivity at a voltage difference of less than 10% can be ordered under type number 56DVP/A or 56DVP/03/A respectively.
The 56DVP (and its versions) can be used in a special mounting assembly S5630/01 consisting of two magnetic shields, scintillator holder, voltage divider and mechanical housing.

QUICK REFERENCE DATA

Spectral sensitivity characteristic			type D	
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 401 nm			26	%
Spectral sensitivity of the photocathode at 401 nm			80	mA/W
Supply voltage for a gain of 3 x 10^7			1900	V
Anode pulse rise time (with voltage divider B')		≈	2,1	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-concave
Refractive index at 550 nm	1,48

Photocathode 1)

Semi-transparent, head-on			
Material		Sb-K-Cs	
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)		type D	
Maximum spectral sensitivity at		400 ± 30	nm
Quantum efficiency at 401 nm		26	%
Spectral sensitivity at 401 ± 3 nm 2)	typ.	80	mA/W
	>	60	mA/W

Electron optical input system

This system consists of: the photocathode ; the focusing electrode g_1; the accelerating electrode acc, internally connected to S_1.

Multiplier system

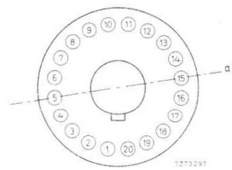
Number of stages			14	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Grid no. 1 to k + S1 + acc	$C_{g1/k, S1, acc}$	≈	25	pF
Anode to all	C_a	≈	9,5	pF
Anode to final dynode	Ca/S14	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1800 V, voltage divider A):

- at a magnetic flux density of 0,2 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,1 mT perpendicular to axis a) (see Fig. below);
- at a magnetic flux density of 0,05 mT parallel to axis a).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



1) The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity: the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at − 30 °C.
If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

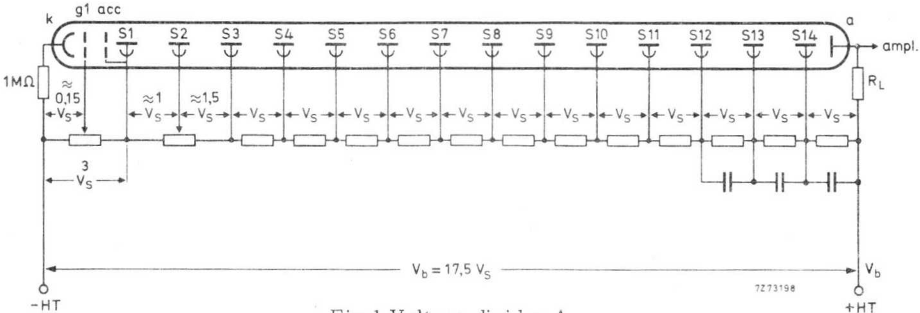


Fig 1 Voltage divider A

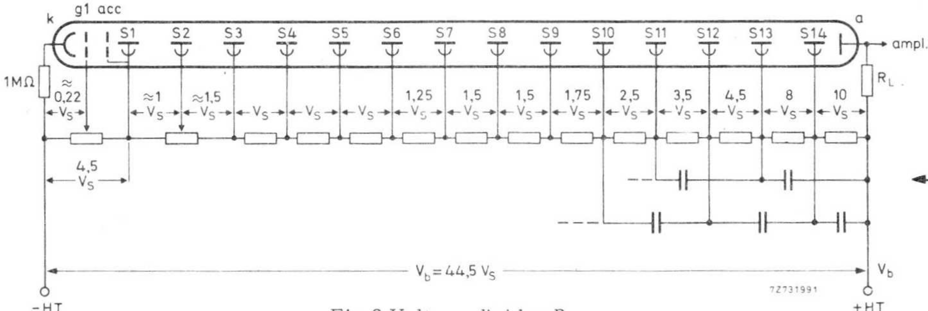


Fig 2 Voltage divider B

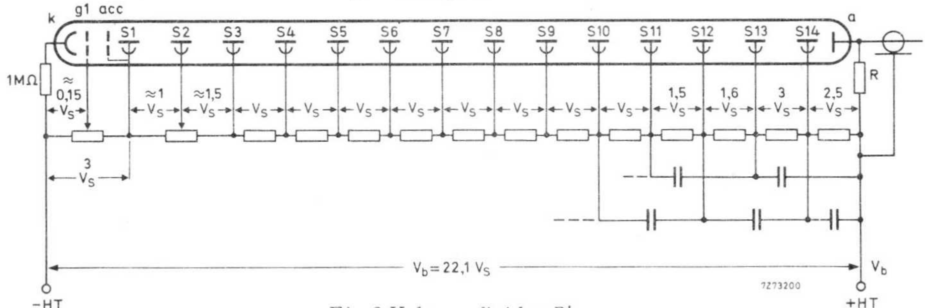


Fig 3 Voltage divider B'

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

R= This resistor connects the anode when the output cable is not terminated. Recommended value: 10 k Ω.

The cathode resistor of 1 M Ω limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1) [1]

Supply voltage for a gain of 3×10^7 (Fig. 6)		<	2300	V
		typ.	1900	V
Anode dark current at a gain of 3×10^7 (Fig. 6)	[2] [3]			
56DVP		<	60	nA
		typ.	6	nA
56DVP/03		<	50	nA
		typ.	4	nA
Background noise at a gain of 3×10^7 (Fig. 8)	[4]			
56DVP		<	3000	c/s
56DVP/03		<	1000	c/s
		typ.	500	c/s
Anode pulse rise time at V_b = 1800 V	[5] [6]	≈	2,3	ns
Anode pulse duration at half height at V_b = 1800 V	[5] [6]	≈	4,5	ns
Signal transit time at V_b = 1800 V	[5] [6]	≈	46	ns
Anode current linear within 2% at V_b = 1800 V up to		≈	30	mA
Obtainable peak anode current		≈	100	mA

With voltage divider B (Fig. 2) 1)

Gain at V_b = 2500 V (Fig. 6)		≈	8×10^6	
Anode pulse rise time at V_b = 2500 V	[5] [6]	≈	2,6	ns
Anode pulse duration at half height at V_b = 2500 V	[5] [6]	≈	3,9	ns
Signal transit time at V_b = 2500 V	[5] [6]	≈	48	ns
Signal transit time difference between the centre of the photo cathode and 18 mm from the centre at V_b = 2500 V		≈	0,8	ns
Anode current linear within 2% at V_b = 2500 V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1	A

Notes see page 6.

With voltage divider B' (Fig. 3)	1)			
Gain at V_b = 2200 V (Fig. 6)		≈	4×10^7	
Anode pulse rise time at V_b = 2200 V	5) 6)	≈	2, 1	ns
Anode pulse duration at half height at V_b = 2200 V	5) 6)	≈	3, 5	ns
Signal transit time at V_b = 2200 V	5) 6)	≈	44	ns
Signal transit time fluctuation at V_b = 2200 V	7)	≈	0, 5	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2200 V		≈	0, 5	ns
Anode current linear within 2% at V_b = 2200 V up to		≈	80	mA
Obtainable peak anode current		≈	300	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	8)	max.	2500	V
Continuous anode current		max.	0, 2	mA
Voltage between first dynode and photocathode	9)	max.	800	V
		min.	250	V
Voltage between focusing electrode, g_1, and photocathode		max.	100	V
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	10)	max.	500	V
		min.	80	V
Ambient temperature range	11)			
Operational (for short periods of time)		max.	+80	°C
		min.	-30	°C
Continuous operation and storage		max.	+50	°C
		min.	-30	°C

Notes see pages 6 and 7.

Notes to pages 4 and 5

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity.
Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the power supply should be arraged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at --HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7.

After a 30 min stabilization period noise pulses with a threshold of $4,25 \times 10^{-13}$ C (corresponding to 0, 1 photoelectron) are recorded.

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$

6) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier Tubes".

7) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

8) Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.

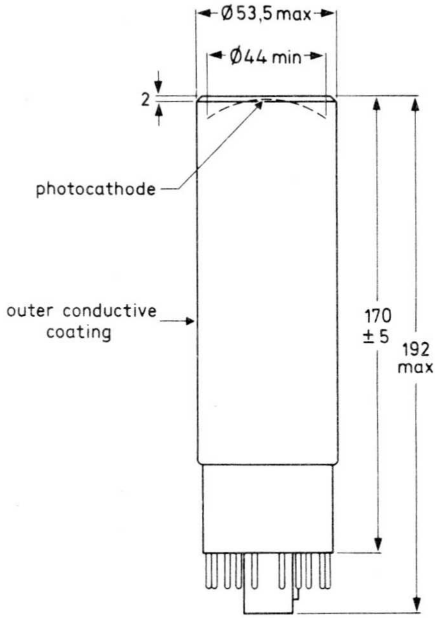
9) Minimum value to obtain good collection in the input optics.

10) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

11) This range of temperatures in limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm



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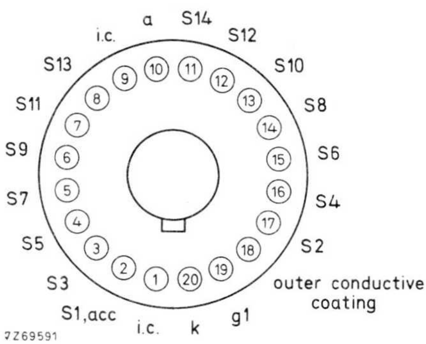


7Z69591

Net mass: 250 g

Base : 20- pin (JEDEC B20-102)

ACCESSORIES

Socket	type	FE1020
Mu-metal shield	type	56130

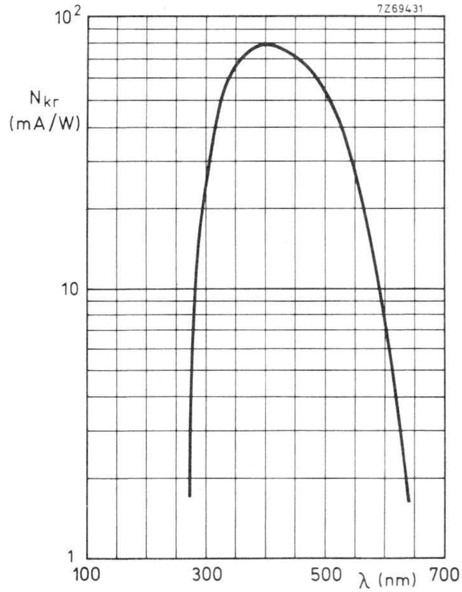


Fig. 4
Spectral sensitivity characteristic

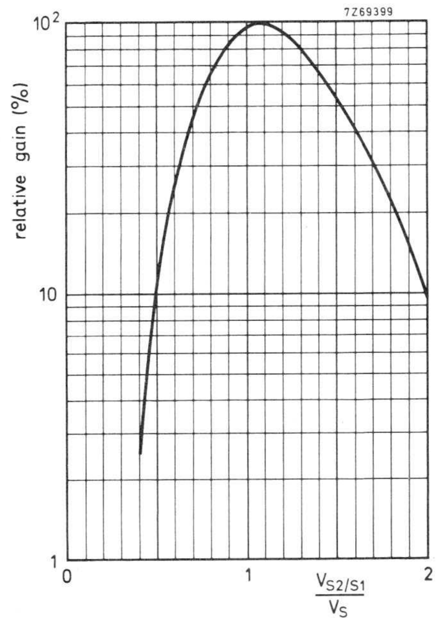


Fig. 5
Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S
$V_{S3/S1}$ constant

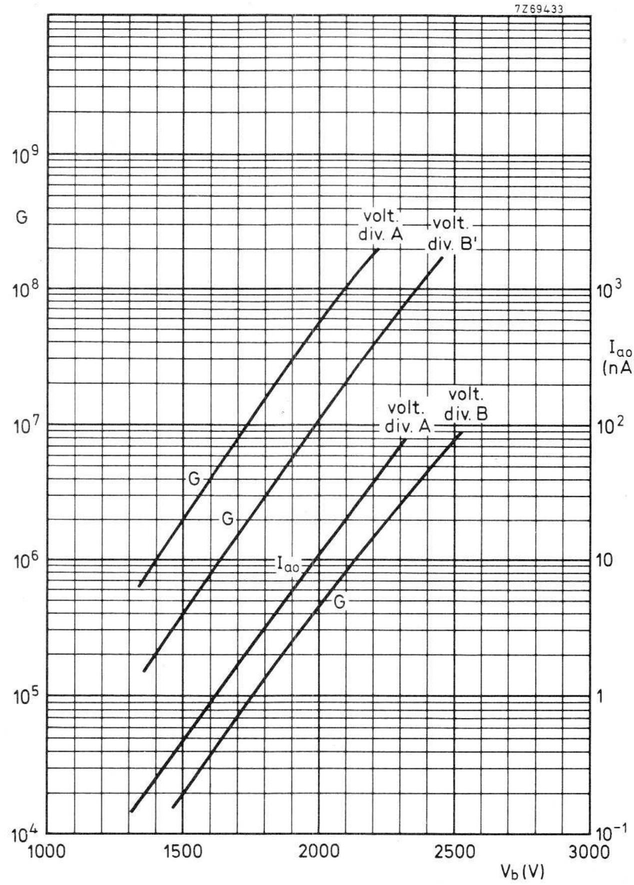


Fig. 6

Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b

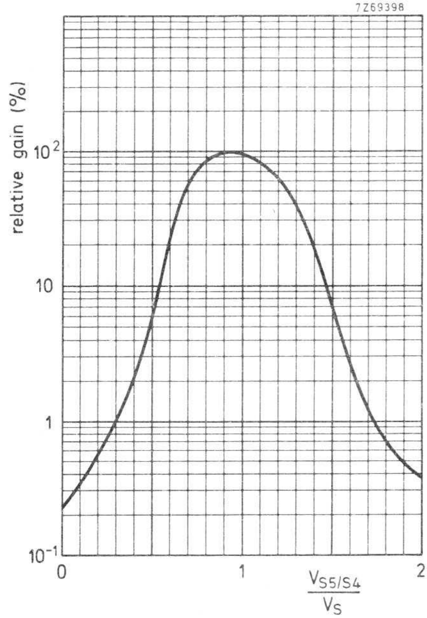


Fig. 7
Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S
$V_{S6/S4}$ constant.

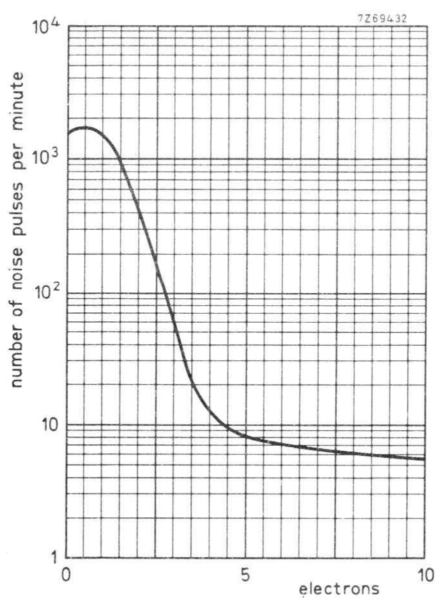


Fig. 8
Typical background spectrum from 0, 1 to 10 equivalent photoelectrons, at a gain of 3 x 10^7 with voltage divider A.

14-STAGE PHOTOMULTIPLIER TUBE

The 56TUVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave quartz window and a semi-transparent trialkaline type TU photocathode.
The tube is intended for use in optical applications where a high sensitivity in the region from ultraviolet to the near infrared is required combined with good time characteristics.
The 56TUVP can be used in a special mounting assembly S5630/01 consisting of two magnetic shields, scintillator holder, voltage divider, and mechanical housing.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		type TU		
Useful diameter of the photocathode		>	44	mm
Spectral sensitivity of the photocathode at 698 nm			15	mA/W
Supply voltage for a gain of 3 x 10^7			2050	V
Anode pulse rise time (with voltage divider B')		≈	2, 1	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	fused silica
Shape	plano-concave
Refractive index at 550 nm	1, 46

Photocathode

Semi-transparent, head-on			
Material	Sb-Na-K-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)	type TU		
Maximum spectral sensitivity at		420 ± 30	nm
Luminous sensitivity 1)	typ.	150	μA/lm
	>	90	μA/lm
Spectral sensitivity at 698 ± 7 nm 2)		15	mA/W

Electron optical input system

This system consists of: the photocathode; the focusing electrode g_1; the accelerating electrode acc, internally connected to S_1.

