

PHILIPS

Data handbook



Electronic
components
and materials

Electron tubes

Part 9 June 1976

Photomultiplier tubes

Photo tubes (diodes)

ELECTRON TUBES

Part 9

June 1976

Photomultiplier tubes

Phototubes

Associated accessories

Index

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, subassemblies 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.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

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ELECTRON TUBES (BLUE SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a	Transmitting tubes for communication and Tubes for r.f. heating Types PE05/25 - TBW15/125	December 1975												
Part 1b	Transmitting tubes for communication Tubes for r.f. heating Amplifier circuit assemblies	January 1976												
Part 2	<table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">Microwave products</td> <td style="width: 50%;"></td> </tr> <tr> <td>Communication magnetrons</td> <td>Diodes</td> </tr> <tr> <td>Magnetrons for microwave heating</td> <td>Triodes</td> </tr> <tr> <td>Klystrons</td> <td>T-R Switches</td> </tr> <tr> <td>Travelling-wave tubes</td> <td>Microwave semiconductor devices</td> </tr> <tr> <td></td> <td>Isolators - circulators</td> </tr> </table>	Microwave products		Communication magnetrons	Diodes	Magnetrons for microwave heating	Triodes	Klystrons	T-R Switches	Travelling-wave tubes	Microwave semiconductor devices		Isolators - circulators	May 1976
Microwave products														
Communication magnetrons	Diodes													
Magnetrons for microwave heating	Triodes													
Klystrons	T-R Switches													
Travelling-wave tubes	Microwave semiconductor devices													
	Isolators - circulators													
Part 3	Special Quality tubes; Miscellaneous devices	January 1975												
Part 4	Receiving tubes	March 1975												
Part 5a	Cathode-ray tubes	April 1975												
Part 5b	Camera tubes; Image intensifier tubes	May 1975												
Part 6	Products for nuclear technology Channel electron multipliers Geiger-Mueller tubes Neutron tubes	July 1975												
Part 7	Gas-filled tubes Voltage stabilizing and reference tubes Counter, selector, and indicator tubes Trigger tubes Switching diodes	August 1975												
Part 8	TV Picture tubes	October 1975												
Part 9	Photomultiplier tubes Phototubes (diodes)	June 1976												

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a	Rectifier diodes, thyristors, triacs		March 1976
	Rectifier diodes	Rectifier stacks	
	Voltage regulator diodes (> 1,5 W)	Thyristors	
	Transient suppressor diodes	Triacs	
Part 1b	Diodes		October 1975
	Small signal germanium diodes	Voltage regulator diodes (< 1,5 W)	
	Small signal silicon diodes	Voltage reference diodes	
	Special diodes	Tuner diodes	
Part 2	Low-frequency transistors		December 1975
Part 3	High-frequency and switching transistors		April 1976
Part 4a	Special semiconductors		June 1976
	Transmitting transistors	Dual transistors	
	Microwave devices	Microminiature devices for	
	Field-effect transistors	thick- and thin-film circuits	
Part 4b	Devices for optoelectronics		December 1974
	Photosensitive diodes and transistors	Infrared sensitive devices	
	Light emitting diodes	Photoconductive devices	
	Photocouplers		
Part 5	Linear integrated circuits		March 1975
Part 6	Digital integrated circuits		May 1976
	LOC MOS HE family		
	GZ family		

COMPONENTS AND MATERIALS (GREEN SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1	Functional units, Input/output devices, Peripheral devices		November 1975
	High noise immunity logic FZ/30-Series	Circuit blocks 90-Series	
	Circuit blocks 40-Series and CSA70	Input/output devices	
	Counter modules 50-Series	Hybrid integrated circuits	
	NORbits 60-Series, 61-Series	Peripheral devices	
Part 2a	Resistors		February 1976
	Fixed resistors	Negative temperature coefficient thermistors (NTC)	
	Variable resistors		
	Voltage dependent resistors (VDR)	Positive temperature coefficient thermistors (PTC)	
	Light dependent resistors (LDR)	Test switches	
Part 2b	Capacitors		April 1976
	Electrolytic and solid capacitors	Ceramic capacitors	
	Paper capacitors and film capacitors	Variable capacitors	
Part 3	Radio, Audio, Television		February 1975
	FM tuners	Components for black and white television	
	Loudspeakers		
	Television tuners and aerial input assemblies	Components for colour television	
Part 4a	Soft ferrites		April 1975
	Ferrites for radio, audio and television	Ferroxcube potcores and square cores	
	Beads and chokes	Ferroxcube transformer cores	
Part 4b	Piezoelectric ceramics, Permanent magnet materials		May 1975
Part 5	Ferrite core memory products		July 1975
	Ferroxcube memory cores	Core memory systems	
	Matrix planes and stacks		
Part 6	Electric motors and accessories		September 1975
	Small synchronous motors	Miniature direct current motors	
	Stepper motors		
Part 7	Circuit blocks		September 1971
	Circuit blocks 100 kHz-Series	Circuit blocks for ferrite core memory drive	
	Circuit blocks 1-Series		
	Circuit blocks 10-Series		
Part 8	Variable mains transformers		July 1975
Part 9	Piezoelectric quartz devices		March 1976
Part 10	Connectors		November 1975

Photomultiplier tubes



Some devices are labelled

Maintenance type

Obsolescent type

or

Obsolete type

Maintenance type - Available for equipment maintenance
No longer recommended for equipment production.

Obsolescent type - Available until present stocks are exhausted.

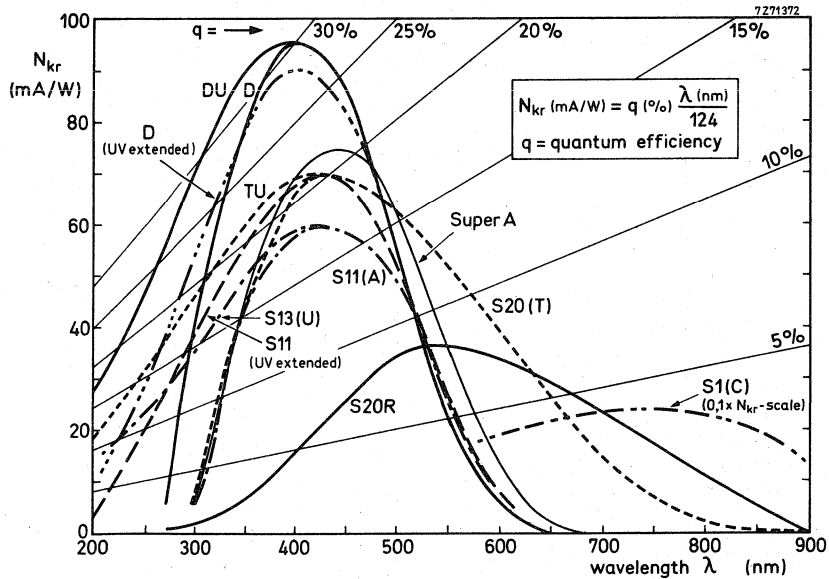
Obsolete type - No longer available.

SURVEY OF TYPES

Photo-cathode dia. (mm)	Tube type	Spectral response											
		Super A	C (S1)	S20R	A (S11)	U (S13)	T (S20)	TU	D	DU			
14	XP1110				X								
	XP1113				X								
	XP1116		X										
	XP1117						X						
	XP1118						X						
32	XP1010	X											
	XP1011	X											
	XP1016							X					
	XP1017			X									
	150AVP	X											
44	150CVP		X										
	150UVP					X							
	XP1002						X						
	XP1003								X				
	XP1004					X							
	XP2000										X		
	XP2020										X		
	XP2230										X		
	XP2230B										X		
	56AVP				X								
	56CVP		X										
56DUVP											X		
56DVP									X				
56TUVP								X					
56TVP						X							

Photomultiplier tubes

Photo-cathode dia. (mm)	Tube type	Spectral response										
		Super A	(S1)	S20R	A (S11)	U (S13)	T (S20)	TU	D	DU		
68	XP2030									X		
110	XP2040				X							
	XP2040Q				X							
	XP2041								X			
	XP2041Q								X			
200	60DVP								X			
	60DVP/H								X			



Typical spectral sensitivity characteristics

LIST OF SYMBOLS

Photocathode	k
Secondary emission electrode (dynode) n	S_n
Anode	a
Accelerating electrode	acc
Grid	g
Luminous cathode sensitivity	N_k
Radiant cathode sensitivity	N_{kr}
Luminous anode sensitivity	N_a
Radiant anode 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_{a0}
Cathode current	I_k
Efficiency	η
Wavelength	λ
Internal connection (do not use)	$i. c.$
Temperature (customary temperature)	T
External conductive coating	m

GENERAL OPERATIONAL RECOMMENDATIONS PHOTOMULTIPLIER TUBES

1. GENERAL *

1.1 A **photomultiplier tube** is a photosensitive vacuum device comprising a photo-emissive 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 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 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 · s ⁻¹ · cm ⁻²)	activation energy (eV)	lowest useful temperature (°C)
Ag-O-Cs (S1)	5 · 10 ⁶	1	-100
Sb-Na ₂ -K-Cs (S20R)	10 ³	1,3	-40
Sb-Na ₂ -K-Cs (S20)	300	1,3	-40
Sb-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.

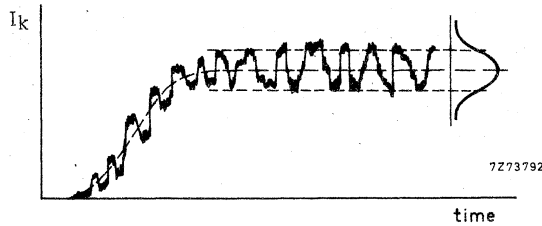
At very low V_b , the major component of the dark current is the - ohmic - leakage current between the pins; this component is proportional to the voltage and increases with dust and high relative humidity.

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:

$$I_a = G \cdot I_k,$$

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:

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

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, and history.

For anode currents between 10 μ A and absolute limiting value - which ranges from 100 to 500 μ A - slow, irreversible changes of gain are observed. As an indication, for an anode current of 30 μ A, 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 μ A, 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 (TI) 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 1000 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.

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 \bar{I}_a . This is given by :

$$\bar{I}_a = I_a \cdot N \cdot T$$

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.

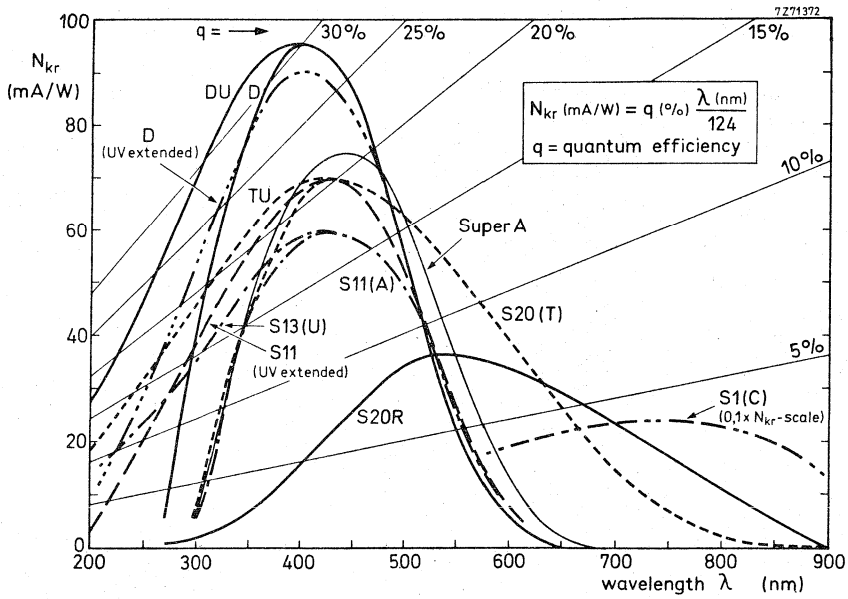


Fig. 1 Typical spectral sensitivity characteristics

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 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 at 632, 8 nm		16	mA/W
	≈	30	mA/W
Supply voltage for an anode luminous sensitivity = 60 A/lm		1460	V
Mean pulse amplitude deviation	≈	1	%
Anode pulse rise time (with voltage divider B)	≈	4	ns
Linearity, with voltage divider A with voltage divider B	up to	≈	30 mA
	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 1) typ. 165 μA/lm

> 110 μA/lm

Spectral sensitivity at 698 ± 7 nm 2) 16 mA/W

at 629 ± 3 nm 2) ≈ 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

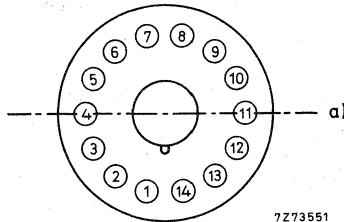
Number of stages	10
Dynode structure	linear focused
Dynode material	Cu-Be
Capacitances	
Anode to all	$C_a \approx 5 \text{ pF}$
Anode to final dynode	$C_{a/S10} \approx 3 \text{ pF}$

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at $V_b = 1200 \text{ V}$, 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.



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

- 1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

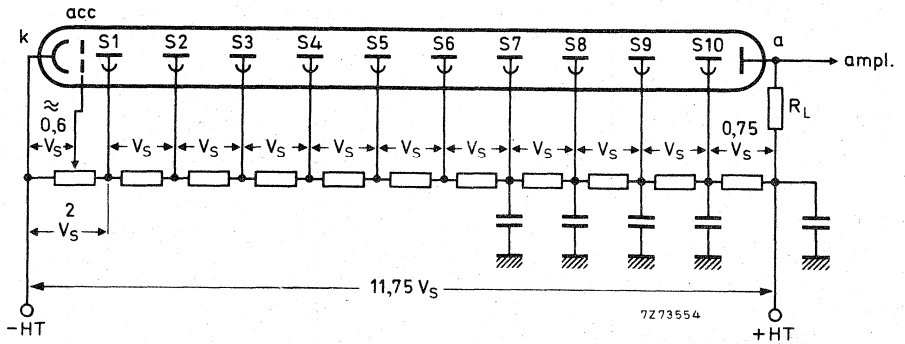


Fig.1 Voltage divider A

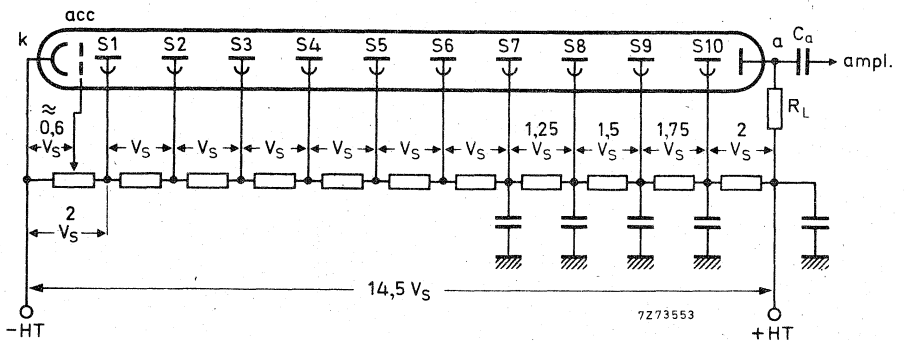


Fig.2 Voltage divider B

k = cathode

Typical value of capacitors: 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>	1)		
Supply voltage for an anode luminous sensitivity $N_a = 60$ A/lm (Fig. 5)		typ.	1460 V
		<	1650 V
Anode dark current at $N_a = 60$ A/lm (Fig. 5)	2)3)	typ.	3 nA
		<	50 nA
Anode current linear within 2% at $V_b = 1700$ V up to		≈	30 mA
Mean pulse amplitude deviation at $V_b = 1200$ V, long term (16 h)	4)	≈	1 %
<u>With voltage divider B (Fig. 2)</u>	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.	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	9)		
Operational (for short periods of time)		max.	+80 °C
		min.	-30 °C
Continuous operation and storage		max.	+50 °C
		min.	-30 °C

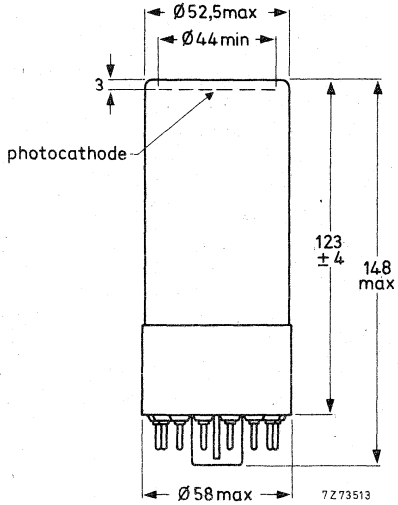
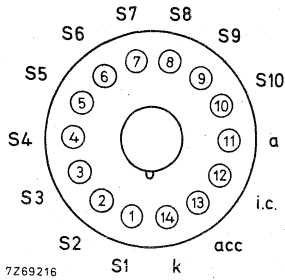
Notes see page 5.

Notes 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 pulse amplitude deviation measurement is carried out with light pulses at a count rate of 10^4 c/s resulting in an average anode current of $0.1 \mu\text{A}$. 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 FE1001

Mu-metal shield: type 56128

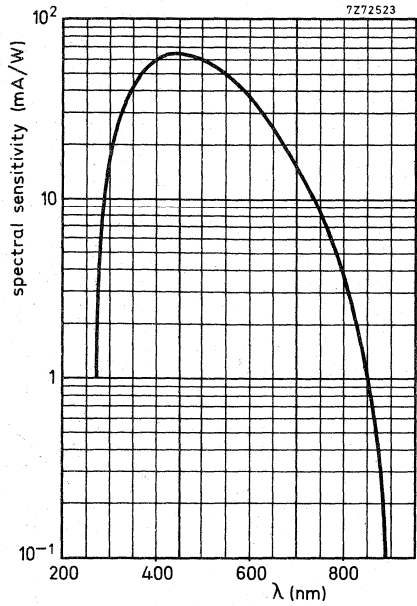


Fig. 3
Spectral sensitivity characteristic

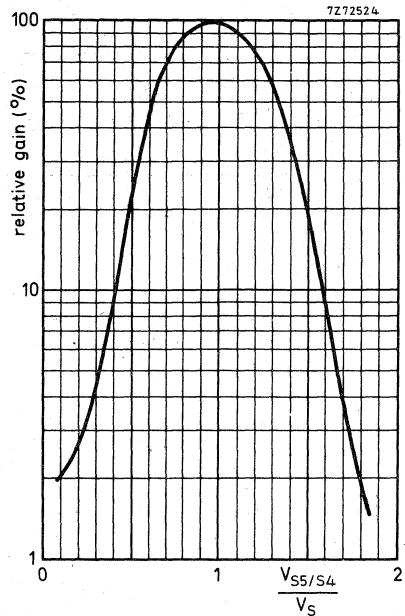


Fig. 4
Relative gain as a function of the voltage between S_5 and S_4 , normalized to V_S $V_{S6/S4}$ constant

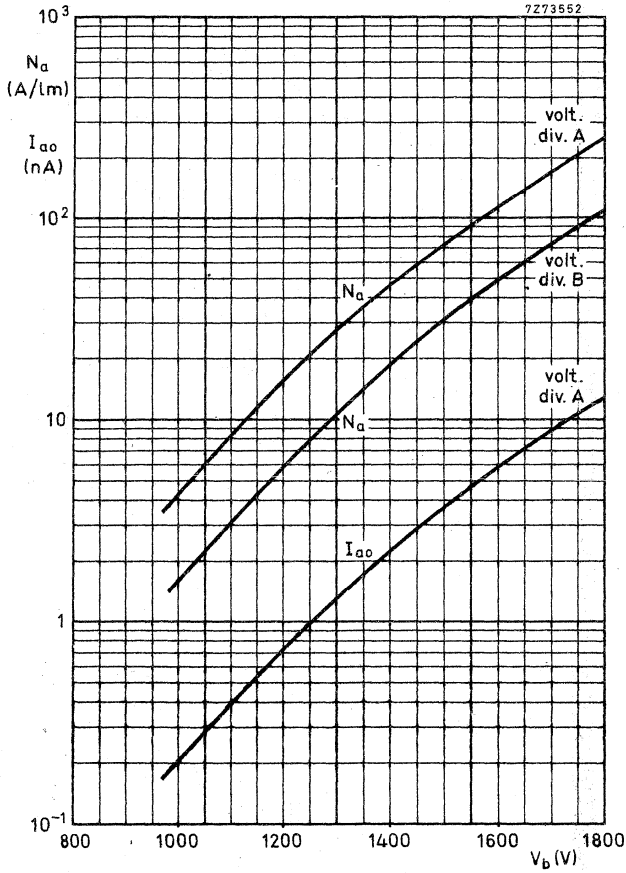


Fig. 5
 Anode luminous sensitivity, N_a , and anode dark current, I_{a0} , as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The XP1003 is a 44 mm useful diameter head-on photomultiplier tube with a flat 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. Its Cu-Be dynode multiplier system offers a high stability.

QUICK REFERENCE DATA		
Spectral sensitivity characteristic		type TU
Useful diameter of the photocathode	>	44 mm
Spectral sensitivity of the photocathode at 698 nm		16 mA/W
Supply voltage for an anode luminous sensitivity = 60 A/Im		1460 V
Mean pulse amplitude deviation	≈	1 %
Anode pulse rise time (with voltage divider B)	≈	4 ns
Linearity, with voltage divider A with voltage divider B	up to ≈	30 mA
	up to ≈	100 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	1,48

Photocathode

Semi-transparent head-on

Material	Sb-Na -K -Cs
Useful diameter	> 44 mm
Spectral sensitivity characteristic (Fig. 3)	type TU
Maximum spectral sensitivity at	420 ± 30 nm

Luminous sensitivity	1)	typ.	165	$\mu\text{A}/\text{lm}$
		>	100	$\mu\text{A}/\text{lm}$
Spectral sensitivity at $698 \pm 7 \text{ nm}$	2)		16	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.

Multiplier system

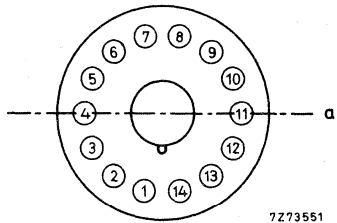
Number of stages			10
Dynode structure			linear focused
Dynode material			Cu-Be
Capacitances			
Anode to all	C_a	\approx	5 pF
Anode to final dynode	$C_a/S10$	\approx	3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at $V_b=1200\text{V}$, 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.



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

- 1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

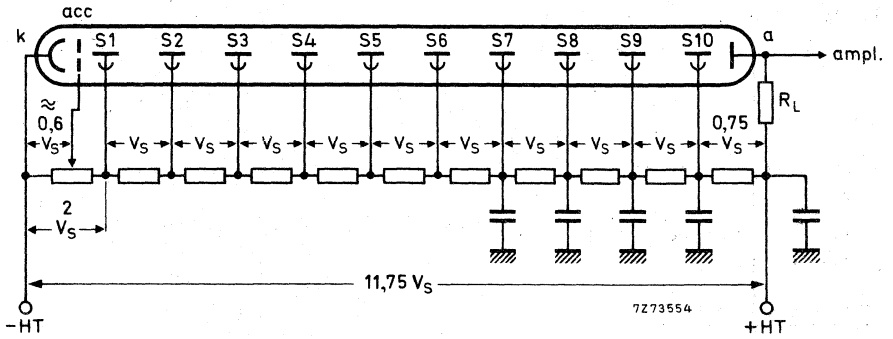


Fig. 1 Voltage divider A

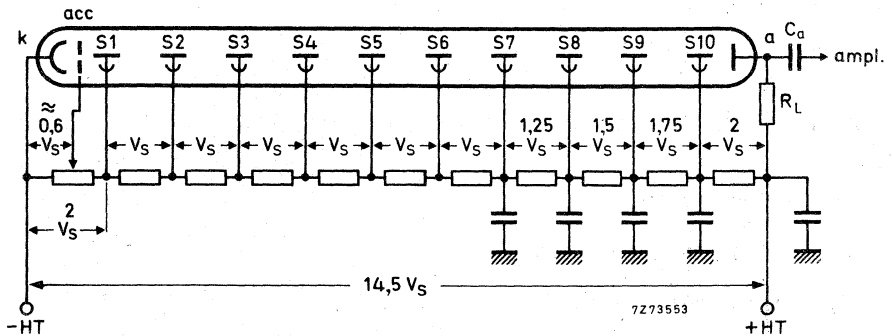


Fig. 2 Voltage divider B

k = cathode

Typical value of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

Supply voltage for an anode luminous

sensitivity $N_a = 60$ A/lm (Fig. 5)

typ. 1460 V
< 1650 V

Anode dark current at $N_a = 60$ A/lm (Fig. 5)

2),3)

typ. 5 nA
< 50 nA

Anode current linear within 2% at $V_b = 1700$ V
up to

~ 30 mA

Mean pulse amplitude 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. 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

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.

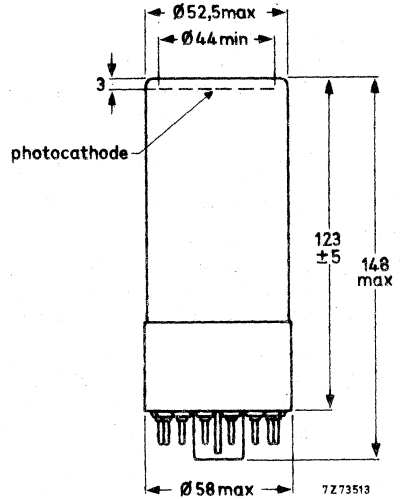
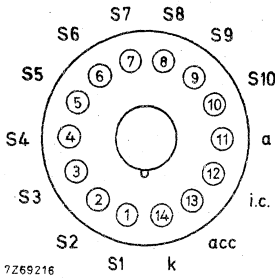
Notes to page 4

- 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 ($\approx 1/4h$).
- 4) The mean pulse amplitude 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/1m, 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 67-1-16a : JEDEC B14-38)

ACCESSORIES

Socket : type FE1001

Mu-metal shield : type 56128

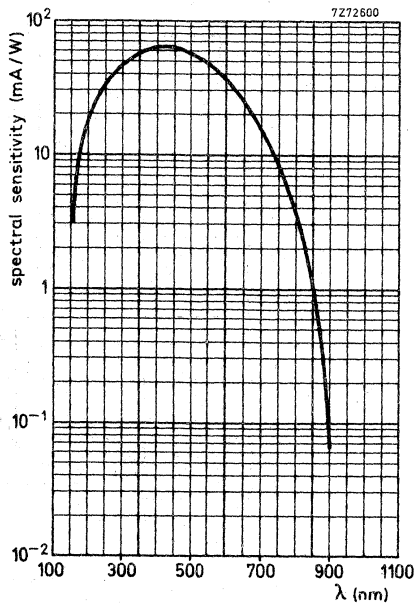


Fig. 3
Spectral sensitivity characteristic

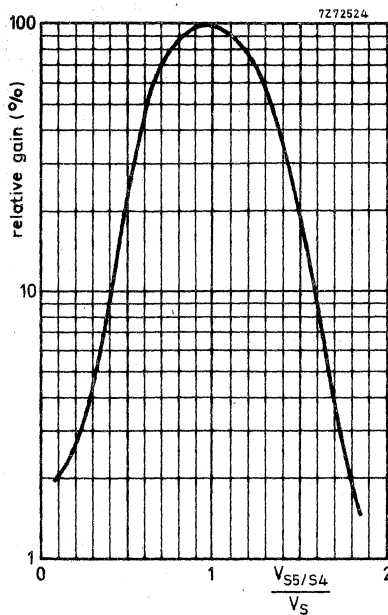


Fig. 4
Relative gain as a function of the voltage between S_5 and S_4 , normalized to V_S , $V_{S6/S4}$ constant

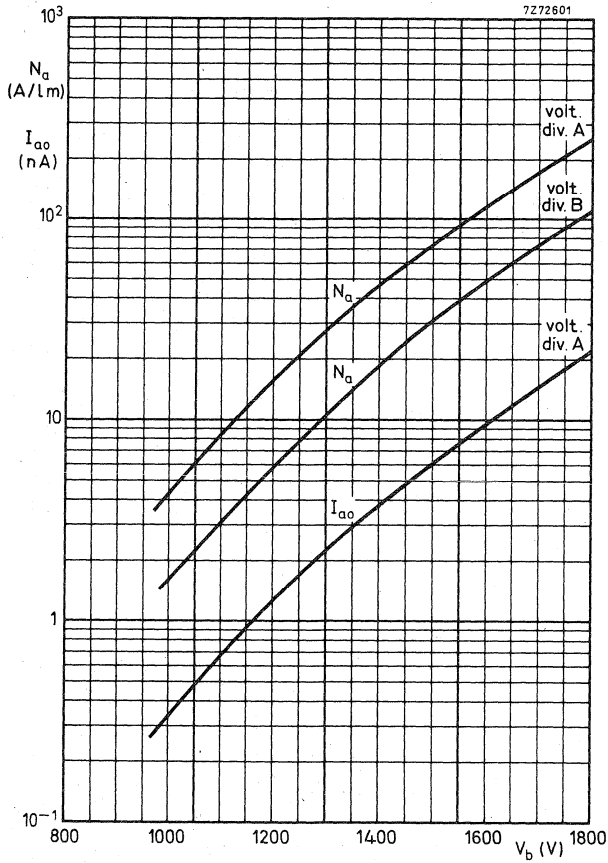


Fig. 5

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

10-STAGE PHOTOMULTIPLIER TUBE

The XP1004 is a 44 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent trialkaline S13 (type U) photocathode. The tube is intended for use in applications where a high sensitivity in the ultraviolet part of the spectrum is needed, such as spectrophotometry.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S13 (type U)	
Useful diameter of the photocathode	>	44	mm
Spectral sensitivity of the photocathode at 437 nm		70	mA/W
Supply voltage for an anode luminous sensitivity = 60 A/lm		1500	V
Anode pulse rise time (with voltage divider B)	≈	4	ns
Linearity, with voltage divider A with voltage divider B	up to	≈	30 mA
	up to	≈	100 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	> 44 mm
Spectral sensitivity characteristic (Fig. 3)	S13 (type U)
Maximum spectral sensitivity at	400 ± 30 nm

Luminous sensitivity	1)	typ.	80 $\mu\text{A}/\text{lm}$
		>	40 $\mu\text{A}/\text{lm}$
Spectral sensitivity at $437 \pm 5 \text{ nm}$	2)		70 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.

Multiplier system

Number of stages	10
Dynode structure	linear focused
Dynode material	Cu-Be

Capacitances

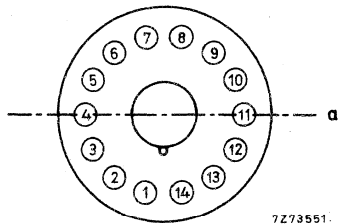
Anode to all	C_a	\approx	5 pF
Anode to final dynode	$C_{a/S10}$	\approx	3 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at $V_b = 1200 \text{ V}$, 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 $> 15 \text{ mm}$ beyond the photocathode.



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

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of: colour temperature $2856 \pm 5 \text{ K}$.

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

RECOMMENDED CIRCUITS

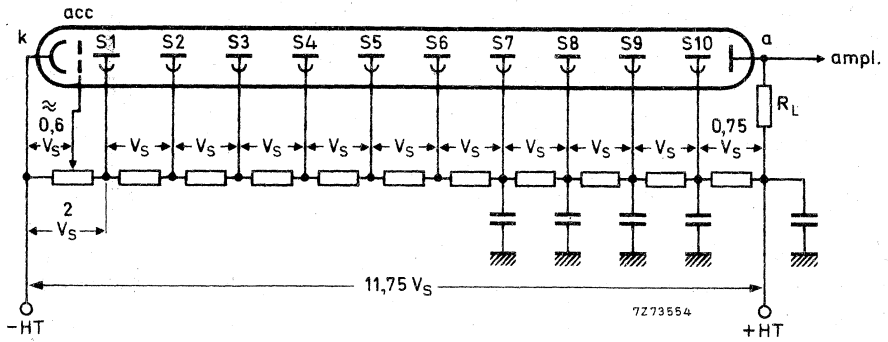


Fig. 1 Voltage divider A

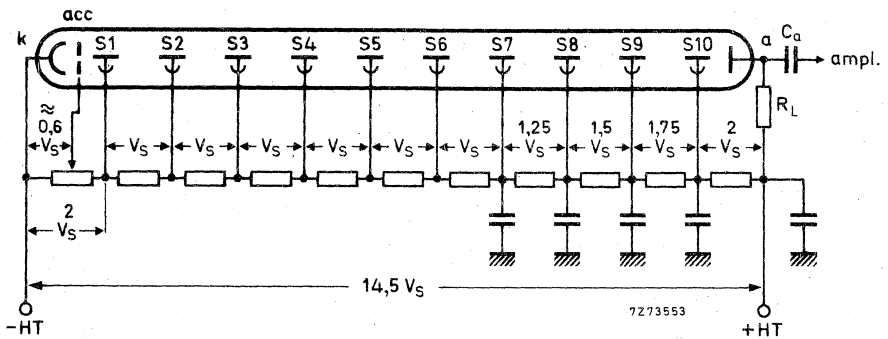


Fig. 2 Voltage divider B

k = cathode

Typical value of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>	1)		
Supply voltage for an anode luminous sensitivity $N_a = 60 \text{ A/lm}$ (Fig. 5)		typ. <	1500 V 1700 V
Anode dark current at $N_a = 60 \text{ A/lm}$ (Fig. 5)	2)3)	typ. <	10 nA 50 nA
Anode current linear within 2% at $V_b = 1700 \text{ V}$ up to		≈	30 mA
<u>With voltage divider B (Fig. 2)</u>	1)		
Anode luminous sensitivity at $V_b = 1700 \text{ V}$ (Fig. 5)		≈	35 A/lm
Anode pulse rise time at $V_b = 1700 \text{ V}$	4)	≈	4 ns
Anode pulse duration at half height at $V_b = 1700 \text{ V}$	4)	≈	12 ns
Signal transit time at $V_b = 1700 \text{ V}$	4)	≈	38 ns
Anode current linear within 2% at $V_b = 1700 \text{ V}$ up to		≈	100 mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	1800 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	6)	max. min.	500 V 120 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	7)	max. min.	300 V 30 V
Ambient temperature range	8)		
Operational (for short periods of time)		max. min.	+80 °C -30 °C
Continuous operation and storage		max. min.	+50 °C -30 °C

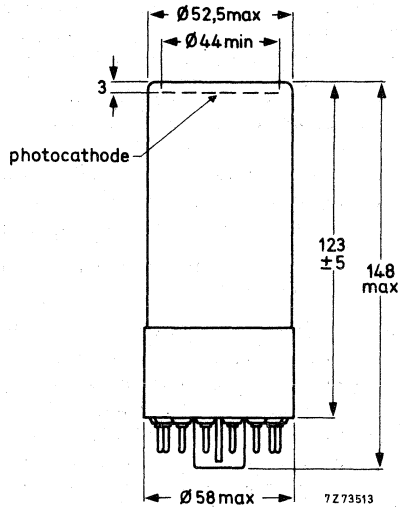
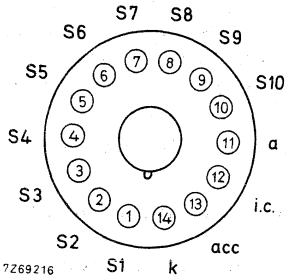
Notes see page 5.

Notes 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) 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 : 150 g

Base : 14-pin (IEC 67-1-16a; JEDEC B14-38)

ACCESSORIES

Socket : type FE 1001

Mu-metal shield : type 56128

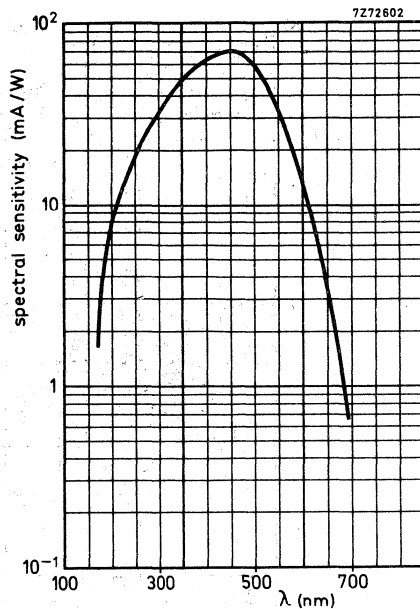


Fig. 3
Spectral sensitivity characteristic

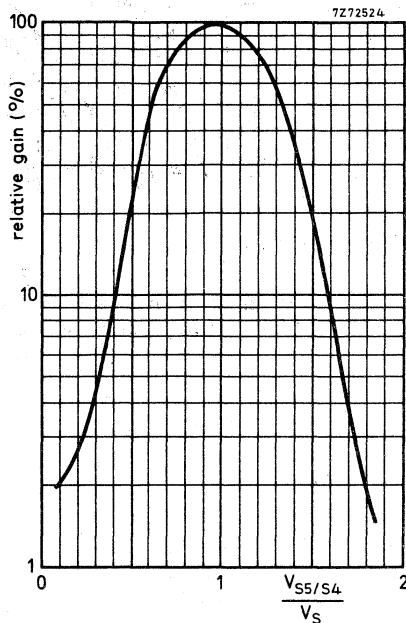


Fig. 4
Relative gain as a function of the voltage between S_5 and S_4 , normalized to V_S $V_{S6/S4}$ constant

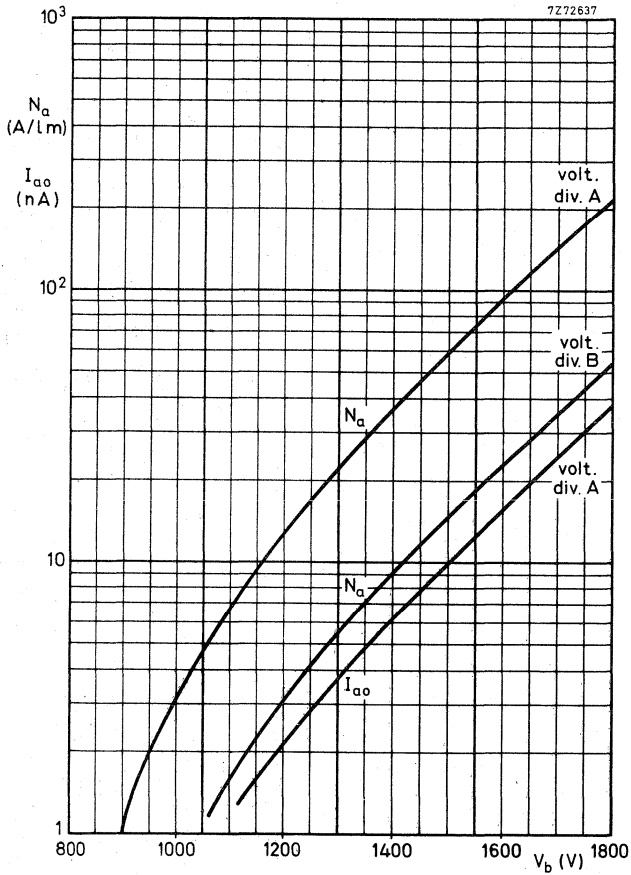


Fig. 5
 Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of the supply voltage V_b .

10-STAGE PHOTOMULTIPLIER TUBE

The XP1010 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.

It has a low noise combined with a high anode sensitivity.

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 = 60 A/lm			1500 V
Pulse amplitude resolution for ^{137}Cs	\approx		7,5 %
Anode pulse rise time (with voltage divider B)	\approx		3,5 ns
Linearity			
with voltage divider A	up to	\approx	30 mA
with voltage divider B	up to	\approx	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-Cs

Useful diameter > 32 mm

Spectral sensitivity characteristic (Fig. 3) type Super A

Maximum sensitivity at 420 ± 30 nm

Luminous sensitivity ¹⁾ typ. 90 $\mu\text{A/lm}$
> 70 $\mu\text{A/lm}$

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

Notes see page 2.

Electron optical input system

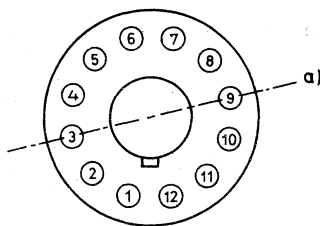
This system consists of : the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

Multiplier system

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



7273512

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

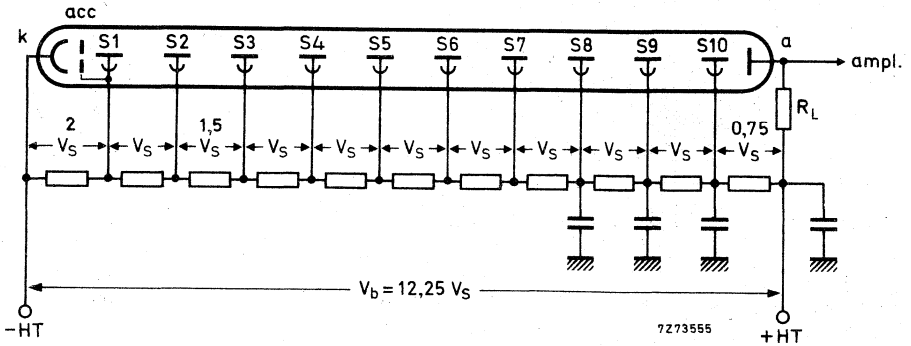


Fig. 1 Voltage divider A

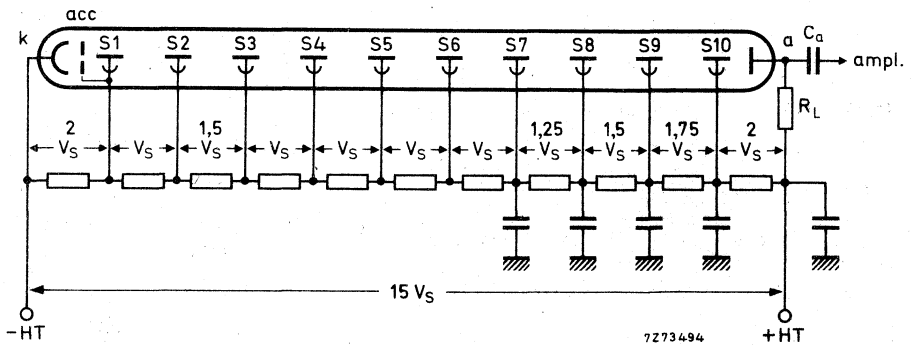


Fig. 2 Voltage divider B

k = cathode

Typical values of capacitors; 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		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.	3 nA
Pulse amplitude resolution for ^{55}Fe at an anode luminous sensitivity $N_a = 60$ A/lm	4)		≈	47 %
Peak to valley ratio for ^{55}Fe at $N_a = 60$ A/lm	4)		≈	30
Pulse amplitude resolution for ^{137}Cs	5)		≈	7,5 %
Anode current linear within 2% at $V_b = 1700$ V up to			≈	30 mA
<u>With voltage divider B (Fig. 2)</u>		1)		
Anode luminous sensitivity at $V_b = 1700$ V (Fig. 4)			≈	35 A/lm
Anode pulse rise time at $V_b = 1700$ V	6)		≈	3,5 ns
Anode pulse duration at half height at $V_b = 1700$ V	6)		≈	6 ns
Signal transit time at $V_b = 1700$ V	6)		≈	34 ns
Anode current linear within 2% at $V_b = 1700$ V up to			≈	100 mA
LIMITING VALUES (Absolute max. rating system)				
Supply voltage	7)		max.	1800 V
Continuous anode current			max.	0,2 mA
Voltage between first dynode and photocathode	8)		max.	500 V
			min.	120 V
Voltage between consecutive dynodes			max.	300 V
Voltage between anode and final dynode	9)		max.	300 V
			min.	30 V
Ambient temperature range			max.	+80 °C
Operational (for short periods of time)	10)		min.	-30 °C
			max.	+50 °C
Continuous operation and storage			min.	-30 °C

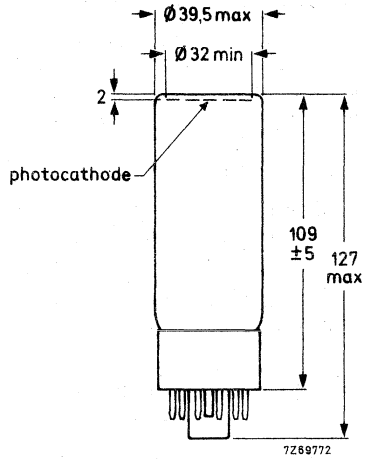
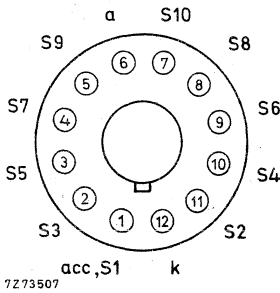
Notes see page 5.

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 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 $\approx 10^3$ 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 $\approx 10^3$ c/s.
- 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 FE1002
Mu-metal shield: type 56127

Fig. 3
Spectral sensitivity characteristic

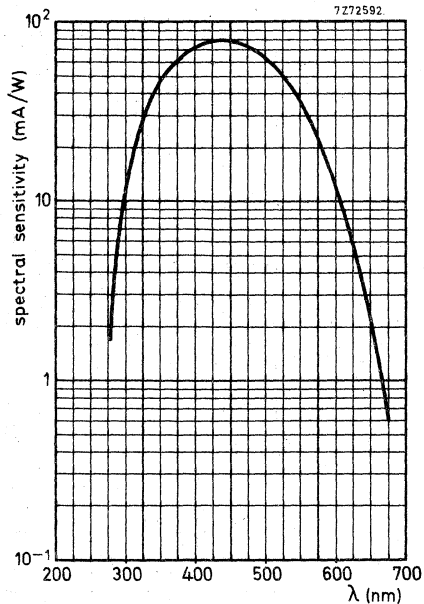
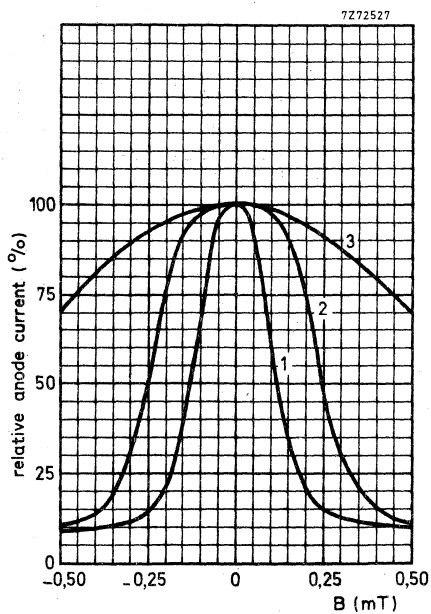


Fig. 4
Relative anode current as a function of the flux density B

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



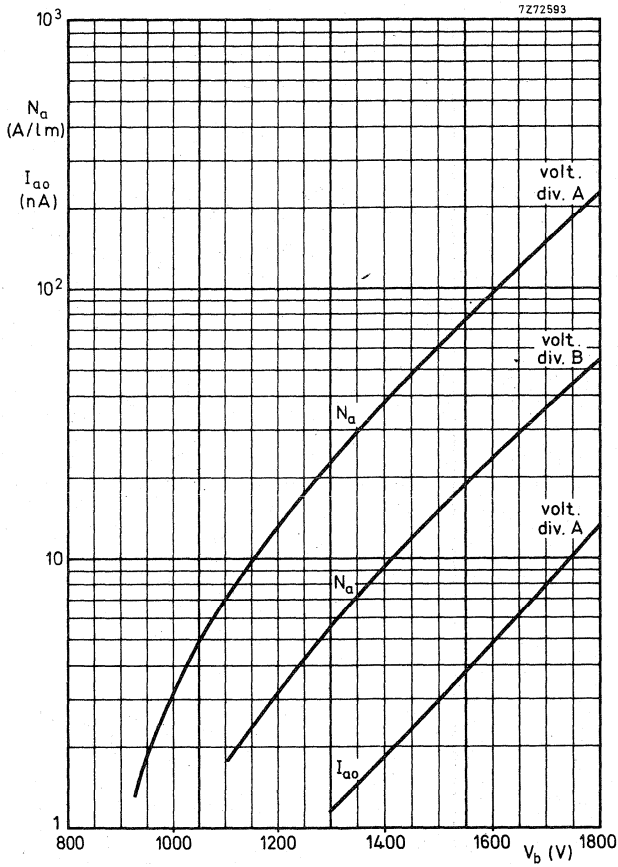


Fig. 5
 Anode luminous sensitivity, N_a and anode dark current, I_{ao} , as a function of supply voltage V_b .

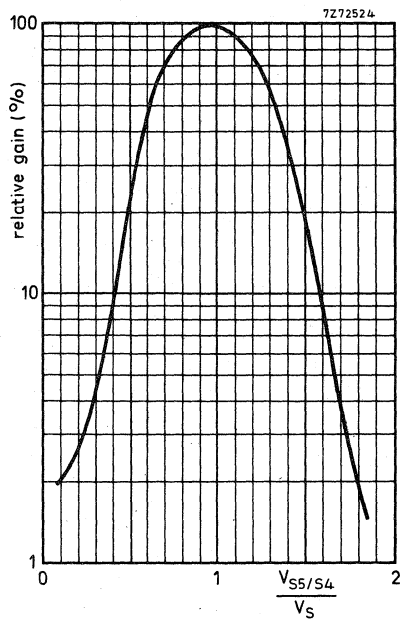


Fig. 5
Relative gain as a function
of the voltage between S_5 and S_4 ,
normalized to V_S
 $V_{S6/S4}$ constant

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

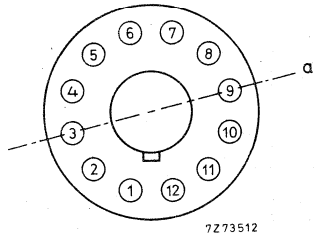
This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc; internally connected to S1.

Multiplier system

Number of stages				10
Dynode structure				linear focused
Dynode material				Ag-Mg
Capacitances				
Anode to all	C_a	\approx	5	pF
Anode to final dynode	C_a/S_{10}	\approx	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

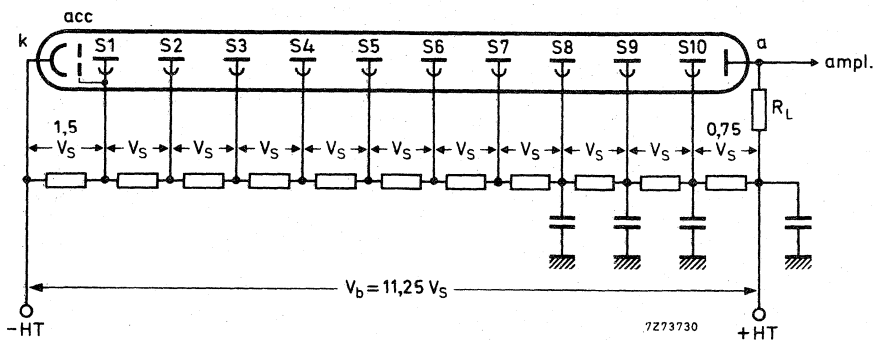


Fig. 1 Voltage divider A

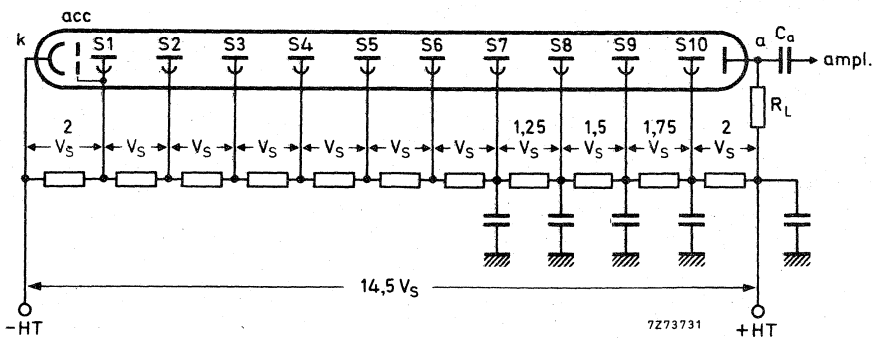


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		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	
<u>With voltage divider B (Fig. 2)</u>		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)		max. +80 °C min. -30 °C	
Operational (for short periods of time)			max. +50 °C min. -30 °C	
Continuous operation and storage			max. +50 °C min. -30 °C	

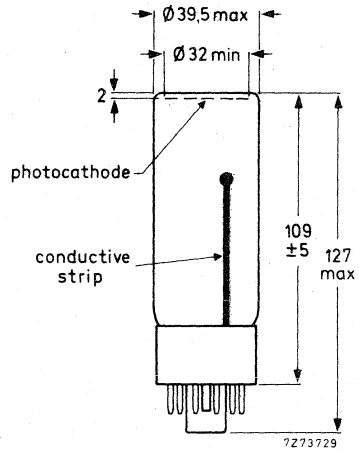
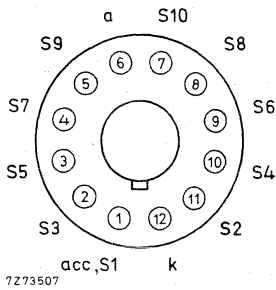
Notes see page 5.

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 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 $\approx 10^3$ 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 FE1002

Mu-metal shield : type 56127

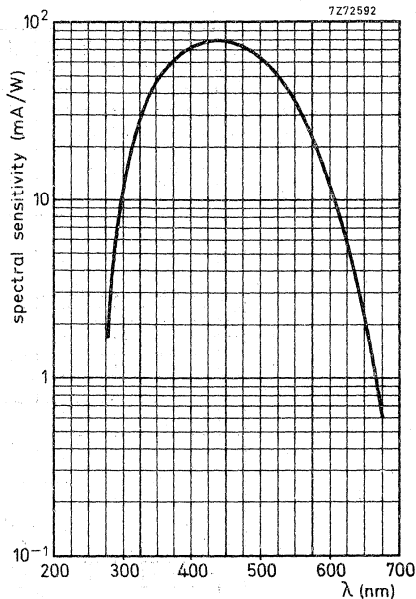


Fig. 3
Spectral sensitivity characteristic

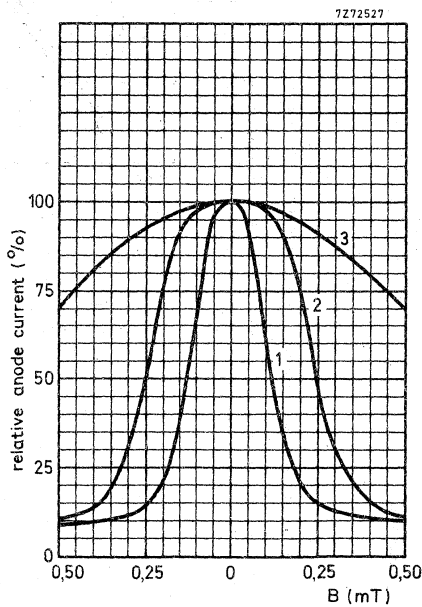


Fig. 4
Relative anode current as a function of the flux density B

1. B \perp tube axis, \parallel axis a)
2. B \perp tube axis, \perp axis a)
3. B \parallel tube axis

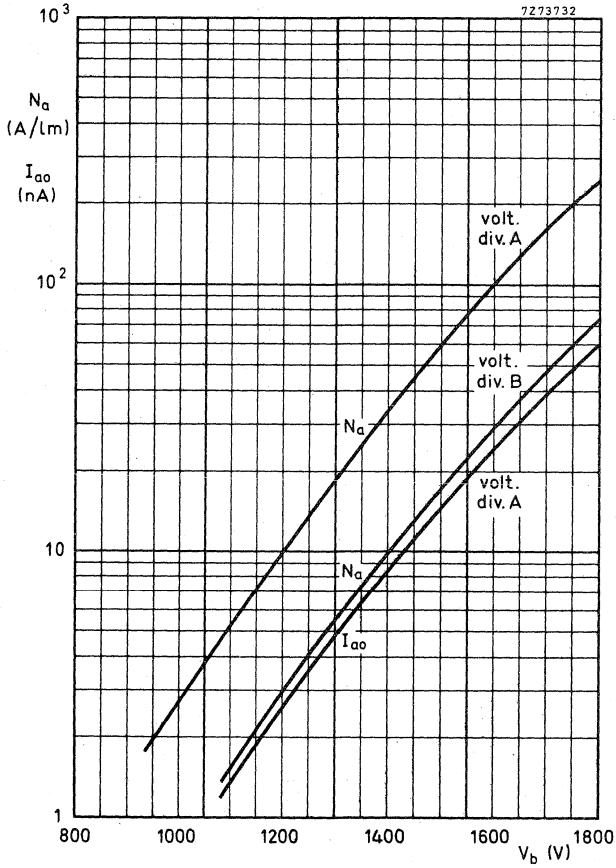


Fig. 5
Anode luminous sensitivity, N_a , and anode dark current, I_{a0} , as a function of supply voltage V_b .

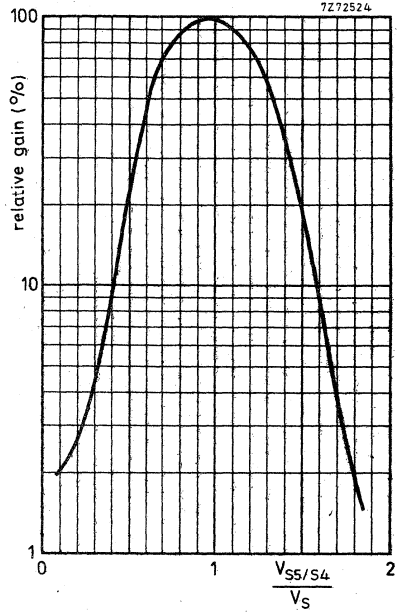


Fig. 6
 Relative gain as a function of the voltage
 between S5 and S4, normalized to V_S
 $V_{S6/S4}$ constant.

10-STAGE PHOTOMULTIPLIER TUBE

The XP1016 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 general applications in the red and near infrared part of the spectrum such as laser detection and pollution monitoring.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S20 (type T)	
Useful diameter of the photocathode	>	32	mm
Spectral sensitivity of the photocathode at 698 nm		16	mA/W
Supply voltage for anode luminous sensitivity = 60 A/lm		1460	V
Mean pulse amplitude deviation	≈	1	%
Anode pulse rise time (with voltage divider B)	≈	3, 5	ns
Linearity, with voltage divider A with voltage divider B	up to	≈	30 mA
	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)	S20 (type T)
Maximum spectral sensitivity at	420 ± 30 nm

Data based on pre-production tubes.

Luminous sensitivity	1)	typ.	160	$\mu\text{A}/\text{lm}$
		>	100	$\mu\text{A}/\text{lm}$
Spectral sensitivity at $698 \pm 7 \text{ nm}$	2)		16	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.

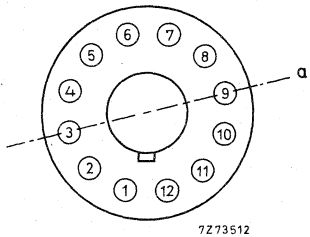
Multiplier system

Number of stages			10	
Dynode structure			linear focused	
Dynode material			Cu-Be	
Capacitances				
Anode to all	C_a	\approx	5	pF
Anode to final dynode	$C_{a/S10}$	\approx	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 $> 15 \text{ mm}$ beyond the photocathode.



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

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.

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

RECOMMENDED CIRCUITS

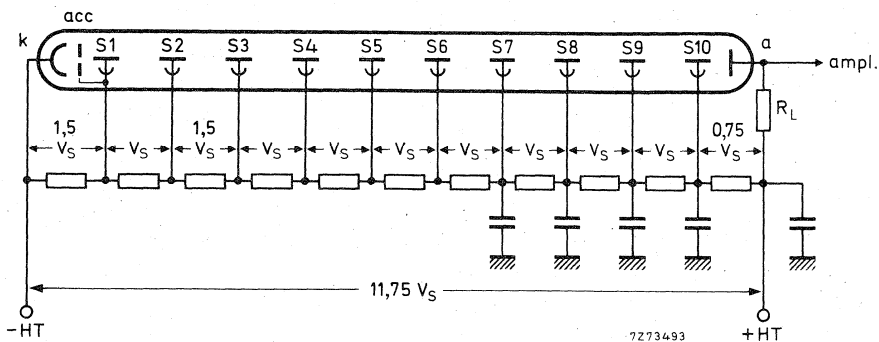


Fig. 1 Voltage divider A

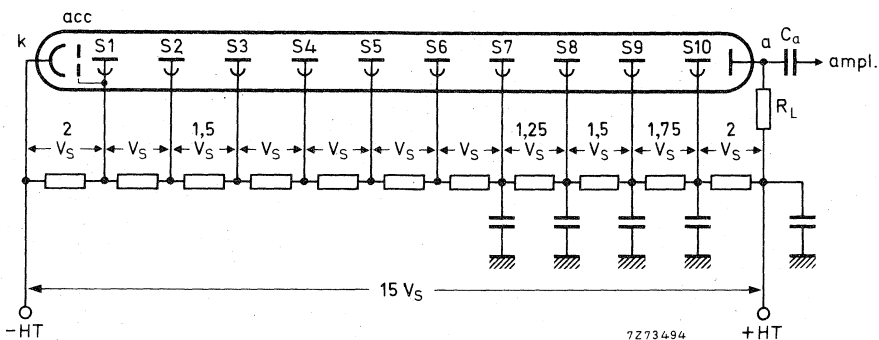


Fig. 2 Voltage divider B

k = cathode

Typical value of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 60 \text{ A/lm}$ (Fig. 5)			typ.	1460 V
			<	1650 V
Supply voltage for a gain $G = 10^6$			≈	1700 V
Anode dark current at $N_a = 60 \text{ A/lm}$ (Fig. 5)	2)3)		typ.	3 nA
			<	50 nA
Anode current linear within 2% at $V_b = 1700 \text{ V}$ up to			≈	30 mA
Mean pulse amplitude deviation at $V_b = 1200 \text{ V}$, long term (16 h)	9)		≈	1 %
<u>With voltage divider B (Fig. 2)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 60 \text{ A/lm}$ (Fig. 5)			≈	1750 V
Anode pulse rise time at $V_b = 1700 \text{ V}$	4)		≈	3,5 ns
Anode pulse duration at half height at $V_b = 1700 \text{ V}$	4)		≈	6 ns
Signal transit time at $V_b = 1700 \text{ V}$	4)		≈	34 ns
Anode current linear within 2% at $V_b = 1700 \text{ V}$ up to			≈	100 mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	1800 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	6)	max.	500 V
		min.	120 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	7)	max.	300 V
		min.	30 V
Ambient temperature range	8)	max.	+80 °C
Operational (for short periods of time)		min.	-30 °C
Continuous operation and storage		max.	+50 °C
		min.	-30 °C

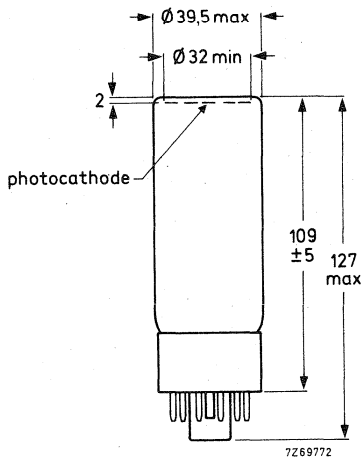
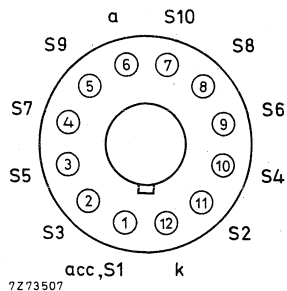
Notes see page 5.

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 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 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.
- 9) The mean pulse amplitude 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 μ A. See also "General Operational Recommendations Photomultiplier Tubes".

MECHANICAL DATA

Dimensions in mm



Net mass: 80 g

Base : 12-pin (JEDEC B12-43)

ACCESSORIES

Socket : type FE 1002

Mu-metal shield: type 56127.

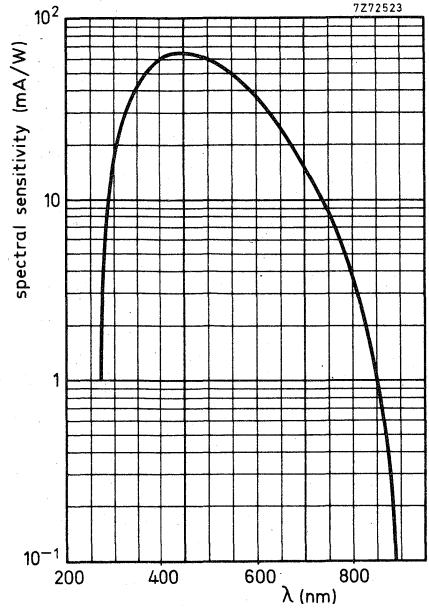


Fig. 3
Spectral sensitivity characteristic

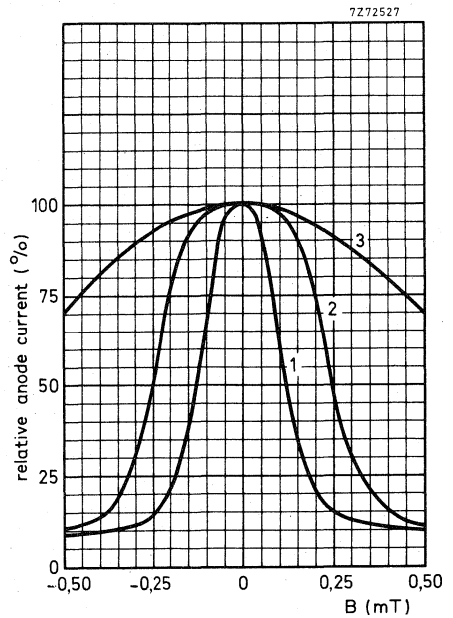


Fig. 4
Relative anode current as a function of
the magnetic flux density B

1. B \perp tube axis, // axis a
2. B \perp tube axis, \perp axis a
3. B // tube axis

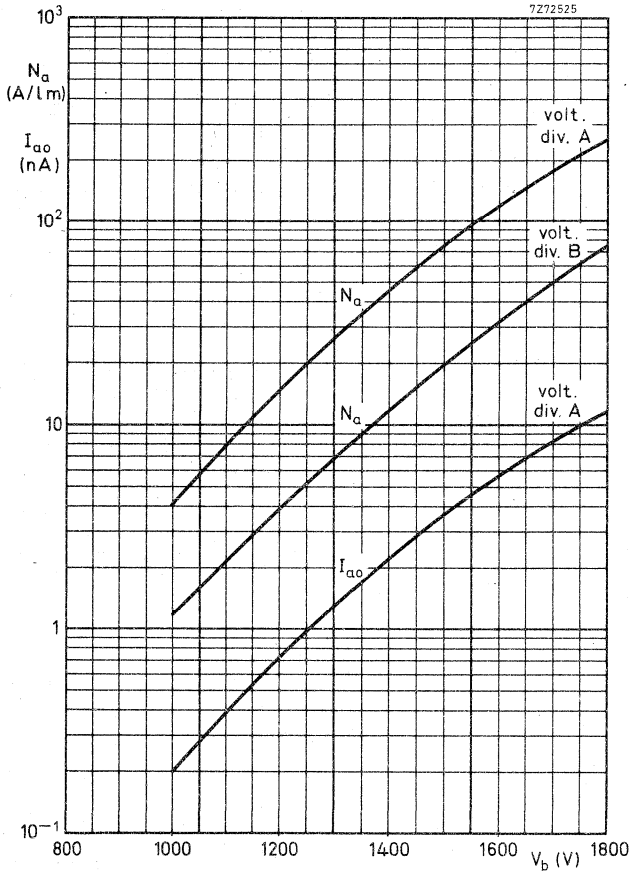
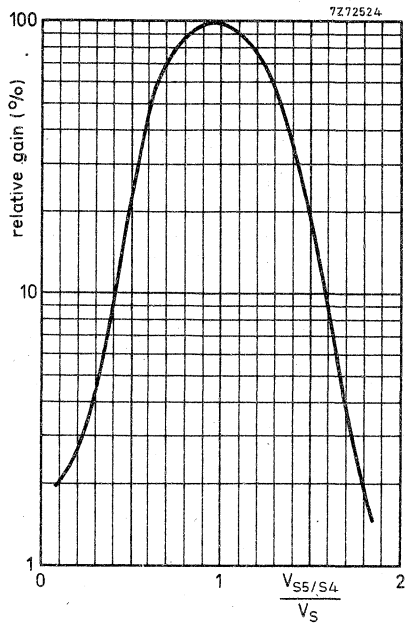


Fig. 5
Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of the supply voltage V_b .

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

Data based on pre-production tubes.

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	1)	typ. 210 μA/lm
		> 150 μA/lm
Spectral sensitivity at 858 ± 8 nm 2)		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

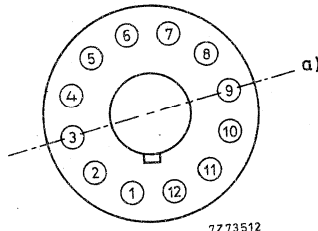
This system consists of: the photocathode, k; a metallized part of the glass envelope, internally connected to the photocathode; an accelerating electrode, acc, internally connected to S1.

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.



7273512
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

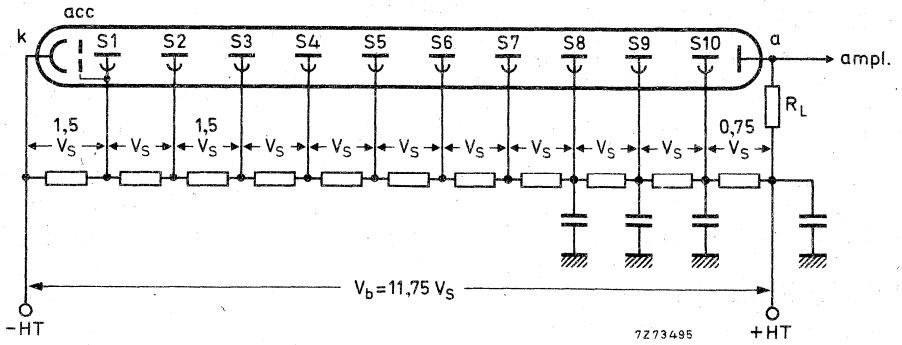


Fig. 1 Voltage divider A

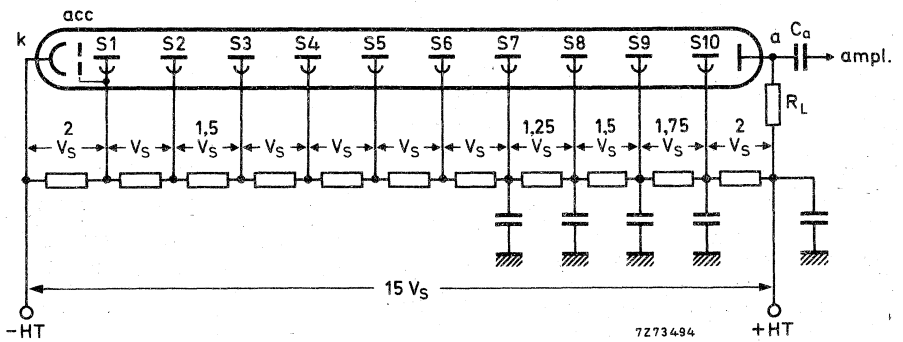


Fig. 2 Voltage divider B

k = cathode

Typical values of capacitors; 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 60$ A/lm (Fig. 5)			<	1650 V
			typ.	1470 V
Supply voltage for a gain $G = 10^6$			≈	1800 V
Anode dark current at $N_a = 60$ A/lm (Fig. 5)	2) 3)		<	50 nA
			typ.	2 nA
Anode current linear within 2% at $V_b = 1700$ V up to			≈	30 mA
<u>With voltage divider B (Fig. 2)</u>		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.	500 V
			min.	120 V
Voltage between consecutive dynodes			max.	300 V
Voltage between anode and final dynode	7)		max.	300 V
			min.	30 V
Ambient temperature range				
Operational (for short periods of time)	8)		max.	+80 °C
			min.	-30 °C
Continuous operation and storage			max.	+50 °C
			min.	-30 °C

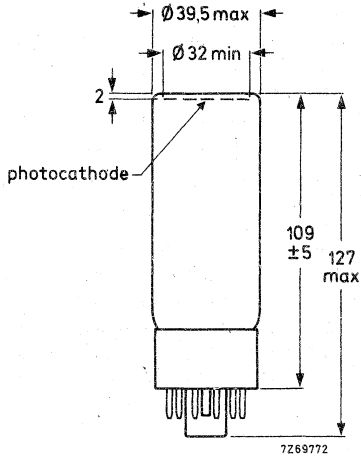
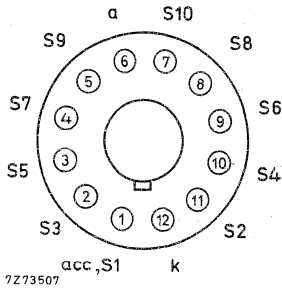
Notes see page 5.

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 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 FE1002
 Mu-metal shield : type 56127

Fig. 3
Spectral sensitivity characteristic

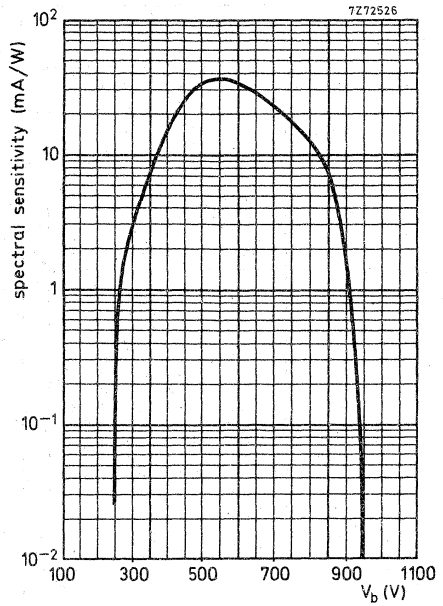
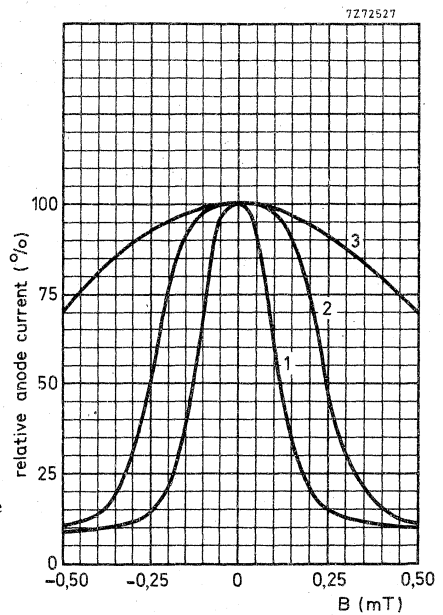


Fig. 4
Relative anode current as a function of the magnetic flux density B

1. B \perp tube axis, // axis a
2. B \perp tube axis, \perp axis a
3. B // tube axis



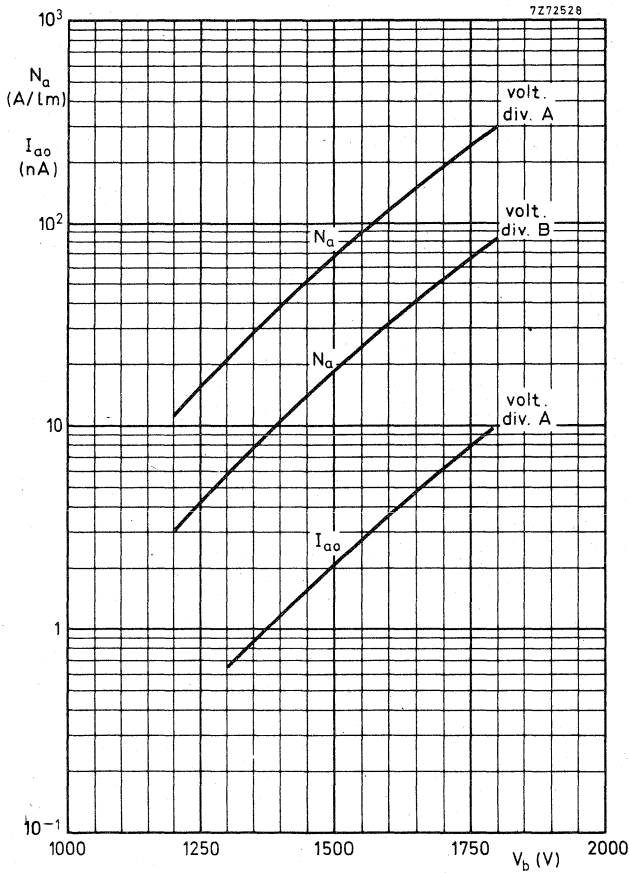


Fig. 5
 Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The XP1110 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.

Its rugged construction makes it particularly suitable for geophysical and astronomical missile experiments as well as for industrial equipment.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic	S11 (type A)		
Useful diameter of the photocathode	>	14	mm
Supply voltage at anode luminous sensitivity = 30 A/lm		1400	V
Anode pulse rise time	≈	3,5	ns
Linearity			
with voltage divider A	≈	10	mA
with voltage divider B	≈	30	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

Useful diameter	>	14	mm
Spectral sensitivity characteristic (Fig. 3)		S11 (type A)	
Material		Sb-Cs	
Maximum sensitivity at		420 ± 30	nm
Luminous sensitivity	1)	typ. 60	µA/lm
		> 40	µA/lm
Spectral sensitivity at 437 ± 5 nm (Fig. 3)	2)	≈ 60	mA/W

Multiplier system

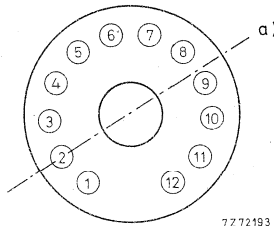
Number of stages		10	
Dynode structure		linear focused	
Dynode material		Ag-Mg	
Capacitances			
Anode to final dynode	$C_a/S_{10} \approx$	1,9	pF
Anode to all	$C_a \approx$	3	pF

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 0,3 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 axis 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

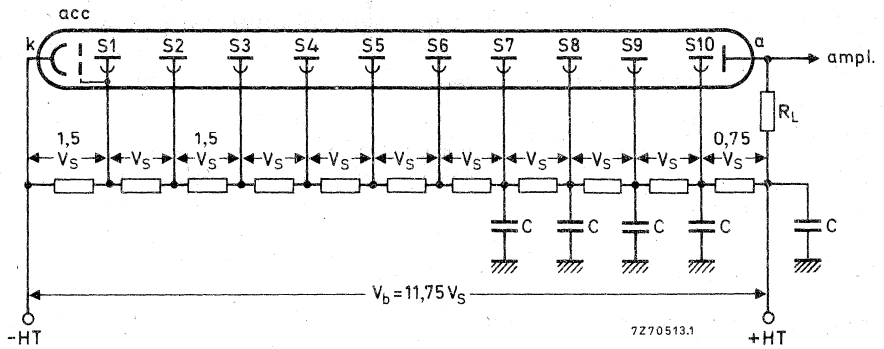


Fig. 1 Voltage divider A

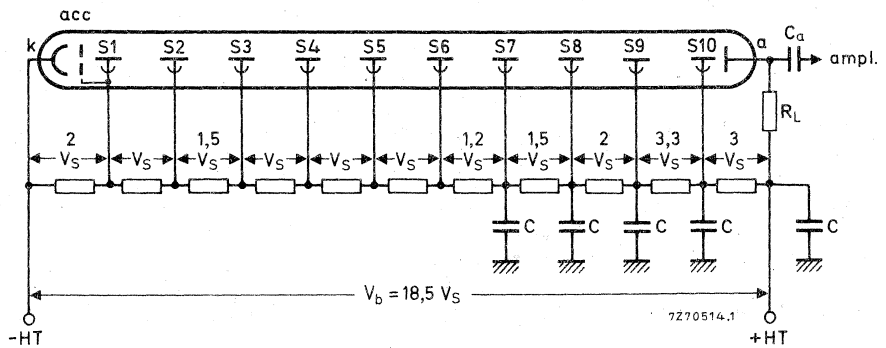


Fig. 2 Voltage divider B

- k = cathode
- acc = accelerating electrode
- S_n = dynode no. n
- a = anode

R_L = Load resistor
 Typical values of capacitors 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

Supply voltage at anode luminous sensitivity = 30 A/lm	typ. >	1400 1800	V V
Anode dark current at $N_a = 30$ A/lm (Fig. 4) ^{1) 2)}	< typ.	25 1,5	nA nA
Anode current linear within 2 % at $V_b = 1800$ V up to	≈	10	mA

With voltage divider B (Fig. 2)

Anode luminous sensitivity at $V_b = 1800$ V (Fig. 4)	≈	25	A/lm
Anode pulse rise time at $V_b = 1800$ V 3)	≈	3,5	ns
Anode pulse duration at half height at $V_b = 1800$ V 3)	≈	6	ns
Signal transit time at $V_b = 1800$ V 3)	≈	30	ns
Anode current linear within 2 % at $V_b = 1800$ V up to	≈	30	mA

LIMITING VALUES (Absolute max. rating system)

Supply voltage 4)	max.	1900	V
Continuous anode current 5)	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
Storage and continuous operation	max.	+50	°C
	min.	-50	°C

Notes see page 5,

- 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. To reduce this effect the glass envelope should only be supported by isolators having an isolation resistance of $> 10^{15} \Omega$.
- 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 duration, and transit time vary as a function of the HT supply voltage V_b , approximately as $V_b^{-1/2}$.
- 4) Total HT supply voltage or the voltage at which the tube has a gain of 1×10^7 , whichever is lower.
- 5) For applications requiring a high stability a value of $< 10 \mu\text{A}$ is recommended.
- 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.

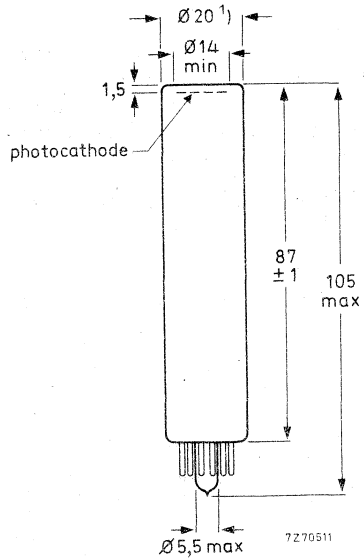
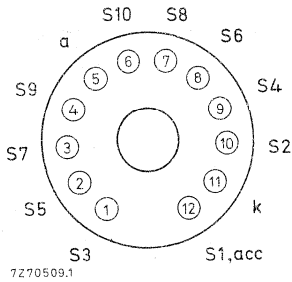
MECHANICAL DATA

Dimensions in mm

Base : 12-pin all glass

A special version with flying leads (Ni 1 mm x 0,1 mm, 80 mm long) can be ordered.

Net mass : 25 g



¹⁾ The tube can be inserted into a cylindrical gauge of $20,0^{+0}_{-0,1}$ mm diameter and a length of 90 ± 1 mm.