Multiplier system

Number of stages			14	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Grid no. 1 to k + S1 + acc	$C_{g1/k, S1, acc}$	≈	25	pF
Anode to all	C_a	≈	9,5	pF
Anode to final dynode	$C_{a/S14}$	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1800 V, voltage divider A):
- at a magnetic flux density of 0,2 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,1 mT perpendicular to axis a) (see Fig. below);
- at a magnetic flux density of 0,05 mT parallel to axis a).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

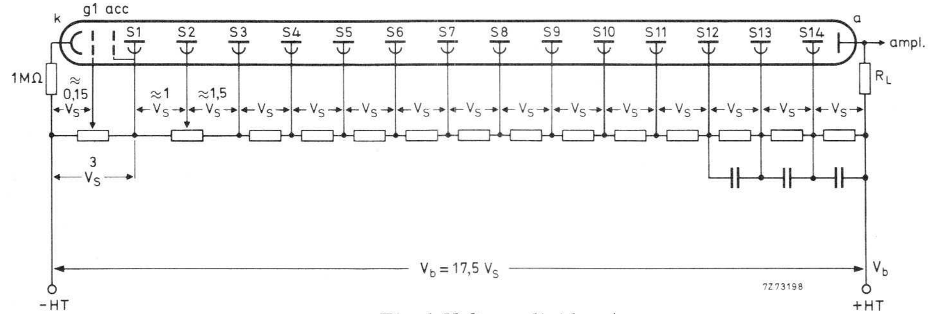


Fig. 1 Voltage divider A

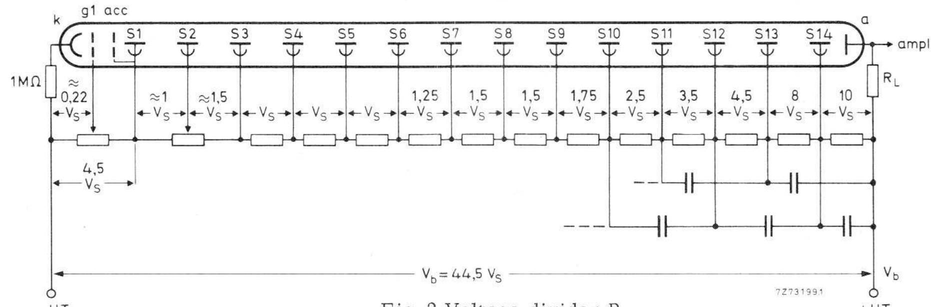


Fig. 2 Voltage divider B

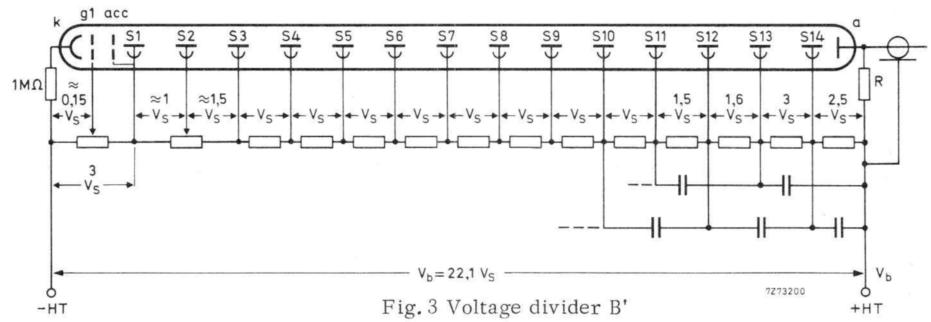


Fig. 3 Voltage divider B'

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

R = This resistor connects the anode when the output cable is not terminated. Recommended value: 10 k Ω.

The cathode resistor of 1 M Ω limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for a gain of 3×10^7		<	2500	V
		typ.	2050	V
Anode dark current at a gain of 3×10^7 (Fig. 6)	2)3)	<	1500	nA
		typ.	60	nA
Anode pulse rise time at V_b = 1800 V	4)5)	≈	2,3	ns
Anode pulse duration at half height at V_b = 1800 V	4)5)	≈	4,5	ns
Signal transit time at V_b = 1800 V	4)5)	≈	46	ns
Anode current linear within 2% at V_b 1800 V up to		≈	30	mA
Obtainable peak anode current		≈	100	mA
With voltage divider B (Fig. 2)	1)			
Gain at V_b = 2500 V (Fig. 6)		≈	3×10^6	
Anode pulse rise time at V_b = 2500 V	4)5)	≈	2,6	ns
Anode pulse duration at half height at V_b = 2500 V		≈	3,9	ns
Signal transit time at V_b = 2500 V	4)5)	≈	48	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2500 V		≈	0,8	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	280	mA
Obtainable peak anode current		≈	0,5 to 1	A
With voltage divider B' (Fig. 3)	1)			
Gain at V_b = 2200 (Fig. 6)		≈	2×10^7	
Anode pulse rise time at V_b = 2200 V	4)5)	≈	2,1	ns
Anode pulse duration at half height, at V_b = 2200 V	4)5)	≈	3,5	ns
Signal transit time at V_b = 2200 V	4)5)	≈	44	ns
Signal transit time fluctuation at V_b = 2200 V	6)	≈	0,5	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2200 V		≈	0,5	ns
Anode current linear within 2% at V_b = 2200 V, up to		≈	80	mA
Obtainable peak anode current		≈	300	mA

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuits B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at − HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

5) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier Tubes".

6) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	2750	V
Continuous anode current	5)	max.	0,2	mA
Voltage between first dynode and photocathode	2)	max.	800	V
		min.	250	V
Voltage between focussing electrode g_1 and photocathode		max.	100	V
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	3)	max.	500	V
		min.	80	V
Ambient temperature range	4)			
Operational (for short periods of time)		max.	+80	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

1) Total HT supply voltage, or the voltage at which the tube in voltage divider "A" has a gain of 2×10^8, whichever is lower.

2) Minimum value to obtain good collection in the input optics.

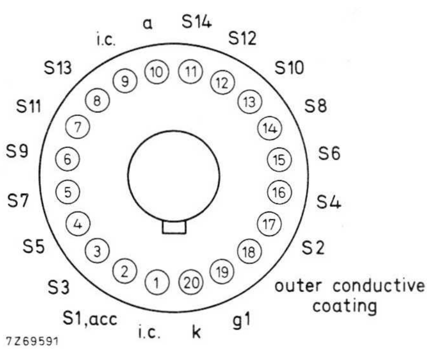
3) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

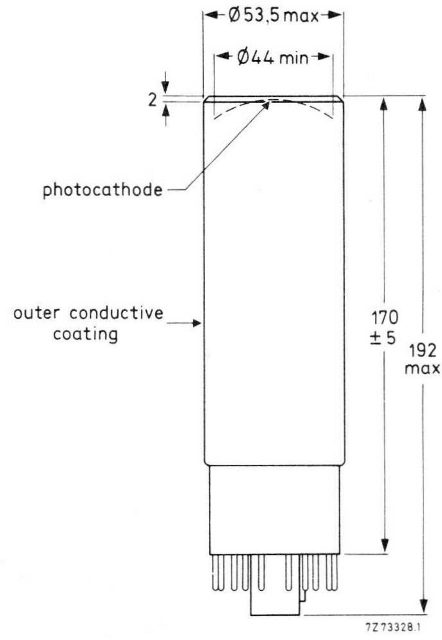
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

5) For applications requiring high stability a value of $<10\ \mu A$ is recommended.

MECHANICAL DATA

Dimensions in mm





Net mass : 225 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56130

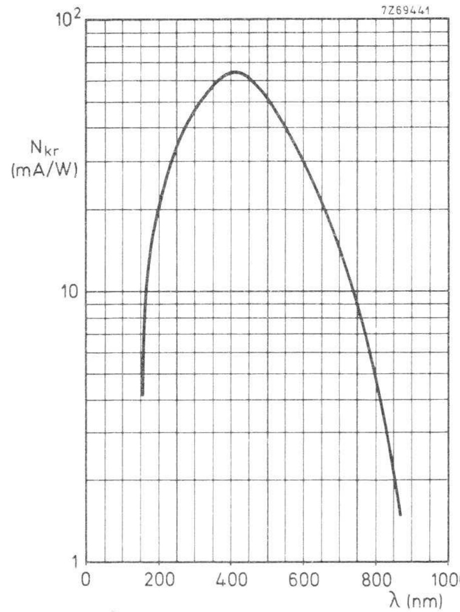


Fig. 4
Spectral sensitivity characteristic.

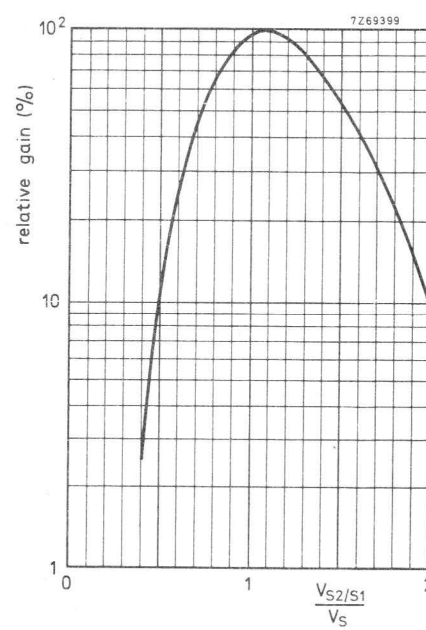


Fig. 5
Relative gain as a function of the voltage between S2 and S1, normalized to V_S
$V_{S3/S1}$ constant.

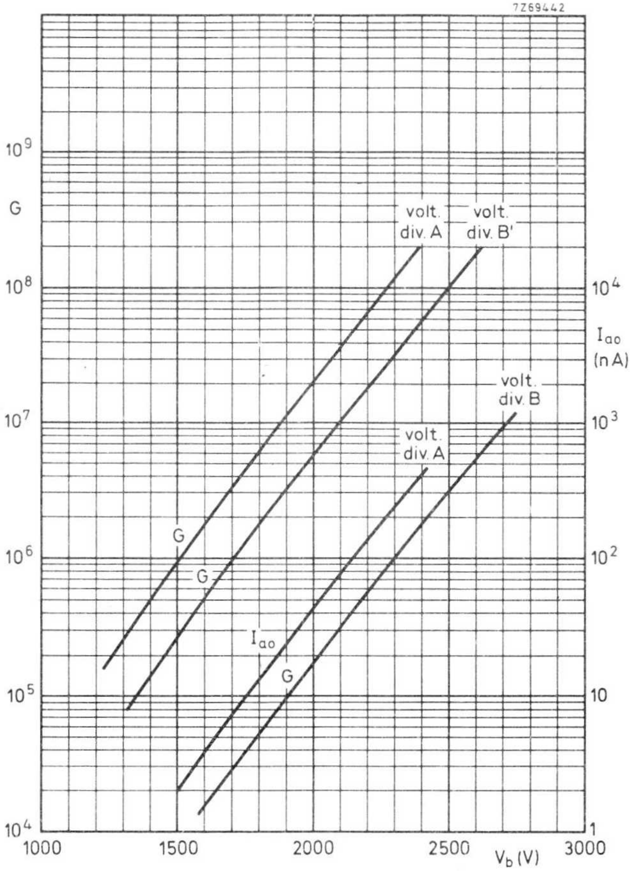


Fig. 6
Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b.

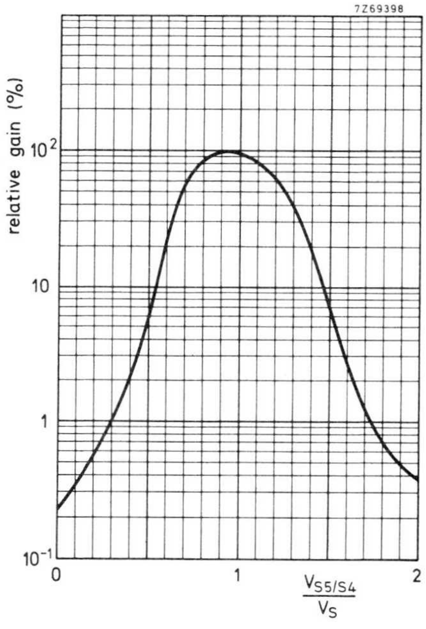


Fig. 7
Relative gain as a function of the voltage between S5 and S4 normalized to V_S
$V_{S6/S4}$ constant.

14-STAGE PHOTOMULTIPLIER TUBE

The 56TVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave window and a semi-transparent S20 (type T) photocathode. The tube is intended for use in low light level physical experiments in the red and near infrared part of the spectrum such as laser detection, pollution monitoring, life time measurements.
The tube also features good time characteristics.
The 56TVP can be used in a special mounting assembly S5630/01 consisting of two magnetic shields, scintillator holder, voltage divider, and mechanical housing.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		S20 (type T)		
Useful diameter of the photocathode		>	44	mm
Spectral sensitivity of the photocathode at 698 nm			15	mA/W
Supply voltage for a gain of 3×10^7			2050	V
Anode pulse rise time (with voltage divider B')		≈	2,1	ns
Linearity				
with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-concave
Refractive index at 550 nm	1,48

Photocathode

Semi-transparent, head-on			
Material	Sb-Na-K-Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)	S20 (type T)		
Maximum spectral sensitivity at		420 ± 30	nm
Luminous sensitivity 1)	typ.	150	μA/lm
	>	90	μA/lm
Spectral sensitivity at 698 ± 7 nm 2)		15	mA/W

Electron optical input system

This system consists of: the photocathode; the focusing electrode g_1; the accelerating electrode acc, internally connected to S_1.

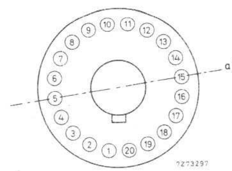
Multiplier system

Number of stages			14	
Dynode structure			linear focused	
Dynode material			Ag-Mg	
Capacitances				
Grid no. 1 to k + S1 + acc	$C_{g1/k, S1, acc}$	≈	25	pF
Anode to all	C_a	≈	9,5	pF
Anode to final dynode	$C_{a/S14}$	≈	7	pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_b = 1800 V, voltage divider A):
- at a magnetic flux density of 0,2 mT in the direction of the longitudinal axis;
- at a magnetic flux density of 0,1 mT perpendicular to axis a) (see Fig. below);
- at a magnetic flux density of 0,05 mT parallel to axis a).

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

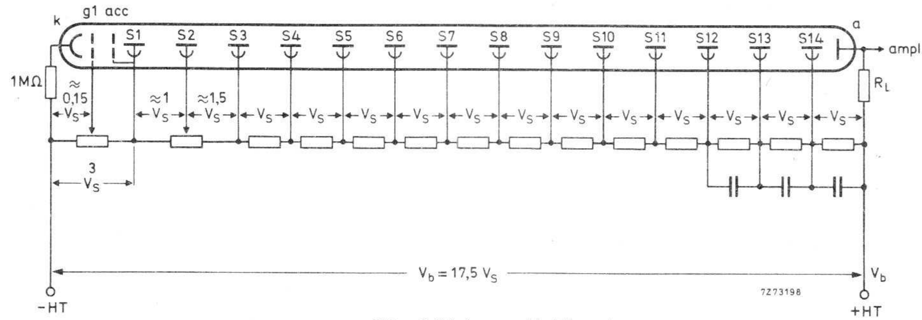


Fig. 1 Voltage divider A

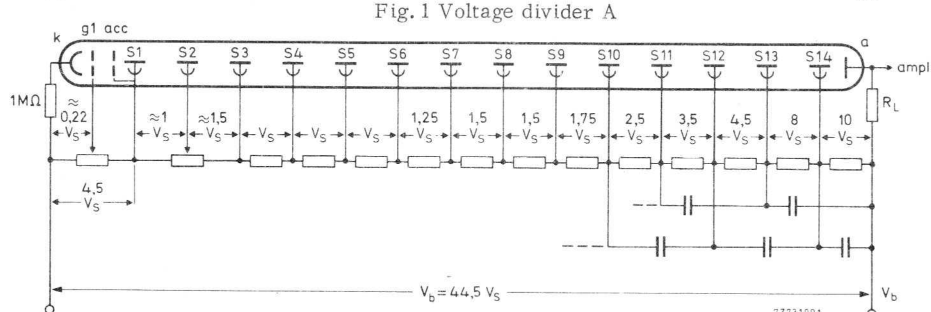


Fig. 2 Voltage divider B

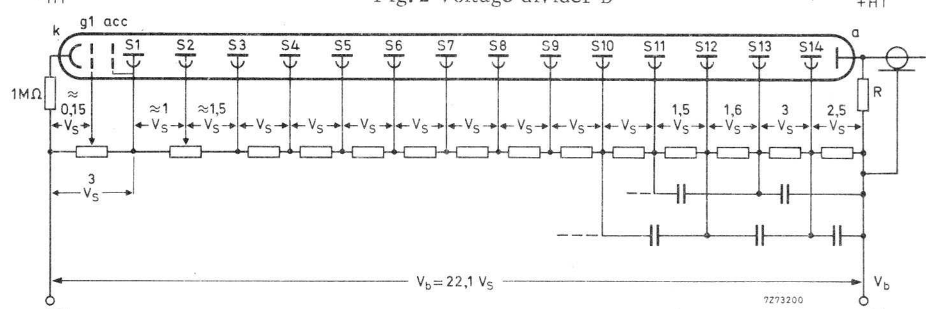


Fig. 3 Voltage divider B'

R = This resistor connects the anode when the output cable is not terminated. Recommended value: 10 k Ω.

The cathode resistor of 1 M Ω limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed.

Typical value of capacitors: 1 nF.

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode no. n
a = anode
R_L = load resistor

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for a gain of 3×10^7		<	2500	V
		typ.	2050	V
Anode dark current at a gain of 3×10^7 (Fig. 6)	2)3)	<	1500	nA
		typ.	60	nA
Anode pulse rise time at V_b = 1800 V	4)5)	≈	2, 3	ns
Anode pulse duration at half height at V_b = 1800 V	4)5)	≈	4, 5	ns
Signal transit time at V_b = 1800 V	4)5)	≈	46	ns
Anode current linear within 2% at V_b = 1800 V up to		≈	30	mA
Obtainable peak anode current		≈	100	mA
With voltage divider B (Fig. 2)	1)			
Gain at V_b = 2500 V (Fig. 6)		≈	3×10^6	
Anode pulse rise time at V_b = 2500 V	4)5)	≈	2, 6	ns
Anode pulse duration at half height at V_b = 2500 V		≈	3, 9	ns
Signal transit time at V_b = 2500 V	4)5)	≈	48	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2500 V		≈	0, 8	ns
Anode current linear within 2%, at V_b = 2500 V up to		≈	280	mA
Obtainable peak anode current		≈	0, 5 to 1	A
With voltage divider B' (Fig. 3)	1)			
Gain at V_b = 2200 (Fig. 6)		≈	2×10^7	
Anode pulse rise time at V_b = 2200 V	4)5)	≈	2, 1	ns
Anode pulse duration at half height, at V_b = 2200 V	4)5)	≈	3, 5	ns
Signal transit time at V_b = 2200 V	4)5)	≈	44	ns
Signal transit time fluctuation at V_b = 2200 V	6)	≈	0, 5	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre, at V_b = 2200 V		≈	0, 5	ns
Anode current linear within 2% at V_b = 2200 V, up to		≈	80	mA
Obtainable peak anode current		≈	300	mA

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuits B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at − HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ 1/4 h).