ACCESSORIES

Socket : type FE1004

Mu-metal shield : type 56134

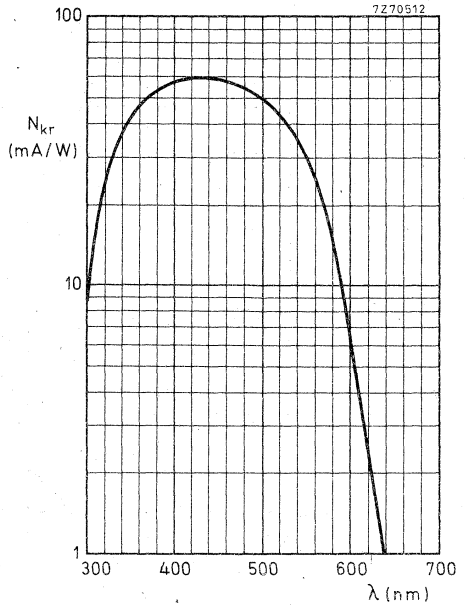


Fig. 3
Spectral sensitivity characteristic

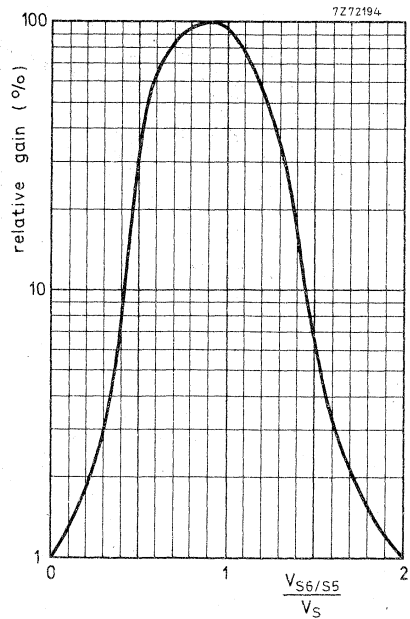


Fig. 5
Relative gain as a function of the voltage
between S_6 and S_5 , normalized to V_S
 $V_{S7/S5}$ constant

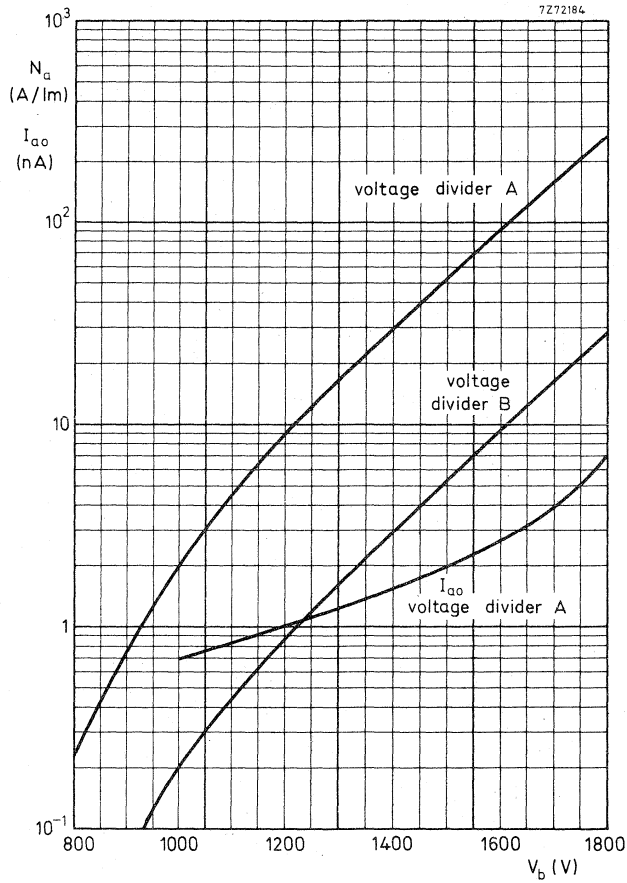


Fig. 4

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

6-STAGE PHOTOMULTIPLIER TUBE

The XP1113 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 rugged 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
Spectral sensitivity of the photocathode at 437 nm	60 mA/W
Supply voltage for an anode luminous sensitivity $N_a = 0,2$ A/lm	820 V
Anode pulse rise time (with voltage divider B)	≈ 3,5 ns
Linearity	
with voltage divider A	up to ≈ 15 mA
with voltage divider B	up to ≈ 30 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-Cs
Useful diameter	> 14 mm
Spectral sensitivity characteristic (Fig. 3)	S11 (type A)

Maximum spectral sensitivity at		420 ± 30 nm
Luminous sensitivity	1)	typ. 60 μA/lm > 30 μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈ 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

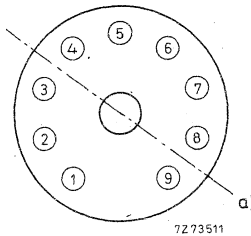
Number of stages		6
Dynode structure		linear focused
Dynode material		Ag - Mg
Capacitances		
Anode to all	C_a	≈ 1,8 pF
Anode to final dynode	$C_{a/S6}$	≈ 1,6 pF

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 0,3 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 field 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

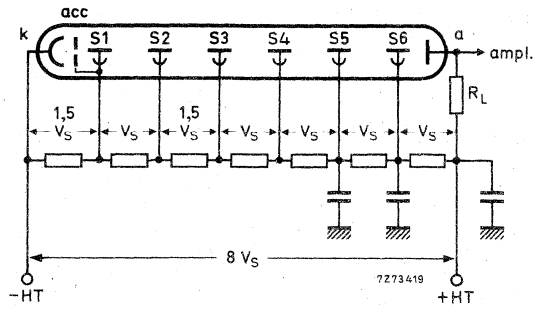


Fig. 1 Voltage divider A

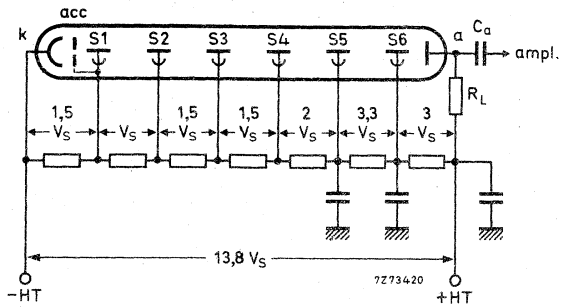


Fig. 2 Voltage divider B

k = cathode

Typical value of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 0,2 \text{ A/lm}$ (Fig. 4)			typ. 820 V < 1200 V	
Anode dark current at $N_a = 0,2 \text{ A/lm}$ (Fig. 4)	2)3)		typ. 2 nA < 6 nA	
Anode current linear within 2% at $V_b = 1100 \text{ V}$ up to			≈ 10 mA	
<u>With voltage divider B (Fig. 2)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 0,1 \text{ A/lm}$ (Fig. 4)			≈ 1050 V	
Anode pulse rise time at $V_b = 1100 \text{ V}$	4)		≈ 3,5 ns	
Anode pulse duration at half height at $V_b = 1100 \text{ V}$	4)		≈ 6 ns	
Signal transit time at $V_b = 1100 \text{ V}$	4)		≈ 17 ns	
Anode current linear within 2% at $V_b = 1100 \text{ V}$ up to			≈ 30 mA	

LIMITING VALUES (Absolute max. rating system)

Supply voltage		max.	1200 V
Continuous anode current		max.	0,2 mA
Voltage between first dynode and photocathode	5)	max. min.	300 V 100 V
Voltage between anode and final dynode	7)	max. min.	300 V 30 V
Voltage between consecutive dynodes		max.	200 V
Ambient temperature range		max. min.	+70 °C -50 °C
Operational (for short periods of time)		max. min.	+50 °C -50 °C
Continuous operation and storage		max. min.	+50 °C -50 °C

Notes see page 5.

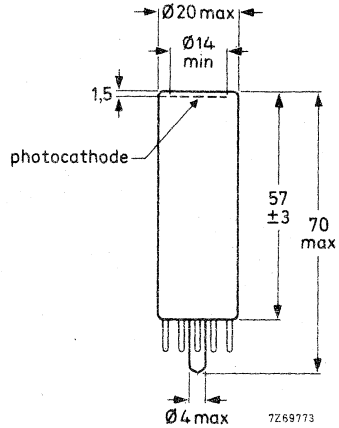
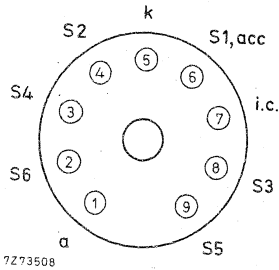
Notes to page 4

- 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 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 ($\approx \frac{1}{4}$ 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 the HT 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.

XP1113

MECHANICAL DATA

Dimensions in mm



Net mass: 15 g

Base : small button noval 9-pin base (JEDEC E9-37, IEC 67-I-12a) with pumping stem

ACCESSORIES

Socket : Noval cat. number 2422 502 90003

Mu-metal shield: type 56134

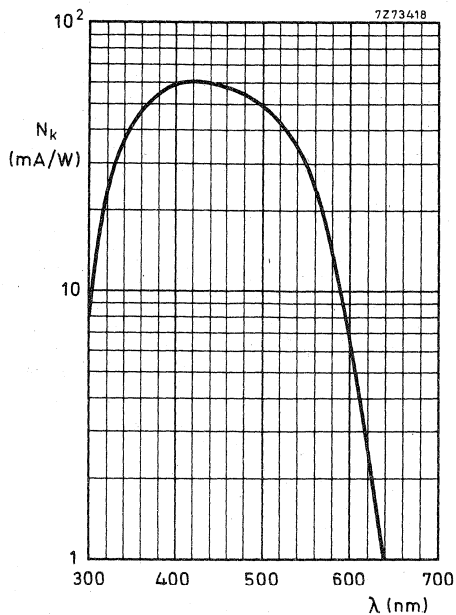


Fig. 3
Spectral sensitivity characteristic

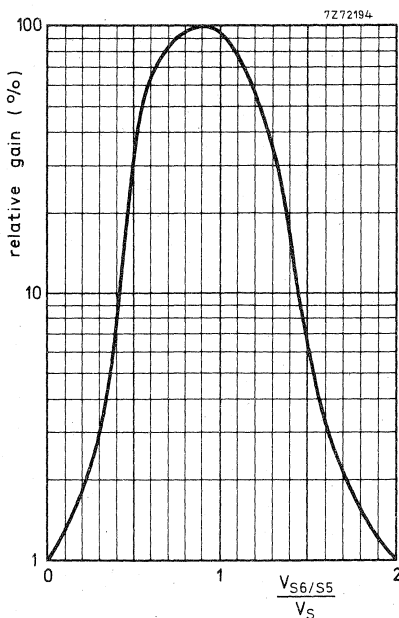


Fig. 4
Relative gain as a function of the voltage
between S_6 and S_5 , normalized to V_S
 $V_{S7/S5}$ constant

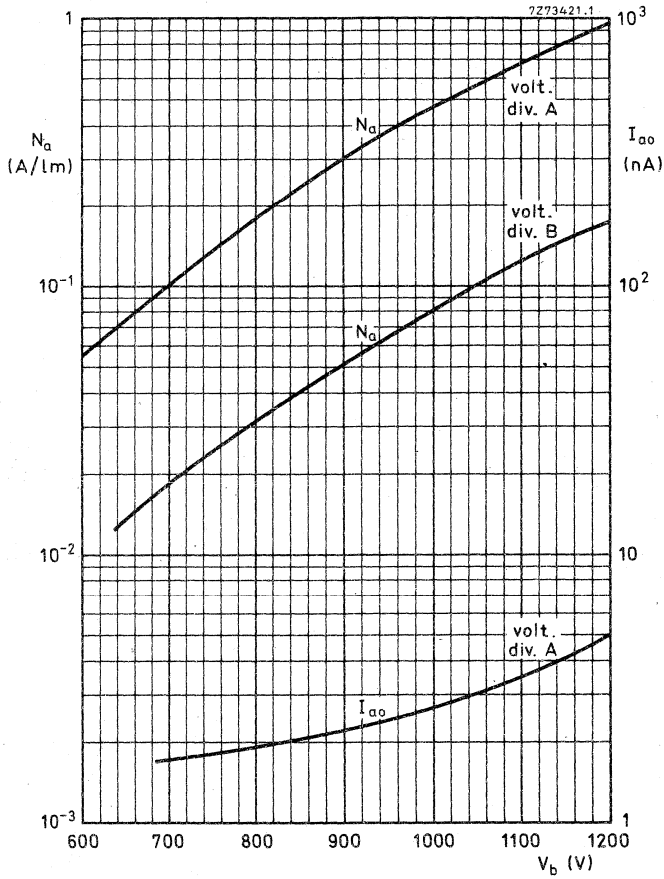


Fig. 5

Anode sensitivity, N_a , 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 $N_a = 10 \text{ A/lm}$		1650	V
Anode pulse rise time (with voltage divider B)	\approx	3,5	ns
Linearity			
with voltage divider A	up to \approx	10	mA
with voltage divider B	up to \approx	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	$800 \pm 100 \text{ nm}$

Luminous sensitivity	1)	typ.	20 $\mu\text{A}/\text{lm}$
		>	15 $\mu\text{A}/\text{lm}$
Spectral sensitivity at $903 \pm 8 \text{ nm}$	2)		1,6 mA/W
at $1060 \pm 10 \text{ nm}$		\approx	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

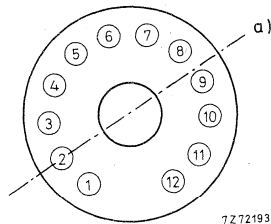
Number of stages		10
Dynode structure		linear focused
Dynode material		Ag-Mg
Capacitances		
Anode to all	C_a	\approx 3 pF
Anode to final dynode	$C_a/S10$	\approx 1,9 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at $V_b = 1200 \text{ V}$; 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 $2856 \pm 5 \text{ K}$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

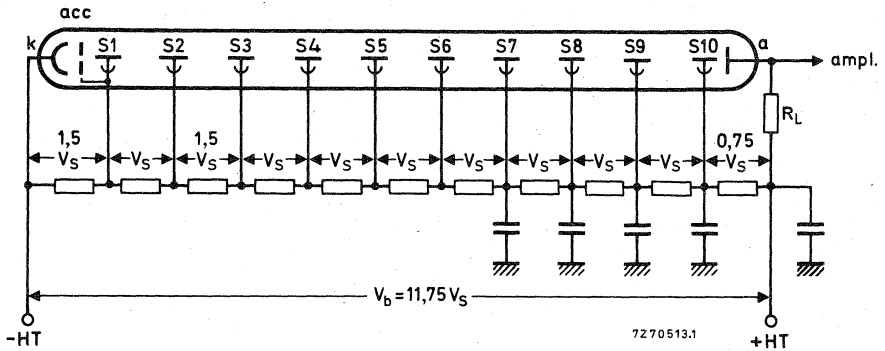


Fig. 1 Voltage divider A

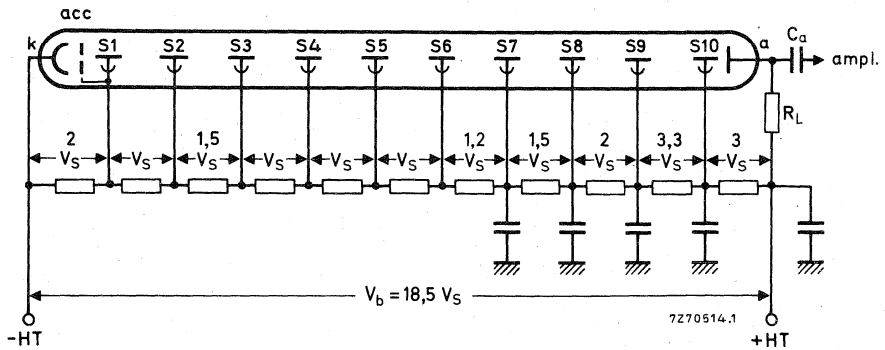


Fig. 2 Voltage divider B

k = cathode

Typical values of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistance

TYPICAL CHARACTERISTICS

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

LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	1900 V
Continuous anode current	6)	max.	10 μ A
Voltage between first dynode and photocathode	7)	max.	350 V
		min.	100 V
Voltage between consecutive dynodes		max.	200 V
Voltage between anode and final dynode		max.	300 V
		min.	30 V
Ambient temperature range		max.	+50 $^{\circ}$ C
Operational (for short periods of time)		min.	-30 $^{\circ}$ C
Continuous operation and storage		max.	+50 $^{\circ}$ C
		min.	-30 $^{\circ}$ C

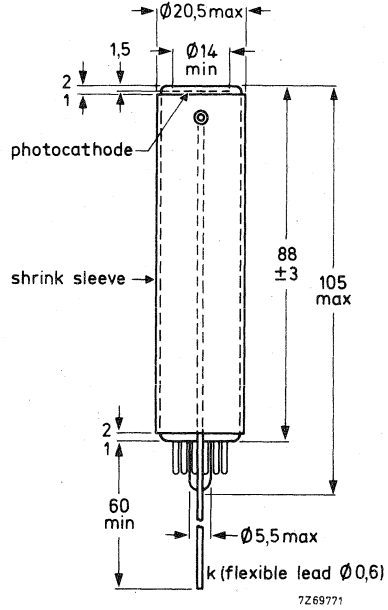
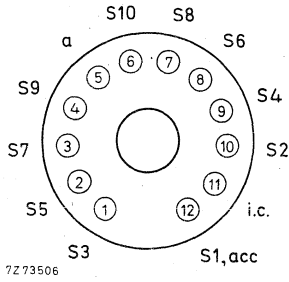
Notes see page 5.

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 °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 °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

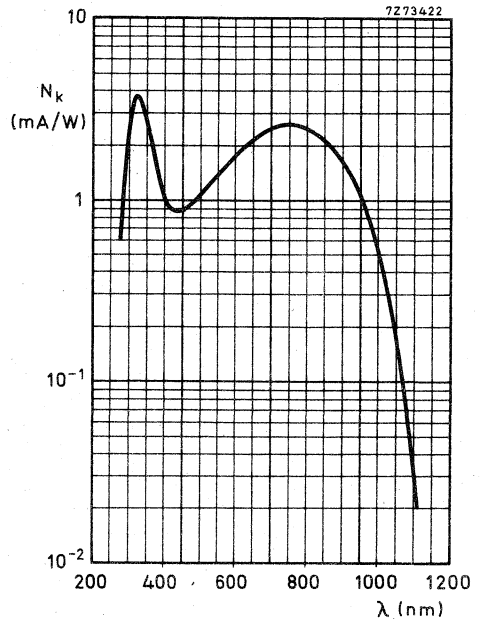


Fig. 3
Spectral sensitivity characteristic

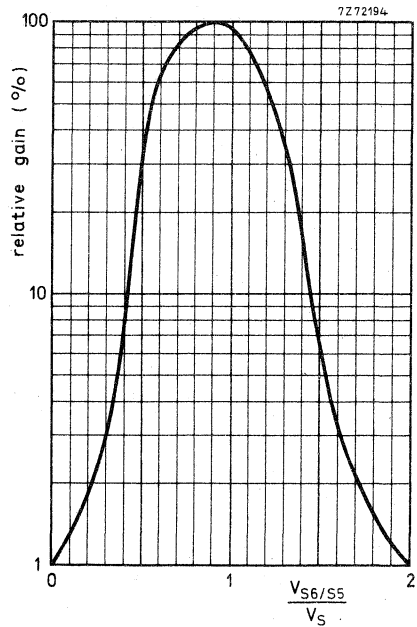


Fig. 4
Relative gain as a function of the
voltage between S6 and S5,
normalized to V_S
 $V_{S7/S5}$ constant

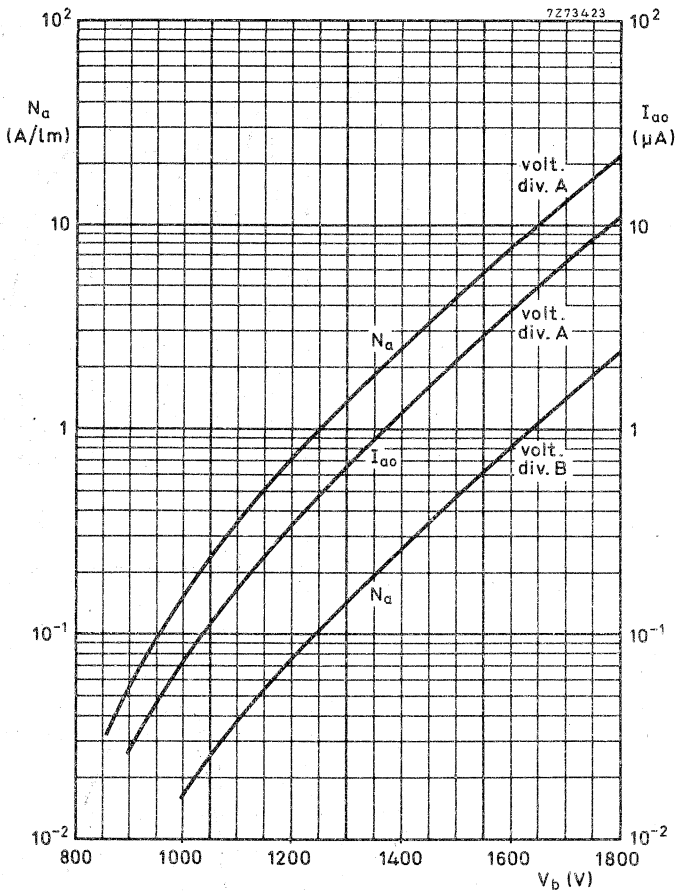


Fig. 5

Anode luminous sensitivity, N_a , and dark current, I_{a0} , 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	1) (see page 2)	typ. 140 μ A/lm > 100 μ A/lm
Spectral sensitivity at 698 ± 7 nm	2) (see page 2)	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

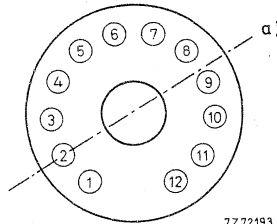
Number of stages			9
Dynode structure		linear	focused
Dynode material			Ag-Mg
Capacitances			
Anode to all	C_a	\approx	3 pF
Anode to final dynode	C_a/S_9	\approx	1,9 pF

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

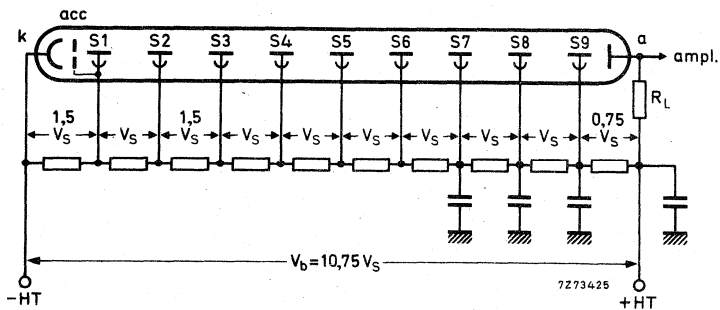


Fig.1 Voltage divider A

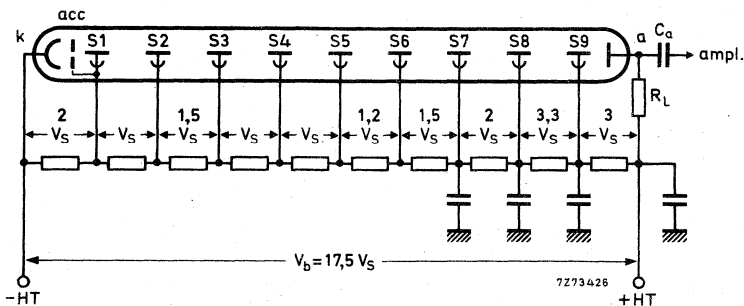


Fig.2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>	1)		
Supply voltage for an anode luminous sensitivity $N_a = 30 \text{ A/lm}$ (Fig. 5)		typ.	1520 V
		<	1800 V
Anode dark current at $N_a = 30 \text{ A/lm}$ (Fig. 5)	2) 3)	typ.	10 nA
		<	100 nA
Anode current linear within 2% at $V_b = 1800 \text{ V}$ up to		≈	10 mA
<u>With voltage divider B (Fig. 2)</u>	1)		
Anode luminous sensitivity at $V_b = 1800 \text{ V}$ (Fig. 5)		≈	15 A/lm
Anode pulse rise time at $V_b = 1800 \text{ V}$	4)	≈	3,5 ns
Anode pulse duration at half height at $V_b = 1800 \text{ V}$	4)	≈	6 ns
Signal transit time at $V_b = 1800 \text{ V}$	4)	≈	28 ns
Anode current linear within 2% at $V_b = 1800 \text{ V}$ 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

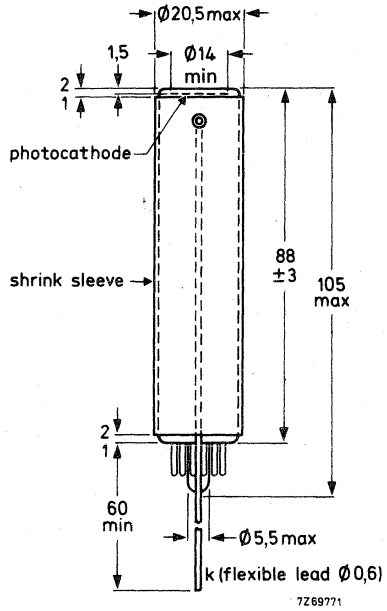
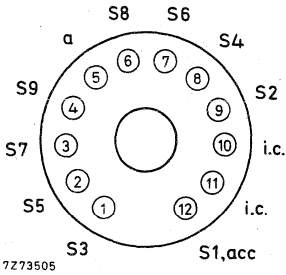
Notes see page 5.

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

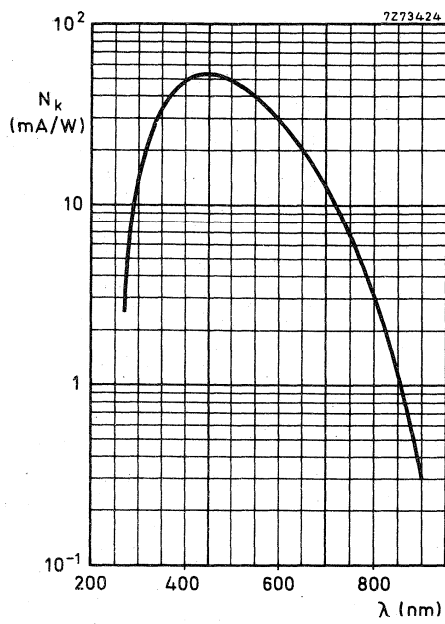


Fig. 3
Spectral sensitivity characteristic

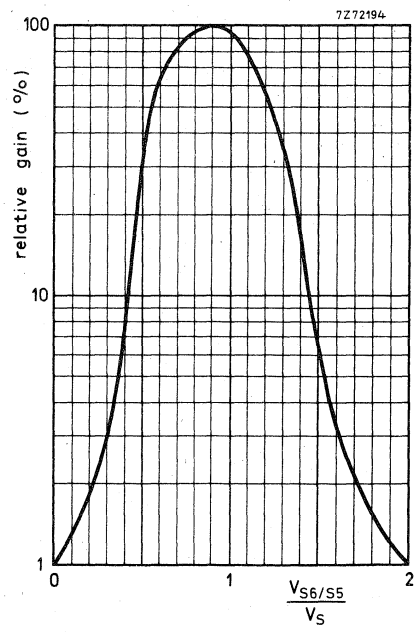


Fig. 4
Relative gain as a function of the voltage between S_6 and S_5 , normalized to V_S $V_{S7/S5}$ constant

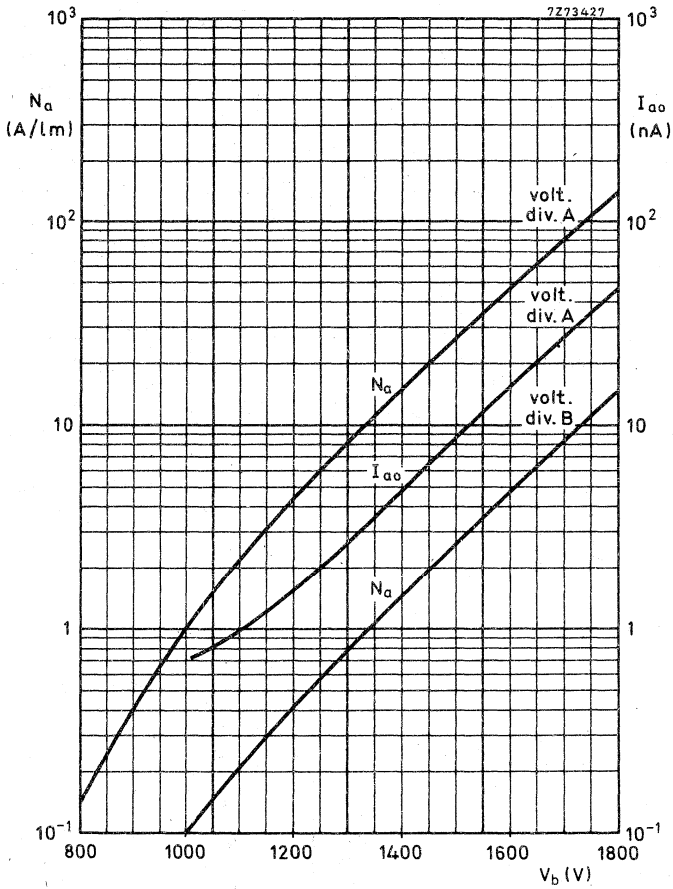


Fig. 5

Anode luminous sensitivity, N_a , and anode dark current, I_{a0} , as a function of supply voltage V_b

10-STAGE PHOTOMULTIPLIER TUBE

The XP1118 is a 14 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S13 photocathode. The tube is intended for use in optical measurements where a good sensitivity in the UV region is needed.

Its rugged construction makes it particularly suitable for industrial applications under limited dimensional conditions.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		S13	
Useful diameter of the photocathode	>	14 mm	
Spectral sensitivity of the photocathode at 437 nm		60 mA/W	
Supply voltage for an anode luminous sensitivity $N_a = 30$ A/lm		1400 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	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	> 14 mm
Spectral sensitivity characteristic (Fig. 3)	S13

Maximum spectral sensitivity at			420 ± 30 nm
Luminous sensitivity	1)	typ.	60 μA/lm
		>	40 μA/lm
Spectral sensitivity at 437 ± 5 nm	2)		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

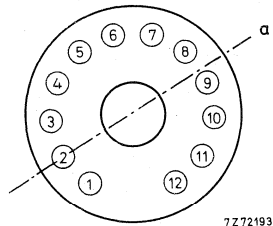
Number of stages			10
Dynode structure			linear focused
Dynode material			Ag-Mg
Capacitances			
Anode to all		C _a	~ 3 pF
Anode to final dynode		C _a /S10	~ 1,9 pF

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

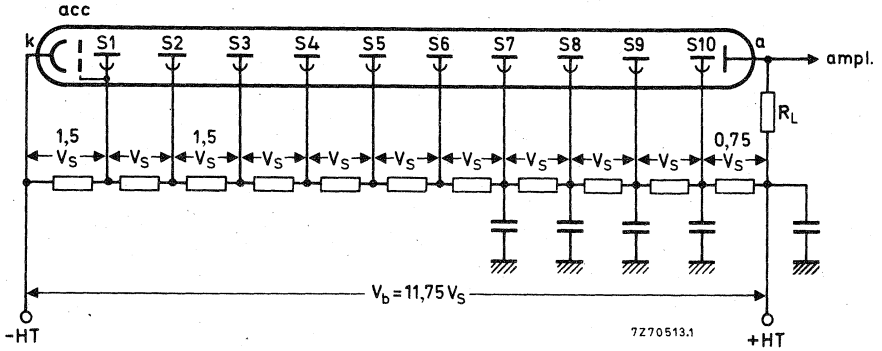


Fig. 1 Voltage divider A

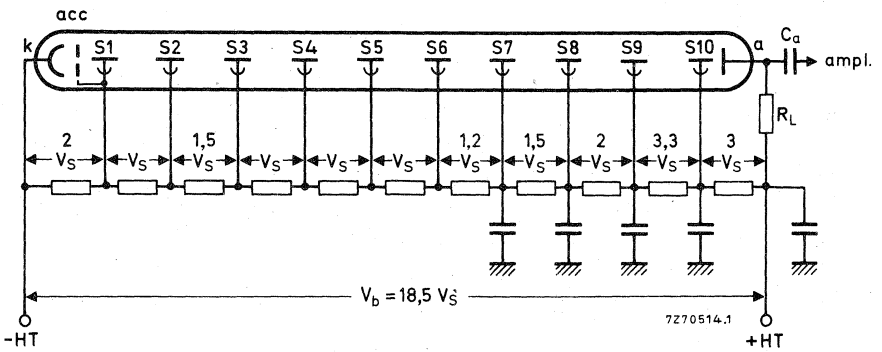


Fig. 2 Voltage divider B

k = cathode

Typical value of capacitors : 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>	1)		
Supply voltage for an anode luminous sensitivity $N_a = 30$ A/lm (Fig. 5)		typ. <	1400 V 1800 V
Anode dark current at $N_a = 30$ A/lm (Fig. 5)	2)3)	typ. <	2 nA 25 nA
Anode current linear within 2% at $V_b = 1800$ V up to		≈	10 mA
<u>With voltage divider B (Fig. 2)</u>	1)		
Anode luminous sensitivity at $V_b = 1800$ V (Fig. 5)		≈	30 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		max.	0,2 mA
Voltage between first dynode and photocathode	6)	max. min.	350 V 100 V
Voltage between consecutive dynodes		max.	200 V
Voltage between anode and final dynode	7)	max. min.	300 V 30 V
Ambient temperature range		max. min.	+70 °C -30 °C
Operational (for short periods of time)		max. min.	+50 °C -30 °C
Continuous operation and storage		max. min.	+50 °C -30 °C

Notes see page 5.

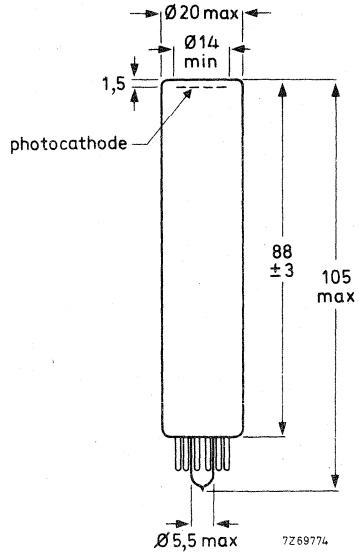
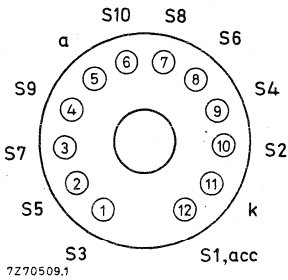
Notes to page 4

- 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 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 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.

XP1118

MECHANICAL DATA

Dimensions in mm



Net mass: 25 g

Base : 12-pin all-glass

ACCESSORIES

Socket : type FE 1004

Mu-metal shield: type 56134

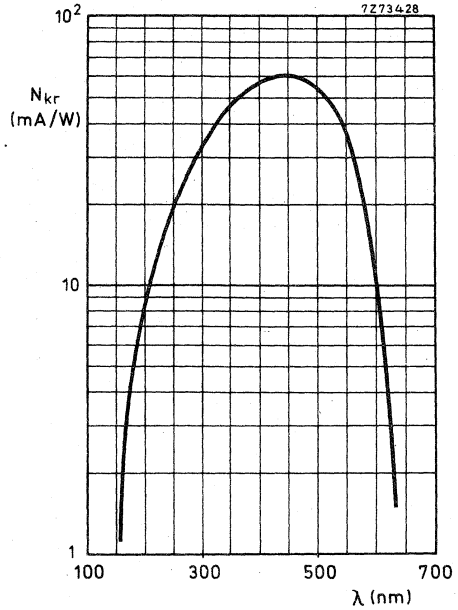


Fig. 3
Spectral sensitivity characteristic

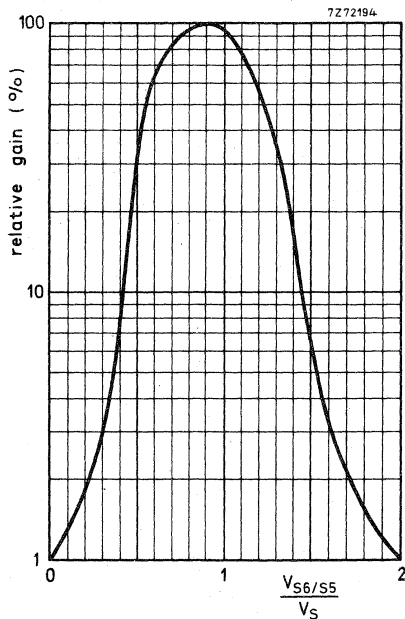


Fig. 4
Relative gain as a function of the voltage between S6 and S5 normalized to V_S
 $V_{S7/S5}$ constant

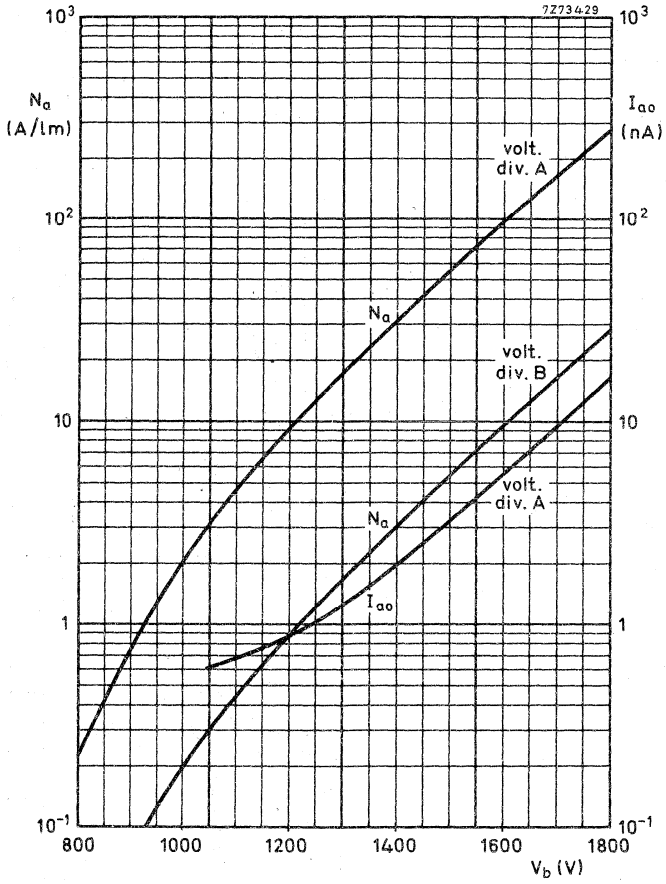


Fig. 5

Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of the 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 features a high cathode sensitivity and a good collection from each point of the photocathode combined with a very low dark current and a high gain stability.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D	
Useful diameter of the photocathode	>	44	mm
Quantum efficiency at 401 nm		29	%
Cathode spectral sensitivity at 401 nm		95	mA/W
Anode spectral sensitivity at $V_b = 1500$ V and 401 nm		20	kA/W
Anode dark current at $V_b = 1500$ V		1	nA
Pulse amplitude resolution (^{137}Cs)	\approx	7,5	%
Gain deviation at $V_b = 1500$ V	\approx	1	%

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on

Useful diameter > 44 mm

Spectral sensitivity characteristic (Fig. 3) type D

Material bialkaline Sb-K-Cs

Maximum spectral sensitivity at 400 ± 30 nm

Quantum efficiency at 401 ± 3 nm 29 %

Luminous sensitivity 1) 80 μA/lm

Spectral sensitivity at 401 ± 3 nm 2) typ. 95 mA/W
> 60 mA/W

Multiplier system

Number of stages 10

Dynode structure venetian blind

Dynode material Cu-Be

Capacitances

Anode to final dynode $C_{a/S10} \approx 7$ pF

Anode to all $C_a \approx 8,5$ pF

Magnetic field

See Fig. 7

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) Cathode spectral sensitivity is measured by placing an interference filter in front of a tungsten filament lamp of colour temperature 2856 ± 5 k. Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

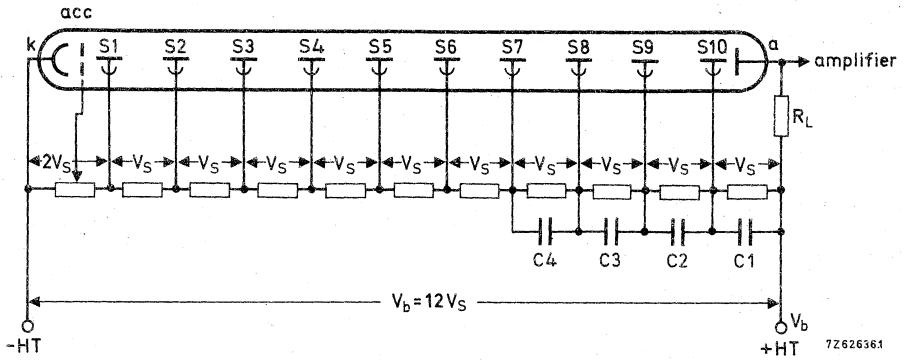


Fig.1 Voltage divider type A

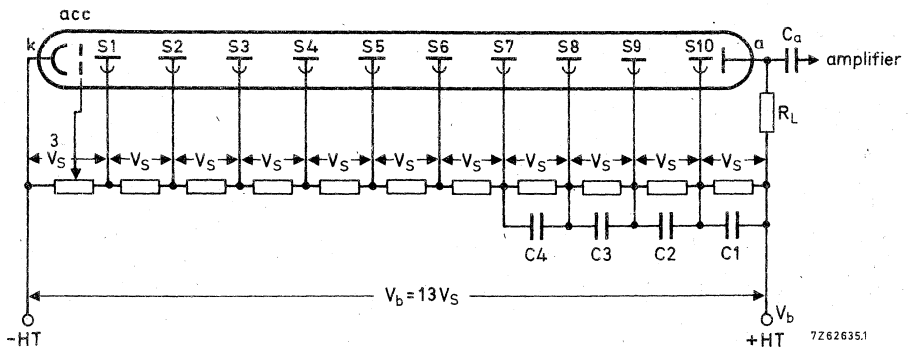


Fig.2 Voltage divider type A-1

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

Typical values of capacitors

C_1, C_2 = 10 nF
 C_3, C_4 = 5 nF

The accelerating electrode potential should be adjusted to obtain maximum anode current.