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

5) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S14. See also "General Operational Recommendations Photomultiplier Tubes".

6) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	2750	V
Continuous anode current	5)	max.	0, 2	mA
Voltage between first dynode and photocathode	2)	max.	800	V
		min.	250	V
Voltage between focussing electrode g_1 and photocathode		max.	100	V
Voltage between consecutive dynodes		max.	500	V
Voltage between anode and final dynode	3)	max.	500	V
		min.	80	V
Ambient temperature range	4)			
Operational (for short periods of time)		max.	+80	^oC
		min.	−30	^oC
Continuous operation and storage		max.	+50	^oC
		min.	−30	^oC

1) Total HT supply voltage, or the voltage at which the tube in voltage divider "A" has a gain of 2×10^8, whichever is lower.

2) Minimum value to obtain good collection in the input optics.

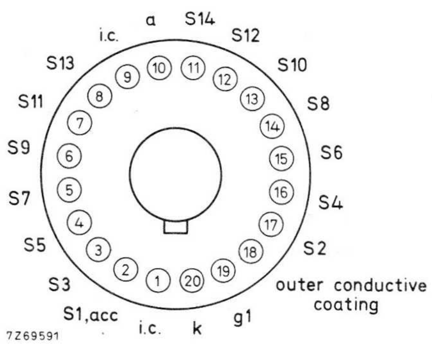
3) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

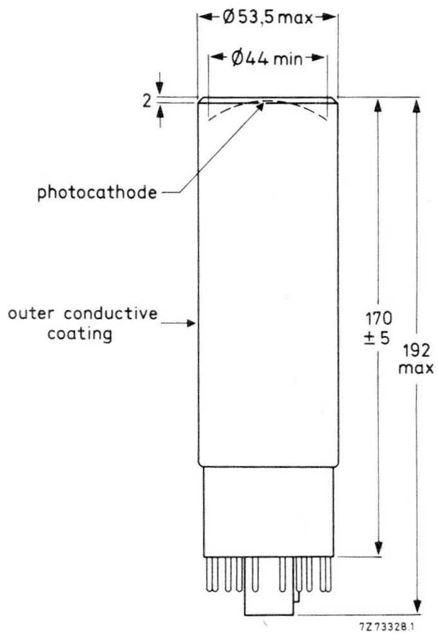
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

5) For applications requiring high stability a value of $<10\ \mu A$ is recommended.

MECHANICAL DATA

Dimensions in mm





Net mass: 225 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56130

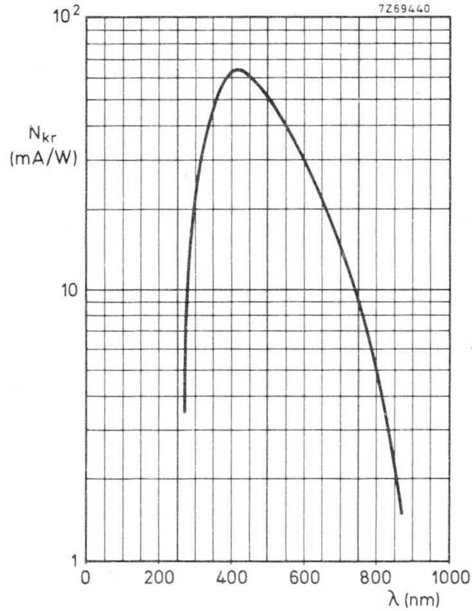


Fig. 4
Spectral sensitivity characteristic

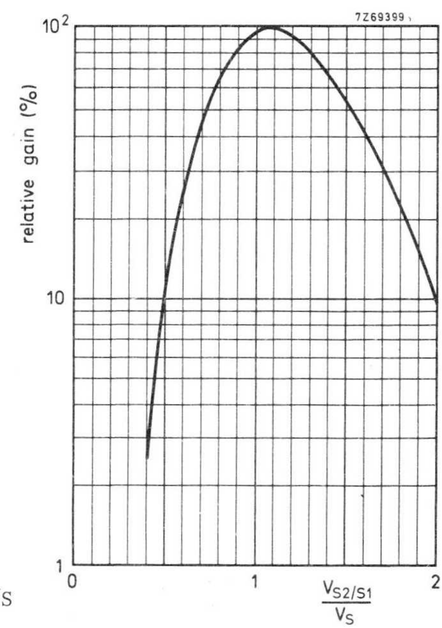


Fig. 5
Relative gain as a function of the voltage between S2 and S1, normalized to V_S
$V_{S3/S1}$ constant.

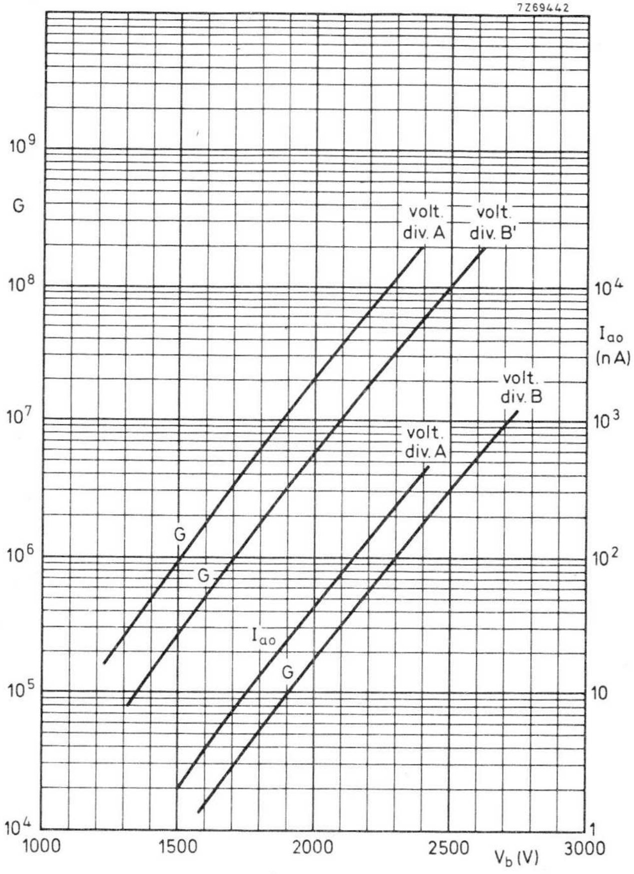


Fig. 6
Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b

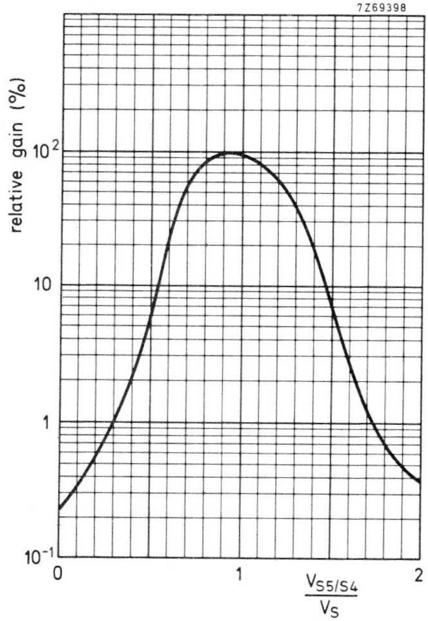


Fig. 7
Relative gain as a function of the voltage between S5 and S4 normalized to V_S
$V_{S6/S4}$ constant.

12-STAGE PHOTOMULTIPLIER TUBE

The 60DVP is a 200 mm useful diameter head-on photomultiplier tube with a concave-convex window and a semi-transparent bialkaline type D photocathode.
The tube is intended for use in physical applications where a high time resolution is required and where the number of photons to be detected is low.
The tube can also be supplied with a plano-concave plastic adapter in a metal housing under type number 60DVP/H.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	200	mm
Spectral sensitivity of the photocathode at 401 nm			70	mA/W
Supply voltage for a gain of 3×10^7			3000	V
Anode pulse rise time (with voltage divider B')		≈	2,5	ns
Linearity, with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	280	mA
with voltage divider B'	up to	≈	80	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate		
Radius of curvature (external)	≈	186	mm
Thickness	≈	2	mm
Shape	concave-convex		
Refractive index at 550 nm		1,48	

Photocathode [1])

Semi-transparent head-on			
Material	Sb-K-Cs		
Useful diameter	>	200	mm

Note see page 2.

Spectral sensitivity characteristic (Fig. 4)	type D		
Maximum spectral sensitivity at		400 ± 30	nm
Luminous sensitivity		65	μA/lm
Spectral sensitivity at 401 ± 3 nm	typ.	70	mA/W
	>	60	mA/W

Electron optical input system

This consists of: the photocathode, k; a metallized part of the glass envelope internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

Multiplier system

Number of stages			12	
Dynode structure		linear focused		
Dynode material		Ag-Mg		
Capacitances				
Anode to all	C_a	≈	8	pF
Anode to final dynode	$C_{a/S12}$	≈	7	pF

Magnetic field

A magnetic field will result in a decrease of anode sensitivity due to a decrease of the collection of the photoelectrons leaving the photocathode.

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding well beyond the photocathode.

[1]) The bialkaline photocathode has a significant resistance, which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at -30 °C.
If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.

RECOMMENDED CIRCUITS

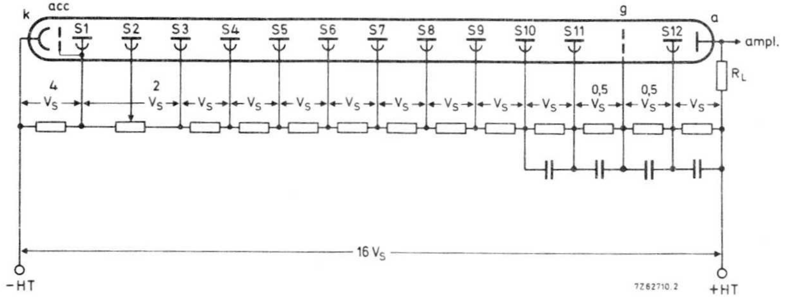


Fig. 1 Voltage divider type A

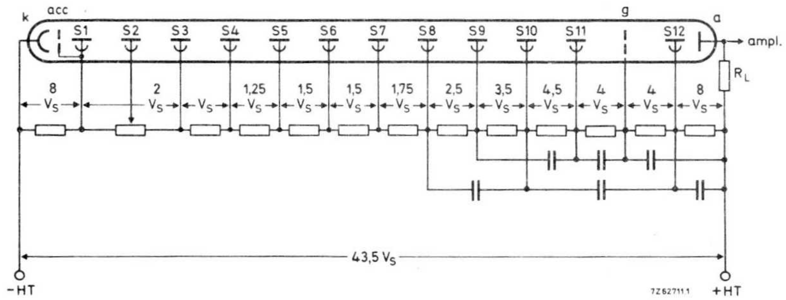


Fig. 2 Voltage divider B

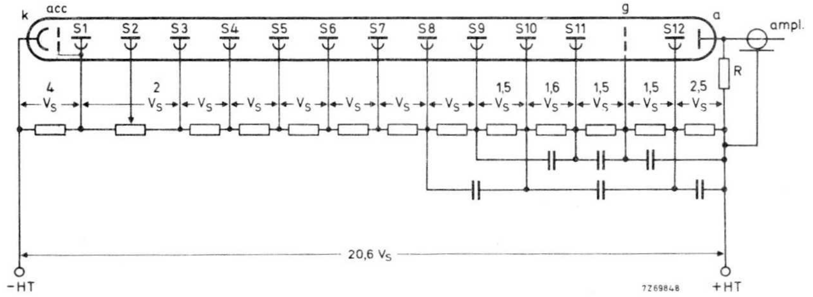


Fig. 3 Voltage divider B'

k = cathode
acc = accelerating electrode
S_n = dynode no. n
R_L = load resistor

R This resistor serves to connect the anode when the output cable is not terminated

Typical value of capacitors : 1 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	1)			
Supply voltage for a gain $G = 3 \times 10^7$ (Fig. 5)		typ. <	3000 3400	V V
Anode dark current at $G = 3 \times 10^7$ (Fig. 5)	2)3)	typ. <	6 40	nA nA
Background noise at $G = 3 \times 10^7$	4)	≈	1000	c/s
Anode current linear within 2% at V_b = 3000 V up to		≈	30	mA
With voltage divider B (Fig. 2)	1)			
Gain G at V_b = 3000 V		≈	3×10^5	
Anode current linear within 2% at V_b = 3000 V up to		≈	280	mA
With voltage divider B' (Fig. 3)	1)			
Gain G at V_b = 3000 V		≈	10^7	
Anode pulse rise time at V_b = 3000 V	5)6)	≈	2,1	ns
Anode pulse duration at half height at V_b = 3000 V	5)6)	≈	3,5	ns
Signal transit time at V_b = 3000 V	5)6)	≈	48	ns
Signal transit time difference between the centre of the photocathode and 90 mm from the centre, at V_b = 3000 V		≈	2	ns
Anode current linear within 2% at V_b = 3000 V up to		≈	250	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	7)	max.	3700	V
Continuous anode current		max.	0,2	mA
Voltage between first dynode and photocathode	8)	max. min.	1000 300	V V
Voltage between consecutive dynodes (except S11 and S12)		max.	400	V
Voltage between dynodes S11 and S12		max.	700	V
Voltage between anode and final dynode	9)	max. min.	700 80	V V
Ambient temperature range	10)	max. min.	+50 −30	°C °C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuits B and B' are examples of progressive dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the photocathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. It is recommended that, if a metal shield is used, this be kept at cathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ h).

4) After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7.
After a 30 min stabilization period noise pulses with a threshold of $4,25 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded.

5) Measured with a pulsed-light source with a pulse duration (FWHM) of <1 ns; the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum.
Rise time, pulse duration, and transit time vary as a function of the HT supply voltage, V_b, approximately as $V_b^{-1/2}$.

6) A non-inductive resistor of 50 Ω is incorporated in the base, connected to S12. See also "General Operational Recommendations Photomultiplier Tubes".

7) Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.

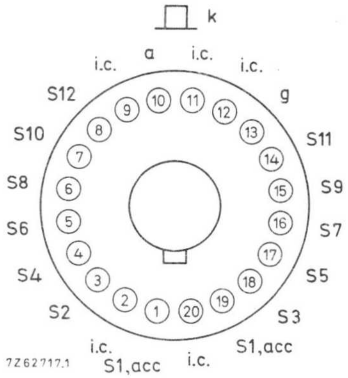
8) Minimum value to obtain good collection in the input optics.

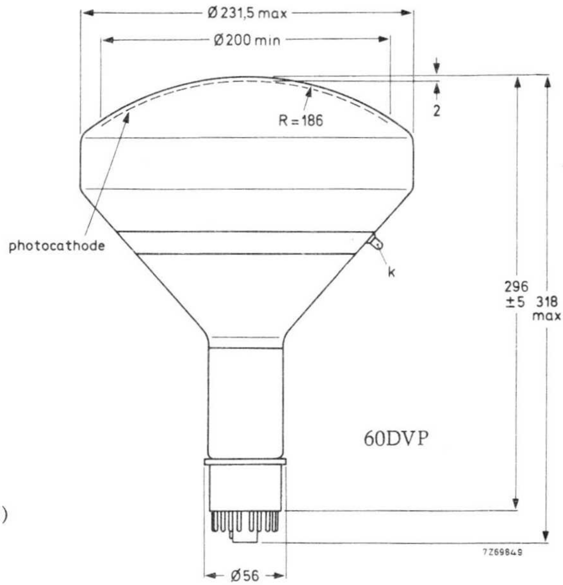
9) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

10) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low-temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass : approx. 1 kg (60DVP)
approx. 2, 5 kg (60DVP/H)

Base : 20-pin (JEDEC B20-102)

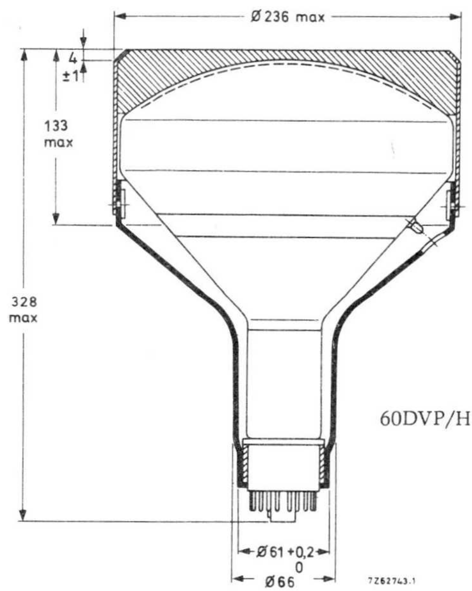
ACCESSORIES

→ Socket : type FE1020

Mu-metal shield: type 56132

Female plug for connecting the photocathode : supplied with each tube

Optical silicone grease, supplied with each tube, should be applied to the adapter-photomultiplier interface before operation.



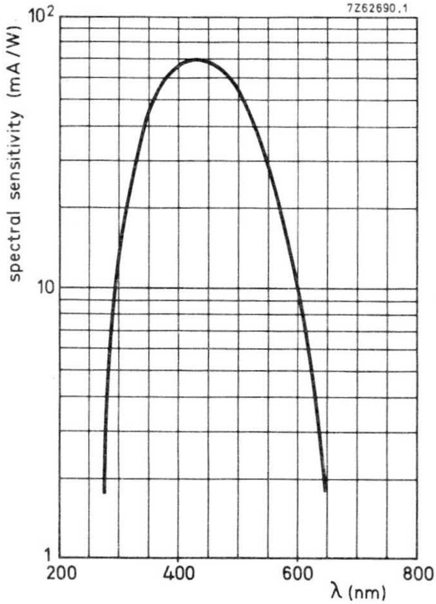


Fig. 4

Spectral sensitivity characteristic

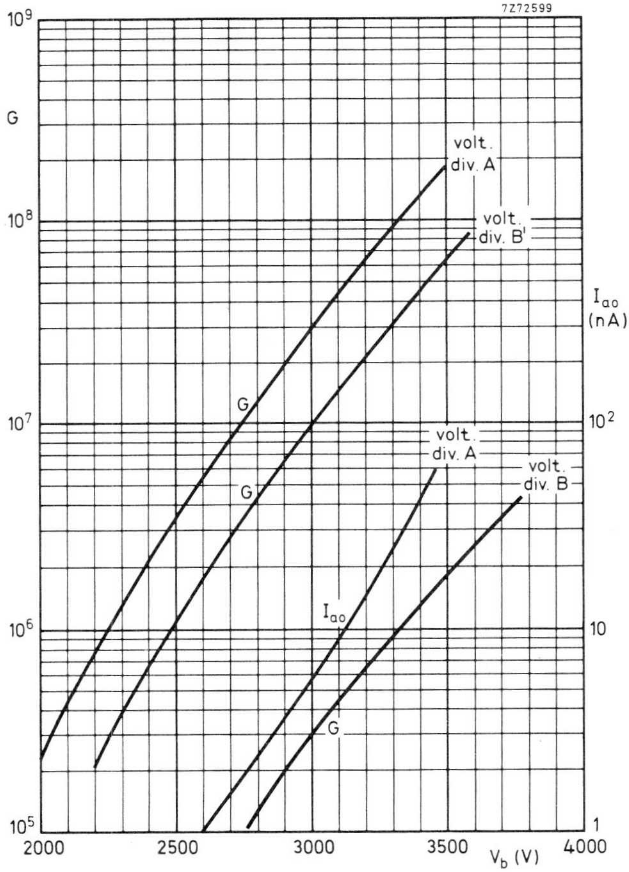


Fig. 5

Gain, G, and anode dark current, I_{ao}, as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The 150CVP is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S1 (type C) photocathode.
The tube is intended for use in applications where a good sensitivity in the red and near-infrared part of the spectrum is required, such as laser detection and pollution monitoring.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		S1 (type C)		
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode at 903 nm			1,4	mA/W
Supply voltage for anode luminous sensitivity = 10 A/lm			1600	V
Anode pulse rise time (with voltage divider B)		≈	3,5	ns
Linearity, with voltage divider A	up to	≈	30	mA
with voltage divider B	up to	≈	100	mA

To be read in conjunction with "General Operational Recommendations Photomultiplier Tubes".

GENERAL CHARACTERISTICS

Window

Material	borosilicate	
Shape	plano-plano	
Refractive index at 550 nm	1,48	

Photocathode

Semi-transparent, head-on			
Material	Ag-O-Cs		
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig. 3)	S1 (type C)		
Maximum spectral sensitivity at		800 ± 100	nm

Luminous sensitivity		typ.	20	μA/lm
		>	15	μA/lm
Spectral sensitivity at 903 ± 8 nm			1,4	mA/W
at 1060 ± 10 nm		≈	0,12	mA/W

Electron optical input system

This system consists of: the photocathode, k; a metallized part of the glass envelope internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

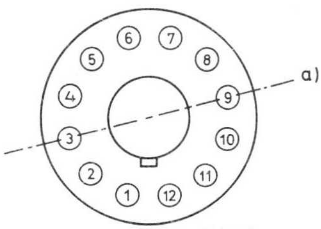
Multiplier system

Number of stages		10		
Dynode structure		linear focused		
Dynode material		Cu-Be		
Capacitance				
Anode to all	C_a	≈	5	pF
Anode to final dynode	$C_{a/S10}$	≈	3	pF

Magnetic field

See Fig. 4

It is recommended that the tube be screened against the influence of magnetic fields by a mu-metal shield protruding > 15 mm beyond the photocathode.



Axis a) with respect to base pins (bottom view)

RECOMMENDED CIRCUITS

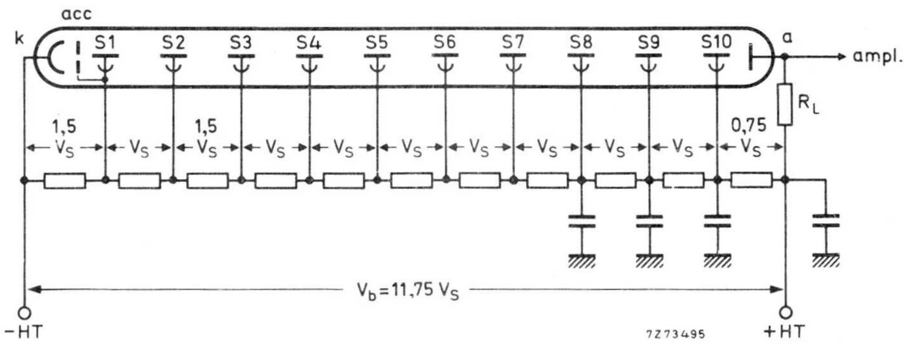


Fig. 1 Voltage divider A

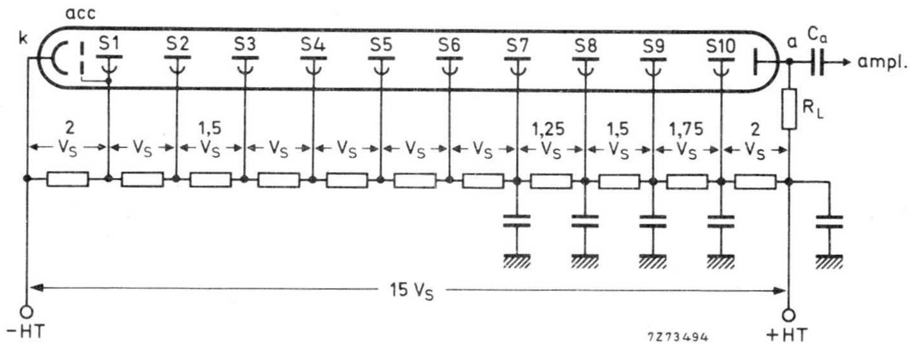


Fig. 2 Voltage divider B

Typical values of capacitors: 10 nF

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1) [1]

Supply voltage for an anode luminous sensitivity N_a = 10 A/lm (Fig. 5)			<	1700	V
			typ.	1600	V
Anode dark current at N_a = 10 A/lm (Fig. 5)	[2][3]		<	10	μA
			typ.	2	μA
Anode current linear within 2% at V_b = 1700 V		up to	≈	30	mA

With voltage divider B (Fig. 2)

Anode luminous sensitivity at V_b = 1700 V (Fig. 5)			≈	5	A/lm
Anode pulse rise time at V_b = 1700 V	[4]		≈	3,5	ns
Anode pulse duration at half height at V_b = 1700 V	[4]		≈	6	ns
Signal transit time at V_b = 1700 V	[4]		≈	34	ns
Anode current linear within 2% at V_b = 1700 V		up to	≈	100	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	[5]	max.	1800	V
Continuous anode current	[6]	max.	20	μA
Voltage between first dynode and photocathode	[7]	max.	500	V
		min.	120	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	[8]	max.	300	V
		min.	30	V
Ambient temperature range				
Operational (for short periods of time)	[6][9]	max.	+50	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

Notes see page 5.

Notes to page 4

1) To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.

2) Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at -HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.

3) Dark current for S1(type C) photocathodes is measured at a temperature of 20 °C. The dark current varies sharply with temperature. See also note 6.

4) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.

5) Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of 60 A/lm, whichever is lower.

6) As the dark current increases by a factor of 2 for every 7 °C increase in temperature, the anode sensitivity should be limited so that the continuous anode current limit is not exceeded.

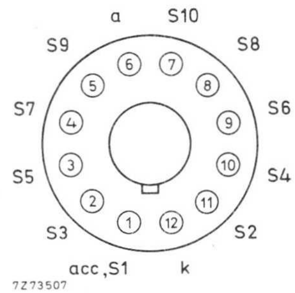
7) Minimum value to obtain good collection in the input optics.

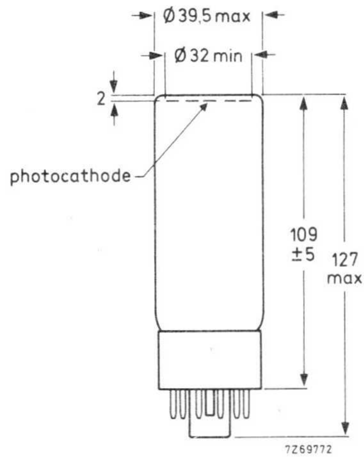
8) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

9) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm





Net mass	:	80 g
Base	:	12-pin (JEDEC B12-43)

ACCESSORIES

→ Socket : type FE1012

Mu-metal shield : type 56127

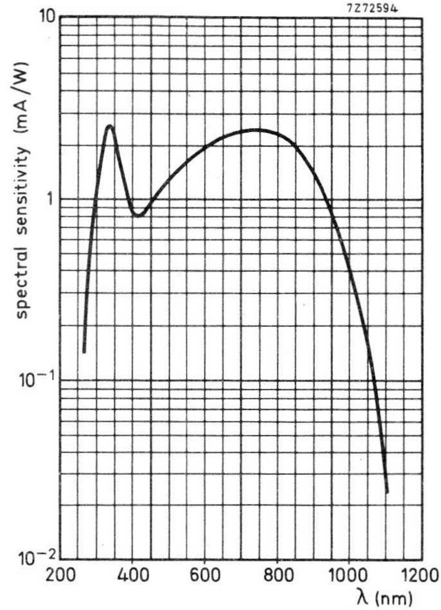


Fig. 3
Spectral sensitivity characteristic.

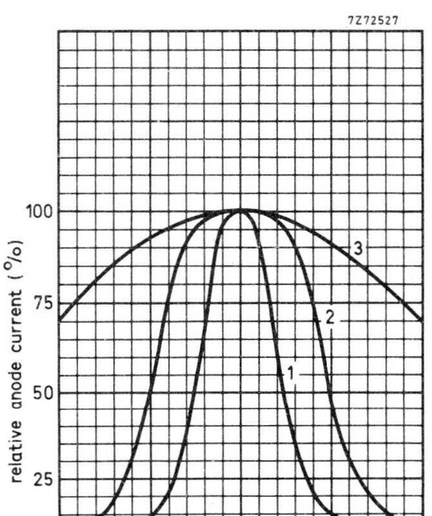


Fig. 4
Relative anode current as a function of the magnetic flux density B
1. B ⊥ tube axis, // axis a
2. B ⊥ tube axis, ⊥ axis a
3. B // tube axis

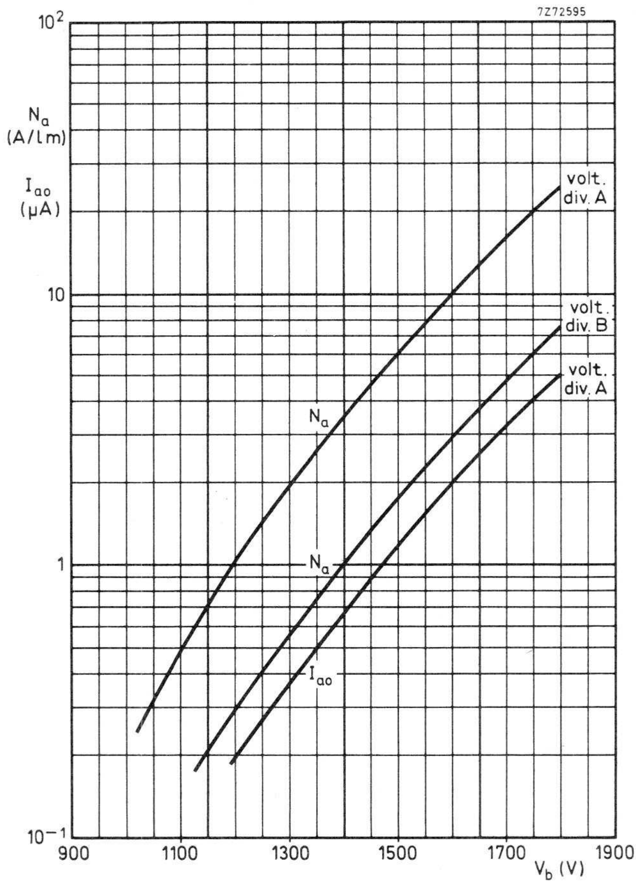


Fig. 5
Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b.

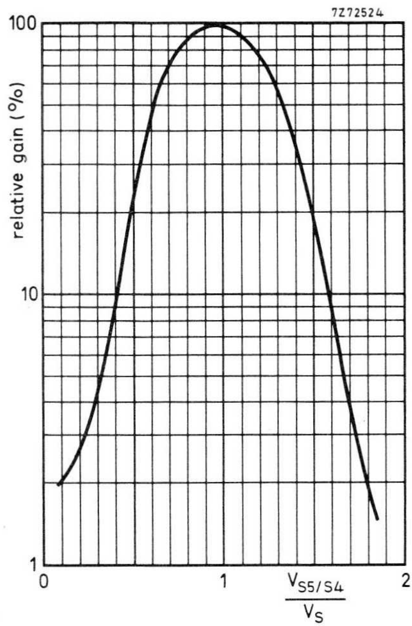


Fig. 6
Relative gain as a function of the voltage between S_5 and S_4, normalized to V_S
$V_{S6/S4}$ constant.

Phototubes (diodes)

SURVEY OF TYPES

Photocathode dimensions (mm)	Tube type	Spectral response				
		A (S11)	C (S1)	S4	T (S20)	U (S13)
20ϕ	XA1002			X		
	XA1003		X			
26ϕ	150CV		X			
	150TV				X	
30ϕ	150AV	X				
	150UV					X
40ϕ	TVHC40				X	
108ϕ	AVHC201			X		
22 x 11	92AG	X				
	92AV	X				
	90CG		X			
	90CV		X			

LIST OF SYMBOLS

Supply voltage	V_b
Cathode current	I_k
Anode series resistance	R_a
Sensitivity	N
Capacitance, anode to cathode	C_{ak}
Ambient temperature	t_{amb}
Envelope temperature	t_{env}

GENERAL OPERATIONAL RECOMMENDATIONS
PHOTOTUBES

1. GENERAL

1.1 **Phototubes** are photoelectric devices of the emissive type, as distinct from the barrier-layer and photo-conductive cells. They may be divided into two groups :

1. Vacuum phototubes,
2. Gas-filled phototubes

For a vacuum phototube, the anode current for a fixed quantity of light, is constant at anode voltages above a certain low value known as the "saturation voltage".
The gas-filled phototube contains a quantity of inert gas, the ionizing potential of which is generally somewhat higher than the saturation voltage of an equivalent vacuum phototube, so that the anode current is substantially constant between the saturation voltage and the voltage at which ionization commences. Above this voltage range, ionization increases, resulting in a progressive increase in anode current.
Since a gas-filled phototube operates at a higher voltage than the ionizing potential it will have a greater sensitivity than a similar vacuum phototube.
Within the operating ranges of both groups of phototubes the anode current is directly proportional to the quantity of light incident on the cathode surface.

1.2 Spectral response

The materials used for the photocathode are of great importance to the spectral response. Many substances show photoemission, but often differ greatly in their spectral sensitivity and quantum yield.

1.2.1 The S11 (A-type) tubes are equipped with a semi-transparent caesium antimony photocathode on an MnO_2 layer, evaporated on the inside of a glass window. These types are sensitive to radiation in the visible region of the spectrum and have their maximum sensitivity at approximately 420 nm.

1.2.2 The S13 (U-type) tubes have the same photocathodes as the S11 tubes, but are provided with a fused silica (quartz) window, giving them a sensitivity that extends into the ultraviolet region of the spectrum.

1.2.3 The S1 (C-type) tubes have a semi-transparent caesium-on-silver-oxide photocathode on a glass window.
The sensitivity lies mainly in the red and near infrared regions of the spectrum, with a maximum at approximately 800 nm.

1.2.4 The S20 (T-type) tubes have a tri-alkaline (Sb-Na-K-Cs) semi-transparent photocathode on a glass window. This photocathode has a good sensitivity from the ultraviolet to the near infrared part of the spectrum, with a maximum at approximately 420 nm.

1.2.5 The S4 tubes have a Sb-Cs emission layer deposited on an opaque substrate. This photocathode is intended for use in applications with relatively high illumination in the visible region of the spectrum.

Spectral response curves are given in the data sheets of each type.

2. INTERPRETATION OF CHARACTERISTICS

In general the characteristics given in the data sheets are typical values. The "typical value" of a parameter is the median of the frequency distribution of the parameter measured on a large number of tubes.
In some cases maximum or minimum values are stated. These values are defined on test-limits carried out on each tube. Approximate values are given when these values are obtained from batch sample data.

2.1 Cathode luminous sensitivity

The cathode luminous sensitivity is defined (IEC) as the quotient of the photocurrent of the cathode by the incident luminous flux, expressed in amperes per lumen.
The cathode current, I_k, (corrected for dark current) is about 100 nA.

The voltage used should be sufficient to ensure saturation.

The sensitivity is given by: $N_k = \frac{I_k}{\phi}$

where ϕ is the luminous flux, in lumen, of a tungsten filament lamp having a colour temperature of 2856 K.

2.2 Cathode radiant sensitivity

The cathode radiant sensitivity is the quotient of the photocurrent of the cathode by the incident radiant power, expressed in amperes per watt (IEC).