TYPICAL CHARACTERISTICS

1)

With voltage divider A (Fig. 1)

Anode luminous sensitivity at $V_b = 1800$ V		~	60	A/lm
Anode spectral sensitivity at $V_b = 1500$ V and 401 nm (Fig. 4)		typ.	20	kA/W
		>	10	kA/W
Anode dark current at $V_b = 1500$ V (Fig. 4)	2)	<	10	nA
		typ.	1	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. 4)		~	14	kA/W
Anode pulse rise time at $V_b = 1500$ V	3)	~	9	ns
Anode pulse width at half height at $V_b = 1500$ V	3)	~	18	ns
Signal transit time at $V_b = 1500$ V	3)	~	46	ns
Pulse amplitude resolution for ^{137}Cs at $V_b = 1500$ V 4)		~	7,5	%
Anode current linear within 2% at $V_b = 1500$ V up to		~	10	mA
Gain deviation at $V_b = 1500$ V				
- Long term (24 h)		~	1	%
- After change of count rate		~	1	%

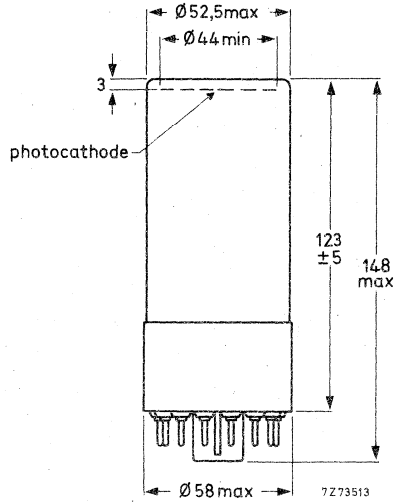
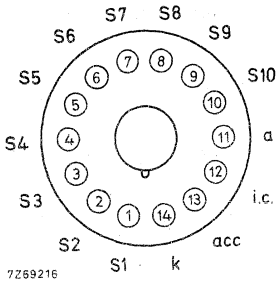
LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	2000	V
Continuous anode current	6)	max.	0,2	mA
Voltage between first dynode and photocathode	7)	max.	500	V
		min.	100	V
Voltage between accelerating electrode and photocathode	7)	max.	500	V
		min.	100	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	8)	max.	300	V
Ambient temperature range				
Operational (for short periods of time)		max.	+70	°C
		min.	-30	°C
Continuous operation and storage		max.	+50	°C
		min.	-30	°C

- 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.
To reduce this effects the glass envelope of the tube should only be supported by isolators having an insulation resistance of $> 10^{15} \Omega$.
- 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) 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.
- 5) Total HT supply voltage, or the voltage at which the tube has a gain of 3×10^6 , whichever is lower.
- 6) For applications requiring a high stability a value of $< 10 \mu\text{A}$ is recommended.
- 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



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

Net mass: 205 g

ACCESSORIES

Socket

type FE 1001

Mu-metal shield

type 56130

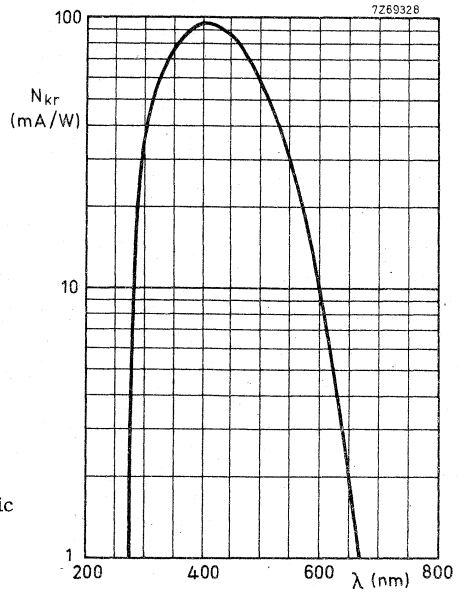


Fig. 3. Spectral sensitivity characteristic

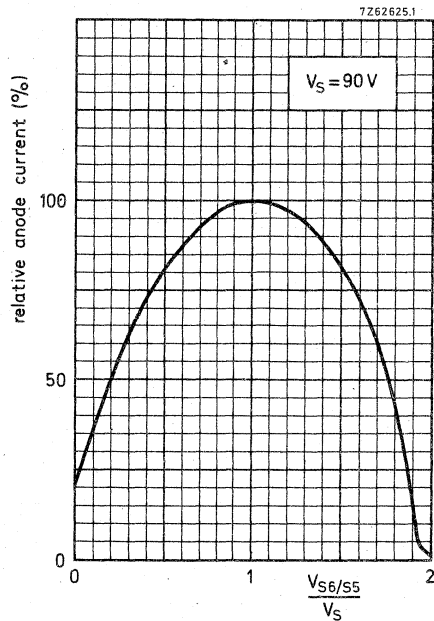


Fig. 5. Relative anode current as a function of the voltage between S6 and S5, normalized to V_S $V_{S7/S5}$ constant

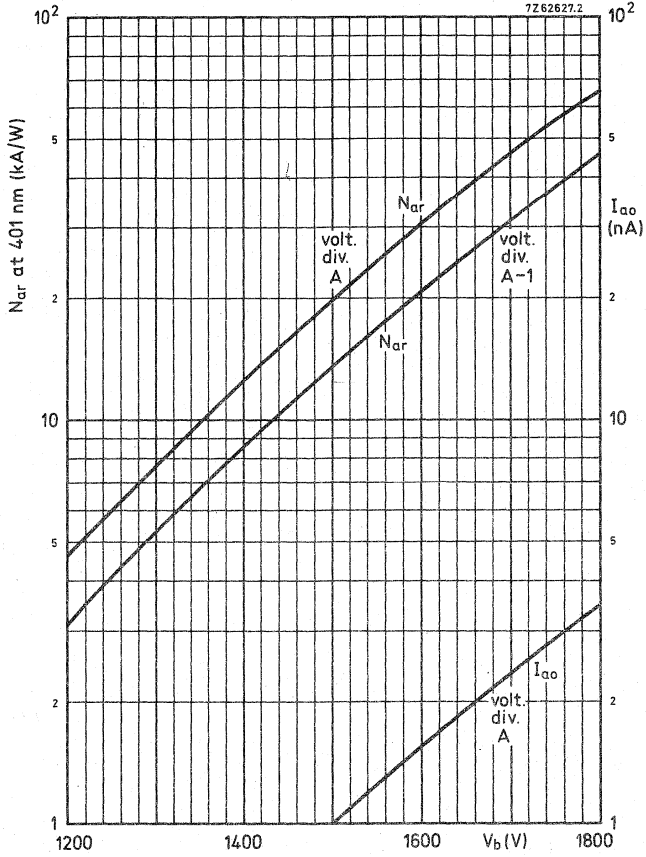


Fig. 4. Anode spectral sensitivity N_{ar} , and anode dark current I_{ao} as a function of the supply voltage V_b

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

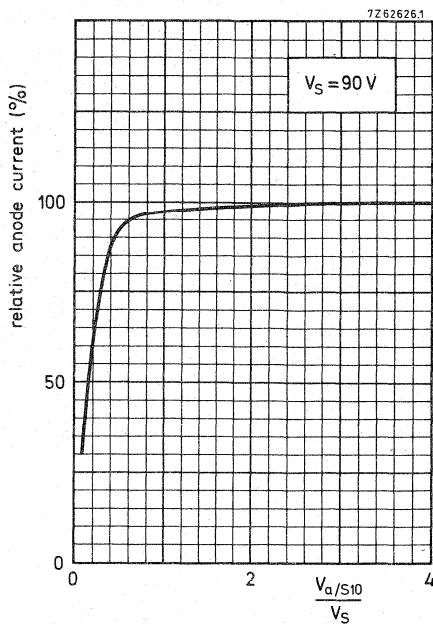
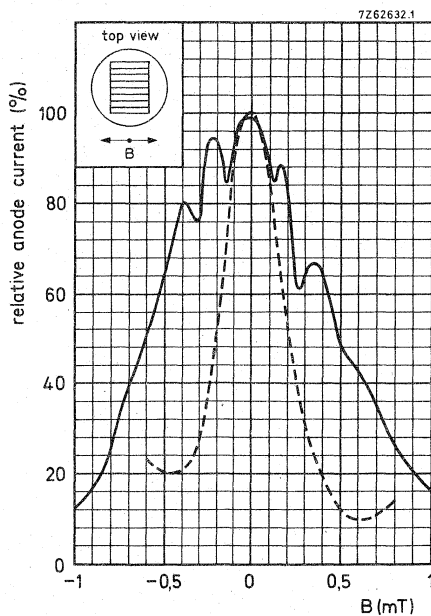


Fig. 7. Relative anode current as a function of the magnetic flux density B

----- $V_{acc} = V_{S1}$
 ——— V_{acc} adjusted for max. anode current
 Voltage divider A-1; $V_D = 1300 \text{ V}$



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		26	%
Spectral sensitivity of the photocathode at 401 nm		85	mA/W
Supply voltage for a gain of 3×10^7		2200	V
Pulse amplitude resolution for ^{137}Cs	\approx	7,5	%
Anode pulse rise time (with voltage divider B')	\approx	1,5	ns
Linearity, with voltage divider B	up to \approx	280	mA
Signal transit time fluctuation	\approx	0,25	ns

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

GENERAL CHARACTERISTICS

Window

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

Photocathode 1)

Semi-transparent, head-on	
Material	Sb-K-Cs
Useful diameter	> 44 mm

1) See page 5.

Spectral sensitivity characteristic (Fig. 4)

type D

Maximum spectral sensitivity at

400 ± 30 nm

Quantum efficiency at 401 nm

26 %

Spectral sensitivity at 401 ± 5 nm ²⁾

typ. 85 mA/W
> 60 mA/W

Electron-optical input system

This system consists of: the photocathode, k; the focusing electrode g_1 ; the accelerating electrode, acc, internally connected to S_5 ; the electrode g_2 , internally connected to S_1 .

Multiplier system

Number of stages

12

Dynode structure

linear focused

Dynode material

Ag-Mg

Capacitances

Grid no. 1 to $k + S_1 + acc + g_2 + S_5$

$C_{g, /k, S1, acc, g2, S5} \approx 20$ pF

Anode to all

$C_a \approx 7$ pF

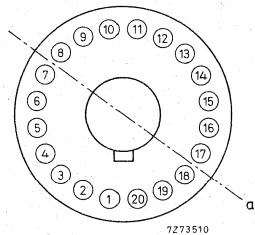
Anode to final dynode

$C_{a/S12} \approx 4$ pF

Magnetic field

See Fig. 5

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).

²⁾ See page 5.

RECOMMENDED CIRCUITS

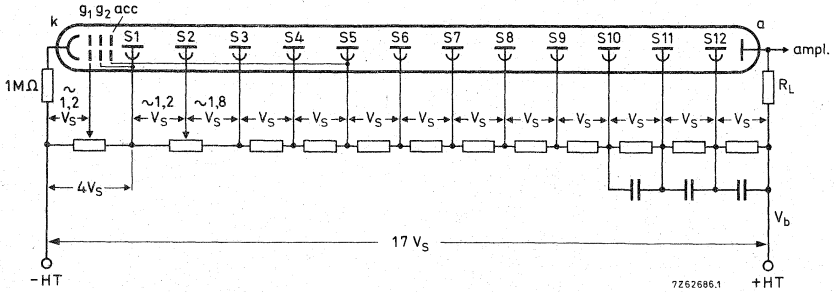


Fig. 1. Voltage divider type A

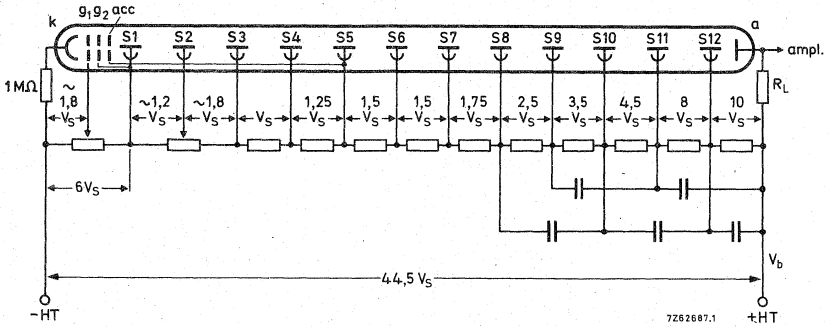


Fig. 2. Voltage divider type B

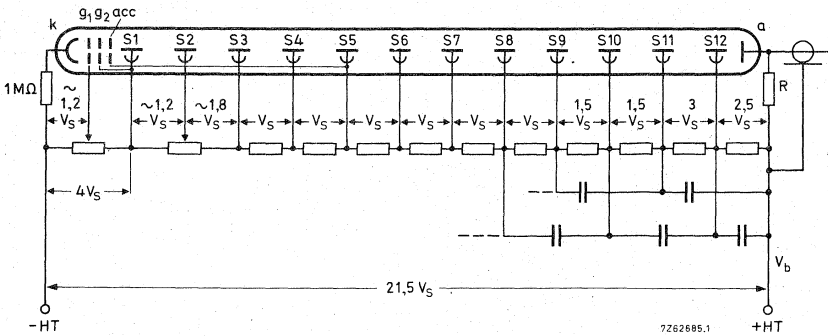


Fig. 3. Voltage divider type B'

- k = cathode
- g₁, g₂ = 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

<u>With voltage divider A (Fig. 1)</u>	3)		
Supply voltage for a gain $G = 3 \times 10^7$ (Fig. 6)		typ.	2200 V
		<	2600 V
Anode dark current at $G = 3 \times 10^7$ (Fig. 6)	4)5)	typ.	7 nA
		<	100 nA
Background noise at $G = 3 \times 10^7$ (Fig. 9)	6)	typ.	900 c/s
		<	2500 c/s
Pulse amplitude resolution for ^{55}Fe at $V_b = 1500$ V	7)	~	43 %
Peak to valley ratio for ^{55}Fe at $G = 3 \times 10^7$		~	34
Pulse amplitude resolution for ^{137}Cs at $V_b = 1500$ V	7)	~	7,5 %
Anode pulse rise time at $V_b = 2000$ V	8)14)	~	1,6 ns
Anode pulse duration at half height at $V_b = 2000$ V	8)14)	~	3,7 ns
Signal transit time at $V_b = 2000$ V	8)14)	~	28 ns
Anode current linear within 2% at $V_b = 2000$ V up to		~	25 mA
Obtainable peak anode current		~	100 mA
<u>With voltage divider B (Fig. 2)</u>	3)		
Gain at $V_b = 2800$ V		~	2×10^6
Anode pulse rise time at $V_b = 2800$ V	8)14)	~	1,7 ns
Anode pulse duration at half height at $V_b = 2800$ V	8)14)	~	2,7 ns
Signal transit time at $V_b = 2800$ V	8)14)	~	31 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2800$ V		~	0,25 ns
Anode current linear within 2% at $V_b = 2800$ V up to		~	280 mA
Obtainable peak anode current		~	0,5 to 1 A
<u>With voltage divider B' (Fig. 3)</u>	3)		
Gain at $V_b = 2500$ V		~	2×10^7
Anode pulse rise time at $V_b = 2500$ V	8)14)	~	1,5 ns
Anode pulse duration at half height at $V_b = 2500$ V	8)14)	~	2,4 ns
Signal transit time at $V_b = 2500$ V	8)14)	~	30 ns

Notes see page 5 and 6.

Signal transit time fluctuation at $V_b = 2500$ V	13)14)	\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

- 1) The alkali 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.
- 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. 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.
- 4) 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 $> 10^{15} \Omega$.
- 5) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ 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 (Fig.9).
- 7) 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 $\approx 10^3$ c/s.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	9)	max.	3000	V
Continuous anode current		max.	0,2	mA
Voltage between focusing electrode, g_1 and photocathode	10)	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}	14)	max.	600	V
Voltage between anode and final dynode	11)	max.	700	V
		min.	80	V
Ambient temperature range	12)	max.	+80	°C
Operational (for short periods of time)		min.	-30	°C
		max.	+50	°C
Continuous operation and storage		min.	-30	°C

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 a gain of 2×10^8 , 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.

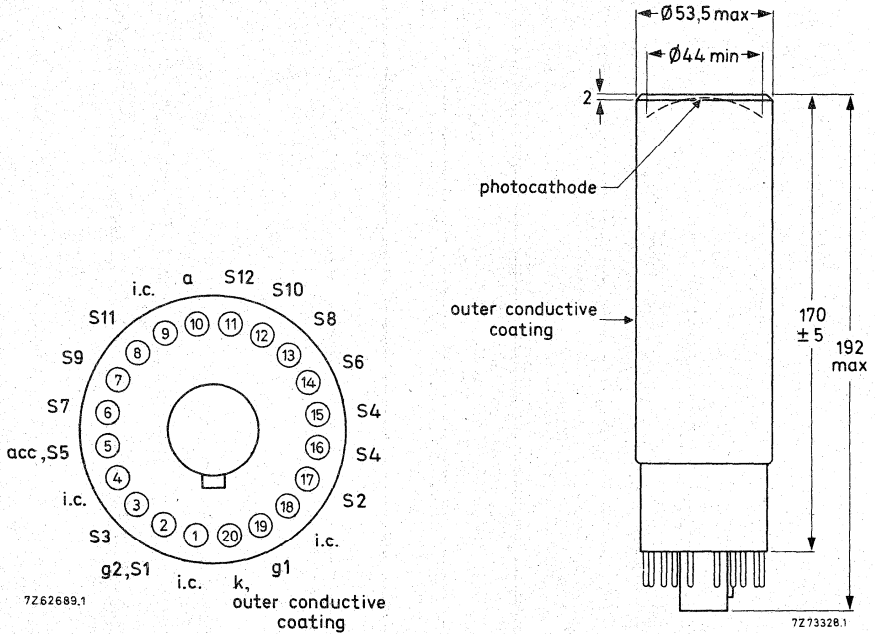
12) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

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

14) Non-inductive resistors of 50Ω are incorporated in the base connected to S_{11} and S_{12} . See also "General Operational Recommendations Photomultiplier Tubes".

MECHANICAL DATA

Dimensions in mm



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

Net mass: 240 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket : type FE1003

Mu-metal shield: type 56130

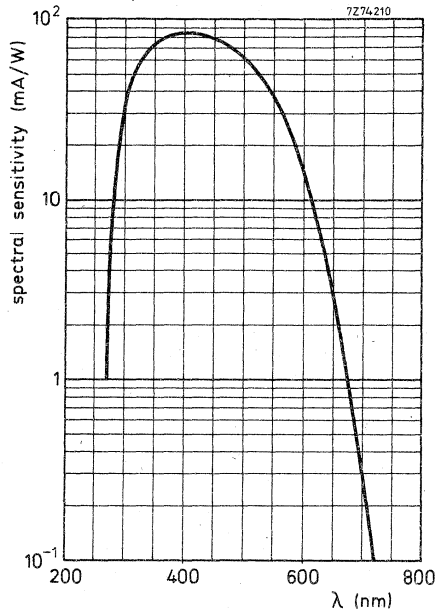


Fig. 4
Spectral sensitivity characteristic

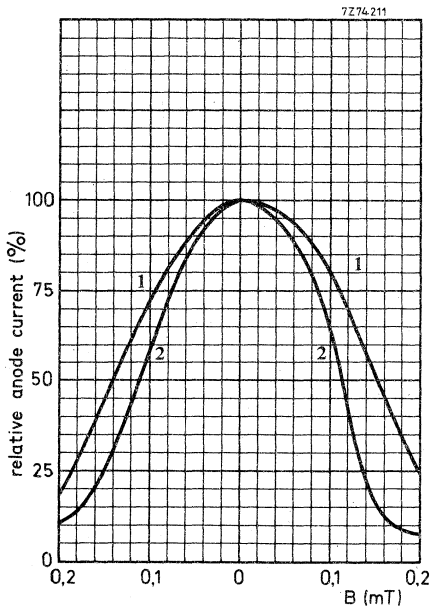


Fig. 5
Relative anode current as a function
the magnetic flux density B.
1. \perp axis a
2. \parallel axis a

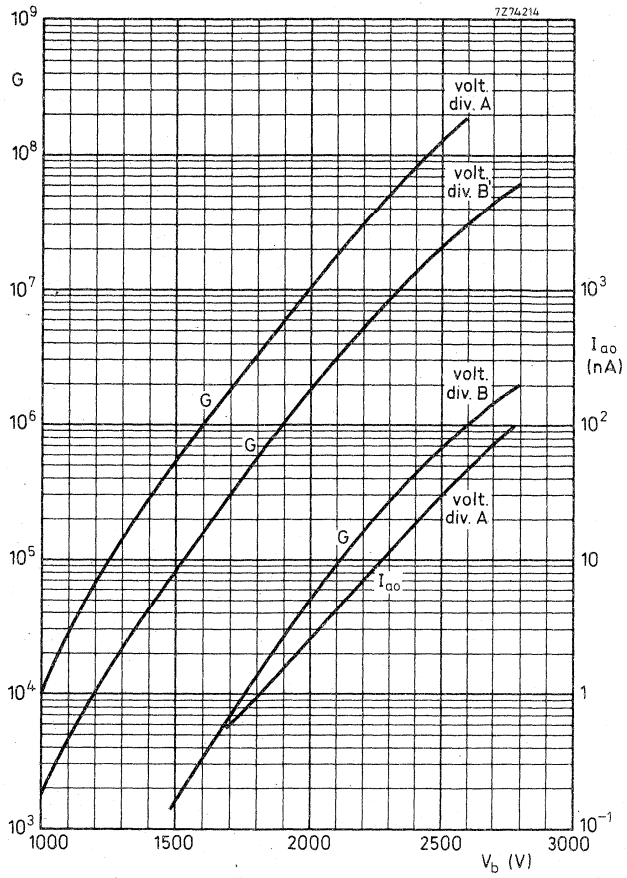


Fig. 6

Gain, G , and anode dark current, I_{a0} , as a function of supply voltage V_b .

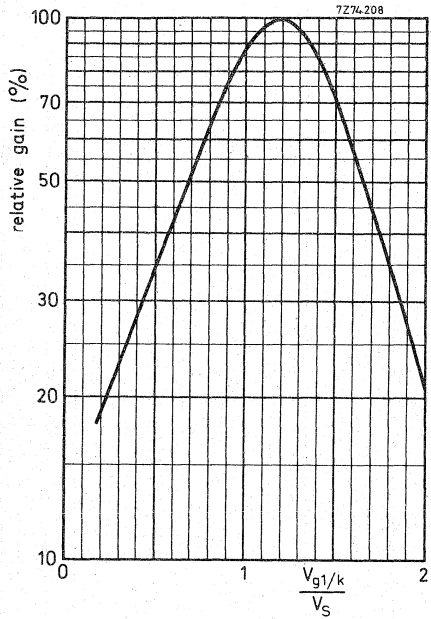


Fig. 7
Relative gain as a function of the voltage between grid no. 1 and cathode, normalized to V_S . $V_{S1/k}$ constant.

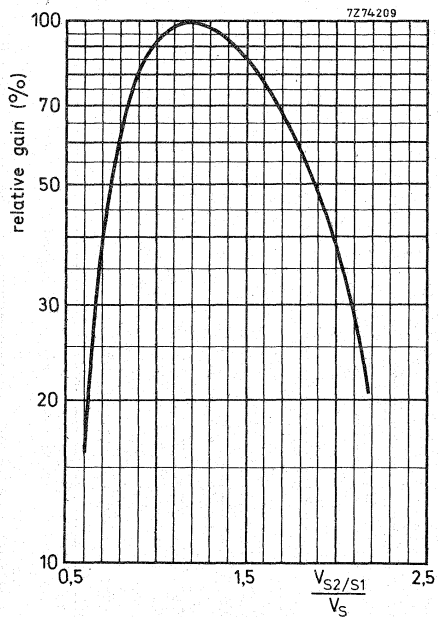


Fig. 8
Relative gain as a function of the voltage between S_2 and S_1 , normalized to V_S . $V_{S3/S1}$ constant.

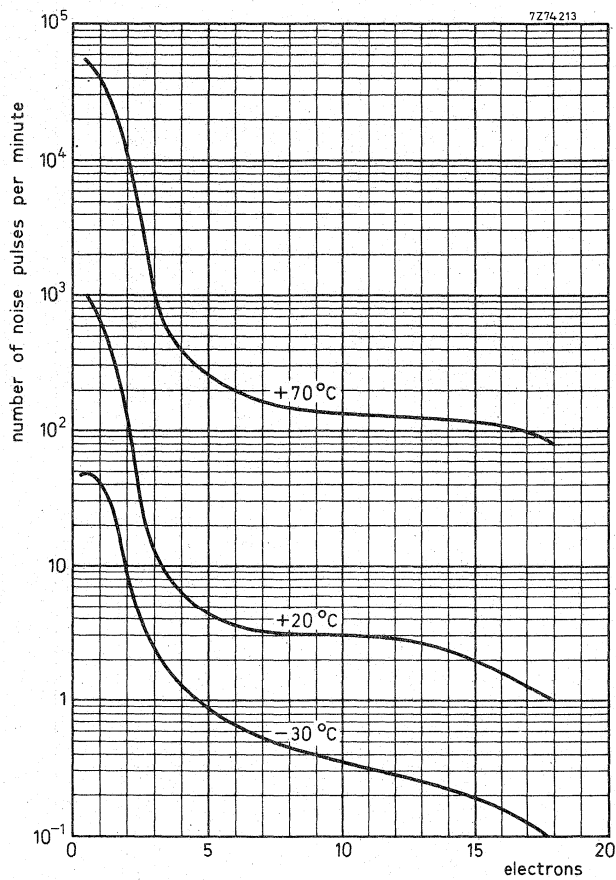


Fig. 9

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

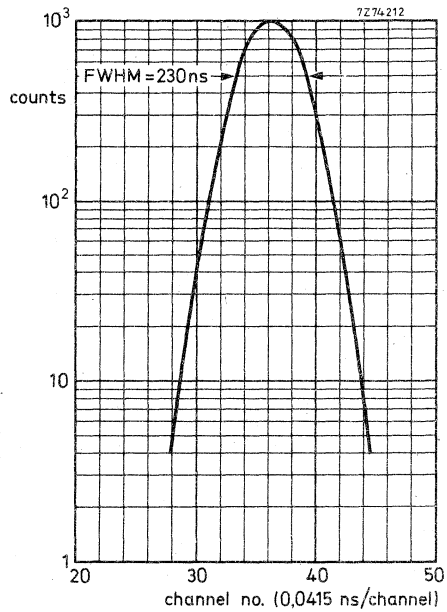


Fig. 10

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%.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

The XP2030 is a 68 mm (useful diameter) head-on photomultiplier tube with a flat window and a semi-transparent bilakaline type D photocathode. The tube is intended for use in nuclear physics where a very good pulse amplitude resolution is required. The tube features a high cathode sensitivity and a good collection from each point of the photocathode combined with a very low dark current and a high gain stability.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		type D	
Useful diameter of the photocathode	>	68	mm
Quantum efficiency at 401 nm		35	%
Cathode spectral sensitivity at 401 nm		115	mA/W
Anode spectral sensitivity at $V_b = 1500$ V and 401 nm		20	kA/W
Anode dark current at $V_b = 1500$ V		1	nA
Pulse amplitude resolution (^{137}Cs)	\approx	7,5	%
Gain deviation at $V_b = 1500$ V	\approx	1	%

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on

Useful diameter	>	68	mm
Spectral sensitivity characteristic (Fig. 3)		type D	
Material		bialkaline Sb-K-Cs	
Maximum spectral sensitivity at		400 ± 30	nm
Quantum efficiency at 401 ± 3 nm		≈ 35	%
Luminous sensitivity	1)	90	μA/lm
Spectral sensitivity at 401 ± 3 nm	2)	typ. 115	mA/W
		> 60	mA/W

Multiplier system

Number of stages		10	
Dynode structure		venetian blind	
Dynode material		Cu-Be	
Capacitances			
Anode to final dynode	$C_a/S10$	≈ 7	pF
Anode to all	C_a	≈ 8,5	pF

Magnetic field

See Fig. 7

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) Cathode spectral sensitivity is measured by placing an interference filter in front of a tungsten filament lamp of colour temperature 2856 ± 5 K. Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUIT

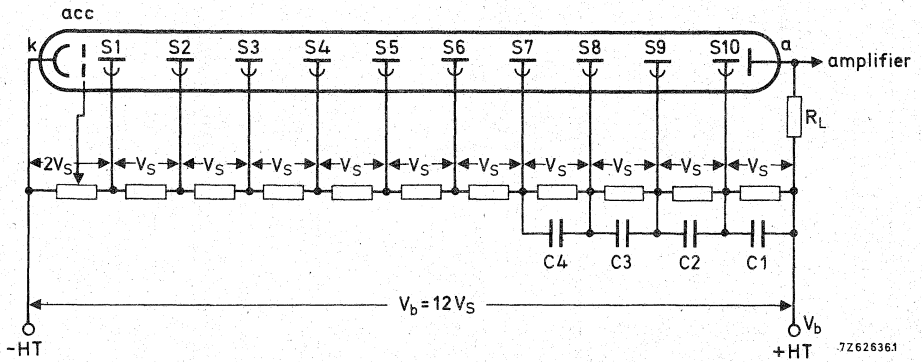


Fig. 1. Voltage divider type A

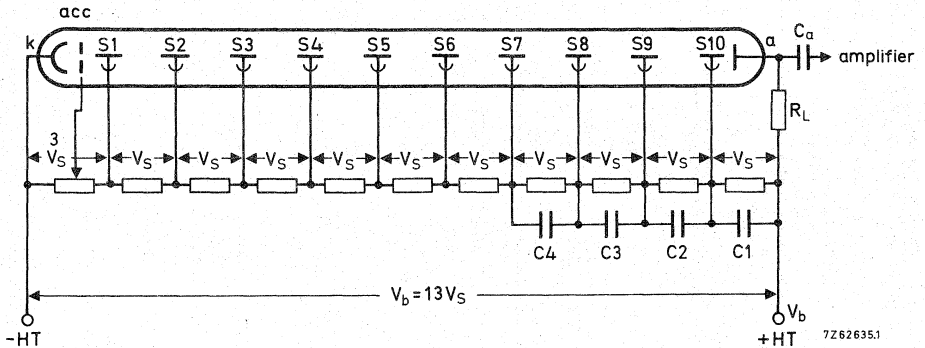


Fig. 2. Voltage divider type A-1

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

Typical values of capacitors

- C_1, C_2 = 10 nF
- C_3, C_4 = 5 nF

The accelerating electrode potential should be adjusted to obtain maximum anode current.

TYPICAL CHARACTERISTICS

1)

With voltage divider A (Fig. 1)

Anode luminous sensitivity at $V_b = 1800$ V		~	60	A/lm
Anode spectral sensitivity at $V_b = 1500$ V and 401 nm (Fig. 4)		typ.	20	kA/W
		>	10	kA/W
Anode dark current at $V_b = 1500$ V (Fig. 4)	2)	<	10	nA
		typ.	1	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. 4)		~	14	kA/W
Anode pulse rise time at $V_b = 1500$ V	3)	~	10	ns
Anode pulse width at half height at $V_b = 1500$ V	3)	~	20	ns
Signal transit time at $V_b = 1500$ V	3)	~	53	ns
Pulse amplitude resolution for ^{137}Cs at $V_b = 1500$ V 4)		~	7,5	%
Anode current linear within 2% at $V_b = 1500$ V up to		~	10	mA
Gain deviation at $V_b = 1500$ V				
-Long term (24 h)		~	1	%
-After change of count rate		~	1	%

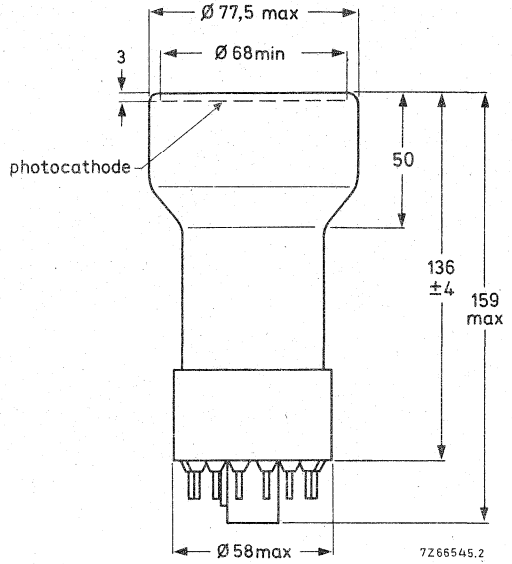
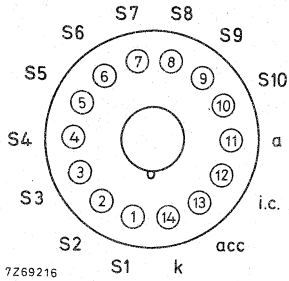
LIMITING VALUES (Absolute max. rating system)

Supply voltage	5)	max.	2000	V
Continuous anode current	6)	max.	0,2	mA
Voltage between first dynode and photocathode	7)	max.	500	V
		min.	100	V
Voltage between accelerating electrode and photocathode	7)	max.	500	V
		min.	100	V
Voltage between consecutive dynodes		max.	300	V
Voltage between anode and final dynode	8)	max.	300	V
Ambient temperature range				
Operational (for short periods of time)		max.	+70	°C
		min.	-30	°C
Continuous operation and storage		max.	+50	°C
		min.	-30	°C

- 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.
To reduce this effect the glass envelope of the tube should only be supported by isolators having an insulation resistance $> 10^{15} \Omega$.
- 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) Pulse amplitude resolution for ^{137}Cs is measured with a NaI(Tl) cylindrical scintillator, with a diameter of 75 mm and a height of 75 mm.
- 5) Total HT supply voltage, or the voltage at which the tube has a gain of 3×10^6 , whichever is lower.
- 6) For applications requiring a high stability a value of $< 10 \mu\text{A}$ is recommended.
- 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



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

Net mass : 245 g

ACCESSORIES

Socket type FE 1001

Mu-metal shield type 56135

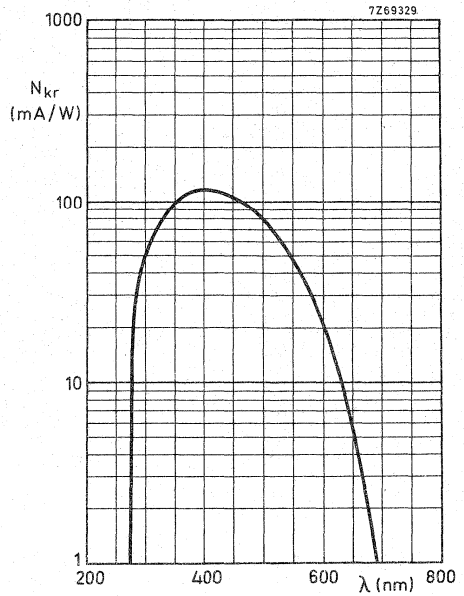


Fig. 3. Spectral sensitivity characteristic

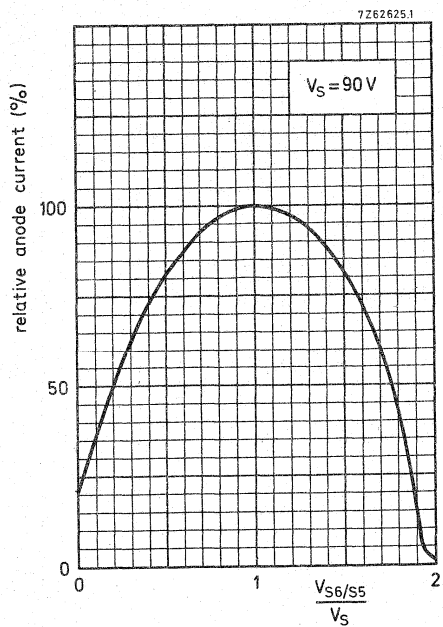


Fig. 5. Relative anode current as a function of the voltage between S6 and S5, normalized to V_S VS7/S5 constant

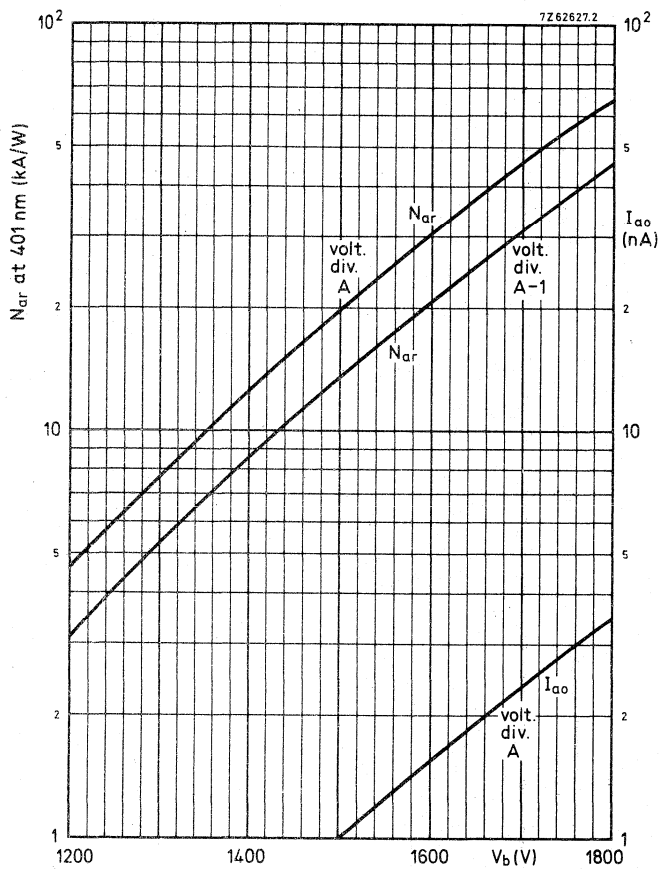


Fig. 4. Anode spectral sensitivity N_{ar} , and anode dark current I_{a0} as a function of the supply voltage V_b

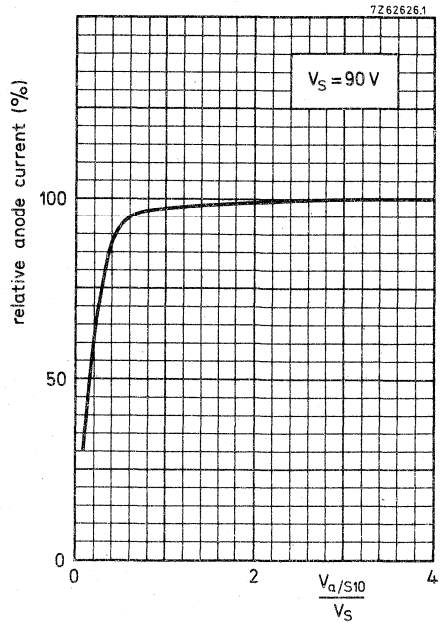


Fig. 6. Relative anode current as a function of the voltage between anode and last dynode, normalized to V_S

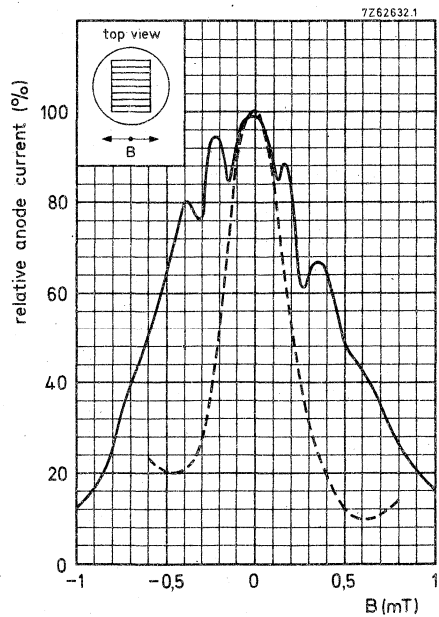


Fig. 7. Relative anode current as a function of the magnetic flux density B

---- $V_{acc} = V_{S1}$

— V_{acc} adjusted for max. anode current

Voltage divider A-1; $V_b = 1300\text{ V}$

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	1)	typ. 70	μA/lm
		> 45	μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈ 70	mA/W

Multiplier system

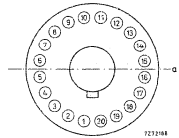
Number of stages		14
Dynode structure		linear focused
Dynode material		Ag-Mg
Capacitances		
Grid no. 1 to k+g2+acc+S1	$C_{g1/k, g2, acc, S1} \approx$	70 pF
Anode to final dynode	$C_{a/S14} \approx$	5 pF
Anode to all	$C_a \approx$	7 pF

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.



- 1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.
- 2) Cathode spectral sensitivity is measured by placing an interference filter in front of a tungsten filament lamp of colour temperature 2856 ± 5 K.
Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

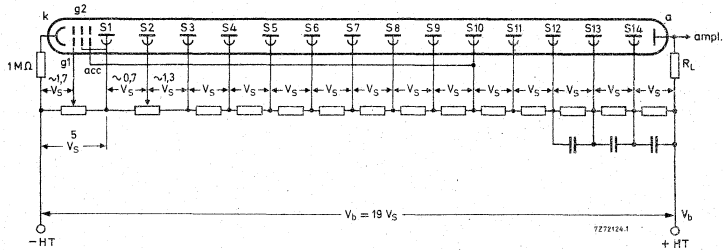


Fig. 1 Voltage divider A

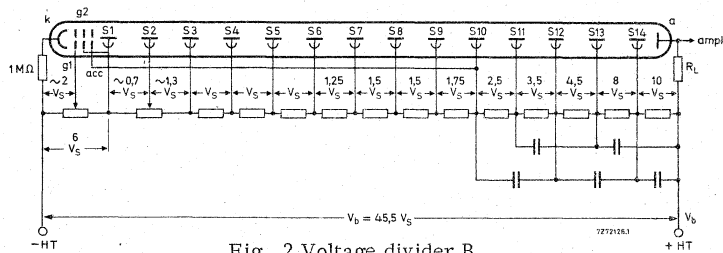


Fig. 2 Voltage divider B

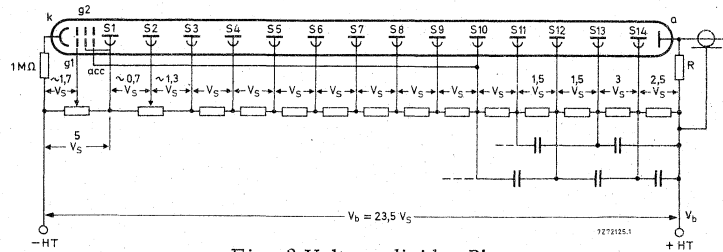


Fig. 3 Voltage divider B'

- k = cathode
- g₁, g₂ = 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 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)	< typ.	2700 2000	V V
Anode dark current at $G = 3 \times 10^7$, Fig. 6	1) 2)	< typ.	4 0,2	μ A μ A
Anode pulse rise time at $V_b = 2200$ V	3) 4)	\approx	2,5	ns
Anode pulse width at half height at $V_b = 2200$ V	3)	\approx	5	ns
Signal transit time at $V_b = 2200$ V	3)	\approx	46	ns
Anode current linear within 2%, at $V_b = 2200$ V up to		\approx	30	mA
Obtainable peak anode current		\approx	200	mA

With voltage divider B (Fig. 2)

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

With voltage divider B' (Fig. 3)

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

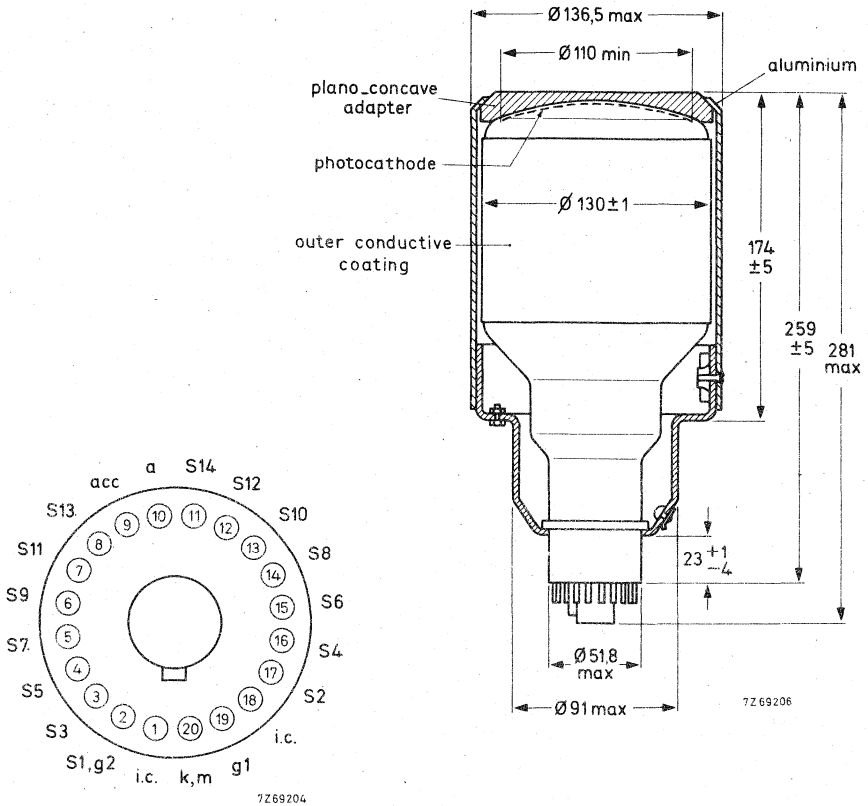
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.

Where low temperature operation is contemplated, the supplier should be consulted.

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

MECHANICAL DATA

Dimensions in mm



Base : 20-pin (JEDEC B20-102)

Net mass : 1340 g

ACCESSORIES

Socket type FE1003

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.

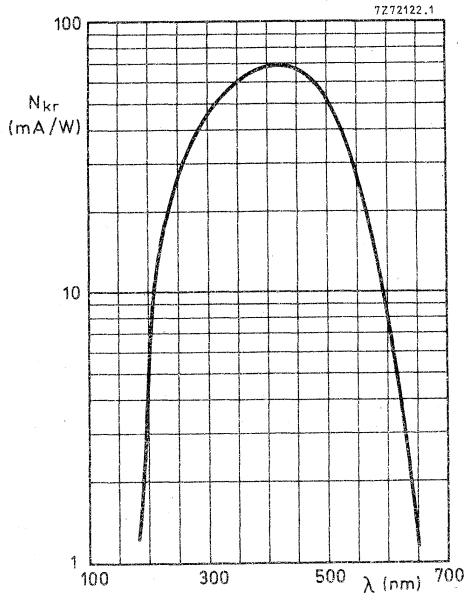


Fig. 4
Spectral sensitivity characteristic
(without adapter, or with quartz adapter).

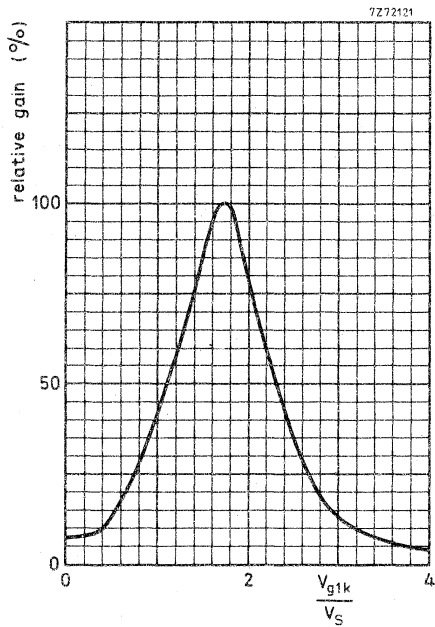


Fig. 5
Relative gain as a function of the voltage
between focusing electrode g_1 and photo-
cathode k , normalized to V_S .

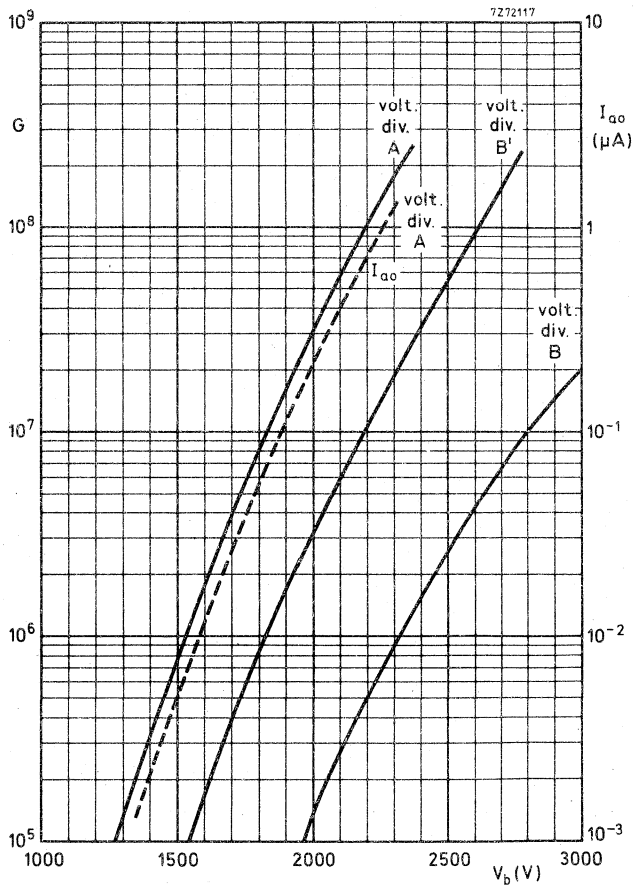


Fig. 6

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

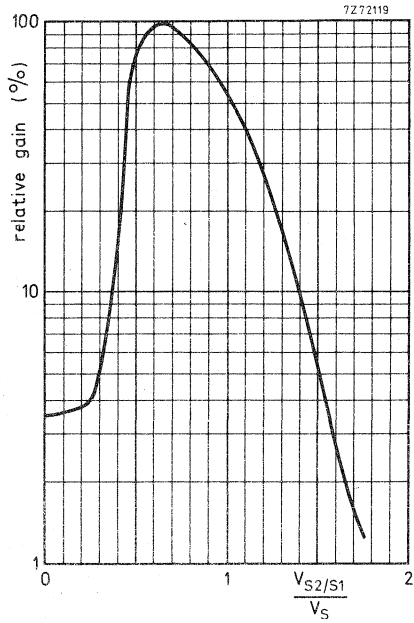


Fig. 7

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

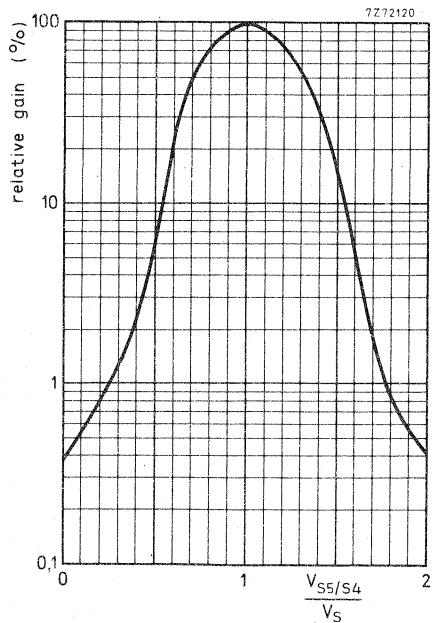


Fig. 8

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 1) typ. 85 mA/W
> 65 mA/W

Multiplier system

Number of stages 14

Dynode structure linear focused

Dynode material Ag-Mg

Capacitances

Grid no. 1 to k+g₂+acc+S1 $C_{g1/k, g2, acc, S1} \approx 70$ pF

Anode to final dynode $C_{a/S14} \approx 5$ pF

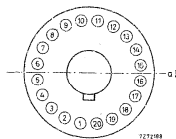
Anode to all $C_a \approx 7$ pF

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.



1) Cathode spectral sensitivity is measured by placing an interference filter in front of a tungsten filament lamp of colour temperature 2856 ± 5 K.

Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

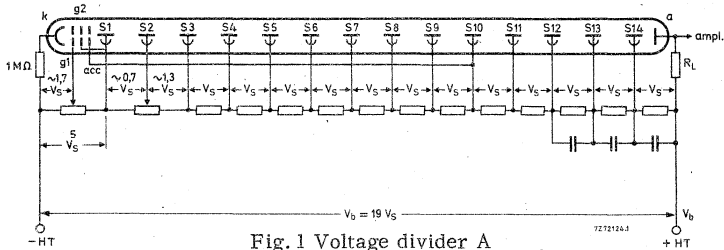


Fig. 1 Voltage divider A

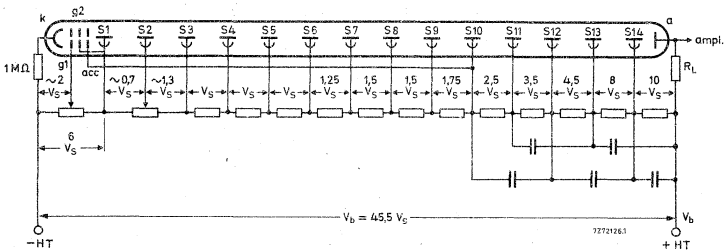


Fig. 2 Voltage divider B

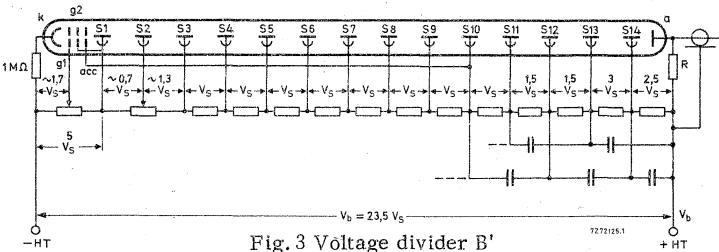


Fig. 3 Voltage divider B'

- k = cathode
- g1, g2 = 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 2V_S for voltage divider B.

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 $G = 3 \times 10^7$, 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 $V_b = 2500$ 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 ($\approx 1/4$ 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 50Ω 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	$^{\circ}C$
		min.	-30	$^{\circ}C$
continuous operation and storage		max.	+50	$^{\circ}C$
		min.	-30	$^{\circ}C$

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.

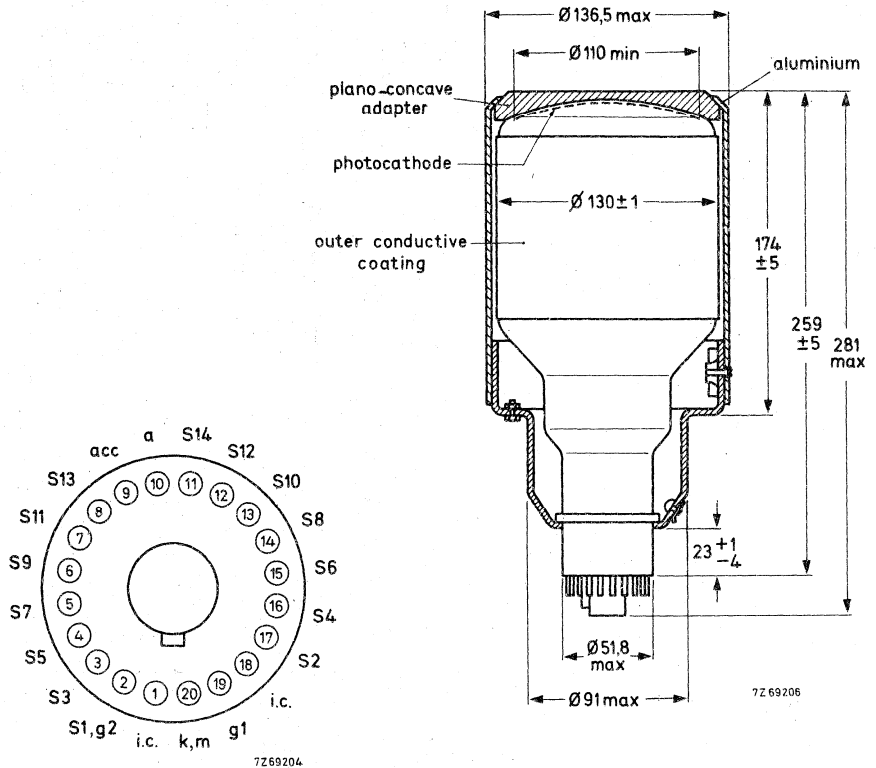
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.

Where lowtemperature 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 FE1003
 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.

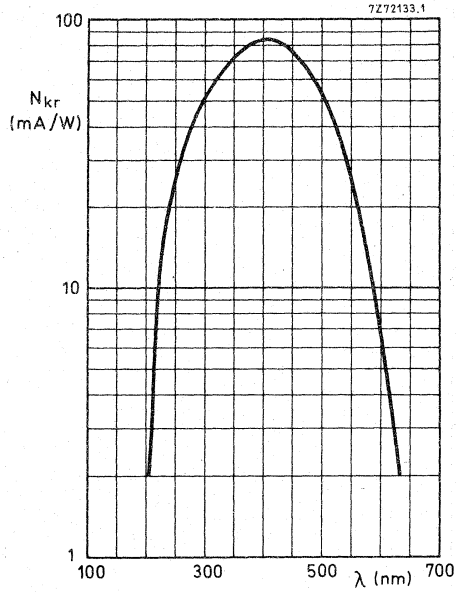


Fig. 4

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

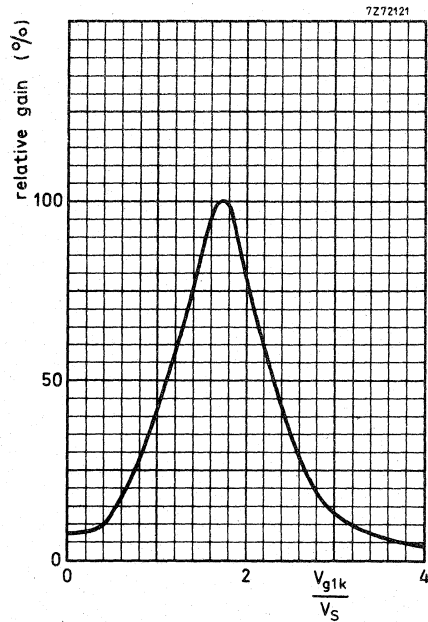


Fig. 5

Relative gain as a function of the voltage
between focusing electrode g_1 and photo-
cathode, normalized to V_s .

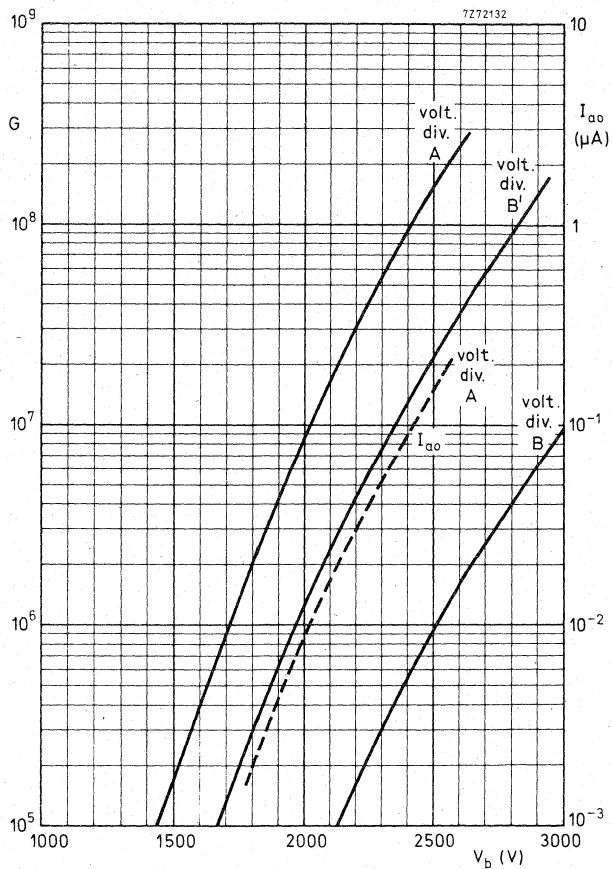


Fig. 6

Gain, G , and anode dark current, I_{a0} , as a function of supply voltage V_b .

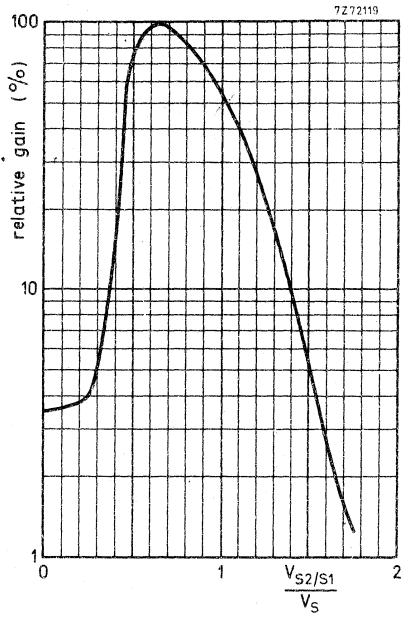


Fig. 7

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

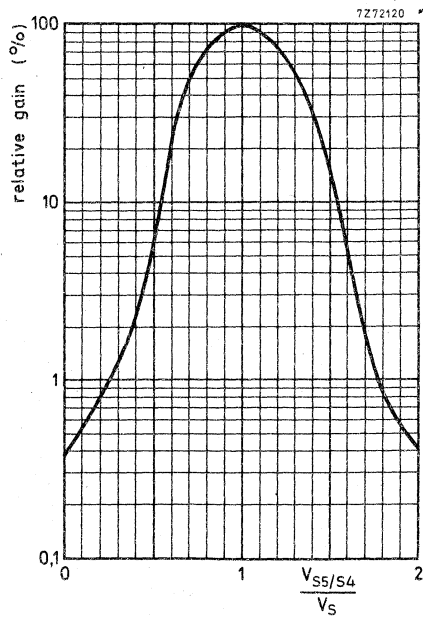


Fig. 8

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

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

Data based on pre-production tubes.

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.

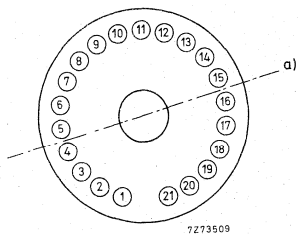
Multiplier system

Number of stages	12
Dynode structure	linear focused
Dynode material	Ag-Mg
Capacitances	
Anode to all	$C_a \approx 6$ pF
Anode to final dynode	$C_a/S12 \approx 4$ pF

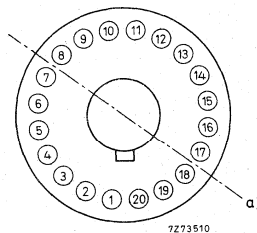
Magnetic field

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

Dynode axis with respect to base pins (bottom view)

Notes see page 5.

RECOMMENDED CIRCUITS

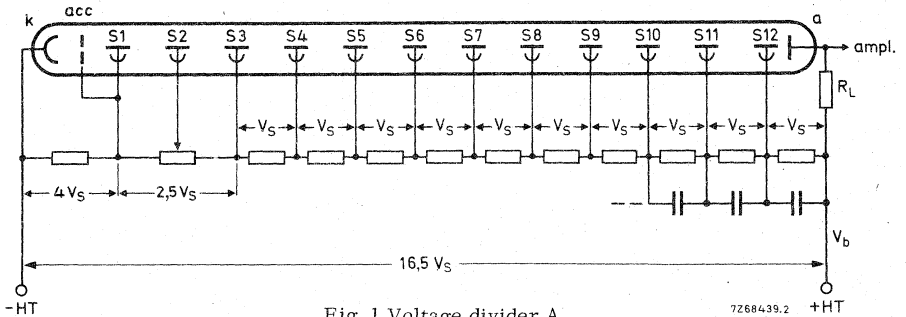


Fig. 1 Voltage divider A

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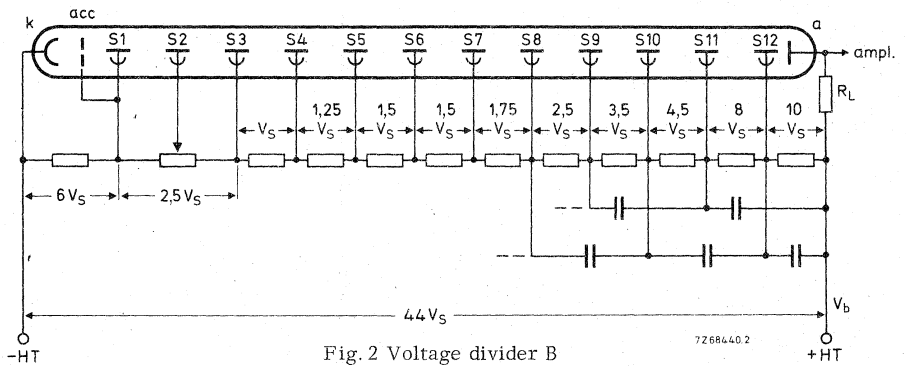


Fig. 2 Voltage divider B

7Z68440.2

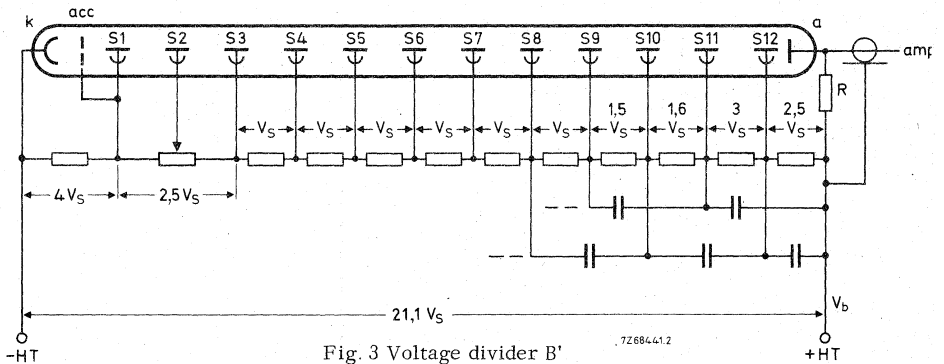


Fig. 3 Voltage divider B'

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- 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

<u>With voltage divider A</u> (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
<u>With voltage divider B</u> (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
<u>With voltage divider B'</u> (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	\approx	70 mA
Obtainable peak anode current	\approx	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 precautions to protect the user. The glass envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15} \Omega$.
- 5) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4$ 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 $V_b^{-1/2}$.
- 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		max.	+80	°C
Operational (for short periods of time)		min.	-80	°C
Continuous operation and storage		max.	+50	°C
		min.	-80	°C
XP2230B		max.	+80	°C
Operational (for short periods of time)	13)	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.

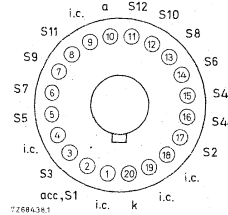
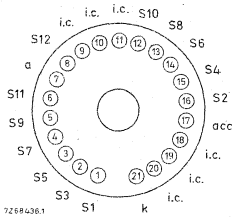
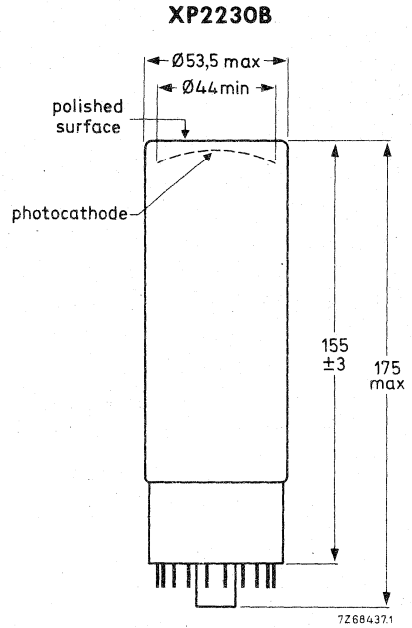
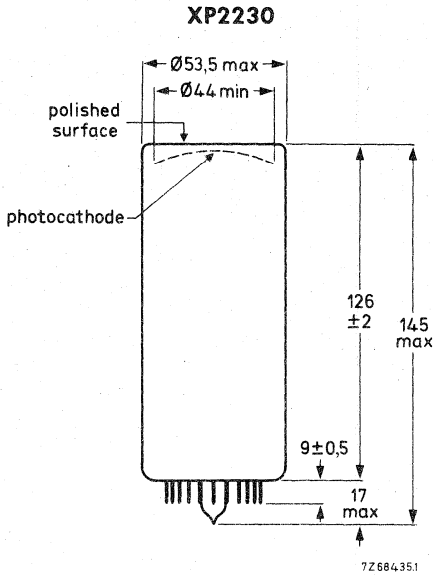
12) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

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



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 FE2003

for XP2230B type FE1003

Mu-metal shield: type 56128 or type 56130

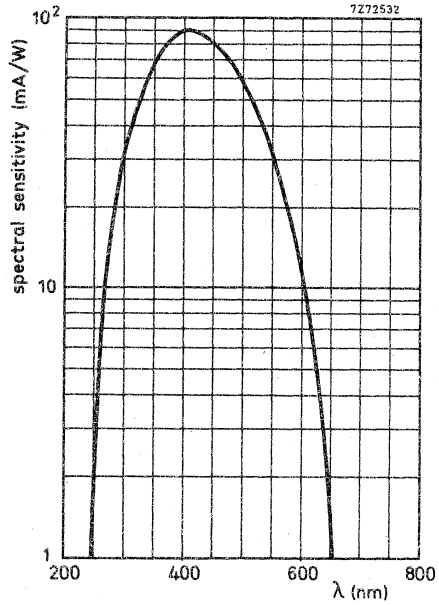


Fig. 4
Spectral sensitivity characteristic.

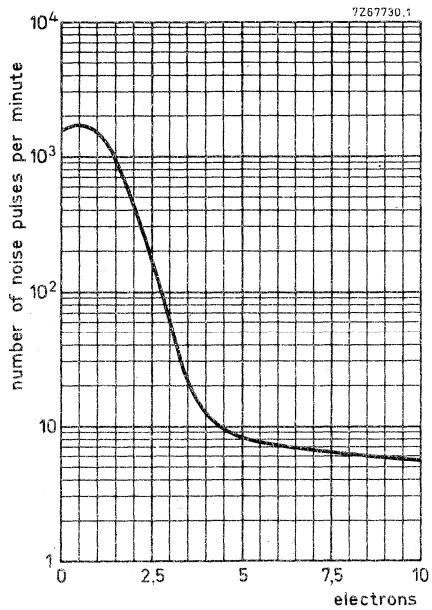


Fig. 5
Typical background spectrum from 0, 1 to 10 equivalent photoelectrons, at a gain of 3×10^7 , voltage divider A.

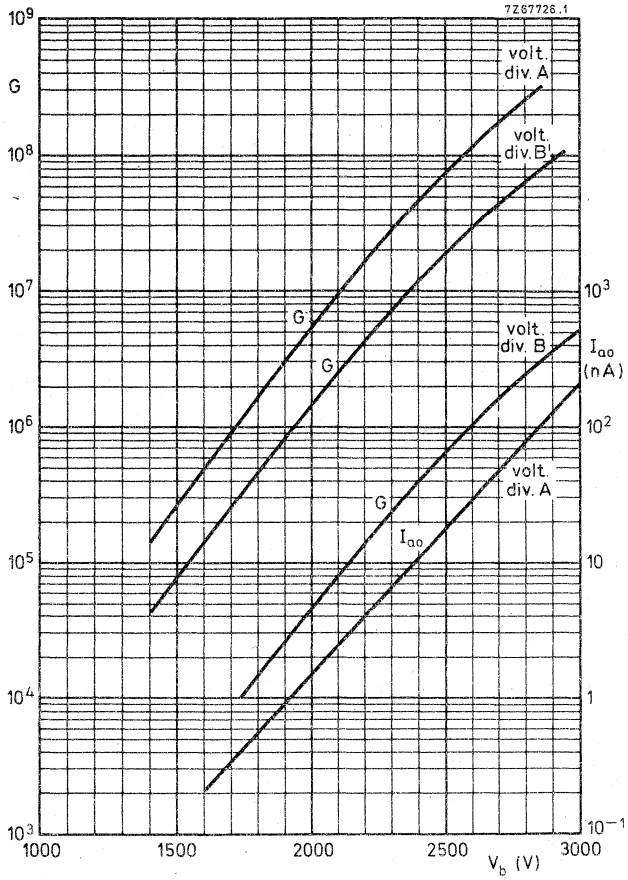


Fig. 6

Gain G , and anode dark current, I_{a0} , as a function of supply voltage V_b .

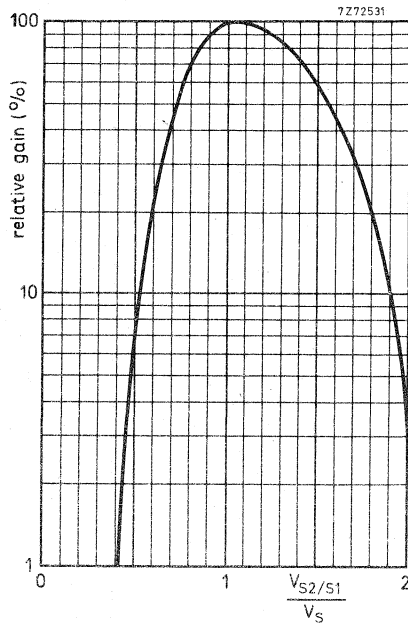


Fig. 7
Relative gain as a function of the
voltage between dynodes S_2 and S_1 ,
normalized to V_S .
 $V_{S3/S1}$ constant.

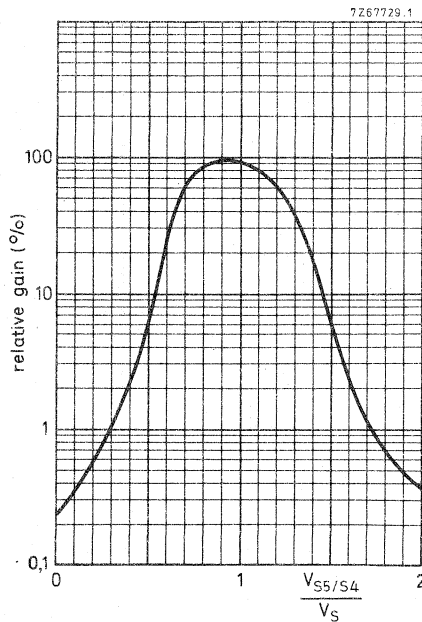
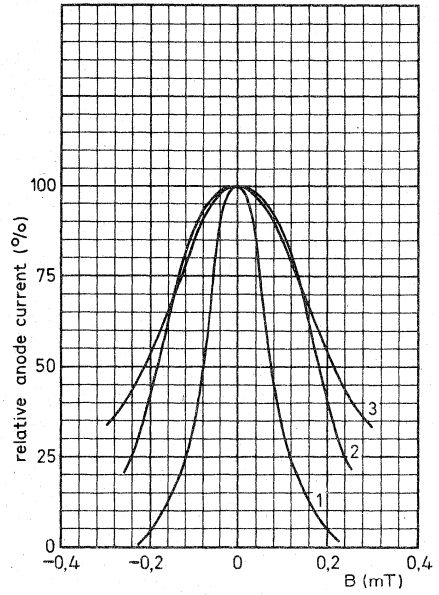


Fig. 8
Relative gain as a function of the
voltage between dynodes S_5 and S_4 ,
normalized to V_S .
 $V_{S6/S4}$ constant.

7Z72533

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 \perp 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	1)	typ. 60 μA/lm
	>	45 μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	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

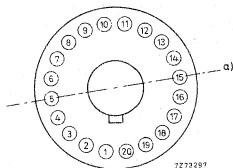
Number of stages		14
Dynode structure		linear focused
Dynode material		Ag-Mg
Capacitances		
Grid no.1 to k + S_1 + acc	$C_{g1/k, S1, acc}$	≈ 25 pF
Anode to all	C_a	≈ 9,5 pF
Anode to final dynode	$C_a/S14$	≈ 7 pF

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.



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

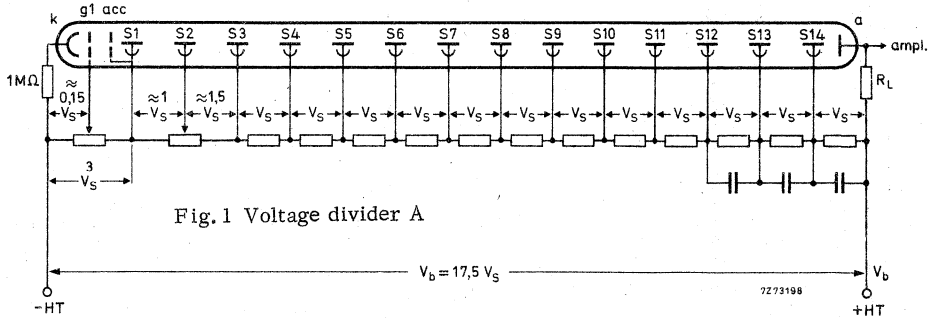


Fig. 1 Voltage divider A

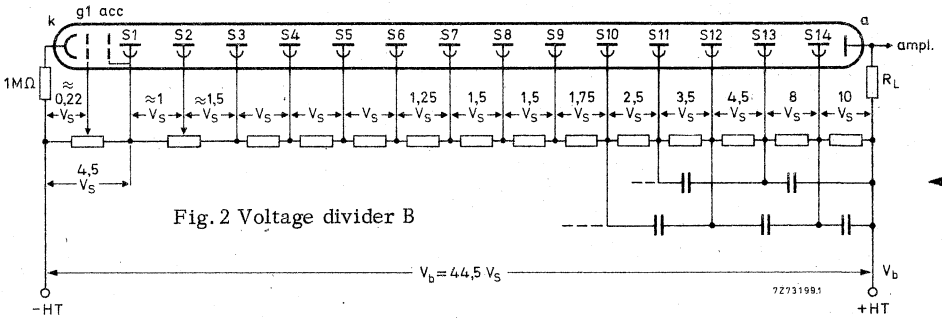


Fig. 2 Voltage divider B

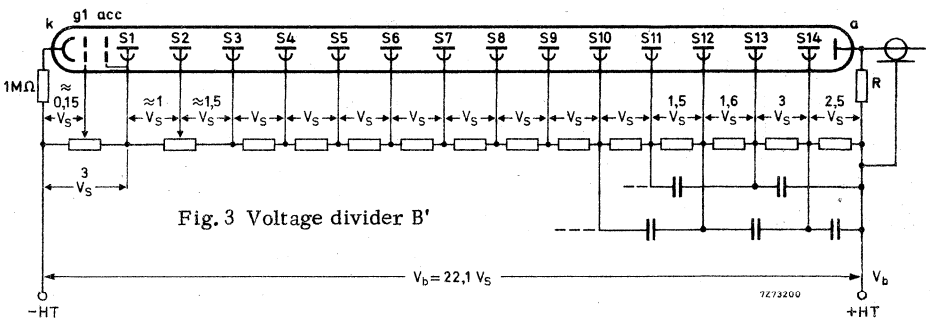


Fig. 3 Voltage divider B'

- 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 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 50Ω 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

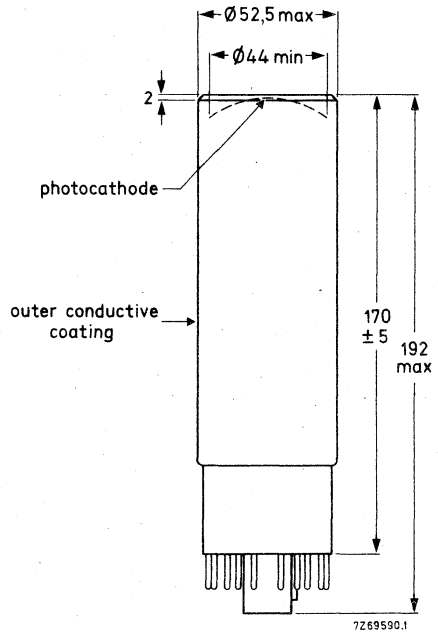
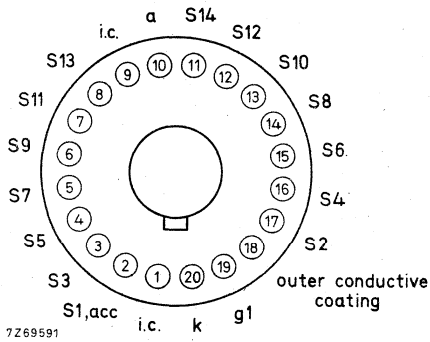
³⁾ When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

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 $< 10 \mu\text{A}$ is recommended.

MECHANICAL DATA

Dimensions in mm



Net mass: 235 g

Base: 20-pin (JEDEC B20-102)

ACCESSORIES

Socket type FE 1003

Mu-metal shield type 56130

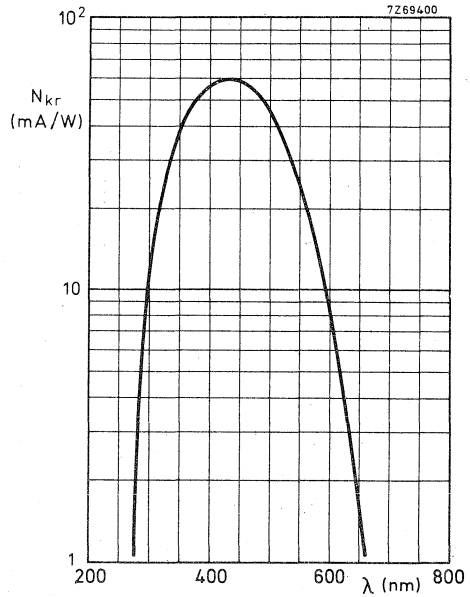


Fig. 4
Spectral sensitivity characteristic

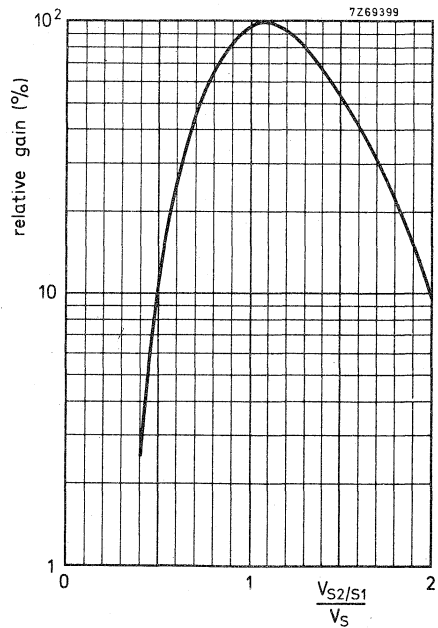


Fig. 5
Relative gain as a function of the voltage
between S2 and S1, normalized to V_S
 $V_{S3/S1}$ constant

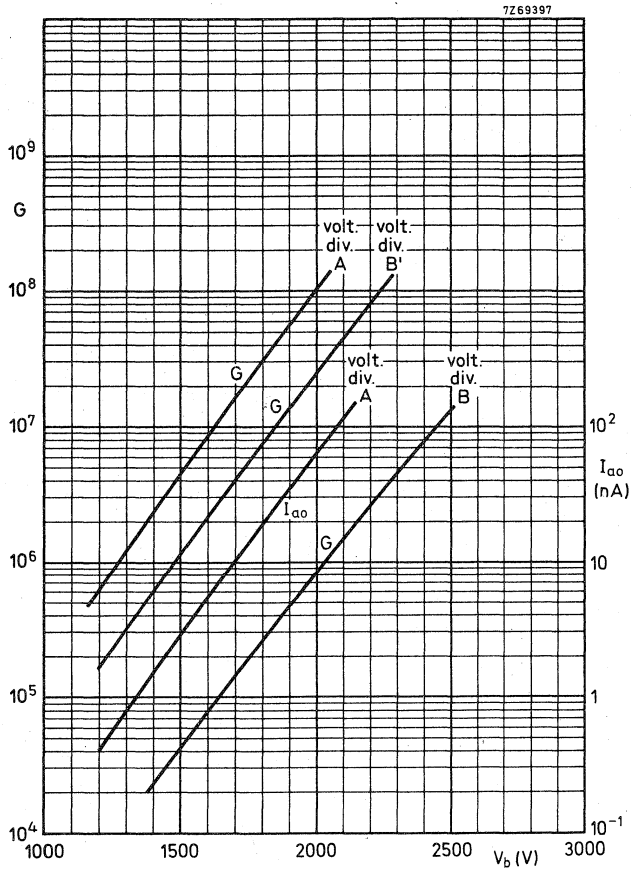


Fig. 6

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

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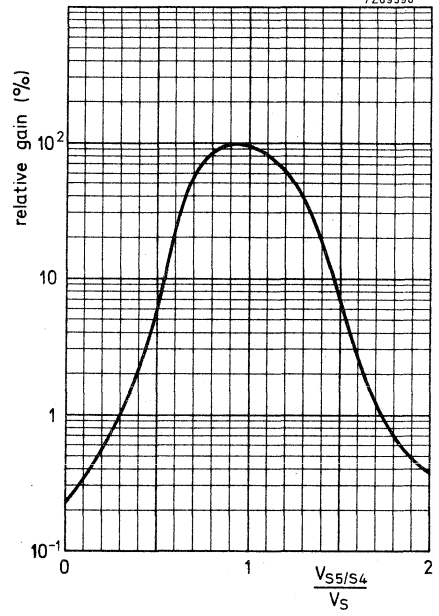


Fig. 7
Relative gain as a function of the voltage
between S5 and S4 normalized to V_S
 $V_{S6/S4}$ constant

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	μ A/lm
Supply voltage for an anode sensitivity of 10 A/lm		1800	V
Anode pulse rise time (with voltage divider B')	\approx	2,1	ns
Linearity			
with voltage divider A	up to	\approx 30	mA
with voltage divider B	up to	\approx 280	mA
with voltage divider B'	up to	\approx 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	1)	typ.	20 μA/lm
		>	15 μA/lm
Spectral sensitivity at 903 ± 8 nm	2)		1,4 mA/W
at 1060 ± 10 nm	2)	≈	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

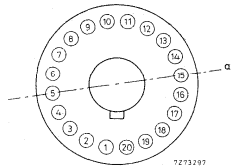
Number of stages			10
Dynode structure			linear focused
Dynode material			Ag-Mg
Capacitances			
Grid no. 1 to k + S_1 + acc	$C_{g1/k, S1, acc}$	≈	25 pF
Anode to all	C_a	≈	9,5 pF
Anode to final dynode	$C_{a/S10}$	≈	7 pF

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.



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

2) Measuring equipment is calibrated with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

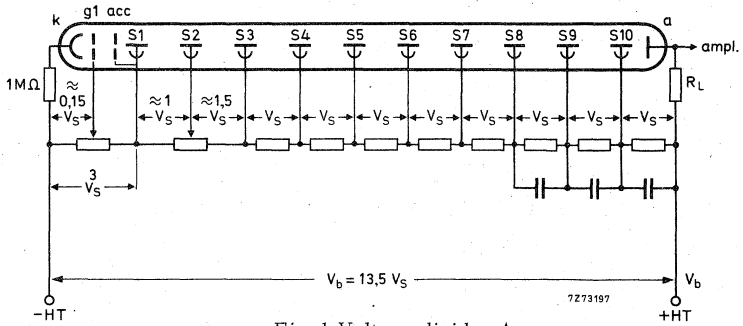


Fig. 1 Voltage divider A

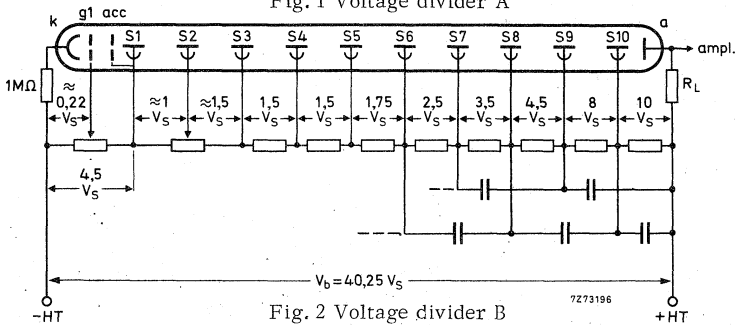


Fig. 2 Voltage divider B

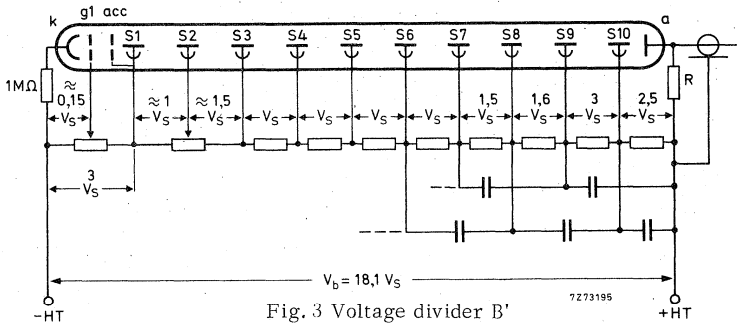


Fig. 3 Voltage divider B'

- k = cathode
- g₁ = 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

<u>With voltage divider A (Fig. 1)</u>		1)		
Supply voltage for an anode sensitivity $N_a = 10$ A/lm			typ. 1800 V < 2500 V	
Anode dark current at $N_a = 10$ A/lm (Fig. 6)	2)3)		typ. 4 μ A < 20 μ A	
Anode pulse rise time at $V_b = 1800$ V	4)5)	\approx	2, 3	ns
Anode pulse duration at half height at $V_b = 1800$ V	4)5)	\approx	4, 2	ns
Signal transit time at $V_b = 1800$ V	4)5)	\approx	32	ns
Anode current linear within 2% at $V_b = 1800$ V up to		\approx	30	mA
Obtainable peak anode current		\approx	100	mA
<u>With voltage divider B (Fig. 2)</u>		1)		
Anode sensitivity at $V_b = 2500$ V		\approx	1, 5	A/lm
Anode pulse rise time at $V_b = 2500$ V	4)5)	\approx	2, 4	ns
Anode pulse duration at half height at $V_b = 2500$ V	4)5)	\approx	3, 3	ns
Signal transit time at $V_b = 2500$ V	4)5)	\approx	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)	\approx	0, 8	ns
Anode current linear within 2%, at $V_b = 2500$ V up to		\approx	280	mA
Obtainable peak anode current			0, 5 to 1	A
<u>With voltage divider B' (Fig. 3)</u>		1)		
Anode sensitivity at $V_b = 2200$ V		\approx	12	A/lm
Anode pulse rise time at $V_b = 2200$ V	4)5)	\approx	2, 1	ns
Anode pulse duration at half height at $V_b = 2200$ V	4)5)	\approx	3	ns
Signal transit time at $V_b = 2200$ V	4)5)	\approx	32	ns
Signal transit time fluctuation at $V_b = 2200$ V		\approx	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)	\approx	0, 5	ns
Anode current linear within 2%, at $V_b = 2200$ V up to		\approx	80	mA
Obtainable peak anode current		\approx	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 $> 10^{15} \Omega$.
- 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.