2.3 Absolute spectral sensitivity

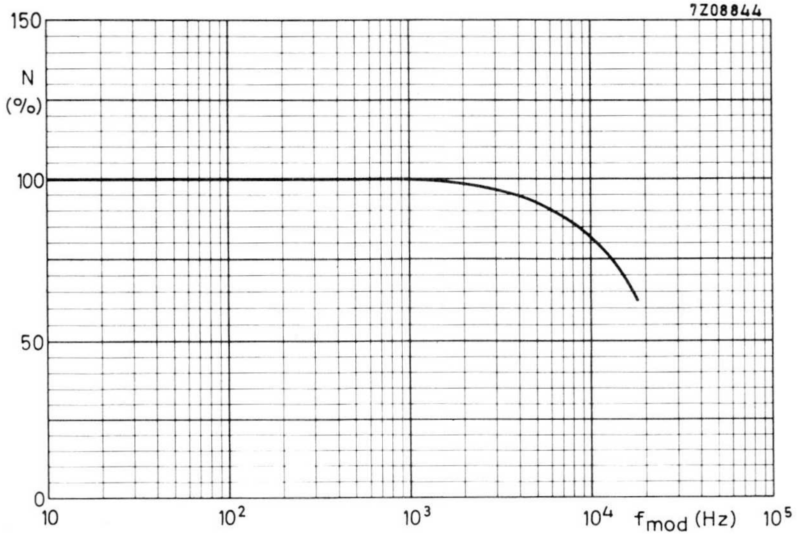
The absolute spectral sensitivity is the radiant sensitivity for monochromatic radiation of a stated wavelength (IEC).
Measurements of this parameter are carried out with a tungsten filament lamp with a colour temperature of 2856 K and spectral filters. Tolerances of the spectral filters are stated in the tube data. The measuring equipment is calibrated by comparison with a Schwartz thermocouple.

2.4 **Dark current** is the current flowing in a photoelectric device in the absence of irradiation (IEC).
Possible causes of dark current are electrical leakage, thermionic emission, field emission, residual gas ionization, and glass fluorescence.

2.5 Time characteristics

2.5.1 The **anode pulse rise time** of a phototube is defined as the time required for the amplitude to rise from a stated low percentage to a stated higher percentage of maximum value when a steady state of radiation is instantaniously applied. Normally the 10% and 90% levels are considered.

2.5.2 The **sensitivity** of gas-filled phototubes decreases with **frequency**. At a frequency of 15000 Hz this decrease is about 3 dB; see Figure below.



Frequency response curve

3. THERMAL DATA

Ambient temperature. The temperature of the photocathode may not be too high otherwise evaporation of the emissive cathode layer may result, with consequent reduction in sensitivity and life. As it is difficult to measure this temperature a limiting value for the ambient temperature is given in the published data sheets. It must be considered, however, that even when the ambient temperature in the immediate vicinity of the phototube is not beyond the limit, an excessive temperature rise of the photocathode can be caused, e.g. by infrared heat radiation. If the possibility of this radiation exists, a suitable filter should be inserted in the optical path to minimize this effect.

4. OPERATING NOTES

Stability during life. Where a gas-filled phototube is continuously operated at its maximum rated voltage its sensitivity may fall by as much as 50%, during 500 hours.
Vacuum phototubes are inherently more stable.

The stability of both types of phototube will be improved if the current density of the photocathode is reduced (e.g. by reducing the incident light or enlarging the illuminated area of the photocathode).
Particularly with gas-filled phototubes, reduction of the anode voltage will improve the stability.

Phototubes must not be exposed to strong radiation, such as direct sunlight, even during idle periods.

A loss of sensitivity of both vacuum and gas-filled phototubes during operation will be wholly or partially restored during idle periods.

Prevention of glow discharge. Gas-filled phototubes must not be operated above the published maximum voltage since a glow discharge, indicated by a faint blue glow in the bulb, may occur which adversely affects the good operation of the phototube, and can even result in rapid destruction of the photocathode. If accidental over-running can be expected, the anode resistance should have a value of at least 0,1 MΩ.
Where it is necessary to use the maximum operating voltage a stabilized supply is recommended.

5. MOUNTING

If no restrictions are made in the individual published data sheets, phototubes may be mounted in any position.

6. STORAGE

It is necessary that phototubes always be stored in darkness.

7. LIMITING VALUES

The limiting values of phototubes are given in the absolute maximum rating system.

8. OUTLINE DIMENSIONS

The outline dimensions are given in mm.

PHOTOTUBE

The AVHC201 is a 102 mm useful diameter head-on phototube with a flat window and an opaque S4 photocathode. The tube is intended for use in applications with relatively high illumination and features a short rise time and a high linearity.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic		S4		
Useful diameter of the photocathode			102	mm
Spectral sensitivity of the photocathode at 437 nm			40	mA/W
Anode voltage	up to		5	kV
Rise time			1	ns
Linearity	up to		30	A

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Opaque head-on, flat

Material		Sb-Cs		
Useful diameter		>	102	mm
Spectral sensitivity characteristic Fig. 1		S4		
Maximum spectral sensitivity at			400 ± 50	nm
Luminous sensitivity	1)	typ.	35	µA/lm
		>	20	µA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈	40	mA/W

Notes see page 3.

Operating characteristics

Dark current at V_b = 2,5 kV	3)		typ.	1	nA
			<	10	nA
Saturation voltage			see note 4		
Rise time	5)		≈	1	ns
Anode current linear within 10% at V_b = 2,5 kV up to	6)		≈	30	A
			≥	20	A
Capacitance, anode to cathode		C_{ak}	<	25	pF

LIMITING VALUES (Absolute max. rating system)

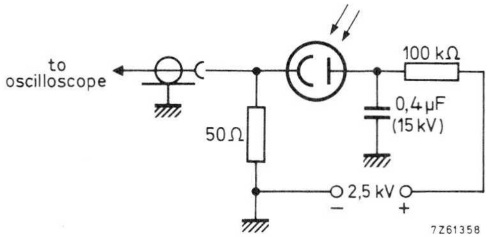
Anode voltage, d.c.		max.	5	kV	
Total cathode current,	8)				
peak		max.	100	A	
mean, averaging time 1 s		max.	10	µA	
Ambient temperature		max.	60	°C	7)
		min.	−40	°C	

REMARKS

After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

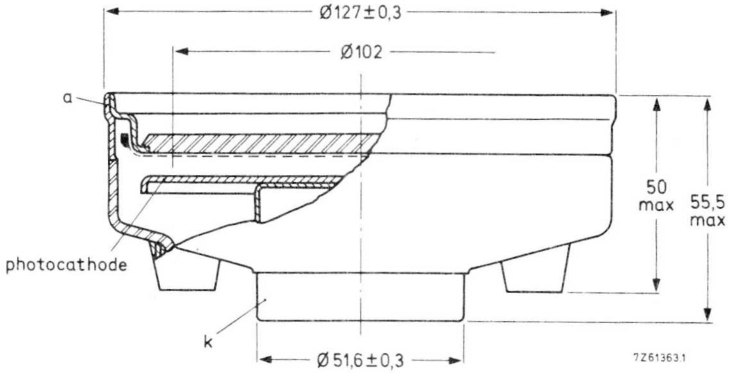
MEASURING CIRCUIT



MECHANICAL DATA

Dimensions in mm

Net mass : 530 g



Distance anode - cathode 4,6 mm

Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of 0,5 h.

4) Due to the geometry of the device and the high electric field strength the anode current increases with anode voltage and wavelength (see Fig. 2).

5) Measured with a pulsed-light source, with a pulse duration of < 1 ns, the cathode being completely illuminated.

6) The linearity is measured with a light pulse with:
pulse duration = 1 µs
pulse energy = 35 J (2 Mlm)
pulse repetition frequency = 2 p.p.min
Blue filter inserted in light path.
The linearity is observed on a X - Y oscilloscope by comparison with a standard phototube.
The cathode current may not exceed a peak value of 100 A.

7) During not more than some hours.

8) Cathode completely illuminated.

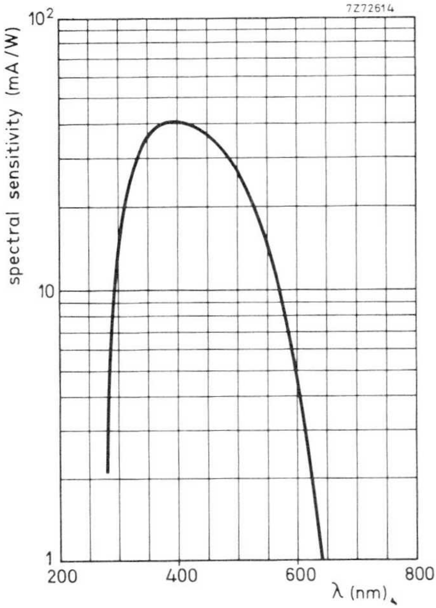


Fig. 1

Spectral sensitivity characteristic

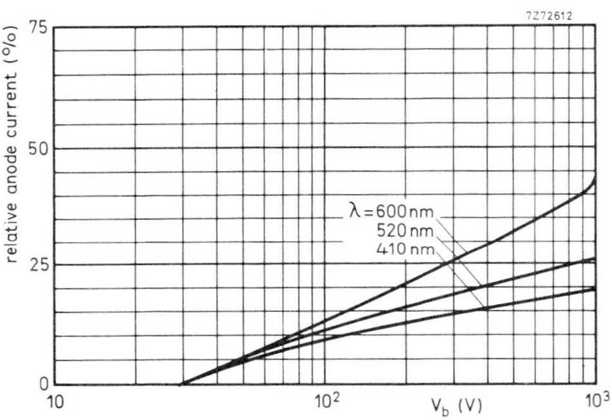


Fig. 2

Relative anode current as a function of anode voltage; wavelength as parameter.

PHOTOTUBE

The TVHC40 is a 40 mm useful diameter head-on phototube with a flat window and an opaque S20 (type T) photocathode. The tube is intended for use in applications with a relatively high illumination especially in LASER detectors and features a short rise time and a high linearity.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S20 (type T)	
Useful diameter of the photocathode		40	mm
Spectral sensitivity of the photocathode at 420 nm		70	mA/W
at 698 nm		10	mA/W
Anode voltage	up to	5	kV
Rise time		0,4	ns
Linearity	up to	6	A

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Opaque head-on

Material			Sb-K-Na-Cs	
Useful diameter		>	40	mm
Spectral sensitivity characteristic Fig. 1			S20 (type T)	
Maximum spectral sensitivity at			450 ± 100	nm
Luminous sensitivity	1)	≈	150	μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈	70	mA/W
at 698 ± 7 nm		≈	10	mA/W
		≥	5	mA/W

Notes see page 3.

Operating characteristics

Dark current at V_b = 2,5 kV	3)	typ.	0,15	nA
		<	5	nA
Saturation voltage	4)		100	V
Rise time	5)	≈	0,4	ns
Anode current linear within 10% at V_b = 2,5 kV up to		≈	6	A
		≥	5	A
Capacitance, anode to cathode			3	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.	max.	5	kV
Total cathode current,			
peak	max.	10	A
mean, averaging time 1 s	max.	10	μA

REMARKS

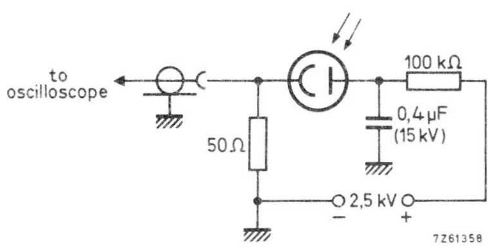
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type SC110

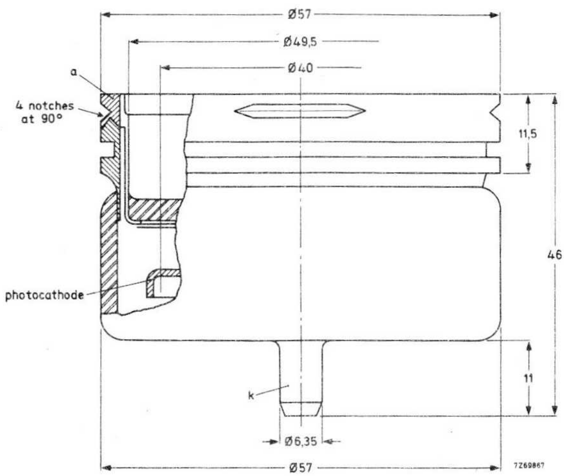
MEASURING CIRCUIT



MECHANICAL DATA

Dimensions in mm

Net mass : 85 g



Distance anode - cathode 6 mm

Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of 0,5 h.

4) Due to the geometry of the device and the high electric field strength the anode current is more or less dependent on the anode voltage and the wavelength of the irradiation.

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
Tube mounted in socket SC110.

6) The linearity is measured with a light pulse with:
pulse duration = 1 µs
pulse energy = 35 J (2 Mlm)
pulse repetition frequency = 2 p.p.min
Blue filter inserted in light path.
The linearity is observed on a X - Y oscilloscope by comparison with a standard phototube.
The cathode current may not exceed a peak value of 100 A.

7) During not more than some hours.

8) Cathode completely illuminated.

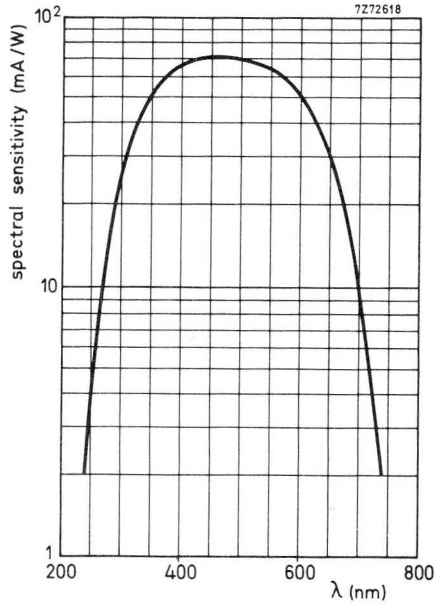


Fig. 1

Spectral sensitivity characteristic

PHOTOTUBE

The XA1002 is a 20 mm useful diameter head-on phototube with a flat window and an opaque S4 photocathode. The tube is intended for use in applications with relatively high illumination and high peak currents.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S4	
Useful diameter of the photocathode		20	mm
Spectral sensitivity of the photocathode at 437 ± 5 nm		35	mA/W
Anode voltage	up to	4	kV
Rise time	≈	0,2	ns
Linearity	up to	8	A

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Opaque head-on, flat surface

Material		Sb-Cs		
Useful diameter		>	20	mm
Spectral sensitivity characteristic Fig. 1		S4		
Maximum spectral sensitivity at			400 ± 50	nm
Luminous sensitivity	1)	typ.	30	μA/lm
		>	20	μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈	35	mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5$ kV	3)	typ.	0,5	nA
		<	5	nA
Saturation voltage		see note 4		
Rise time	5)	≈	0,2	ns
Anode current linear within 5% at $V_b = 4$ kV up to	6)7)	≈	8	A
		≥	5	A
Capacitance, anode to cathode		C_{ak}	2	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.	max.	4	kV	
Total cathode current,				
peak	max.	10	A	
mean, averaging time 1 s	max.	10	µA	
Ambient temperature	max.	+60	°C	8)
	min.	−40	°C	

REMARKS

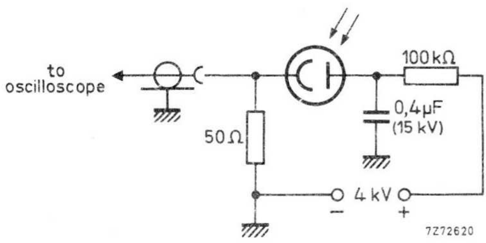
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type 56041

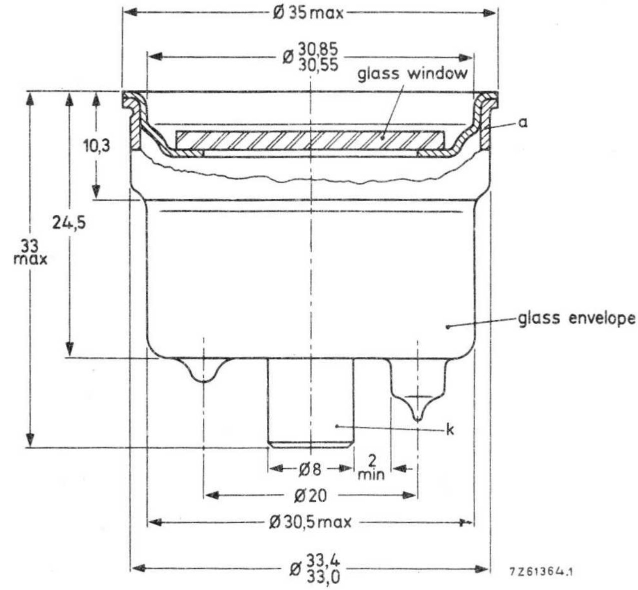
MEASURING CIRCUIT



Notes see pages 3 and 4.

MECHANICAL DATA Dimensions in mm

Net mass : 300 g



Transmission of anode grid	85%
Distance anode - cathode	3,5 mm

Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of ≈ 0,5 h.

4) Due to the geometry of the device and the high electric field strength the anode current increases with anode voltage and wavelength. See Fig. 2.

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. Tube mounted in socket 56041.

6) When the tube is used with socket 56041 with a build-in capacitor of 500 pF this linearity is obtained only if the electrical charge transported by the pulse - or pulse train - does not exceed 1 μC. To prevent a considerable decrease in anode voltage when measuring light pulses of high magnitude and/or long duration, an external capacitor should be mounted between anode and earth (chassis).

The value can be calculated with:

$$V_a = V_b - \Delta V = V_b - \frac{I}{C}\,\Delta t$$

in which : $V_a > 2$ kV
I = peak current
Δt = pulse duration

7) The linearity is measured with a light pulse with
pulse duration = 1 μs
pulse energy = 35 J (2 Mlm)
pulse repetition frequency = 2 p.p.min
Blue filter inserted in light path.
The linearity is observed on an X - Y oscilloscope by comparison with a standard phototube.
The cathode current may not exceed a peak value of 10 A.

8) During not more than some hours.

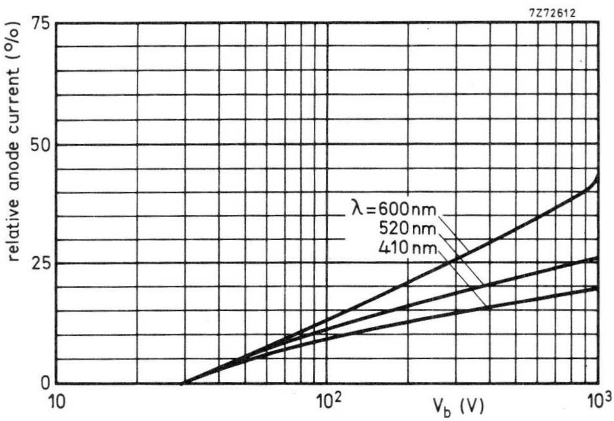


Fig. 1

Relative anode current as a function of anode voltage; wavelength as parameter.

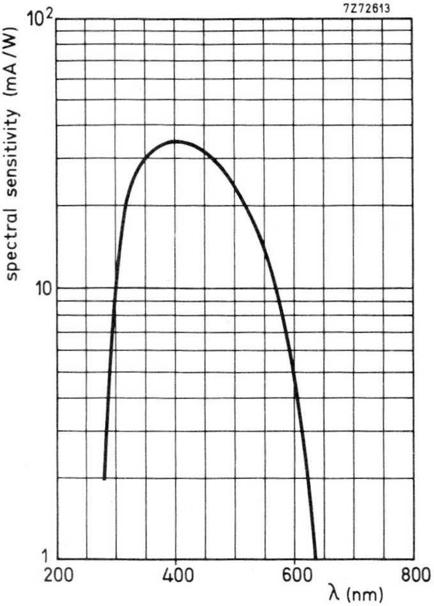


Fig. 2

Spectral sensitivity curve

PHOTOTUBE

The XA1003 is a 20 mm useful diameter head-on phototube with a flat window and an opaque S1 photocathode. The tube is intended for use in applications with relatively high illumination especially for use as LASER detector.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S1 (type C)	
Useful diameter of the photocathode		20	mm
Spectral sensitivity of the photocathode at 800 nm		2,5	mA/W
Anode voltage	up to	2,5	kV
Rise time		0,2	ns
Linearity	up to	1	A

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Opaque head-on, flat surface

Material		AgO-Cs		
Useful diameter		>	20	mm
Spectral sensitivity characteristic Fig. 1		S1 (type C)		
Maximum spectral sensitivity at			800 ± 100	nm
Luminous sensitivity	1)	typ.	20	μA/lm
		>	15	μA/lm
Spectral sensitivity at 903 ± 8 nm	2)	≈	1,4	mA/W
1060 ± 10 nm		≈	0,12	mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5$ kV	3)	typ.	5	nA
		<	10	nA
Saturation voltage		see note 4		
Rise time	5)	≈	0,2	ns
Anode current linear within 5% at $V_b = 2,5$ kV up to	6)7)	≈	1	A
		≥	0,8	A
Capacitance, anode to cathode		C_{ak}	2	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.	max.	2,5	kV	
Total cathode current,				
peak	max.	2	A	
mean, averaging time 1 s	max.	1	μA	
Ambient temperature	max.	60	°C	8)
	min.	-40	°C	

REMARKS

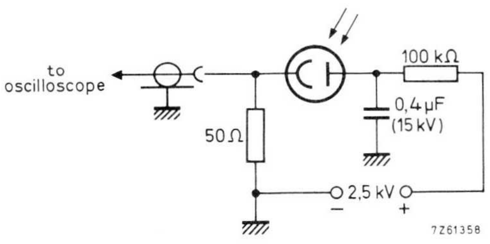
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type 56041

MEASURING CIRCUIT

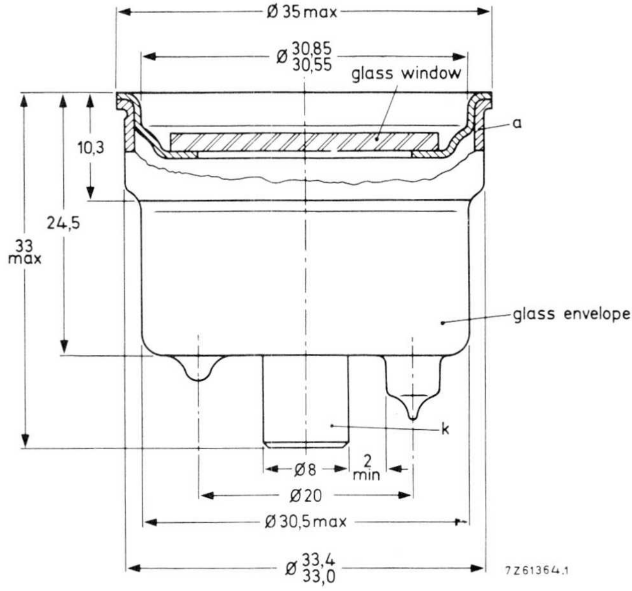


Notes see pages 3 and 4.

MECHANICAL DATA

Dimensions in mm

Net mass : 33 g



Transmission of anode grid 85%
Distance anode-cathode 3, 5 mm

Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 20 °C after a stabilization period in darkness, with anode voltage applied, of ≈ 0, 5 h.

4) Due to the geometry of the device and the high electric field strength the anode current is more or less dependent on the anode voltage and the wavelength of irradiation.

5) Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. Tube mounted in socket 56041.

[6]) When the tube is used with socket 56041, with a build-in capacitor of 500 pF, this linearity is obtained only if the electrical charge transported by the pulse - or pulse train - does not exceed 1 μC.
To prevent a considerable decrease in anode voltage when measuring pulses of high magnitude and/or long duration an external capacitor should be mounted between anode and earth (chassis).
The value can be calculated with:

$$V_a = V_b - \Delta V = V_b - \frac{I}{C}\,\Delta t$$

in which : $V_a > 2$ kV
I = peak current
Δt = pulse duration

[7]) The linearity is measured with a light pulse with
pulse duration = 1 μs
pulse energy = 35 J (2 Mlm)
pulse repetition frequency = 2 p.p.min

The linearity is observed on an X - Y oscilloscope by comparison with a standard phototube.
The cathode current may not exceed a peak value of 2 A.

[8]) During not more than some hours.

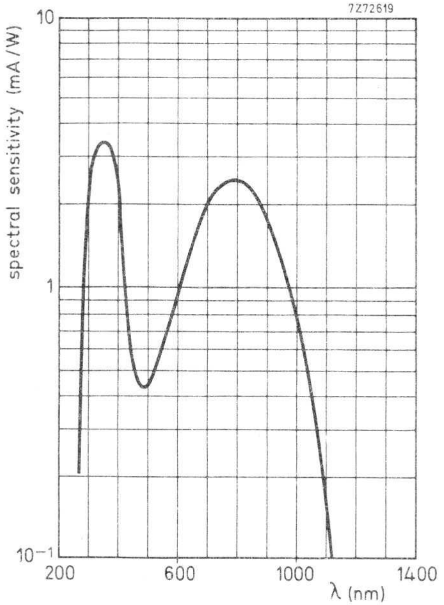


Fig. 1

Spectral sensitivity characteristic. With this type of cathode the sensitivity of each individual tube can deviate considerably from the curve shown: the maximum at 800 nm may be less pronounced and the curve may be flat between 550 nm and 950 nm and extend to ≈ 1200 nm.

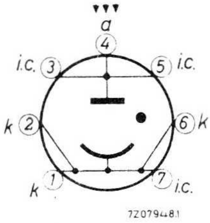
GAS FILLED PHOTOTUBE

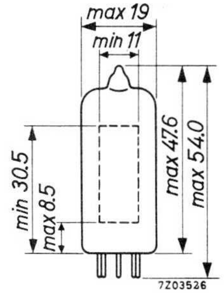
Gas filled phototube particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		125	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x	54	mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium on oxidized silver
Projected sensitive area	3.0 cm^2

ELECTRICAL DATA

Operating characteristics

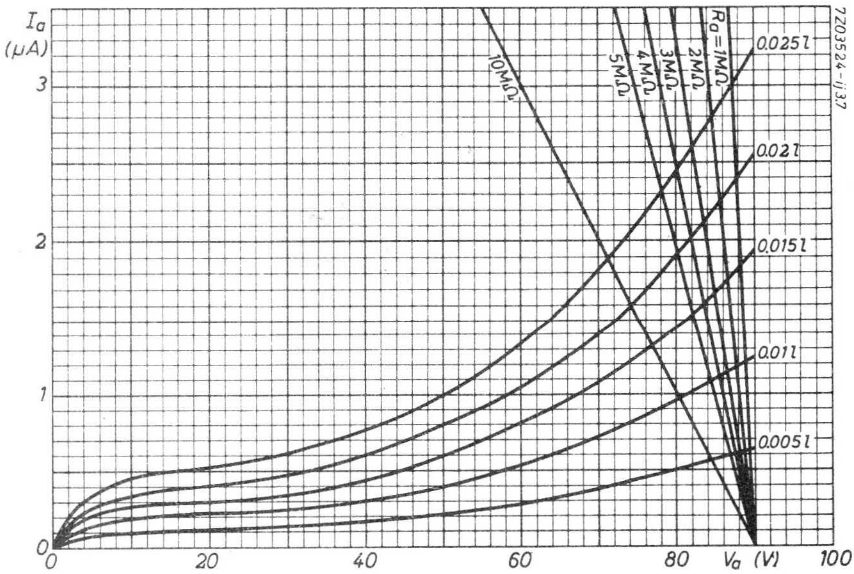
Anode supply voltage	V_b		90	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		125	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

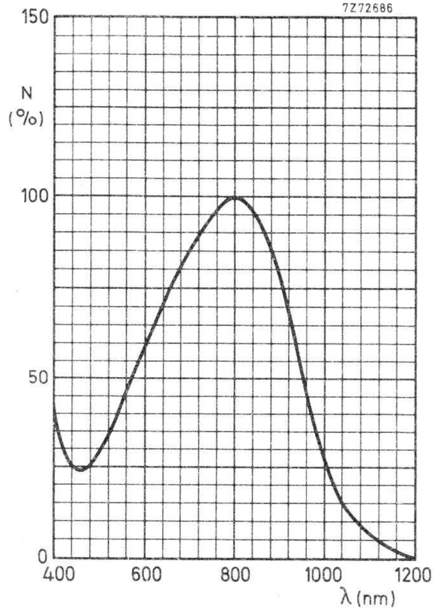
Capacitance

Anode to cathode	C_{ak}		1.1	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	2.0	μA
Ambient temperature	t_{amb}	max.	100	°C





Relative spectral response curve

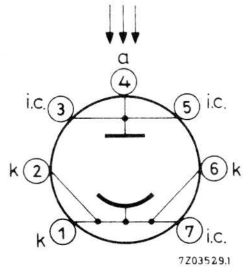
VACUUM PHOTOTUBE

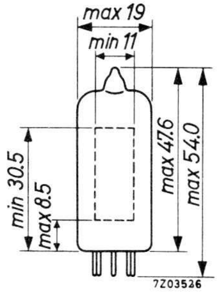
Vacuum phototube, particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	250	V
Luminous sensitivity	N		20	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photo cathode

Surface	Ceasium on oxidised silver
Projected sensitive area	3.0 cm^2

ELECTRICAL DATA

Operating characteristics

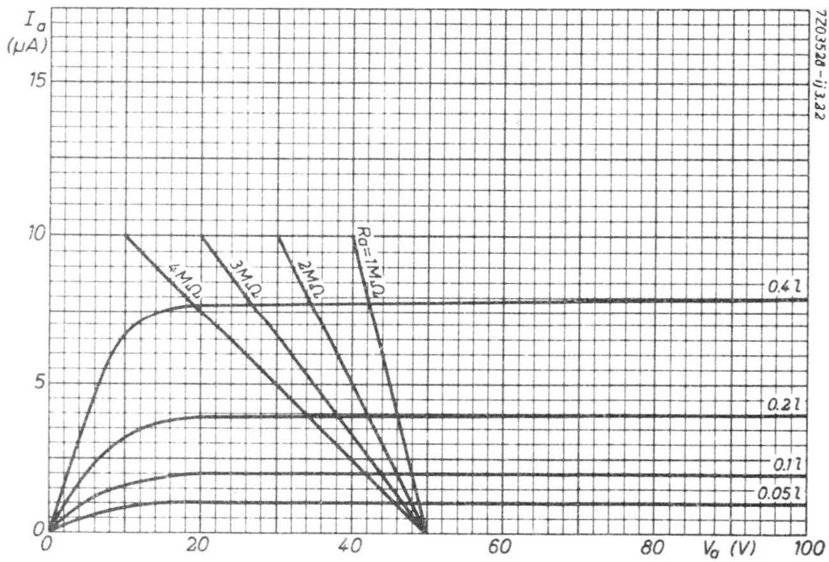
Anode supply voltage	V_b	50	V
Anode series resistor	R_a	1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N	20	μA/lumen
Dark current (at V_a = 100 V)	I_{dark}	max. 0.05	μA

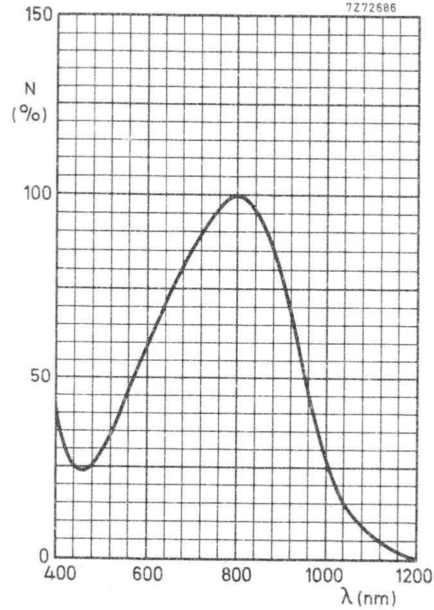
Capacitance

Anode to cathode	C_{ak}	0.8	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	250	V
Cathode current	I_k	max.	10	μA
Ambient temperature	t_{amb}	max.	100	°C





Relative spectral response curve

GAS FILLED PHOTOTUBE

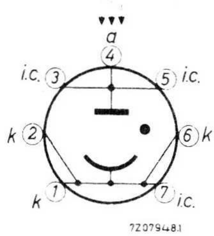
Gas-filled phototube particularly sensitive to daylight and to radiation having a blue predominance.

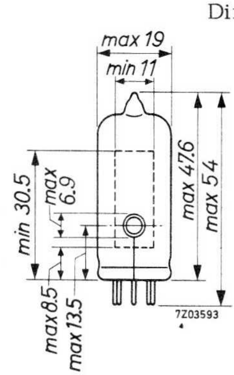
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		130	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA

Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium antimony
Projected sensitive area	2.1 cm^2

ELECTRICAL DATA

Operating characteristics

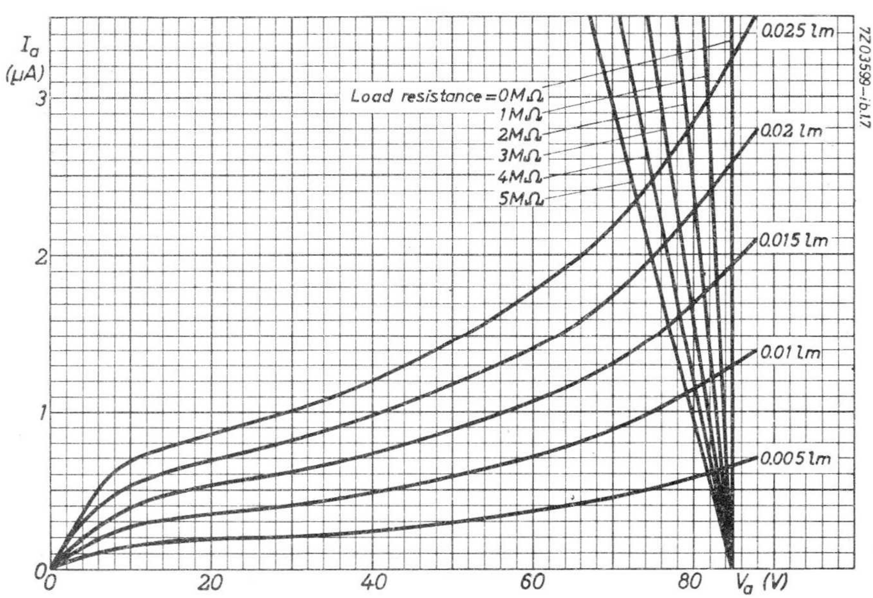
Anode supply voltage	V_b		85	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		130	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

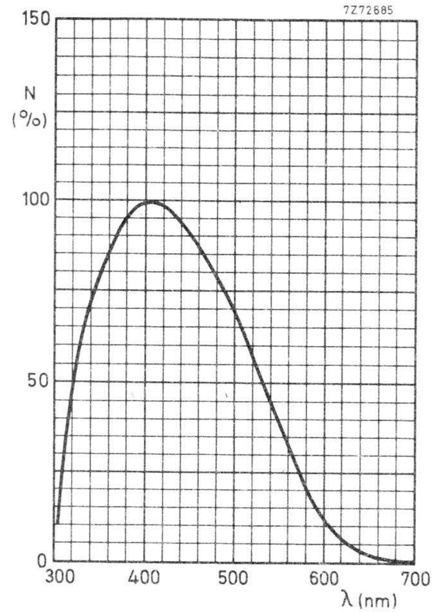
Capacitance

Anode to cathode	C_{ak}		0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	0.0125	μA/mm2
Ambient temperature	t_{amb}	max.	70	°C





Relative spectral response curve

VACUUM PHOTOTUBE

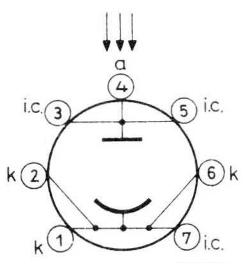
Vacuum phototube particularly sensitive to daylight and to light radiation with a blue predominance.