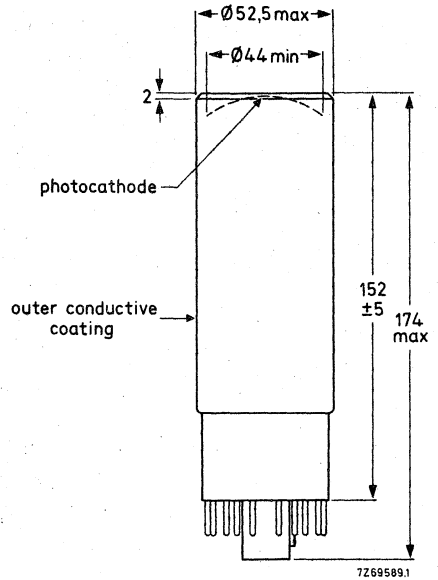
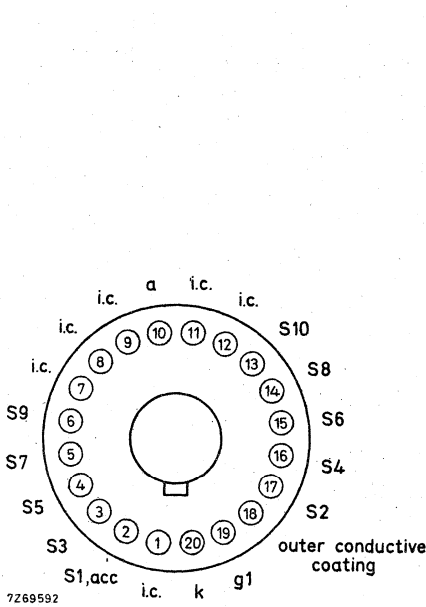
LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	3000	V
Continuous anode current	5)	max.	20	μ A
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	$^{\circ}$ C
		min.	-30	$^{\circ}$ C
Continuous operation and storage		max.	+50	$^{\circ}$ C
		min.	-30	$^{\circ}$ 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 $^{\circ}$ 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 FE1003

Mu-metal shield : type 56130

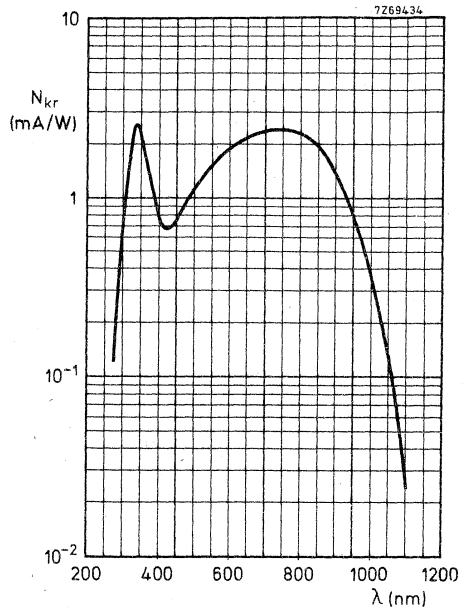


Fig. 4
Spectral sensitivity characteristic

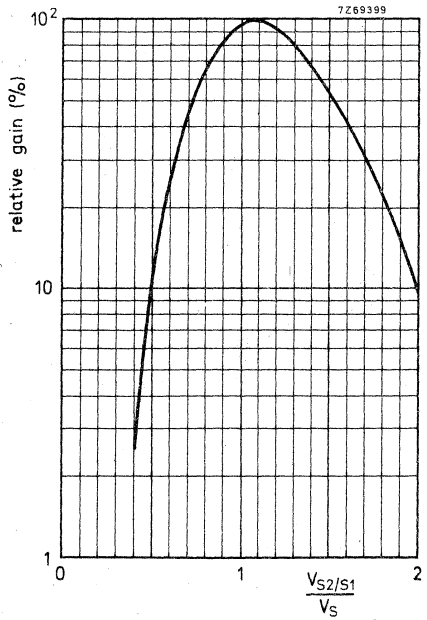


Fig. 5
Relative gain as a function of the voltage between S2 and S1, normalized to V_S $V_{S3/S1}$ constant.

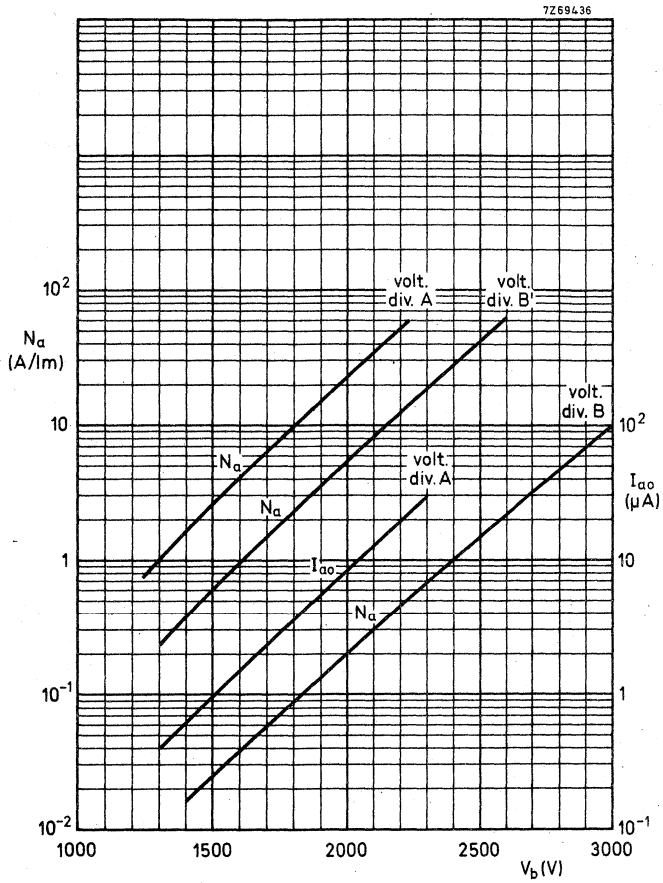


Fig. 6
Anode sensitivity, N_a , and anode dark current I_{ao} , as a function of supply voltage V_b

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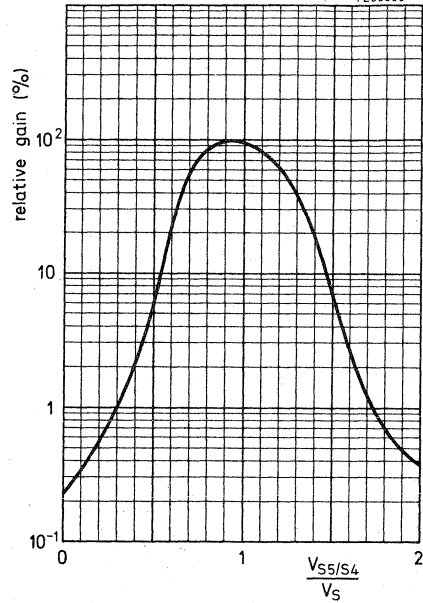


Fig. 7
Relative gain as a function of the voltage
between S5 and S4 normalized to V_S
 $V_{S6/S4}$ constant.

14-STAGE PHOTOMULTIPLIER TUBE

The 56DUVP is a 44 mm (useful diameter) head-on photomultiplier tube with a plano-concave window and a semi-transparent bialkaline type DU photocathode. The tube is intended for use in low luminous flux applications like single photon counting and liquid scintillation counting of ^{14}C and ^3H . The tube features a high cathode sensitivity, that extends into the ultra-violet region, and a very good collection efficiency combined with very low background noise and good time characteristics.

A special version, the 56DUVP/03, features a background noise 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 numbers 56DUVP/A and 56DUVP/03/A.

The 56DUVP (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 DU	
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 3×10^7		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	fused silica
Shape	plano-concave
Refractive index at 550 nm	1,46

Photocathode 1)

Semi-transparent, head-on

Material

Sb-K-Cs

Useful diameter

> 44 mm

Spectral sensitivity characteristic (Fig. 4)

type DU

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/WElectron 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 + acc

 $C_{g1/k, S1, acc} \approx 25$ pF

Anode to all

 $C_a \approx 9,5$ pF

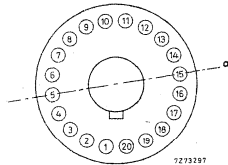
Anode to final dynode

 $C_{a/S14} \approx 7$ pFMagnetic 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 bialkali 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 CIRCUIT

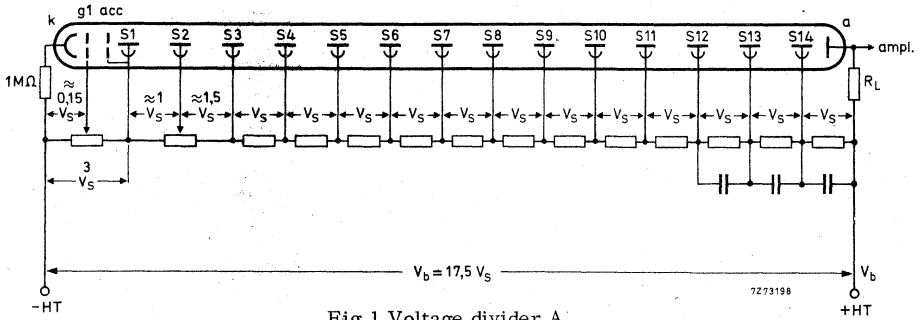


Fig 1 Voltage divider A

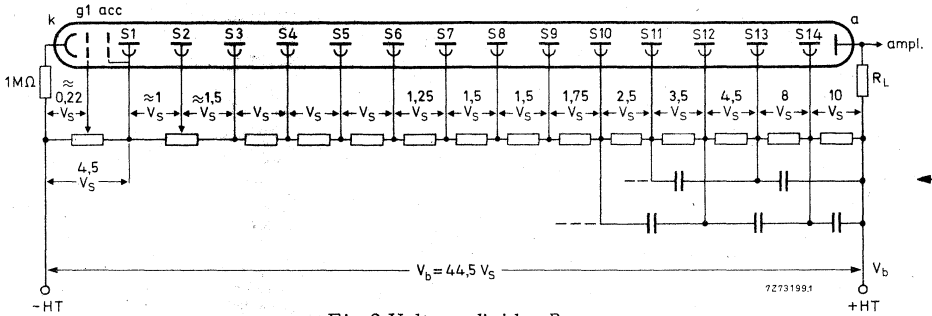


Fig 2 Voltage divider B

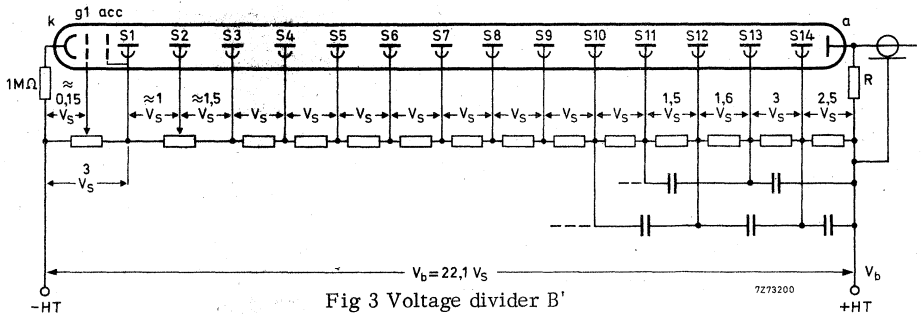


Fig 3 Voltage divider B'

- k = cathode
- g₁ = 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

<u>With voltage divider A</u> (Fig. 1)		1)		
Supply voltage for a gain of 3×10^7	<	2300	V	
	typ.	1900	V	
Anode dark current at a gain of 3×10^7 (Fig. 6)2)3)	<	60	nA	
56DUVP	typ.	6	nA	
56DUVP/03	<	50	nA	
	typ.	4	nA	
Background noise at a gain $6 = 3 \times 10^7$ (Fig. 8) 4)	<	3000	c/s	
56DUVP	<	1000	c/s	
56DUVP/03	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	5) 6)	~	30	mA
Obtainable peak anode current		~	100	mA
<u>With voltage divider B</u> (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 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

Notes see page 6.

<u>With voltage divider B' (Fig. 3)</u>		1)		
Gain at $V_b = 2200$ V (Fig. 6)			\approx	4×10^7
Anode pulse rise time at $V_b = 2200$ V	5) 6)		\approx	2,1 ns
Anode pulse duration at half height at $V_b = 2200$ V	5) 6)		\approx	3,5 ns
Signal transit time at $V_b = 2200$ V	5) 6)		\approx	44 ns
Signal transit time fluctuation at $V_b = 2200$ V	7)		\approx	0,5 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2200$ V			\approx	0,5 ns
Anode current linear within 2% at $V_b = 2200$ V up to			\approx	80 mA
Obtainable peak anode current			\approx	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)			max. +80 °C min. -30 °C
Operational (for short periods of time)				max. +50 °C min. -30 °C
Continuous operation and storage				max. +50 °C min. -30 °C

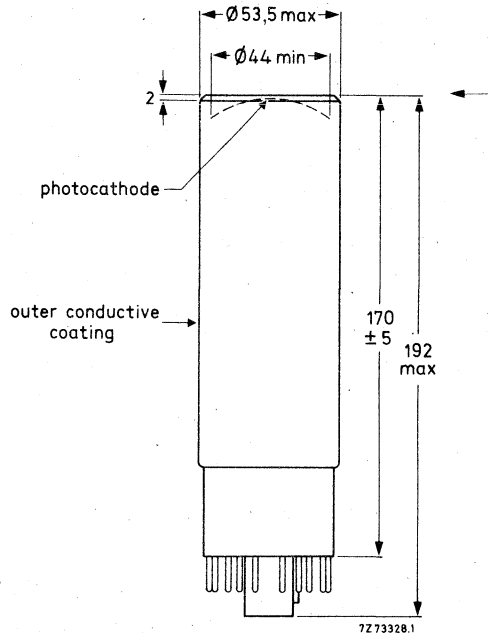
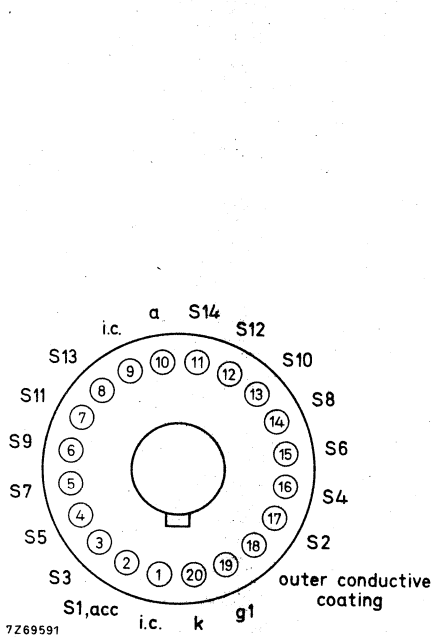
Notes see pages 6 and 7.

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. 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 $> 10^{15} \text{ M}\Omega$.
- 3) Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx 1/4 \text{ h}$).
- 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 $4,25 \times 10^{-13} \text{ C}$ (corresponding to 0,1 photoelectron) are recorded.
- 5) Measured with a pulsed-light source, with a pulse duration (FWHM) of $< 1 \text{ ns}$, 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 50Ω 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. When low temperature operation is contemplated the manufacturer should be consulted.

MECHANICAL DATA

Dimensions in mm



Net mass : 215 g
 Base : 20- pin (JEDEC B20-102)

ACCESSORIES

Socket type FE1003
 Mu-metal shield type 56130

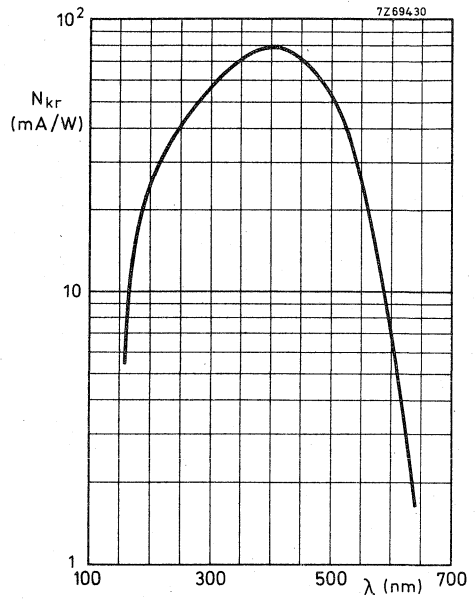


Fig. 4
Spectral sensitivity characteristic

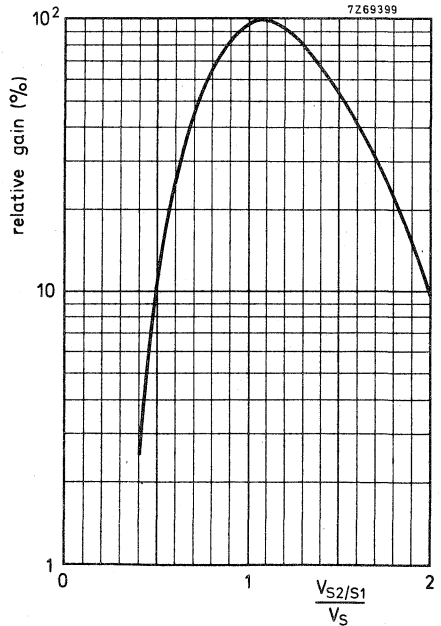


Fig. 5
Relative gain as a function of the voltage
between S_2 and S_1 , normalized to V_S
 $V_{S3/S1}$ constant

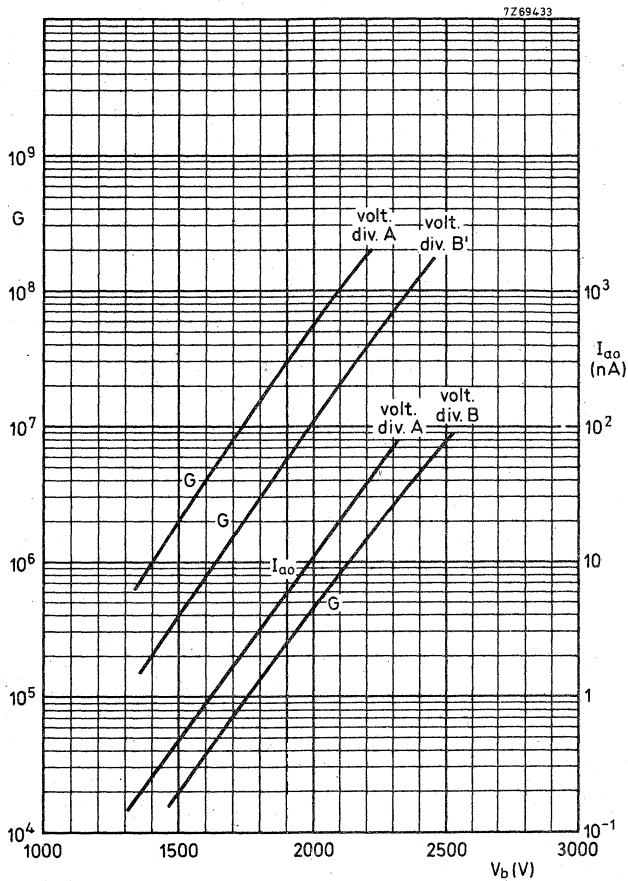


Fig. 6

Gain G , and anode dark current I_{a0} ,
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.

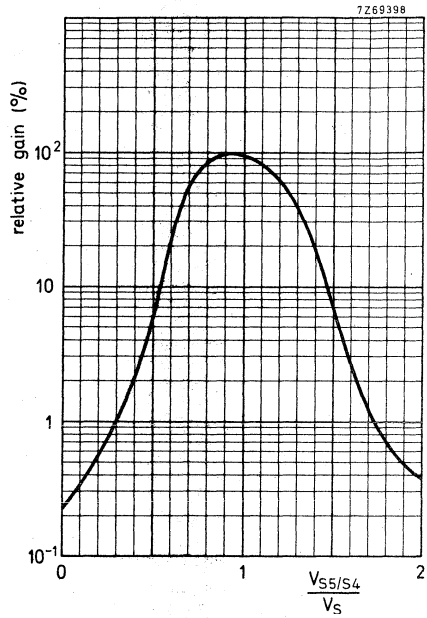
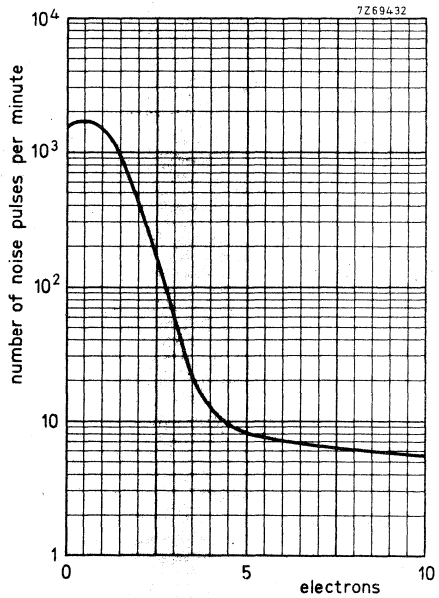


Fig. 8
Typical background spectrum from 0, 1 to 10 equivalent photoelectrons, at a gain of 3×10^7 with voltage divider A.



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 3×10^7		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/WElectron 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 $C_{g1/k, S1, acc} \approx 25$ pF

Anode to all

 $C_a \approx 9,5$ pF

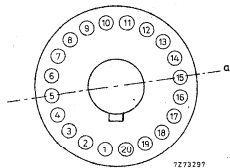
Anode to final dynode

 $C_{a/S14} \approx 7$ pFMagnetic 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

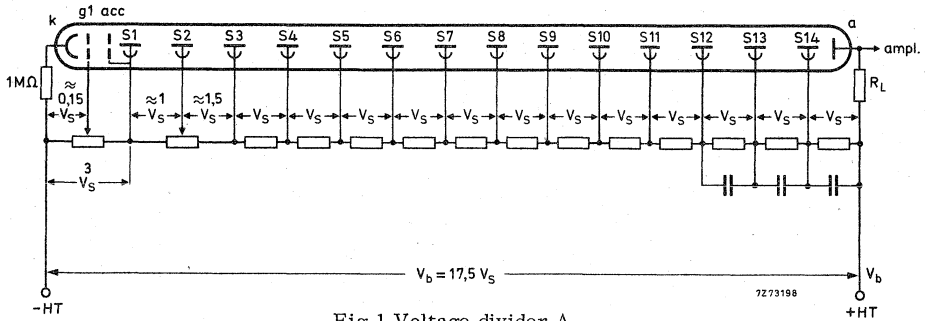


Fig 1 Voltage divider A

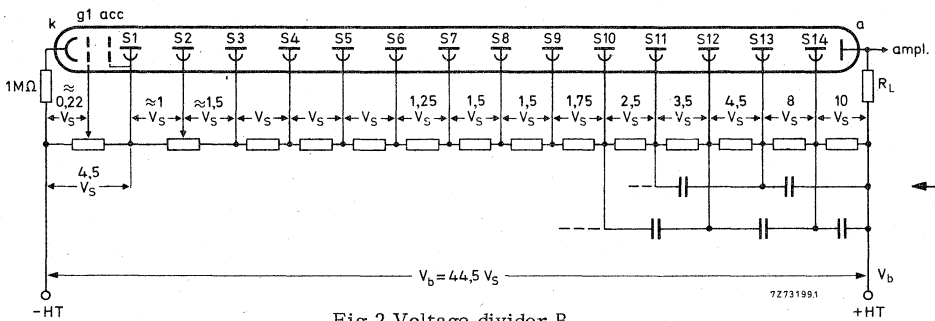


Fig 2 Voltage divider B

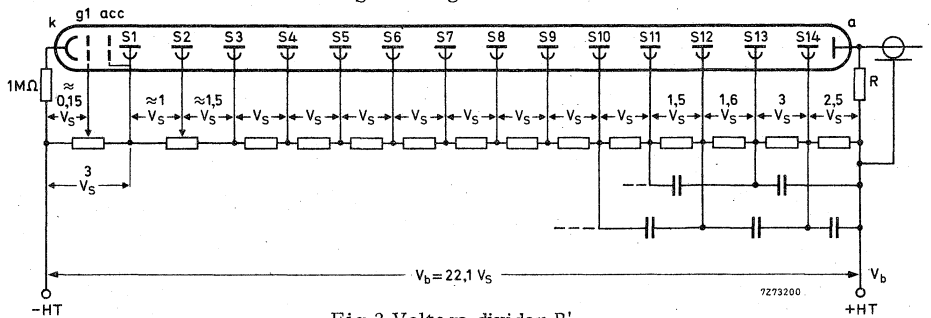


Fig 3 Voltage divider B'

- k = cathode
- g₁ = 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

<u>With voltage divider A</u> (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)		<	60 nA
56DVP			typ.	6 nA
56DVP/03			<	50 nA
Background noise at a gain of 3×10^7 (Fig. 8)	4)		typ.	4 nA
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
<u>With voltage divider B</u> (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 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

Notes see page 6.

<u>With voltage divider B'</u> (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)	max.	+80 °C
Operational (for short periods of time)		min.	-30 °C
Continuous operation and storage		max.	+50 °C
		min.	-30 °C

Notes see pages 6 and 7.

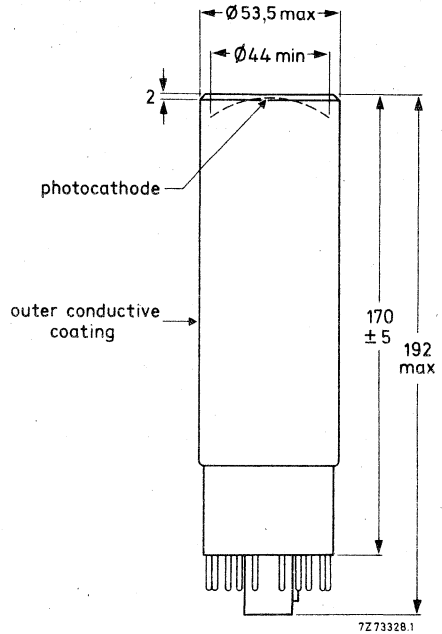
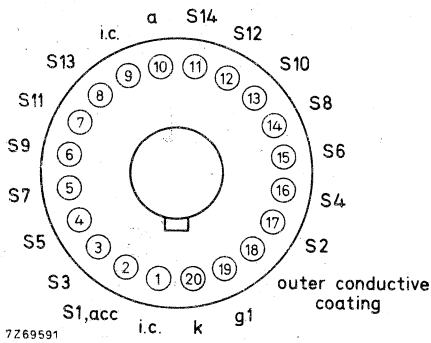
Notes to pages 4 and 5

- 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 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) 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 50Ω 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 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: 250 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket type FE1003

Mu-metal shield type 56130

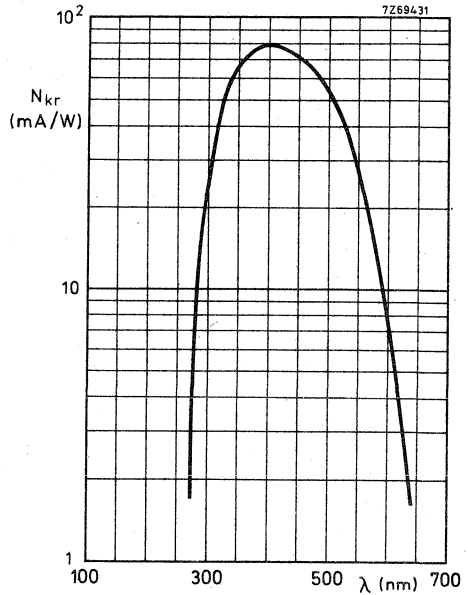


Fig. 4
Spectral sensitivity characteristic

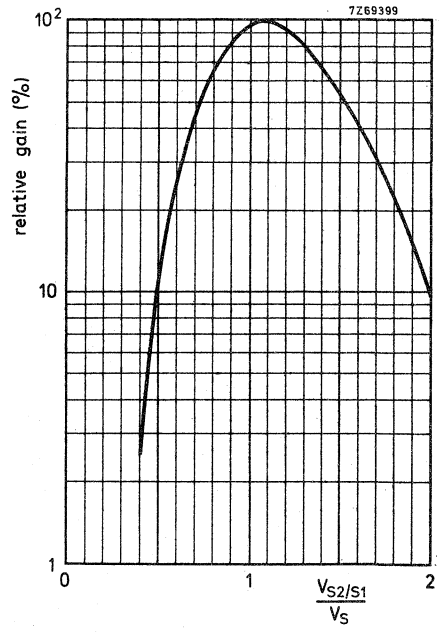


Fig. 5
Relative gain as a function of the voltage
between S_2 and S_1 , normalized to V_S
 $V_{S3/S1}$ constant

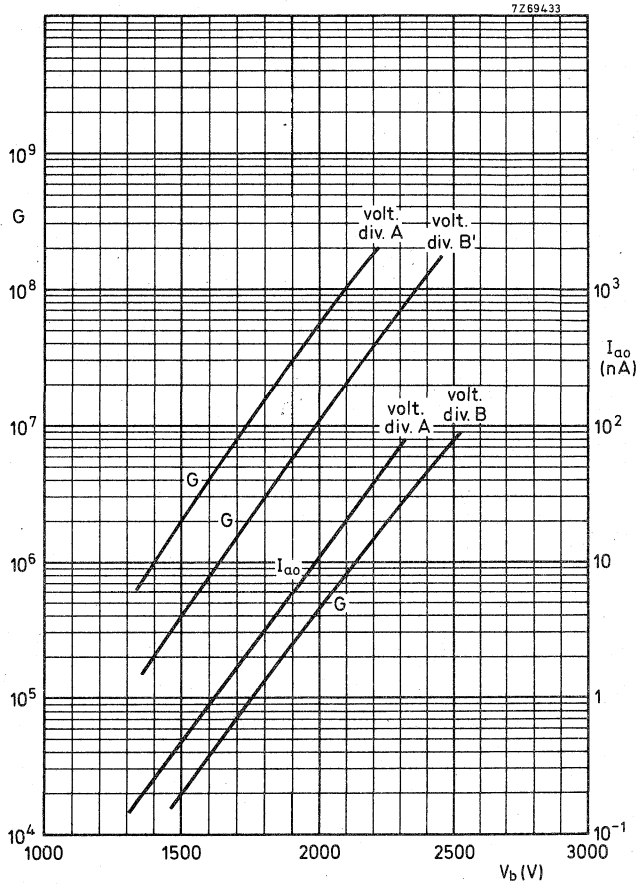


Fig. 6

Gain G , and anode dark current I_{a0} ,
as a function of supply voltage V_b

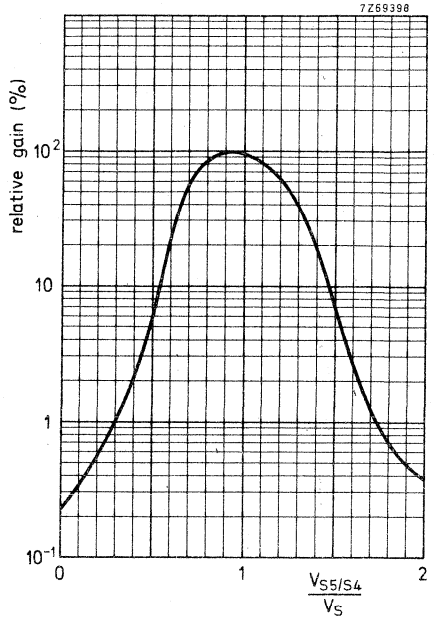


Fig. 7
Relative gain as a function of the voltage between S_5 and S_4 , normalized to V_S $V_{S6/S4}$ constant.

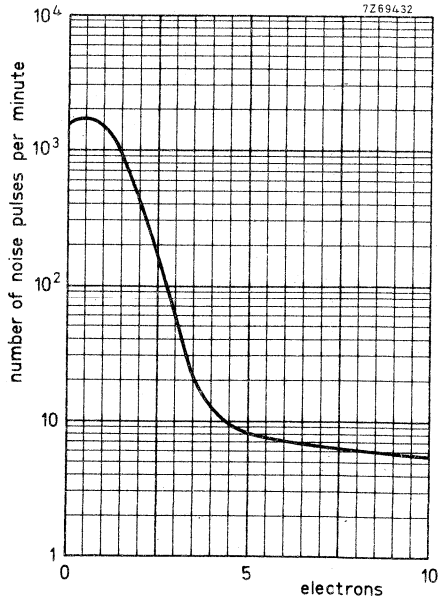


Fig. 8
Typical background spectrum from 0, 1 to 10 equivalent photoelectrons, at a gain of 3×10^7 with voltage divider A.

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 3×10^7		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

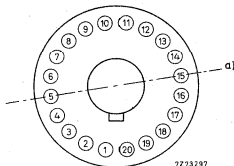
Number of stages			14
Dynode structure			linear focused
Dynode material			Ag-Mg
Capacitances			
Grid no. 1 to k + S_1 + acc		$C_{g1/k, S1, acc}$	≈ 25 pF
Anode to all		C_a	≈ 9,5 pF
Anode to final dynode		$C_{a/S14}$	≈ 7 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at $V_b = 1800$ 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

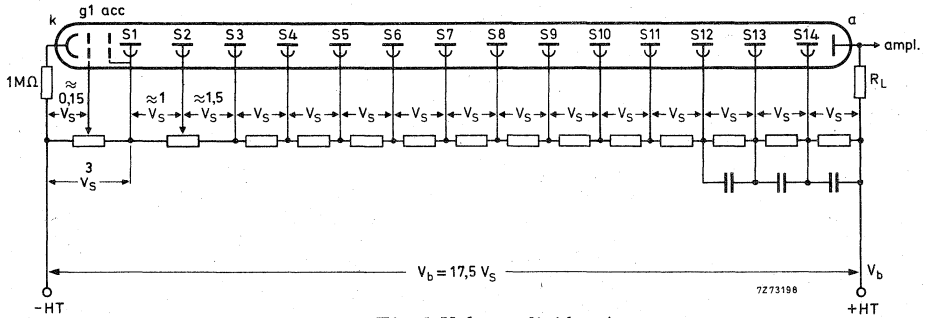


Fig. 1 Voltage divider A

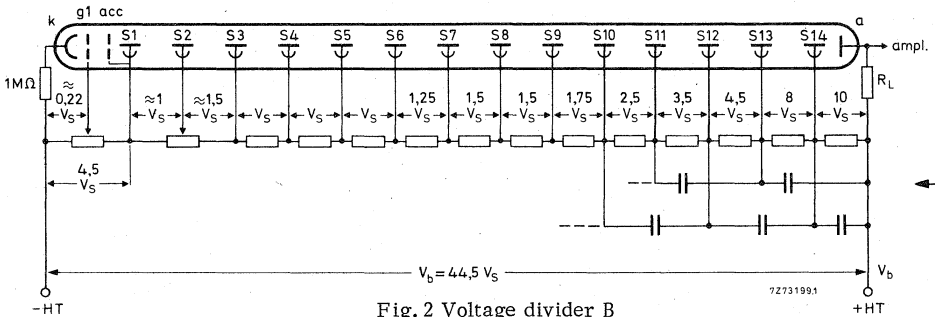


Fig. 2 Voltage divider B

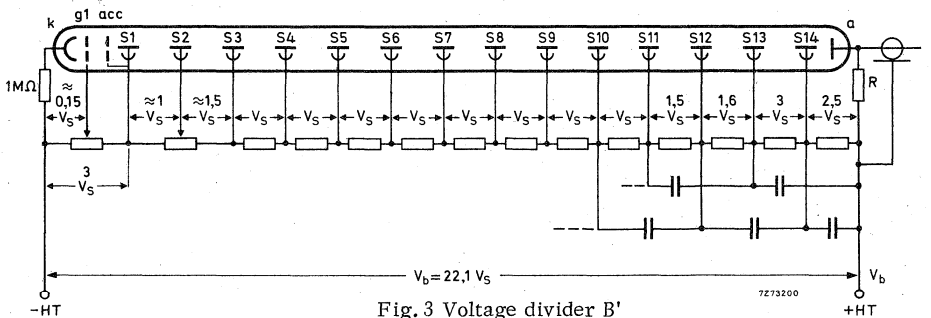


Fig. 3 Voltage divider B'

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
- g₁ = focusing electrode
- acc = accelerating electrode
- S_n = dynode no. n
- a = anode
- R_L = load resistor

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		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
<u>With voltage divider B (Fig. 2)</u>		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
<u>With voltage divider B' (Fig. 3)</u>		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 50Ω 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 Operational (for short periods of time)	4)	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.

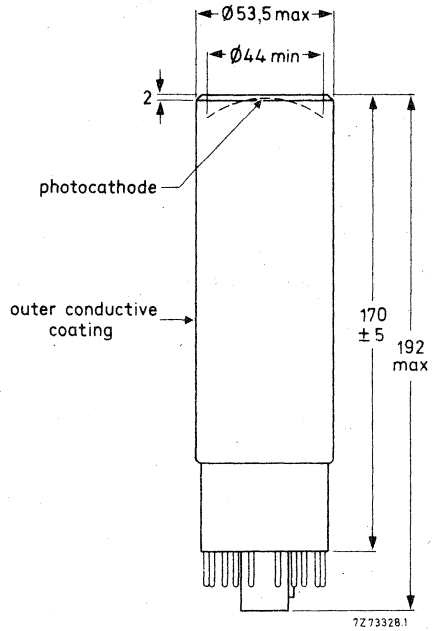
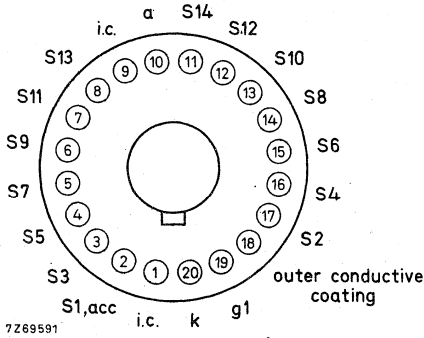
4) This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.

Where low temperature operation is contemplated, the supplier should be consulted.

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

MECHANICAL DATA

Dimensions in mm



Net mass : 225 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket type FE1003

Mu-metal shield type 56130

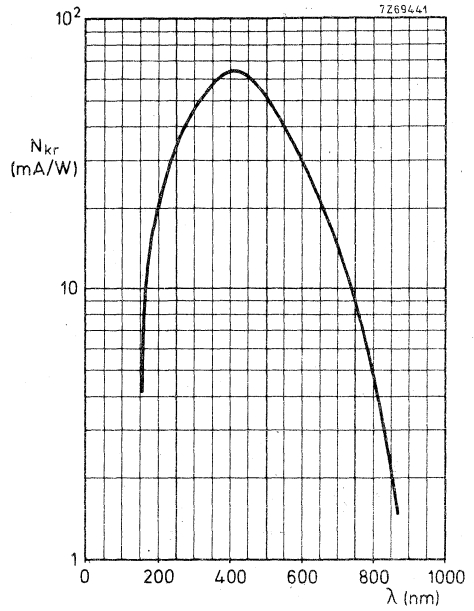


Fig. 4
Spectral sensitivity characteristic.

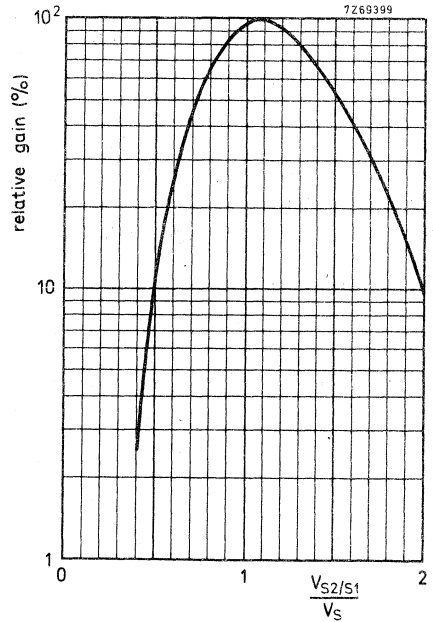


Fig. 5
Relative gain as a function of the
voltage between S2 and S1, normalized to V_S
 $V_{S3/S1}$ constant.

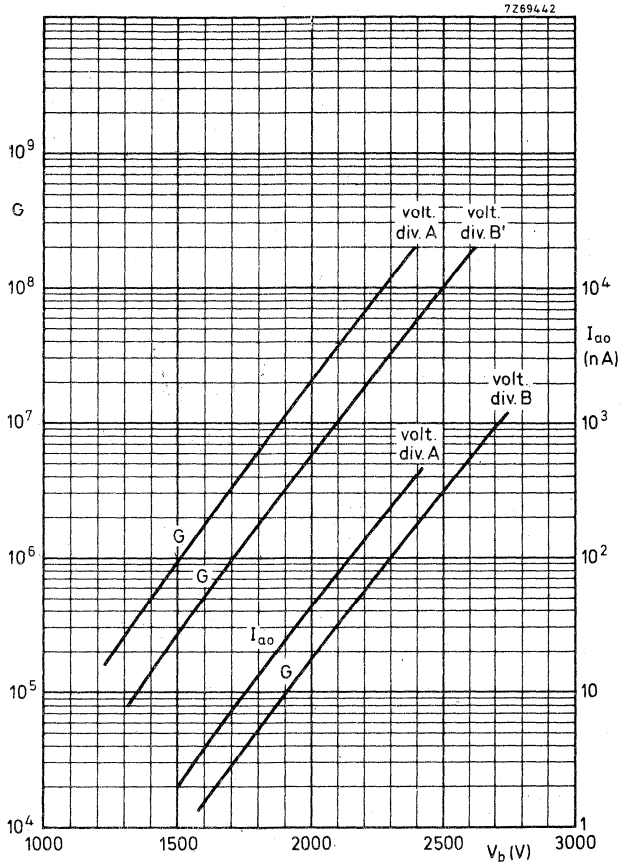


Fig. 6
Gain G , and anode dark current I_{a0} , as a function of supply voltage V_b .

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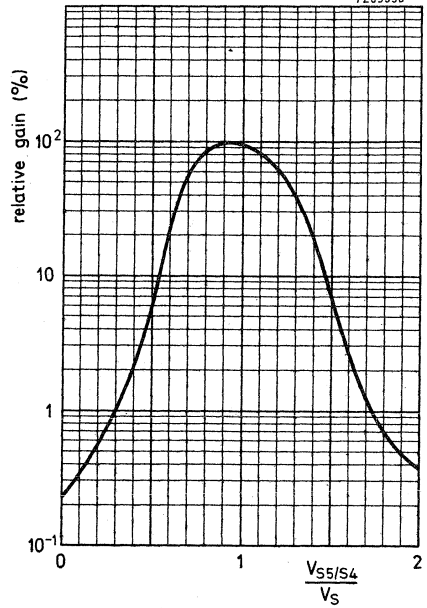


Fig. 7
Relative gain as a function of the voltage
between S5 and S4 normalized to V_S
 $V_{S6/S4}$ constant.

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 $\mu\text{A}/\text{lm}$ Spectral sensitivity at 698 ± 7 nm 2)> 90 $\mu\text{A}/\text{lm}$

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 + S_1 + acc $C_{g1/k, S1, acc} \approx 25$ pF

Anode to all

 $C_a \approx 9,5$ pF

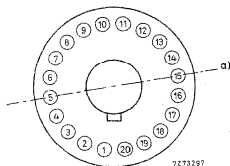
Anode to final dynode

 $C_{a/S14} \approx 7$ pFMagnetic 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

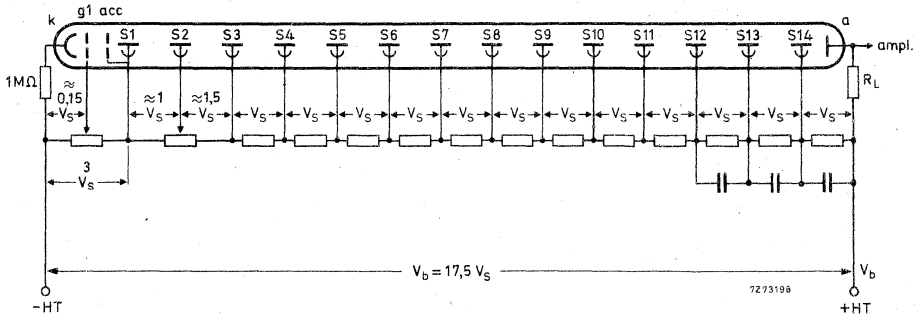


Fig. 1 Voltage divider A

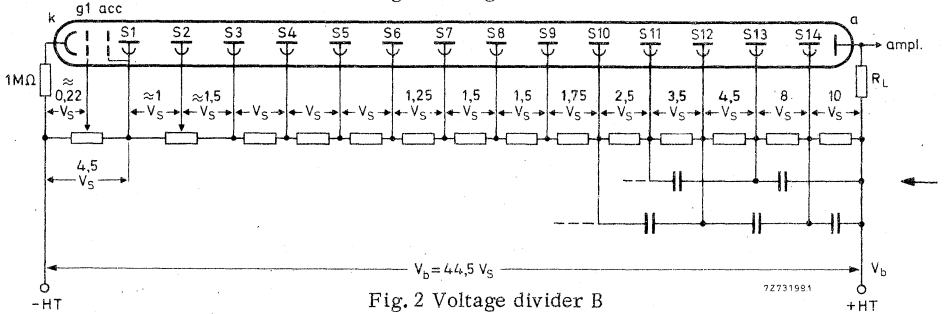


Fig. 2 Voltage divider B

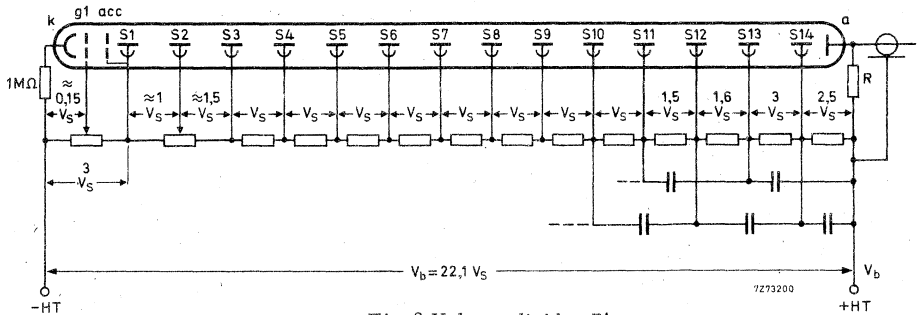


Fig. 3 Voltage divider B'

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

- k = cathode
- g1 = focusing electrode
- acc = accelerating electrode
- S_n = dynode no. n
- a = anode
- R_L = load resistor

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

<u>With voltage divider A (Fig. 1)</u>	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
<u>With voltage divider B (Fig. 2)</u>	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
<u>With voltage divider B' (Fig. 3)</u>	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 50Ω 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.

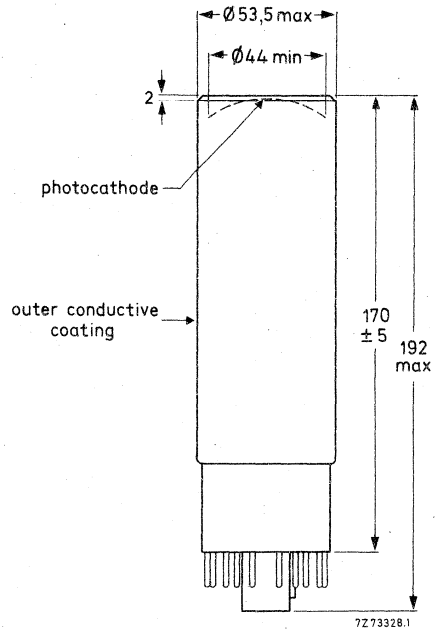
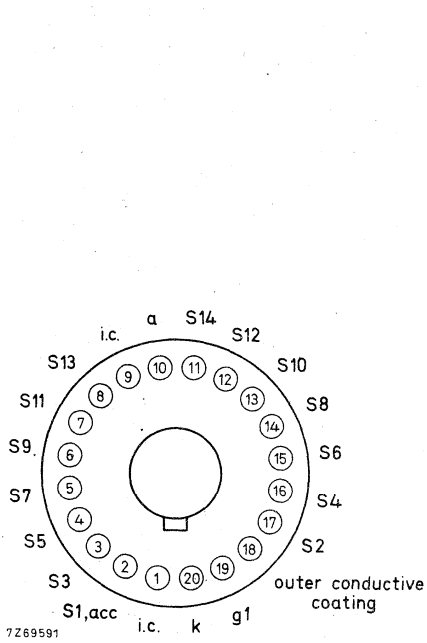
LIMITING VALUES (Absolute max. rating system)

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)	max.	+80	°C
Operational (for short periods of time)		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 $<10 \mu\text{A}$ is recommended.

MECHANICAL DATA

Dimensions in mm



Net mass: 225 g

Base : 20-pin (JEDEC B20-102)

ACCESSORIES

Socket type FE1003

Mu-metal shield type 56130

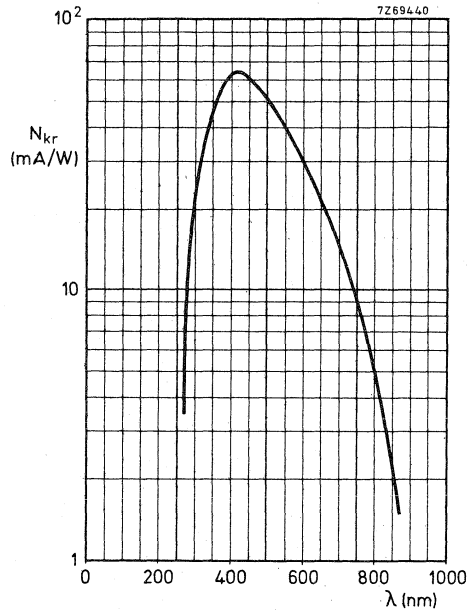


Fig. 4
Spectral sensitivity characteristic

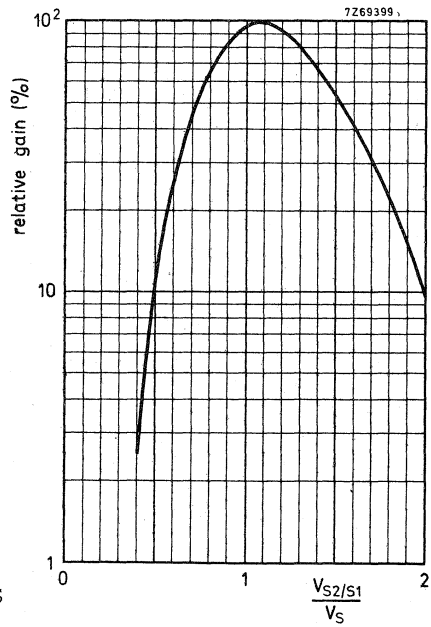


Fig. 5
Relative gain as a function of the voltage between S2 and S1, normalized to V_S $V_{S3/S1}$ constant.

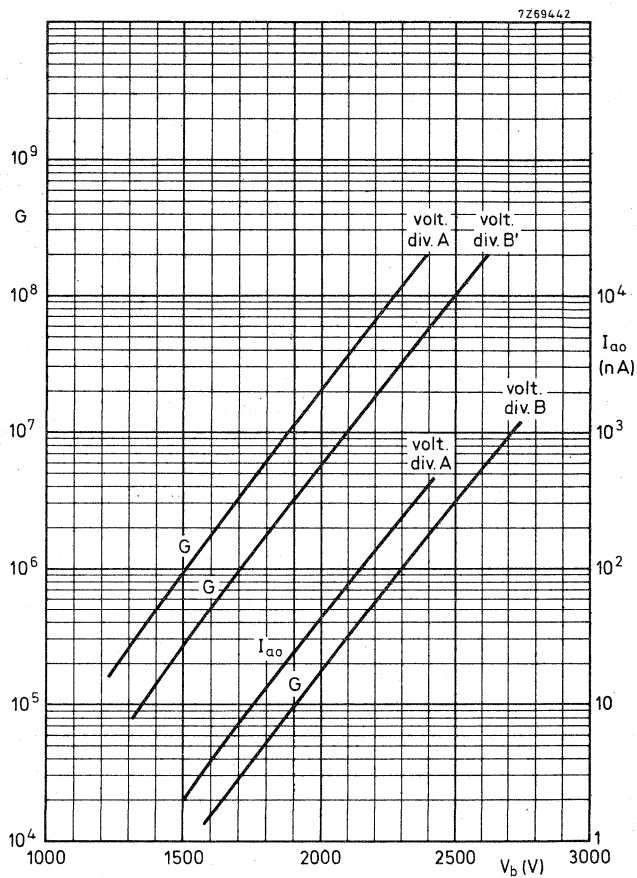


Fig. 6
Gain G , and anode dark current I_{a0} , as a
function of supply voltage V_b

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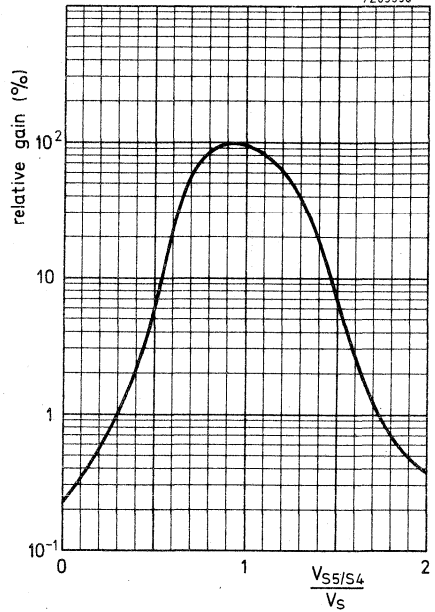


Fig. 7
Relative gain as a function of the voltage
between S5 and S4 normalized to V_S
 $V_{S6/S4}$ constant.

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

Notes see page 2.

Spectral sensitivity characteristic (Fig. 4)		type D
Maximum spectral sensitivity at		400 ± 30 nm
Luminous sensitivity	2)	65 μA/lm
Spectral sensitivity at 401 ± 3 nm	3)	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.
- 2) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 ± 5 K.
- 3) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

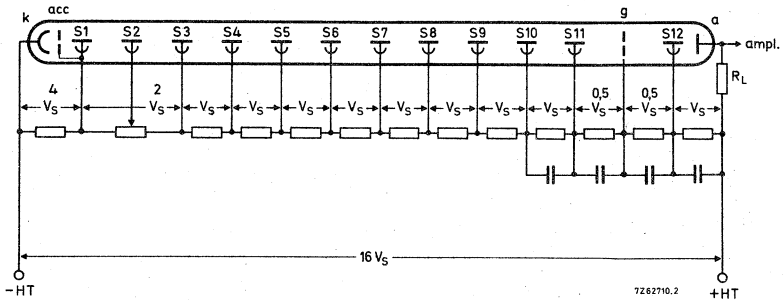


Fig. 1 Voltage divider type A

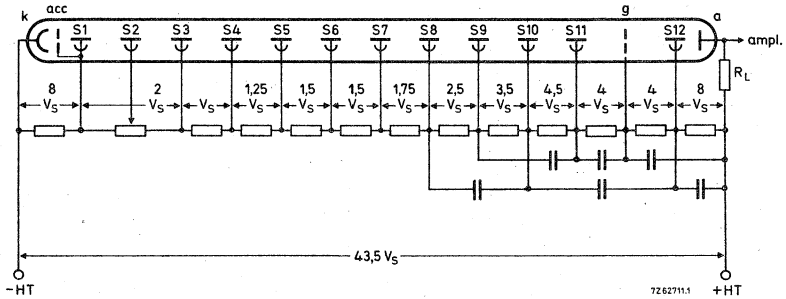


Fig. 2 Voltage divider B

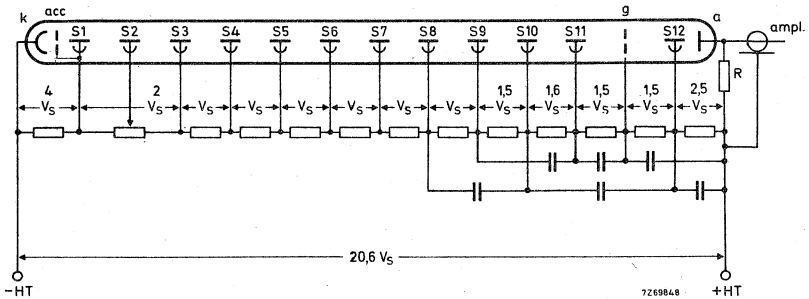


Fig. 3 Voltage divider B'

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	V
		<	3400	V
Anode dark current at $G = 3 \times 10^7$ (Fig. 5)	2)3)	typ.	6	nA
		<	40	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.	1000	V
		min.	300	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.	700	V
		min.	80	V
Ambient temperature range	10)	max.	+50	°C
		min.	-30	°C

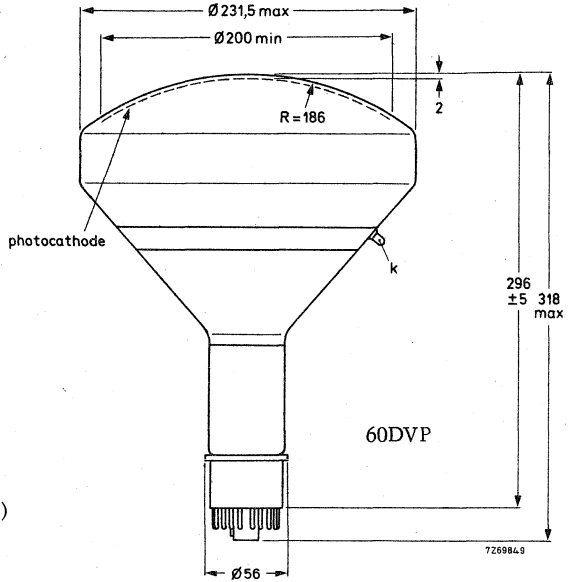
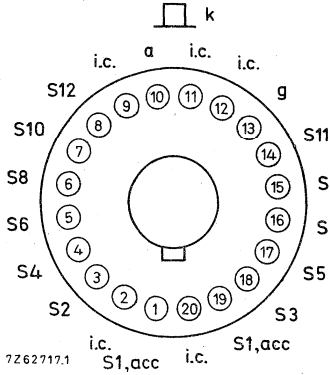
Notes see page 5.

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 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 50Ω 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)

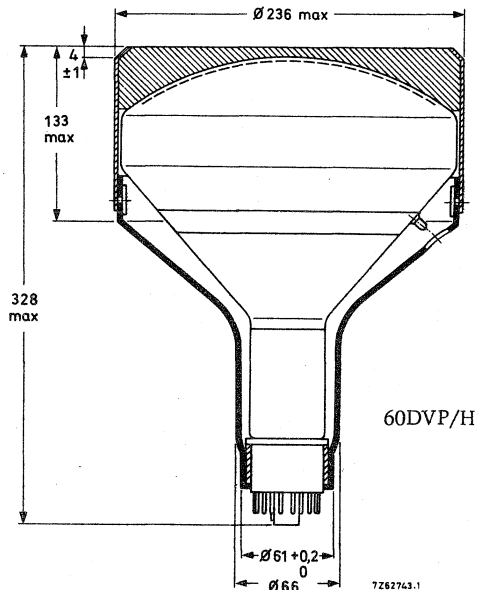
ACCESSORIES

Socket : type FE1003

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.



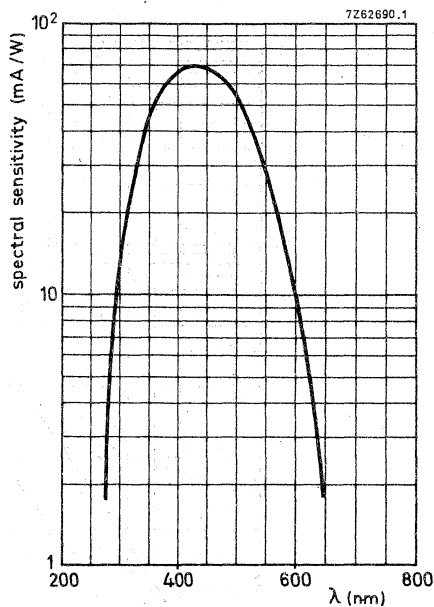


Fig. 4
Spectral sensitivity characteristic

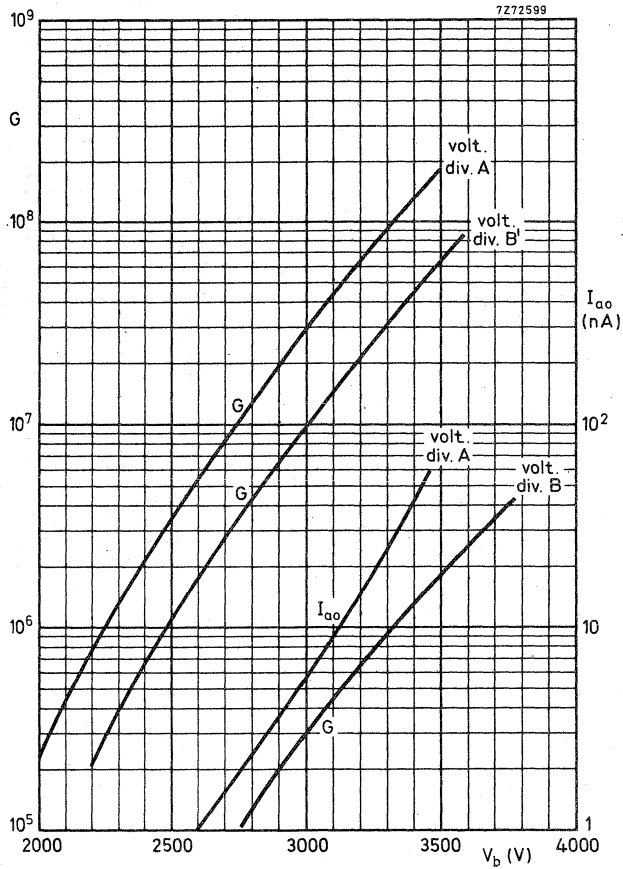


Fig. 5

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

10-STAGE PHOTOMULTIPLIER TUBE

The 150AVP 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.

QUICK REFERENCE DATA			
Spectral sensitivity characteristic		type Super A	
Useful diameter of the photocathode	>	32	mm
Spectral sensitivity of the photocathode at 437 nm		70	mA/W
Supply voltage for anode 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

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.	80	$\mu\text{A}/\text{lm}$
		>	40	$\mu\text{A}/\text{lm}$
Spectral sensitivity at $437 \pm 5 \text{ nm}$	2)		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.

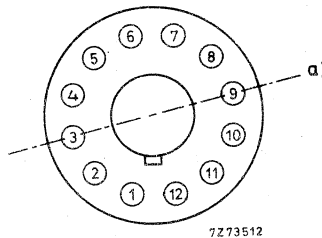
Multiplier system

Number of stages			10
Dynode structure			linear focused
Dynode material			Cu-Be
Capacitances			
Anode to all	C_a	\approx	5 pF
Anode to final dynode	$C_{a/S10}$	\approx	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 by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.

RECOMMENDED CIRCUITS

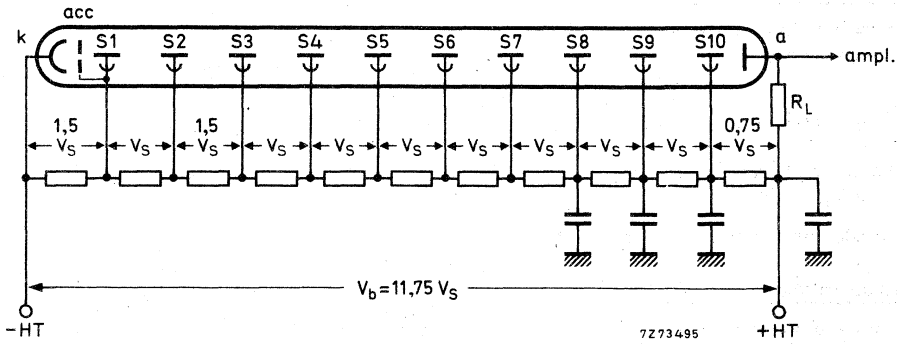


Fig. 1 Voltage divider A

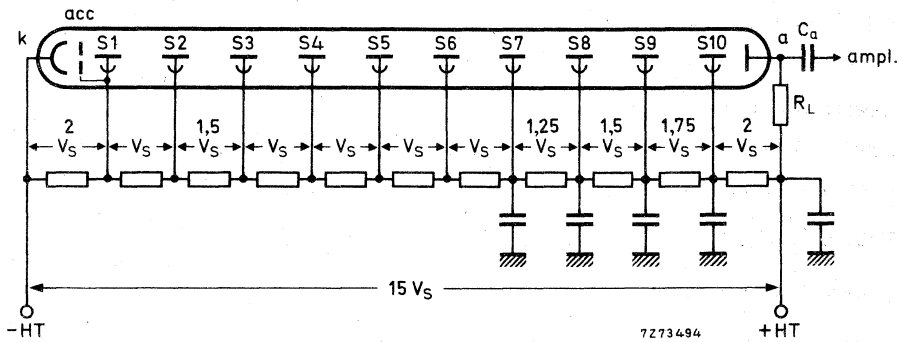


Fig. 2 Voltage divider B

k = cathode

Typical values of capacitors; 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

Supply voltage for an anode luminous sensitivity $N_a = 60 \text{ A/lm}$ (Fig. 5)	1)	<	1700 V
		typ.	1500 V
Anode dark current at $N_a = 60 \text{ A/lm}$ (Fig. 5)	2)3)	<	50 nA
		typ.	5 nA
Pulse amplitude resolution for ^{137}Cs at $V_b = 1200 \text{ V}$	4)	~	8 %
Anode current linear within 2% at $V_b = 1700 \text{ V}$	up to	~	30 mA

With voltage divider B (Fig. 2)

Anode luminous sensitivity at $V_b = 1700 \text{ V}$ (Fig. 5)		~	35 A/lm
Anode pulse rise time at $V_b = 1700 \text{ V}$	5)	~	3,5 ns
Anode pulse duration at half height at $V_b = 1700 \text{ V}$	5)	~	6 ns
Signal transit time at $V_b = 1700 \text{ V}$	5)	~	34 ns
Anode current linear within 2% at $V_b = 1700 \text{ V}$	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			
Operational (for short periods of time)	9)	max.	+80 °C
		min.	-30 °C
Continuous operation and storage		max.	+50 °C
		min.	-30 °C

Notes see page 5.

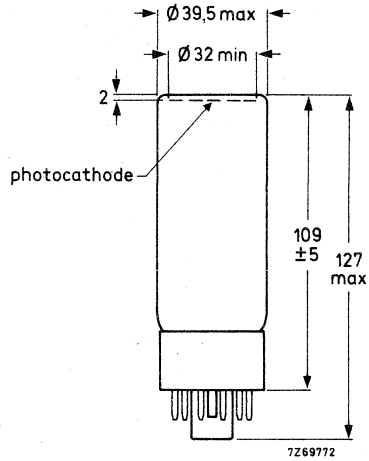
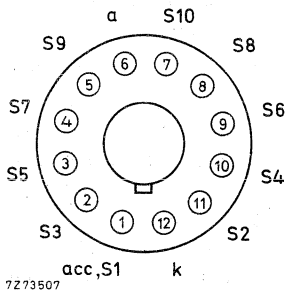
Notes to page 4

- 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 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 $\approx 10^3$ 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.

150AVP

MECHANICAL DATA

Dimensions in mm



Net mass: 80 g

Base : 12-pin (JEDEC B12-43)

ACCESSORIES

Socket :type FE1002

Mu-metal shield;type 56127

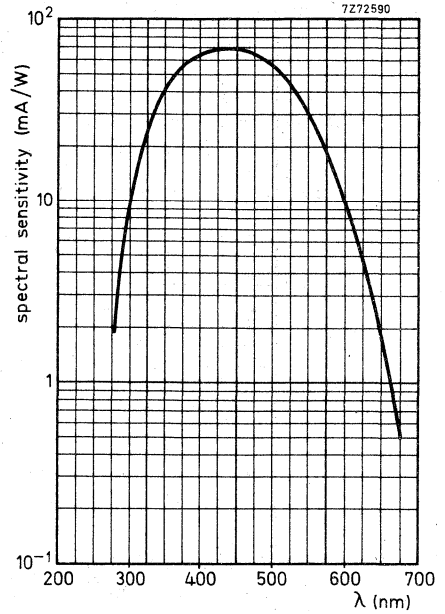


Fig. 3
Spectral sensitivity characteristic.

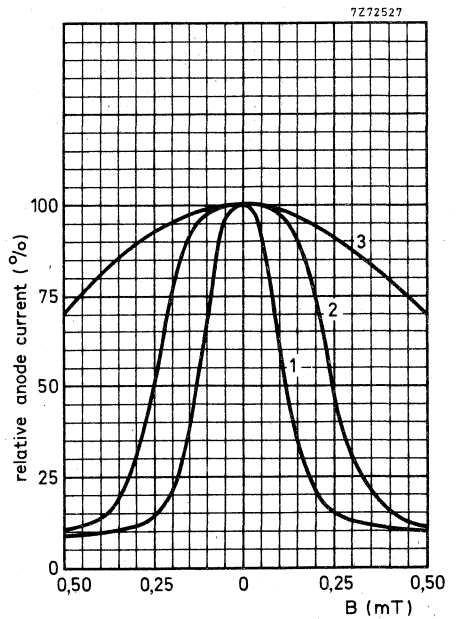


Fig. 4
Relative anode current as a function of the magnetic flux density B

1. B \perp tube axis, // axis a
2. B \perp tube axis, \perp axis a
3. B // tube axis

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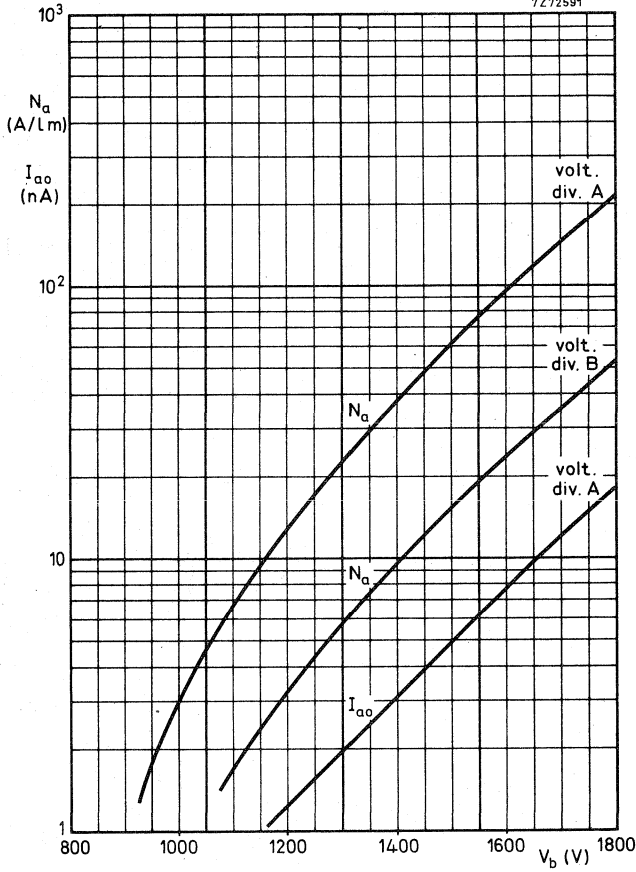


Fig. 5
Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of supply voltage V_b .

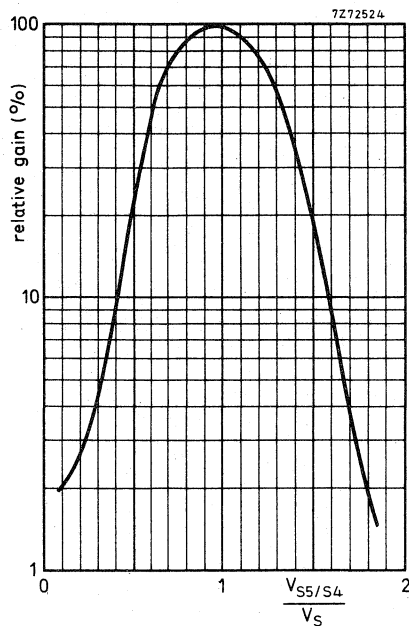


Fig. 6
Relative gain as a function of the voltage
between S_5 and S_4 , normalized to V_S
 $V_{S6/S4}$ constant.

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 with voltage divider B	up to	~	30 mA
	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	1)	typ.	20	$\mu\text{A}/\text{lm}$
		>	15	$\mu\text{A}/\text{lm}$
Spectral sensitivity at $903 \pm 8 \text{ nm}$	2)		1,4	mA/W
at $1060 \pm 10 \text{ nm}$	2)	\approx	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.

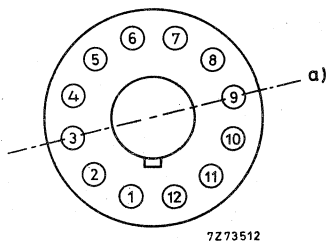
Multiplier system

Number of stages			10	
Dynode structure			linear focused	
Dynode material			Cu-Be	
Capacitance				
Anode to all		C_a	\approx	5 pF
Anode to final dynode		$C_a/S10$	\approx	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 $> 15 \text{ mm}$ beyond the photocathode.



Dynode axis with respect to base pins (bottom view)

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.

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

RECOMMENDED CIRCUITS

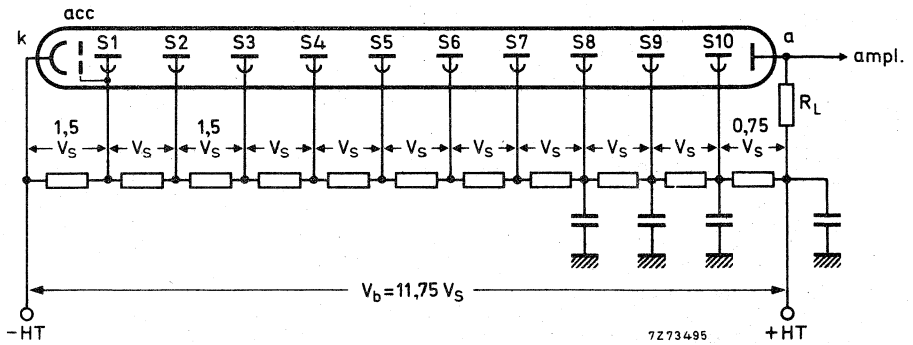


Fig. 1 Voltage divider A

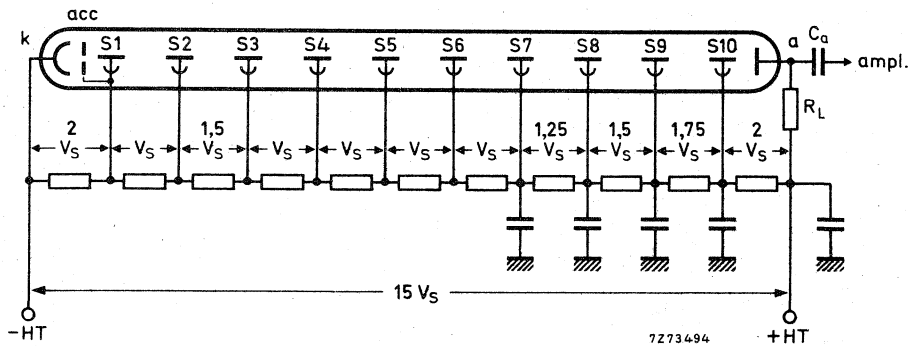


Fig. 2 Voltage divider B

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

<u>With voltage divider A (Fig. 1)</u>		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 μ A
			typ.	2 μ A
Anode current linear within 2% at $V_b = 1700$ V		up to	\approx	30 mA
<u>With voltage divider B (Fig. 2)</u>				
Anode luminous sensitivity at $V_b = 1700$ V (Fig. 5)			\approx	5 A/lm
Anode pulse rise time at $V_b = 1700$ V	4)		\approx	3,5 ns
Anode pulse duration at half height at $V_b = 1700$ V	4)		\approx	6 ns
Signal transit time at $V_b = 1700$ V	4)		\approx	34 ns
Anode current linear within 2% at $V_b = 1700$ V		up to	\approx	100 mA
LIMITING VALUES (Absolute max. rating system)				
Supply voltage	5)	max.		1800 V
Continuous anode current	6)	max.		20 μ A
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 $^{\circ}$ C
		min.		-30 $^{\circ}$ C
Continuous operation and storage		max.		+50 $^{\circ}$ C
		min.		-30 $^{\circ}$ C

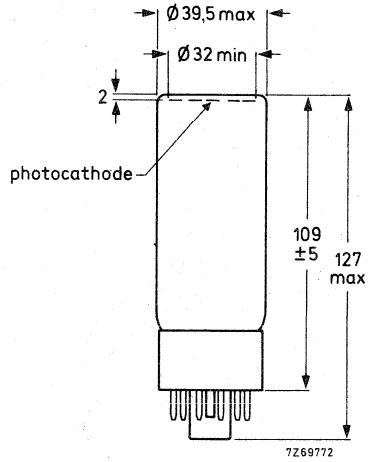
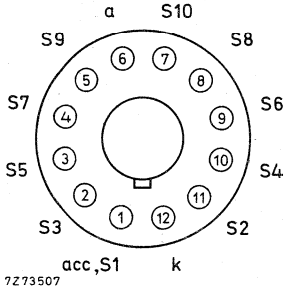
Notes see page 5.

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 FE1002
 Mu-metal shield : type 56127

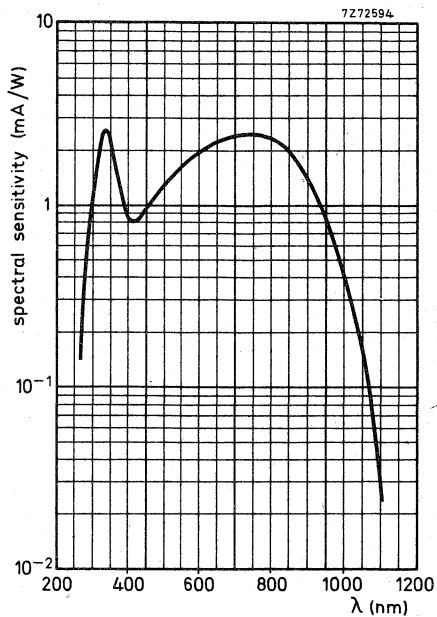


Fig. 3
Spectral sensitivity characteristic.

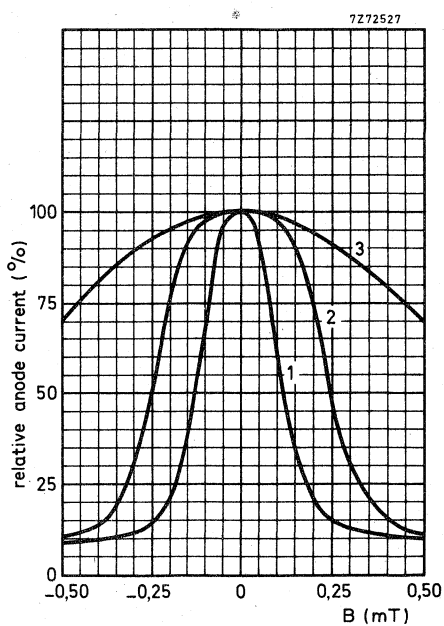


Fig. 4
Relative anode current as a function of
the magnetic flux density B
1. $B \perp$ tube axis, \parallel axis a
2. $B \perp$ tube axis, \perp axis a
3. $B \parallel$ tube axis

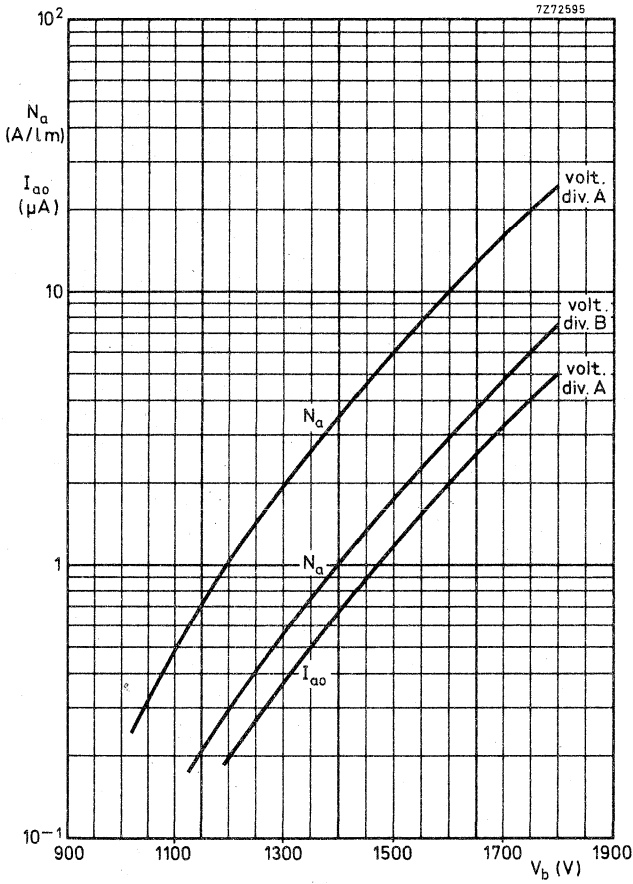


Fig. 5
Anode luminous sensitivity, N_a , and anode dark current, I_{ao} , as a function of supply voltage V_b .

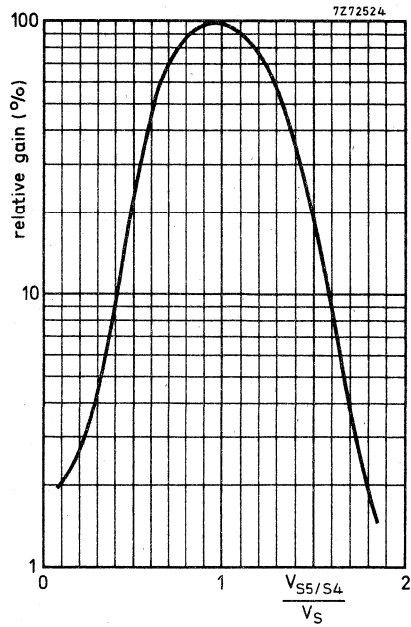


Fig. 6
Relative gain as a function of the voltage
between S₅ and S₄, normalized to V_S
V_{S6/S4} constant.

10-STAGE PHOTOMULTIPLIER TUBE

The 150UVP 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
Spectral sensitivity of the photocathode at 437 nm		75	mA/W
Supply voltage for anode luminous sensitivity = 60 A/lm		1500	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	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. 3)	S13 (type U)
Maximum spectral sensitivity at	400 ± 30 nm

Luminous sensitivity	1)	typ.	85 $\mu\text{A}/\text{lm}$
		>	40 $\mu\text{A}/\text{lm}$
Spectral sensitivity at $437 \pm 5 \text{ nm}$	2)		75 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.

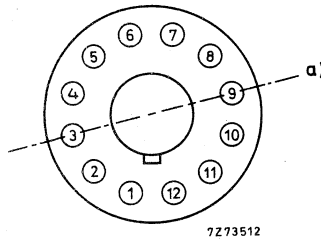
Multiplier system

Number of stages			10
Dynode structure			linear focused
Dynode material			Cu-Be
Capacitances			
Anode to all	C_a	\approx	5 pF
Anode to final dynode	$C_{a/S10}$	\approx	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 $> 15 \text{ mm}$ beyond the photocathode.



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Dynode axis with respect to base pins (bottom view)

1) Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature $2856 \pm 5 \text{ K}$.