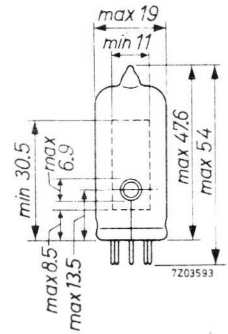
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	100	V
Luminous sensitivity	N		45	µA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA

Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	caesium antimony
Projected sensitive area	2.1 cm^2

ELECTRICAL DATA

Operating characteristics

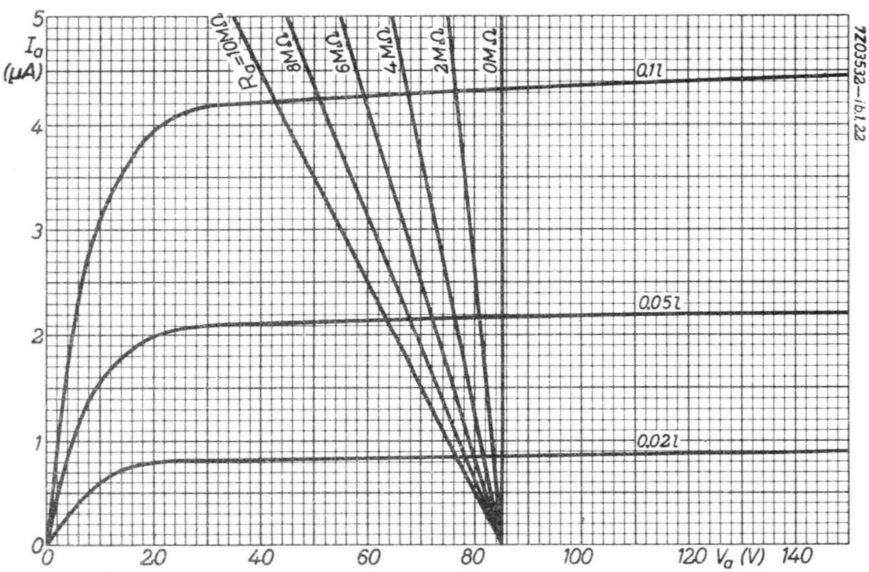
Anode supply voltage	V_b	85	V
Anode series resistor	R_a	1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 ^oK	N	45	μA/lumen
Dark current	I_{dark}	max. 0.05	μA

Capacitance

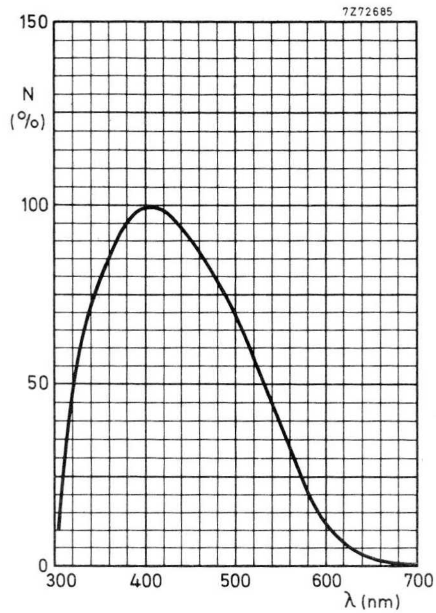
Anode to cathode	C_{ak}	0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max. 100	V
Cathode current	I_k	max. 0.025	$\mu A/mm^2$
Ambient temperature	t_{amb}	max. 70	^oC



Relative spectral response curve



PHOTOTUBE

The 150AV is a 30 mm useful diameter head-on phototube with a flat window and a semi-transparent S11 (type A) photocathode. The tube is intended for use in high precision photometry and for measurement of quickly changing light phenomena and features a high stability and linearity.

QUICK REFERENCE DATA		
Spectral sensitivity characteristic	S11 (type A)	
Useful diameter of the photocathode	30	mm
Spectral sensitivity of the photocathode at 437 nm	60	mA/W
Anode voltage	1 to 90	V

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Semi-transparent head-on

Material		Cs-Sb		
Useful diameter		>	30	mm
Spectral sensitivity characteristic Fig. 1		S11 (type A)		
Maximum spectral sensitivity at			420 ± 30	nm
Luminous sensitivity	1)	typ.	70	μA/lm
		>	35	μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈	60	mA/W

Notes see page 3.

Operating characteristics

Operating voltage, d.c.			1 to 90	V
Saturation voltage				
for a luminous flux of 0,05 lm		≈	4,5	V
0,01 lm		≈	1	V
Dark current at V_b = 1 V	3)	typ.	1	pA
		<	2	pA
Rise time at V_b = 50 V			14	ns
Capacitance, anode to cathode		C_{ak}	13	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.		max.	100	V
Cathode current per mm^2,				
peak		max.	50	nA/mm^2
mean, averaging time 1 s		max.	70	pA/mm^2
Total cathode current,	4)5)			
peak		max.	35	μA
mean, averaging time 1 s		max.	500	nA
Ambient temperature		max.	60	^oC 6)
		min.	-40	^oC

LIFE EXPECTANCY

With a cathode current of 2 μA the decrease in sensitivity may be:
at 400 nm 0,4%/h
at 560 nm 0,8%/h.

With an average cathode current of 50 nA the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

To attain high stability it is recommended that the cathode current be kept as low as possible.

REMARKS

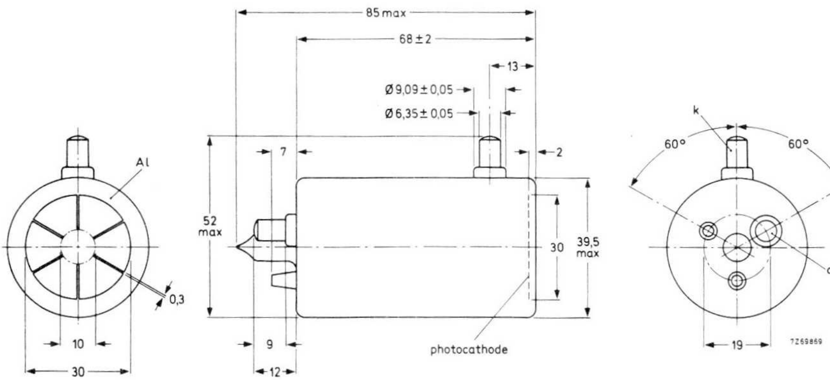
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

MECHANICAL DATA

Dimensions in mm

Net mass : 60 g



An external guard ring significantly decreases the dark current (≈ 10^{-14} A). This can be obtained by applying a ring of silver paste.

Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of 0, 5 h. The dark current is approximately proportional to the applied voltage.
An external guard ring, made of silver paste, may be put on the tube envelope when the tube is used with very low cathode current.

4) Cathode uniformly illuminated.

5) The relation between the incident luminous flux and the cathode current is linear within measuring errors provided the anode voltage is higher than the saturation voltage.

6) During not more than some hours.

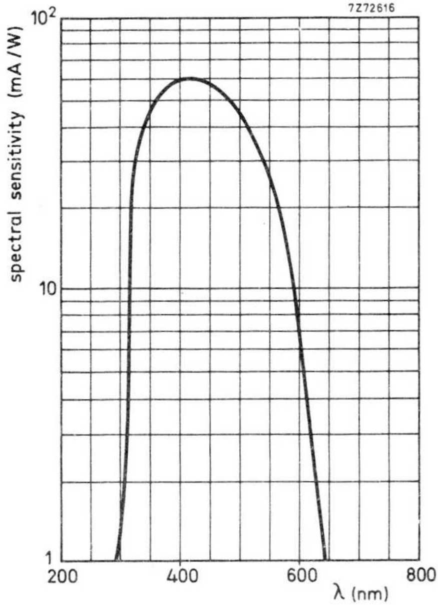


Fig. 3

Spectral sensitivity characteristic

PHOTOTUBE

The 150CV is a 26 mm useful diameter head-on phototube with a flat window and a semi-transparent S1 (type C) photocathode. The tube is intended for use in high precision photometry and for measurement of quick changing light phenomena and features a high stability and linearity.

QUICK REFERENCE DATA		
Spectral sensitivity characteristic	S1 (type C)	
Useful diameter of the photocathode	26	mm
Spectral sensitivity of the photocathode at 800 nm	2,5	mA/W
Anode voltage	1 to 90	V

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Semi-transparent head-on

Material		AgO-Cs		
Useful diameter		>	26	mm
Spectral sensitivity characteristic Fig. 1		S1 (type C)		
Maximum spectral sensitivity at			800 ± 100	nm
Luminous sensitivity	1)	typ.	20	μA/lm
		>	14	μA/lm
Spectral sensitivity at 903 ± 8 nm	2)	≈	1,4	mA/W
1060 ± 10 nm		≈	0,12	mA/W

Notes see page 3.

Operating characteristics

Operating voltage, d.c.			1 to 90	V
Saturation voltage				
for a luminous flux of 0,05 lm		≈	4,5	V
0,01 lm		≈	1	V
Dark current at V_b = 1 V	3)	typ.	10	pA
		<	20	pA
Rise time at V_b = 50 V		≈	14	ns
Capacitance, anode to cathode		C_{ak}	13	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.		max.	100	V
Cathode current per mm^2,				
peak		max.	50	nA/mm^2
mean, averaging time 1 s		max.	70	pA/mm^2
Total cathode current,	4)5)			
peak		max.	25	μA
mean, averaging time 1 s		max.	500	nA
Ambient temperature		max.	50	°C 6)
		min.	−40	°C

LIFE EXPECTANCY

With an average cathode current of 35 nA the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

To attain high stability it is recommended that the cathode current be kept as low as possible.

REMARKS

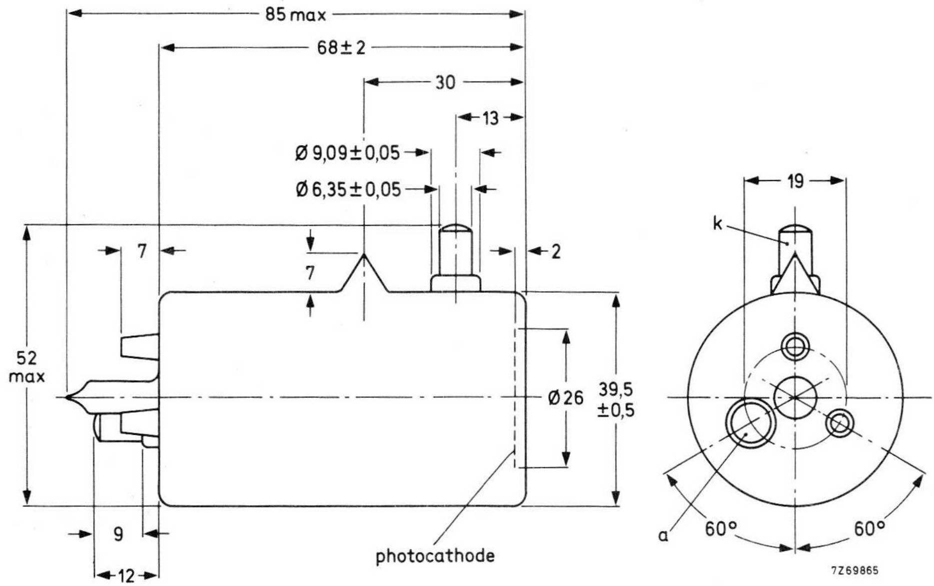
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

MECHANICAL DATA

Dimensions in mm

Net mass : 60 g



Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 20 °C after a stabilization period in darkness, with anode voltage applied, of ≈0,5 h. The dark current is approximately proportional to the applied voltage.
An external guard ring, made of silver paste, may be put on the tube envelope when the tube is used with very low cathode current.

4) Cathode uniformly illuminated.

5) The relation between the incident luminous flux and the cathode current is linear within measuring errors provided the anode voltage is higher than the saturation voltage.

6) During not more than some hours.

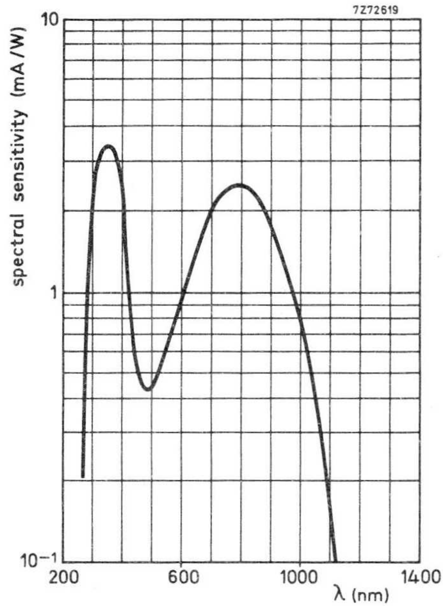


Fig. 1

Spectral sensitivity characteristic

PHOTOTUBE

The 150TV is a 26 mm useful diameter head-on phototube with a flat window and a semi-transparent S20 (type T) photocathode. The tube is intended for use in high precision photometry and for measurement of quick changing light phenomena and features a high stability and linearity.

QUICK REFERENCE DATA		
Spectral sensitivity characteristic	S20 (type T)	
Useful diameter of the photocathode	26	mm
Spectral sensitivity of the photocathode at 698 nm	13	mA/W
Anode voltage	1 to 90	V

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Semi-transparent head-on

Material		Sb-Na-K-Cs		
Useful diameter		>	26	mm
Spectral sensitivity characteristic Fig. 1		S20 (type T)		
Maximum spectral sensitivity at			420 ± 30	nm
Luminous sensitivity	1)	typ.	150	µA/lm
		>	100	µA/lm
Spectral sensitivity at 698 ± 7 nm	2)	≈	13	mA/W

Notes see page 3.

Operating characteristics

Operating voltage, d.c.			1 to 90	V
Saturation voltage for a luminous flux of 0,05 lm		≈	4,5	V
0,01 lm		≈	1	V
Dark current at V_b = 1 V	3)	typ.	2	pA
		<	5	pA
Rise time at V_b = 50 V		≈	14	ns
Capacitance, anode to cathode		C_{ak}	13	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.		max.	100	V
Cathode current per mm^2, peak		max.	50	nA/mm^2
mean, averaging time 1 s		max.	70	pA/mm^2
Total cathode current,	4), 5)			
peak		max.	25	μA
mean, averaging time 1 s		max.	500	nA
Ambient temperature		max.	+60	°C 6)
		min.	-40	°C

LIFE EXPECTANCY

With a cathode current of 1 μA the decrease in sensitivity may be:
at 437 nm 0,2 %/h
at 700 nm 0,4 %/h.

With an average cathode current of 1 x 10^{-7} A the sensitivity will not decrease more than 10 % of its initial value between zero and 500 operating hours.

To attain high stability it is recommended that the cathode current be kept as low as possible.

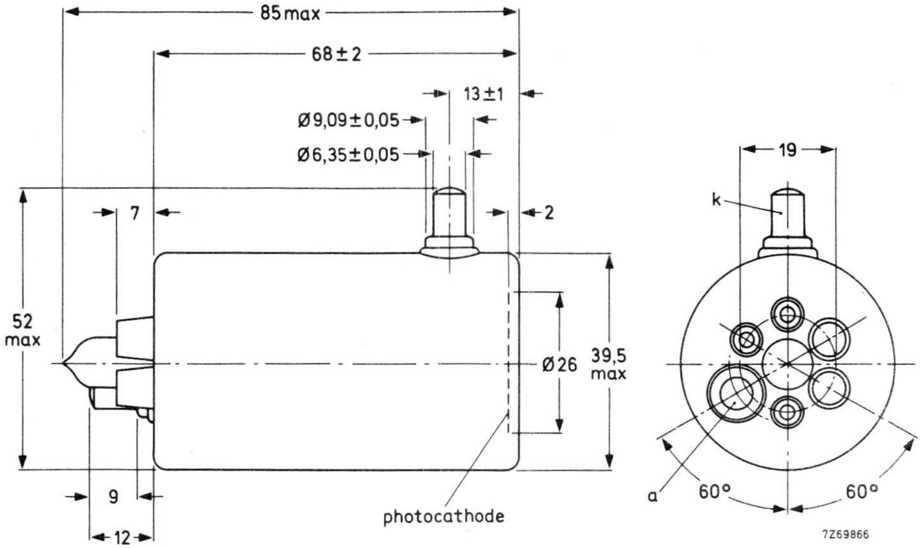
REMARKS

After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

Dimensions in mm

Net mass : 60 g



Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of ≈ 0,5 h. The dark current is approximately proportional to the applied voltage.
An external guard ring, made of silver paste, may be put on the tube envelope when the tube is used with very low cathode current.

4) Cathode uniformly illuminated.

5) The relation between the incident luminous flux and the cathode current is linear within measuring errors provided the anode voltage is higher than the saturation voltage.

6) During not more than some hours.

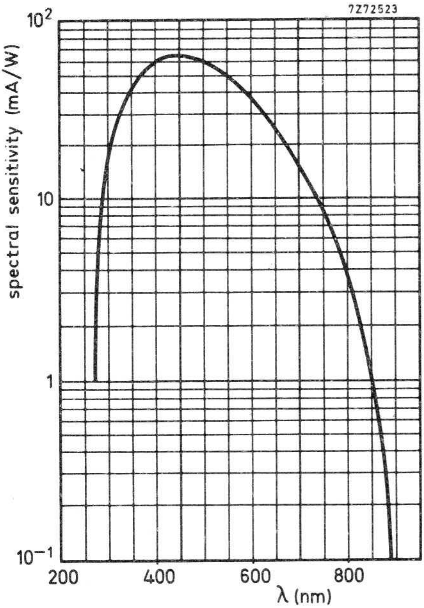


Fig. 1

Spectral sensitivity characteristic

PHOTOTUBE

The 150UV is a 30 mm useful diameter head-on vacuum phototube with a flat window and a semi-transparent S13 (type U) photocathode. The tube is intended for use in high precision photometry and features a high stability and linearity.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic	S13 (type U)		
Useful diameter of the photocathode	>	30	mm
Spectral sensitivity of the photocathode at 437 nm		50	mA/W
Anode voltage		1 to 90	V

To be read in conjunction with "General Operational Recommendations Phototubes".

CHARACTERISTICS

Photocathode

Semi-transparent head-on

Material		Cs-Sb		
Useful diameter		>	30	mm
Spectral sensitivity characteristic Fig. 1		S13 (type U)		
Maximum spectral sensitivity at			400 ± 30	nm
Luminous sensitivity	1)	typ.	60	μA/lm
		>	30	μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈	50	mA/W

Notes see page 3.

Operating characteristics

Operating voltage, d.c.			1 to 90	V
Saturation voltage for a luminous flux of 0,05 lm		≈	4,5	V
0,01 lm		≈	1	V
Dark current at V_b = 1 V	3)	typ.	1	pA
		<	2	pA
Rise time at V_b = 50 V		≈	14	ns
Capacitance, anode to cathode		C_{ak}	13	pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d.c.		max.	100	V
Cathode current per mm^2 peak		max.	50	nA/mm^2
mean, averaging time 1 s		max.	70	pA/mm^2
Total cathode current peak		max.	35	μA
mean, averaging time 1 s	4)5)	max.	500	nA
Ambient temperature		max.	+60	°C 6)
		min.	−40	°C

LIFE EXPECTANCY

With a cathode current of 2 μA the decrease in sensitivity may be:
at 400 nm 0,4%/h
at 560 nm 0,8%/h.

With an average cathode current of 50 nA the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

To attain high stability it is recommended that the cathode current be kept as low as possible.

REMARKS

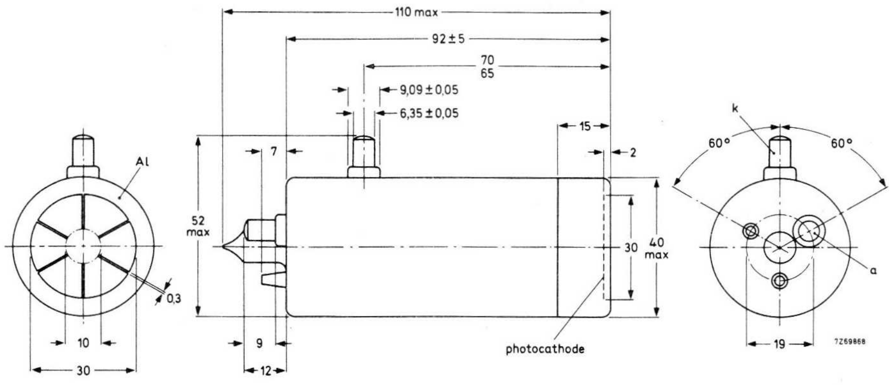
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

MECHANICAL DATA

Dimensions in mm

Net mass.: 60 g



Notes

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.

2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

3) Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of 0, 5 h.
An external guard ring, made of silver paste, may be put on the tube envelope when the tube is used with very low cathode current.

4) Cathode uniformly illuminated.

5) The relation between the incident luminous flux and the cathode current is linear within measuring errors provided the anode voltage is higher than the saturation voltage.

6) During not more than some hours.

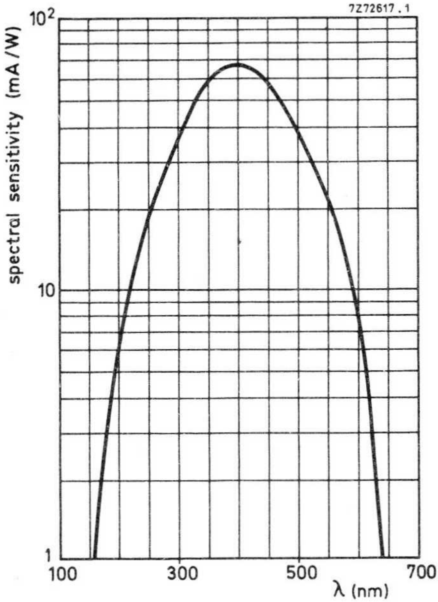


Fig. 1

Spectral sensitivity curve.

Associated accessories

SOCKET

DESCRIPTION

This socket consists of a plastic moulding with 12 gold-plated contacts. The connections to the socket can be made by means of wire soldering. Mounting is done with two M3 screws.

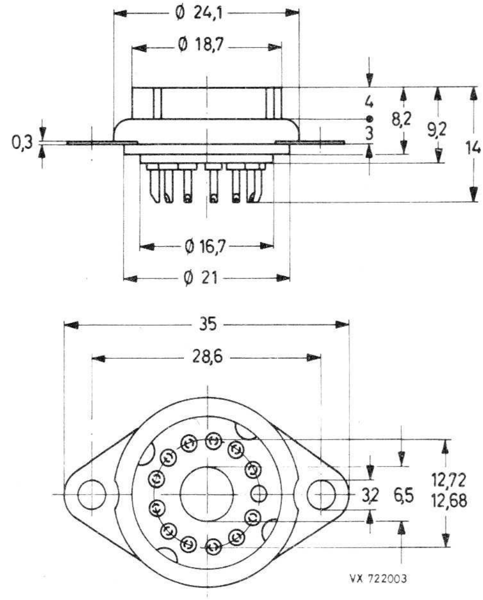
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^7 MΩ
Contact resistance	<	10 mΩ
Capacitance		
between two adjacent contacts		0,8 pF
one contact to all		1,3 pF
Temperature range		−55 to + 100 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass	7 g
Mounting hole diameter	22,5 mm

The use of flexible leads is strongly recommended.

DUODECAL SOCKET

DESCRIPTION

This socket consists of a diallylphthalate moulding with 12 silver-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of two M3 screws.

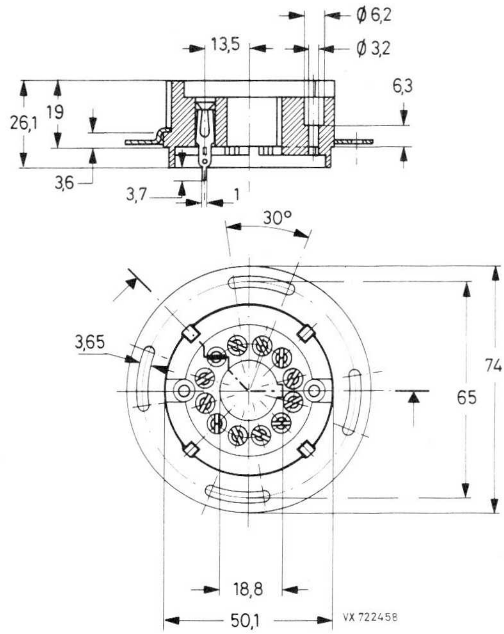
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Maximum working voltage between any contact and saddle		3000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^7 MΩ
Contact resistance	<	50 mΩ
Temperature	max.	80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	45 g
mounting ring	15 g

DIHEPTAL SOCKET

DESCRIPTION

This socket consists of a diallylphthalate moulding with 14 silver-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of two M3 screws.

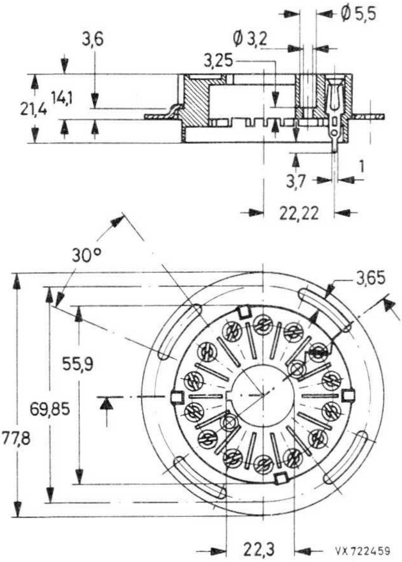
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts	2000 V
Maximum working voltage between any contact and saddle	3000 V
Insulation resistance between two adjacent contacts (at 500 V)	$>$ 10^7 MΩ
Contact resistance	$<$ 50 mΩ
Temperature	max. 80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	40 g
mounting ring	15 g

BIDECAL SOCKET

DESCRIPTION

This socket consists of a diallylphthalate moulding with 20 silver-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of three M4 or three M3 screws respectively.

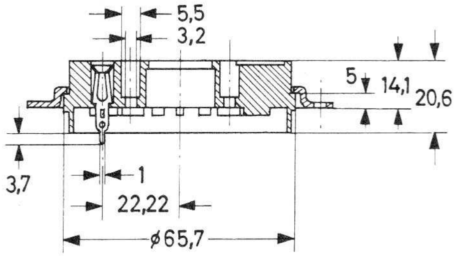
ELECTRICAL DATA

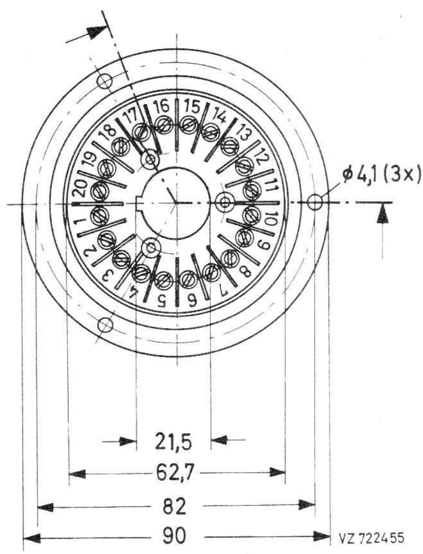
Maximum working voltage between two adjacent contacts		2000	V
Maximum working voltage between any contact and saddle		4000	V
Insulation resistance between two adjacent contacts (at 500 V)	$>$	10^7	MΩ
Contact resistance	$<$	50	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

Outlines





Mass

socket	56 g
mounting ring	44 g

SOCKET

DESCRIPTION

This socket consists of a plastic moulding with 14 gold-plated contacts. The connections to the socket can be made by means of wire soldering. Mounting is done with two M3 screws.

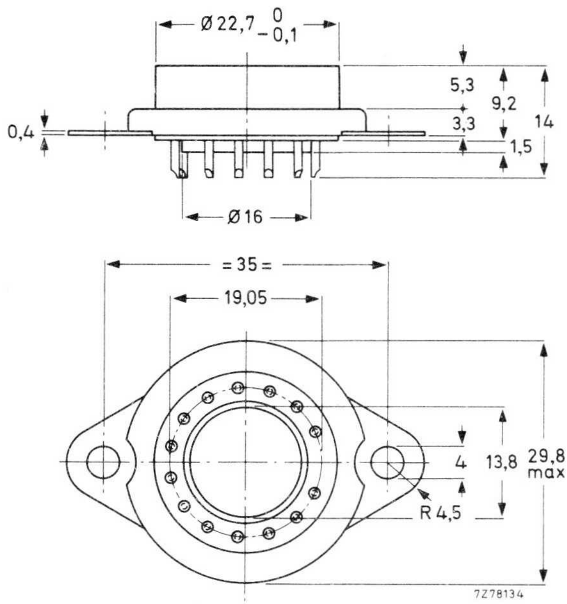
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000	V
Insulation resistance between two adjacent contacts (at 500 V)	$>$	10^7	MΩ
Contact resistance	$<$	10	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

Outlines



The use of flexible leads is strongly recommended.

SOCKET

DESCRIPTION

This socket consists of a polytetrafluoraethylene moulding with 19 silver-plated phosphor-bronze contacts and a separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with the separate mounting ring by means of two M3 screws.

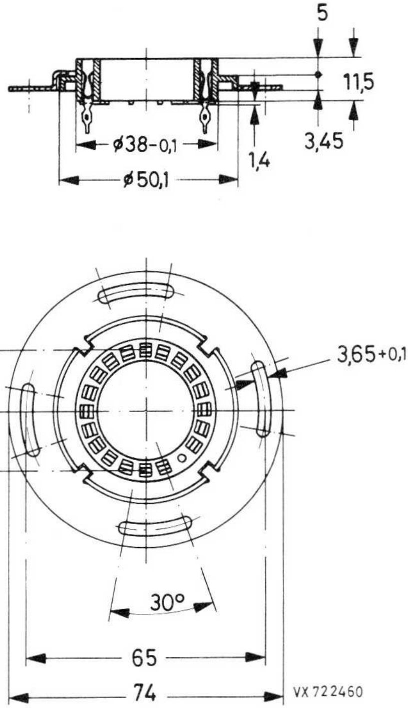
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Maximum working voltage between any contact and saddle		3000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^7 MΩ
Contact resistance	<	50 mΩ
Temperature	max.	80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	18 g
mounting ring	15 g

SOCKET

DESCRIPTION

This socket consists of a polytetrafluoraethylene moulding with 21 silver-plated phosphor bronze contacts and a separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with the separate mounting ring by means of two M3 screws.

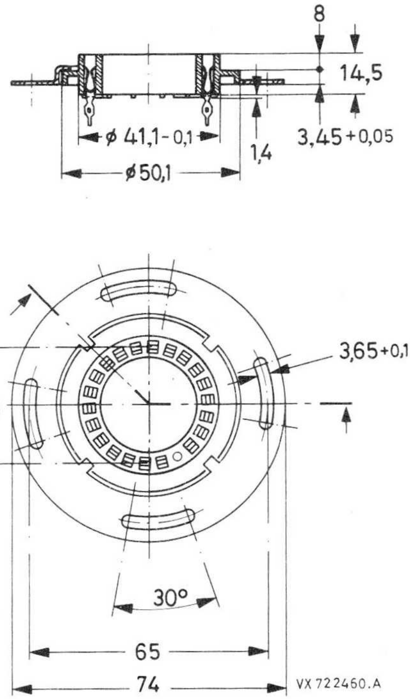
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000	V
Maximum working voltage between any contact and saddle		3000	V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^7	MΩ
Contact resistance	<	50	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

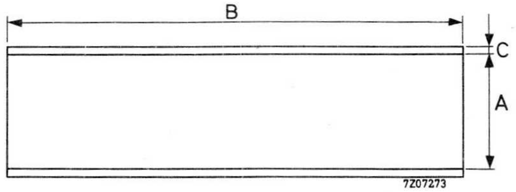
Outlines



Mass

socket	35 g
mounting ring	15 g

MU - METAL CYLINDRICAL SHIELDS



Dimensions

Type No.	A (mm)	B (mm)	C (mm)
56127	42 + 1	90 ± 1	1
56128	57 + 1	90 ± 1	1
56129	132 + 1	150 ± 1	1
56130	57 + 1	110 ± 1	1
56131	75 + 1	110 ± 1	1
56132	240 + 1	300 ± 1	1
56133	145 + 1	250 ± 1	1
56134	21 + 1	80 ± 1	1
56135	78 + 1	130 ± 1	1
56136	28 + 1	110 ± 1	1
56138	28 + 1	80 ± 1	1

Index

Development

Maintenance type list

Obsolete

OBSOLETE TYPES

type number	replaced by
PM2007	XP1017
PM2054	XP2050
PM2203	XP2230
XP1000	PM2202
XP1001	PM2202
XP1003	56TUVP
XP1004	–
XP1005	–
XP1006	PM2202
XP1010	XP2010
XP1015	XP1011
XP1016	PM2013B
XP1020	XP2020
XP1021	XP2020
XP1023	XP2020Q
XP1030	XP2030
XP1031	XP2030
XP1032	–
XP1034	XP2030
XP1040	XP2040
XP1041	XP2041

type number	replaced by
XP1110	PM1910
XP1113	PM1920
XP1114	–
XP1115	PM1910
XP1118	PM1918
XP1119	PM1910
XP1143 *	–
XP1180	PM1980
XP1210	XP2020
XP1220	–
XP1230 *	–
54AVP	XP2050
54DVP	XP2050
54UVP	–
56DUVP	XP2020Q
56SBUVP *	–
56UVP	XP2020Q
58AVP	XP2040
58DVP	XP2041
58UVP	XP2041Q
60AVP	60DVP

* Information available on request.

DEVELOPMENT SAMPLE DATA

type number	replaces
PM1910	XP1110
PM1918	XP1118
PM1920	XP1113
PM1980	XP1180
PM2012B	150DVP
PM2013B	XP1016
PM2018B	150UVP

type number	replaces
PM2060B	–
PM2202	XP1000/XP1006
PM2232	–
PM2232B	56AVP/56DVP
PM2312	–
PM2312B	–
PM2402	–

MAINTENANCE TYPES

type number	replaced by
XP1011	–
XP1116	–
56AVP	PM2232B
56CVP	–
56DVP	PM2232B
56TUVP	–
56TVP	–

Complete data on these types are included in this handbook.

INDEX OF TYPE NUMBERS

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