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

RECOMMENDED CIRCUITS

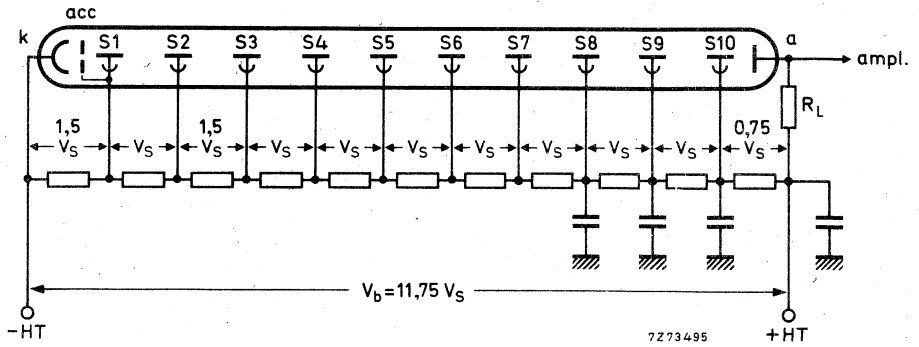


Fig. 1 Voltage divider A

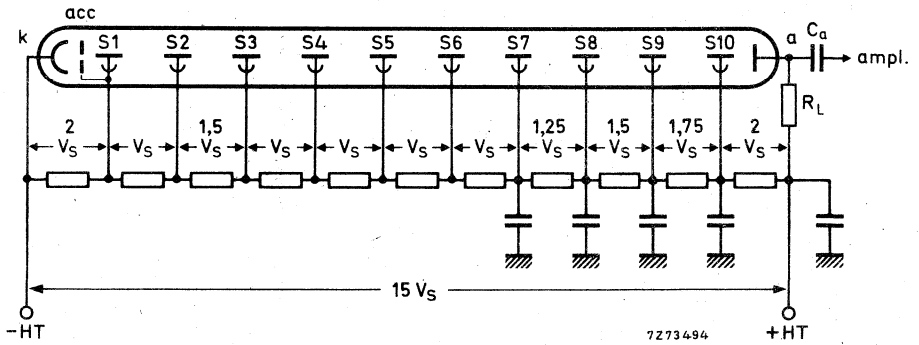


Fig. 2 Voltage divider B

k = cathode

Typical values of capacitors: 10 nF

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

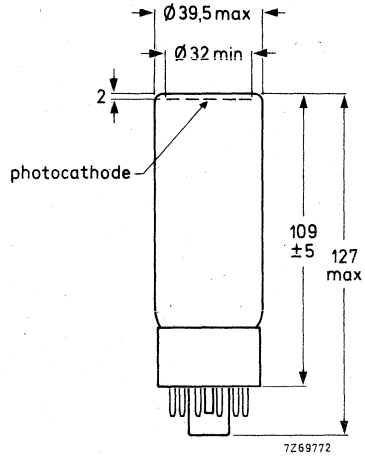
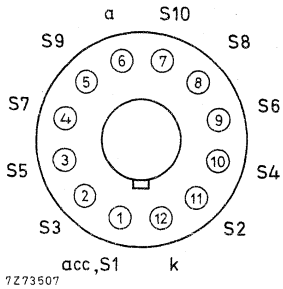
<u>With voltage divider A (Fig. 1)</u>		1)		
Supply voltage for an anode luminous sensitivity $N_a = 60$ A/lm (Fig. 5)			<	1700 V
			typ.	1500 V
Anode dark current at $N_a = 60$ A/lm (Fig. 5)	2)3)		<	50 nA
			typ.	10 nA
Anode current linear within 2% at $V_b = 1700$ V		up to	≈	30 mA
<u>With voltage divider B (Fig. 2)</u>		1)		
Anode luminous sensitivity at $V_b = 1700$ V (Fig. 5)			≈	35 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			max.	0,2 mA
Voltage between first dynode and photocathode	6)		max.	500 V
			min.	120 V
Voltage between consecutive dynodes			max.	300 V
Voltage between anode and final dynode	7)		max.	300 V
			min.	30 V
Ambient temperature range				
Operational (for short periods of time)	8)		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 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



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

ACCESSORIES

Socket : type FE1002
Mu-metal shield : type 56127

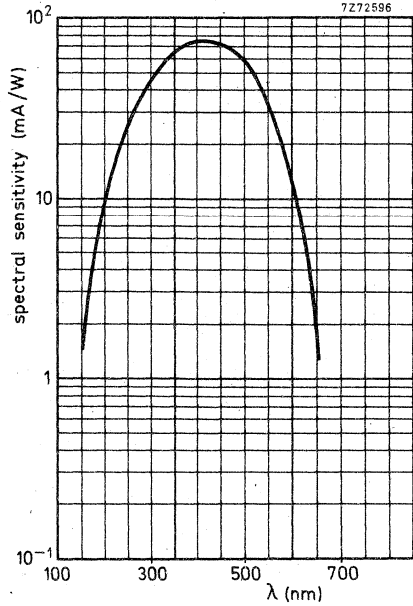


Fig. 3
Spectral sensitivity characteristic.

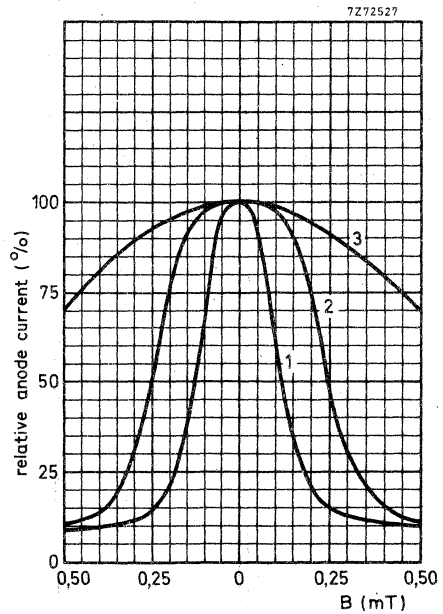


Fig. 4
Relative anode current as a function
of the magnetic flux density B

1. B \perp tube axis, // axis a
2. B \perp tube axis, \perp axis a
3. B // tube axis

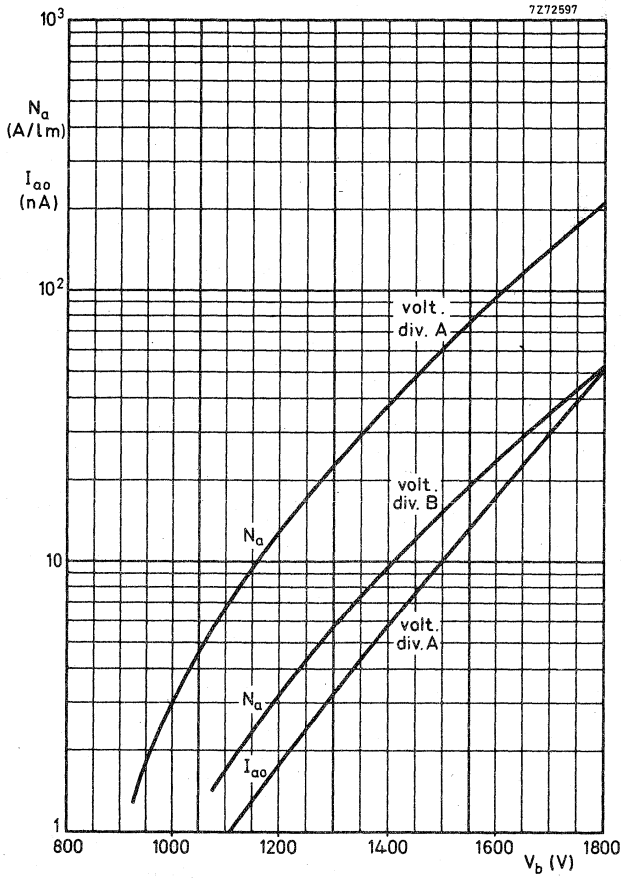


Fig. 5
Anode luminous sensitivity, N_a , and anode dark current, I_{a0} , as a function of supply voltage V_b .

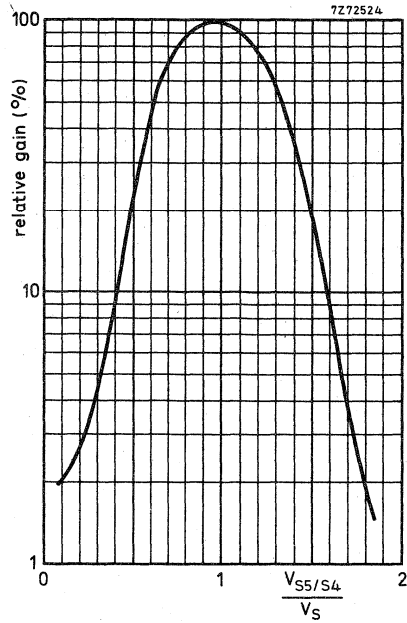


Fig. 6
Relative gain as a function of the voltage
between S_5 and S_4 , normalized to V_S
 $V_{S6/S4}$ constant.

Phototubes (diodes)



SURVEY OF TYPES

Photocathode dimensions (mm)	Tube type	Spectral response				
		A (S11)	C (S1)	S4	T (S20)	U (S13)
20 ϕ	XA 1002			X		
	XA 1003		X			
26 ϕ	150CV		X			
	150TV				X	
30 ϕ	150AV	X				
	150UV					X
40 ϕ	AVHC41			X		
	TVHC40				X	
108 ϕ	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 MnO₂ 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).

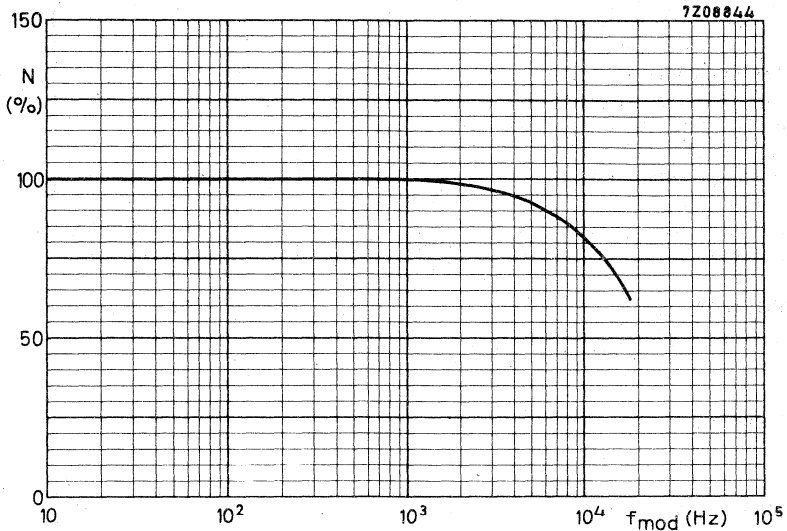
Possible causes of dark current are electrical leakage, thermionic emission, field emission, residual gas ionization, and glass fluorescence.

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 instantaneously 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 M Ω .

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 AVHC41 is a 40 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		40 mm
Spectral sensitivity of the photocathode at 437 nm		50 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-Cs
Useful diameter	>	40 mm
Spectral sensitivity characteristic Fig. 1		S4
Maximum spectral sensitivity at		400 ± 50 nm
Luminous sensitivity	1)	typ. 50 μA/lm > 20 μA/lm
Spectral sensitivity at 437 ± 5 nm	2)	≈ 50 mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5 \text{ kV}$	3)	typ.	1 nA
		<	5 nA
Saturation voltage		see note 4	
Rise time	5)	≈	0,4 ns
Anode current linear within 10% at $V_b = 2,5 \text{ kV}$ up to	6)	≈	6 A
		≈	5 A
Capacitance, anode to cathode		<	5 pF

LIMITING VALUES (Absolute max. rating system)

Anode voltage, d. c.		max.	5 kV
Total cathode current,	8)		
peak		max.	50 A
mean, averaging time 1 s		max.	10 μA
Ambient temperature		max.	60 °C ⁷⁾
		min.	-40 °C

REMARKS

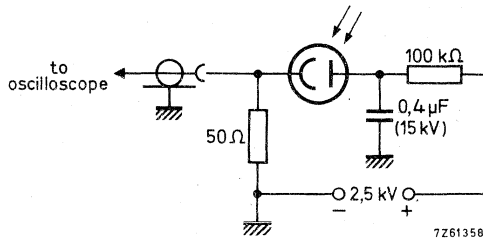
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value:

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type SC110

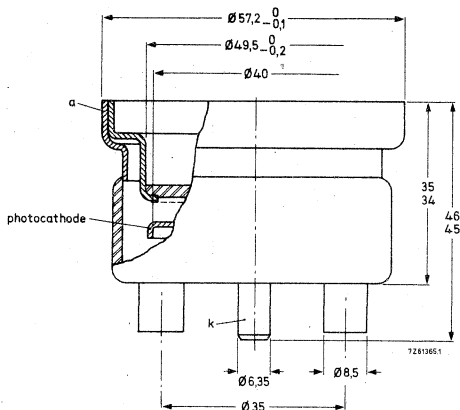
MEASURING CIRCUIT



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 $\approx 0,5$ 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 SC110.
- 6) The linearity is measured with a light pulse with:
 - pulse duration = $1 \mu\text{s}$
 - 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 50 A .
- 7) During not more than some hours.
- 8) Cathode completely illuminated.

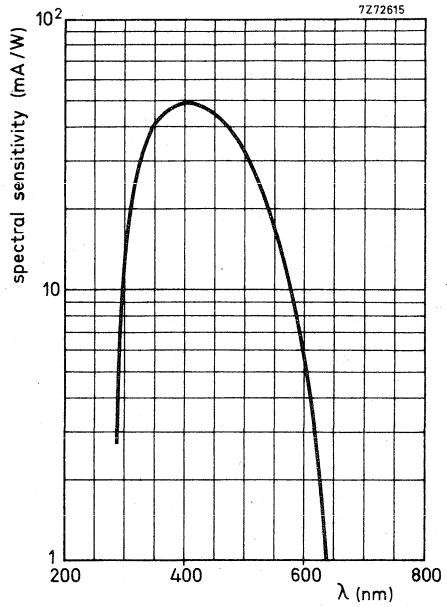


Fig. 1
Spectral sensitivity characteristic

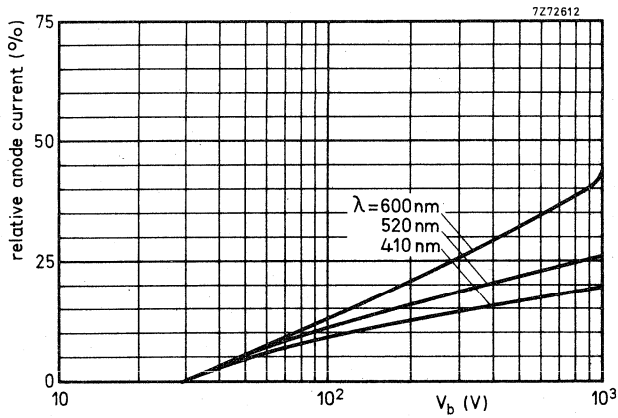


Fig. 2
Relative anode current as a function of anode voltage; wavelength as parameter.

PHOTOTUBE

The 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 $\mu\text{A}/\text{lm}$

>

20 $\mu\text{A}/\text{lm}$

Spectral sensitivity at 437 ± 5 nm

2)

\approx

40 mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5 \text{ kV}$	3)	typ.	1 nA
		<	10 nA
Saturation voltage			see note 4
Rise time	5)	\approx	1 ns
Anode current linear within 10% at $V_b = 2,5 \text{ kV}$ up to	6)	\approx	30 A
		\geq	20 A
Capacitance, anode to cathode	C_{ak}	<	25 pF

LIMITING VALUES (Absolute max. rating system)

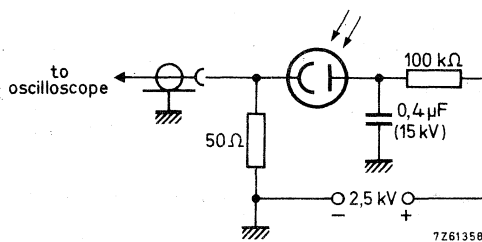
Anode voltage, d.c.		max.	5 kV
Total cathode current,	8)	max.	100 A
- peak		max.	10 μA
- mean, averaging time 1 s		max.	60 $^{\circ}\text{C}$ 7)
Ambient temperature		min.	-40 $^{\circ}\text{C}$

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.

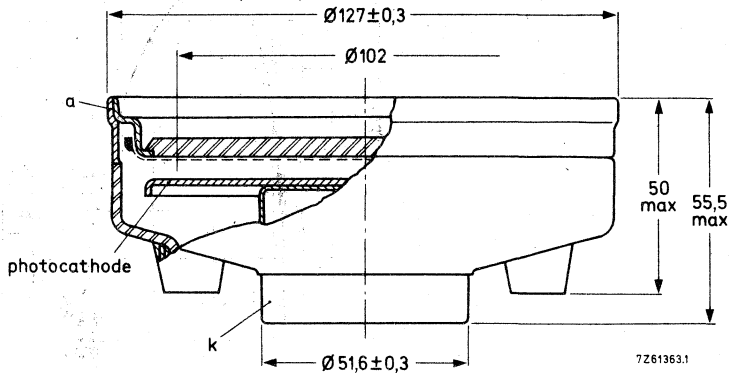
MEASURING CIRCUIT



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 $2856 \pm 5\text{-K}$.
- 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 $< 1\text{ ns}$, the cathode being completely illuminated.
- 6) The linearity is measured with a light pulse with:
 - pulse duration = 1 ps
 - 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.

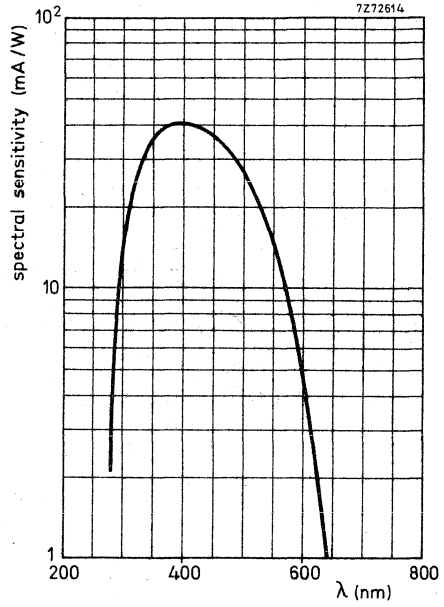


Fig. 1
Spectral sensitivity characteristic

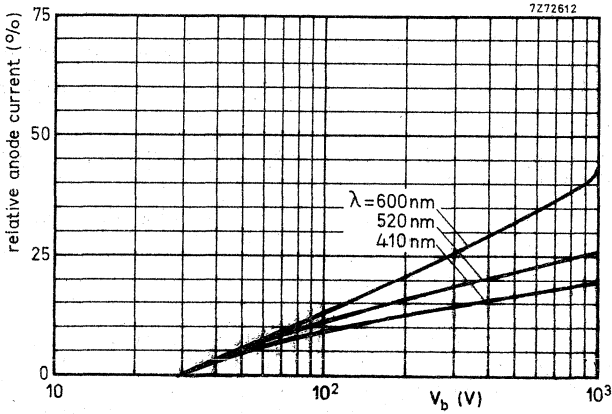


Fig. 2
Relative anode current as a function of anode voltage; wavelength as parameter.

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 $\mu\text{A}/\text{lm}$

Spectral sensitivity at 437 ± 5 nm
at 698 ± 7 nm

2) ≈ 70 mA/W

≈ 10 mA/W

≈ 5 mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5 \text{ kV}$	3)	typ. <	0,15 nA 5 nA
Saturation voltage	4)		100 V
Rise time	5)	≈	0,4 ns
Anode current linear within 10% at $V_b = 2,5 \text{ kV}$ 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

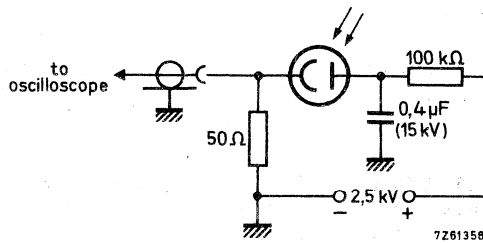
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type SC110

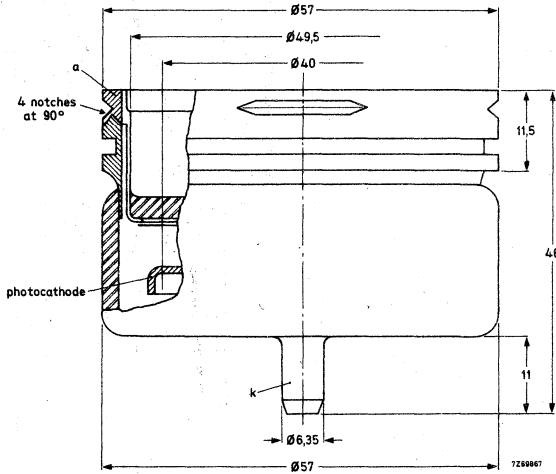
MEASURING CIRCUIT



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 μ s
 - 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.

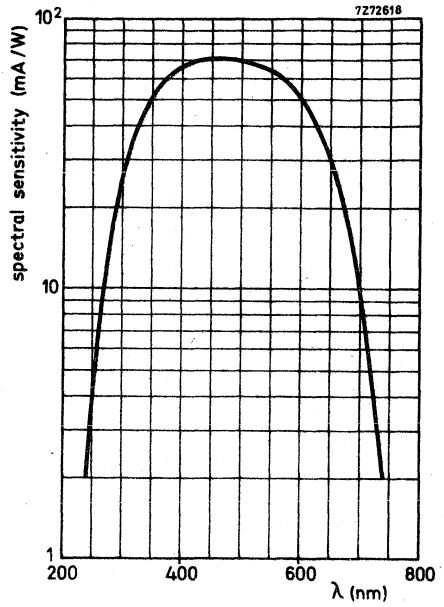


Fig. 1
Spectral sensitivity characteristic

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		$\approx 0,2$	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 $\mu\text{A}/\text{lm}$
		>	20 $\mu\text{A}/\text{lm}$
Spectral sensitivity at 437 ± 5 nm	2)	\approx	35 mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_b = 2,5 \text{ kV}$	3)	typ.	0,5 nA
		<	5 nA
Saturation voltage			see note 4
Rise time	5)	\approx	0,2 ns
Anode current linear within 5% at $V_b = 4 \text{ kV}$ up to	6) 7)	\approx	8 A
		\geq	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

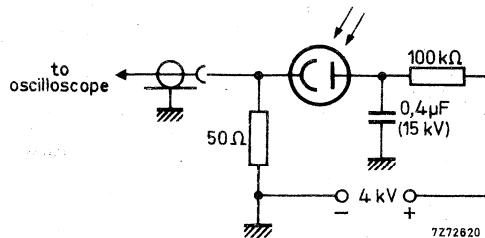
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type 56041

MEASURING CIRCUIT

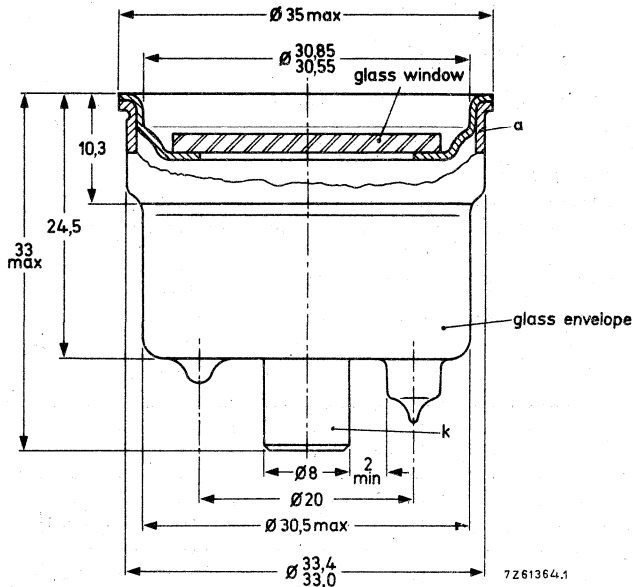


Notes see pages 3 and 4.

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 $2856 \pm 5 \text{ K}$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.
- 3) Dark current is measured at $25 \text{ }^\circ\text{C}$ after a stabilization period in darkness, with anode voltage applied, of $\approx 0,5 \text{ h}$.
- 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 $< 1 \text{ ns}$, 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 $1 \text{ } \mu\text{C}$. 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 :
- $V_a > 2 \text{ kV}$
 - $I = \text{peak current}$
 - $\Delta t = \text{pulse duration}$

- 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.

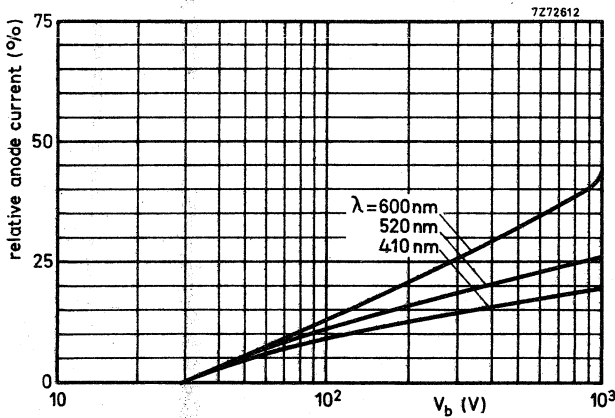


Fig. 1

Relative anode current as a function of anode voltage; wavelength as parameter.

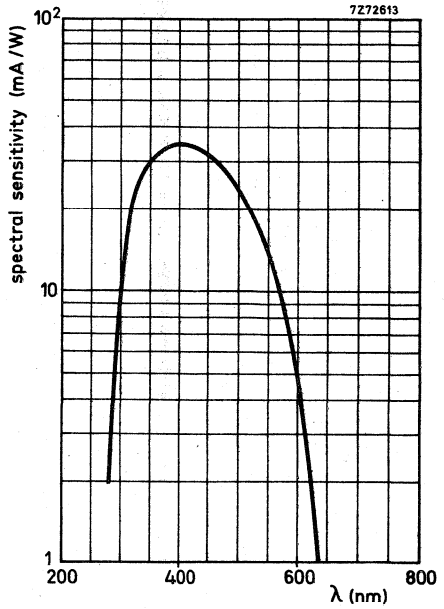


Fig. 2
Spectral sensitivity curve

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 μ A/lm
> 15 μ A/lm

Spectral sensitivity at 903 ± 8 nm
 1060 ± 10 nm

2)

\approx 1,4 mA/W
 \approx 0,12 mA/W

Notes see page 3.

Operating characteristics

Dark current at $V_D = 2,5 \text{ kV}$	3)	typ.	5 nA
		<	10 nA
Saturation voltage			see note 4
Rise time	5)	≈	0,2 ns
Anode current linear within 5% at $V_D = 2,5 \text{ kV}$ 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

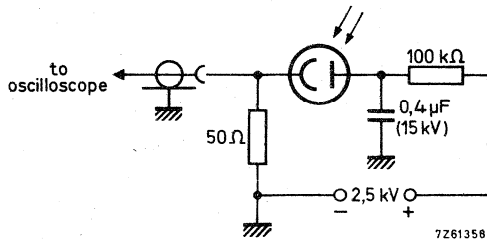
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

The cathode should not be exposed to direct sunlight.

ACCESSORIES

Socket : type 56041

MEASURING CIRCUIT

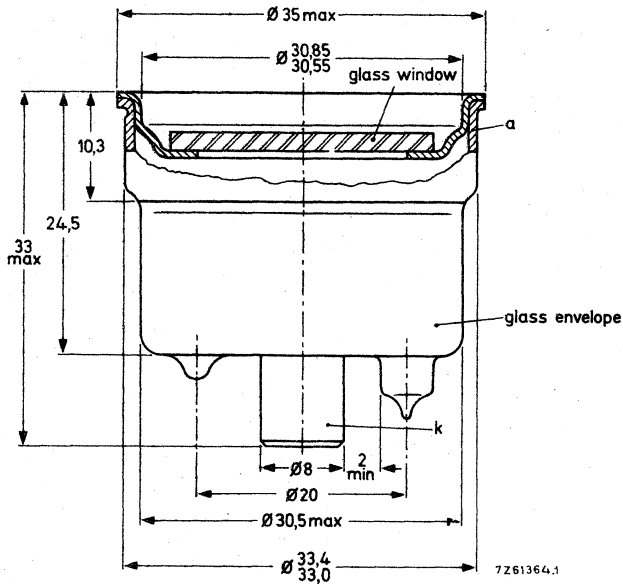


Notes see pages 3 and 4.

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 $\approx 0,5$ 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 μ C.

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 μ s
pulse energy = 35 J (2 Mlm)
pulse repetition frequency = 2 p. p. min

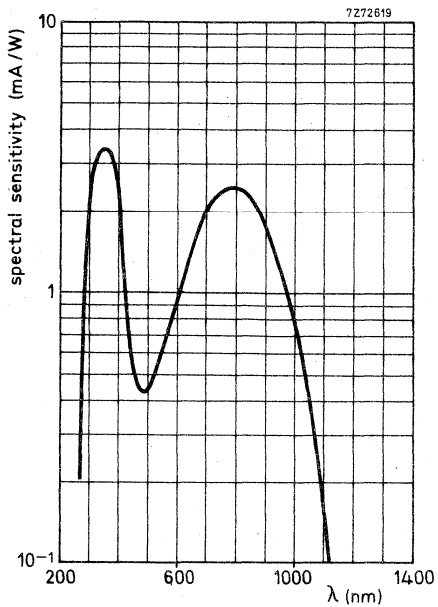
The linearity is observed on an X - Y oscilloscope by comparison with a standard phototube.

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

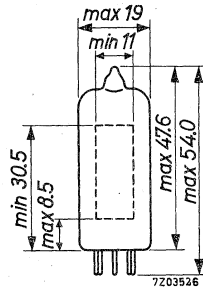
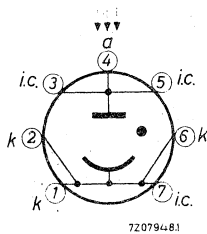
Gas filled phototube particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA			
Anode supply voltage	V_b	max.	90 V
Luminous sensitivity	N		125 $\mu\text{A}/\text{lumen}$
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

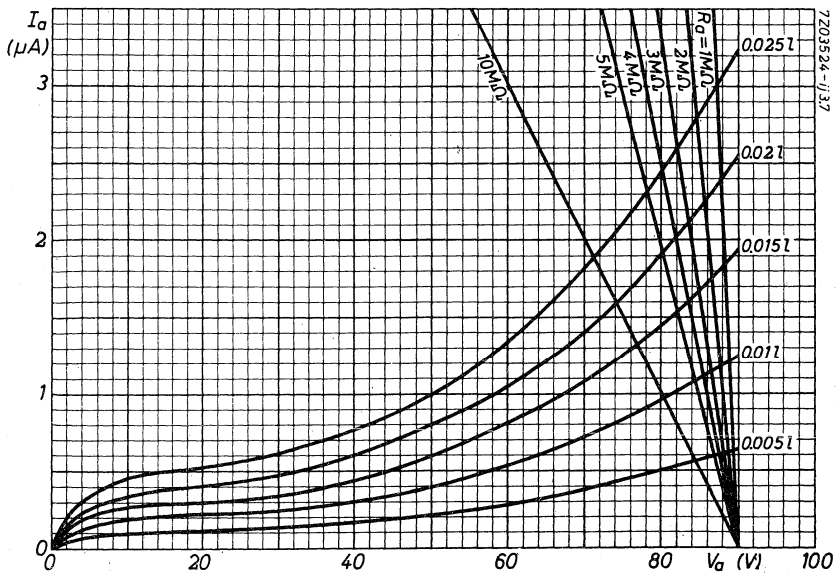
Anode supply voltage	V_b	90 V
Anode series resistor	R_a	1 M Ω
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N	125 μ A/lumen
Dark current	I_{dark} max.	0.1 μ A

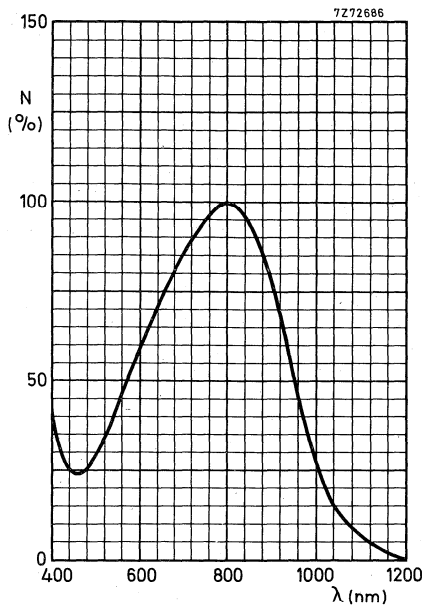
Capacitance

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 μ A
Ambient temperature	t_{amb}	max.	100 °C





Relative spectral response curve

VACUUM PHOTOTUBE

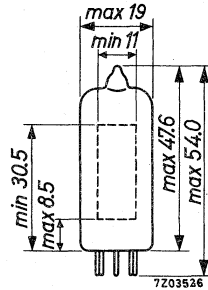
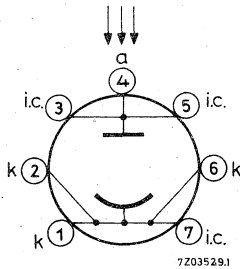
Vacuum phototube, particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA		
Anode supply voltage	V_b max.	250 V
Luminous sensitivity	N	20 $\mu\text{A}/\text{lumen}$
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

Cesium on oxidised silver

Projected sensitive area

3.0 cm^2

ELECTRICAL DATA

Operating characteristics

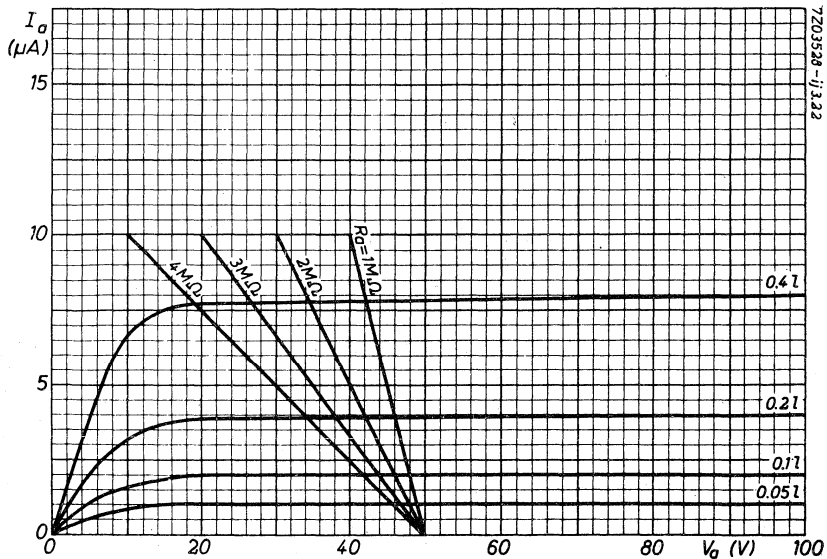
Anode supply voltage	V_b	50 V
Anode series resistor	R_a	1 M Ω
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N	20 μ A/lumen
Dark current (at $V_a = 100$ V)	I_{dark}	max. 0.05 μ A

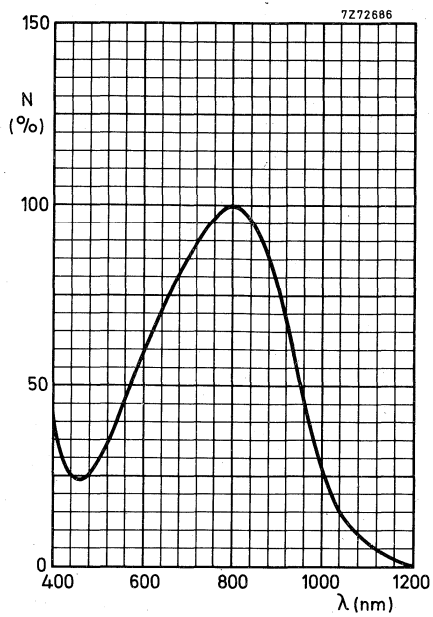
Capacitance

Anode to cathode	C_{ak}	0.8 pF
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LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max. 250 V
Cathode current	I_k	max. 10 μ A
Ambient temperature	t_{amb}	max. 100 °C





Relative spectral response curve



GAS FILLED PHOTOTUBE

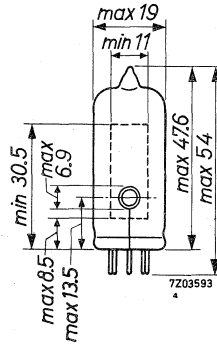
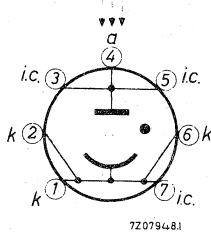
Gas-filled phototube particularly sensitive to daylight and to radiation having a blue predominance.

QUICK REFERENCE DATA			
Anode supply voltage	V_b	max.	90 V
Luminous sensitivity	N		130 $\mu\text{A/lumen}$
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

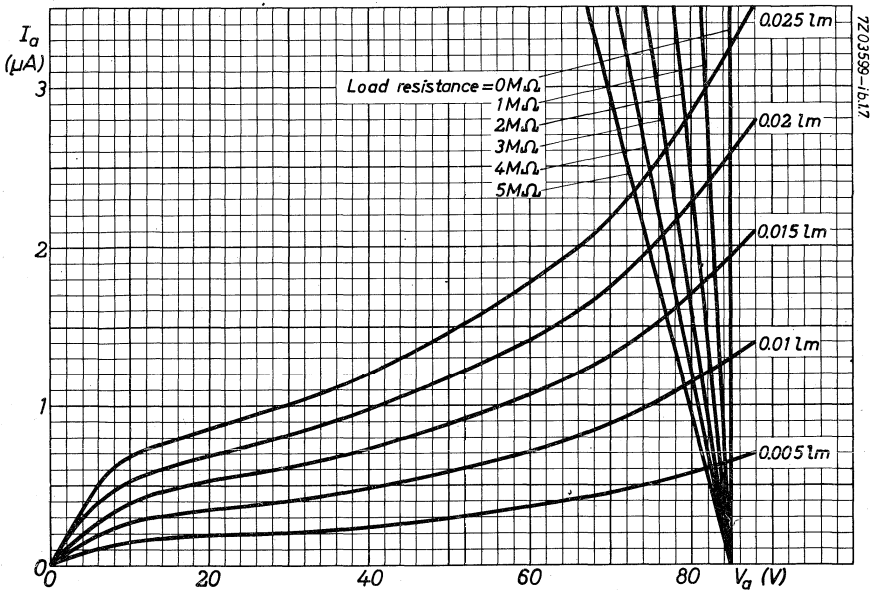
Anode supply voltage	V_b	85 V
Anode series resistor	R_a	1 M Ω
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N	130 μ A/lumen
Dark current	I_{dark}	max. 0.1 μ A

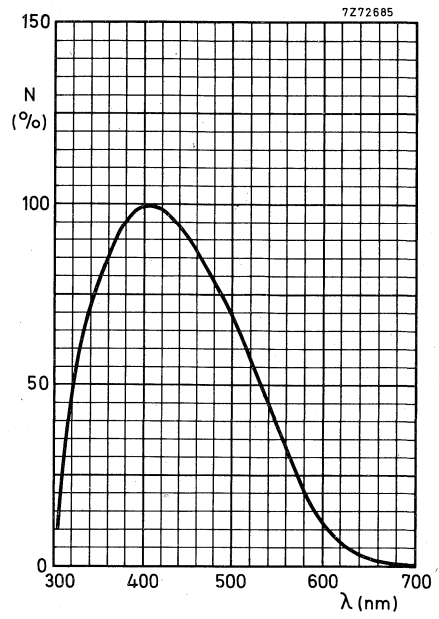
Capacitance

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 μ A/mm ²
Ambient temperature	t_{amb}	max. 70 °C





Relative spectral response curve



VACUUM PHOTOTUBE

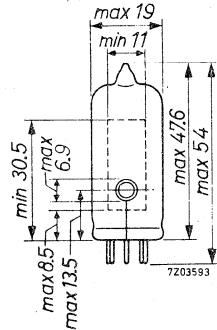
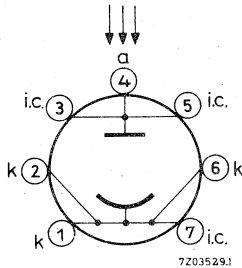
Vacuum phototube particularly sensitive to daylight and to light radiation with a blue predominance.

QUICK REFERENCE DATA			
Anode supply voltage	V_b	max.	100 V
Luminous sensitivity	N		45 $\mu A/lumen$
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

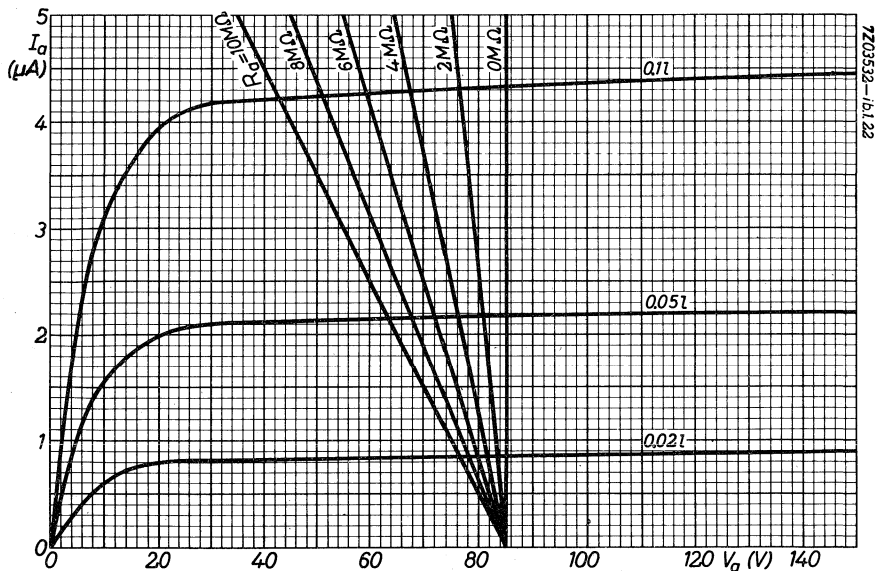
Anode supply voltage	V_b	85 V
Anode series resistor	R_a	1 M Ω
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N	45 μ A/lumen
Dark current	I_{dark}	max. 0.05 μ A

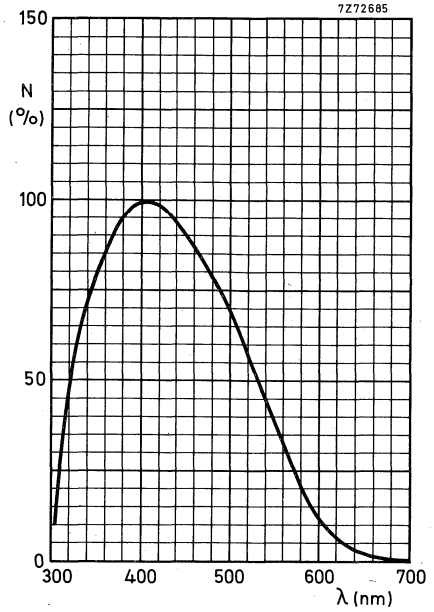
Capacitance

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 μ A/mm ²
Ambient temperature	t_{amb}	max. 70 °C





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	μ A
mean, averaging time 1 s		max.	500	nA
Ambient temperature		max.	60	$^{\circ}C$ 6)
		min.	-40	$^{\circ}C$

LIFE EXPECTANCY

With a cathode current of 2 μ A 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

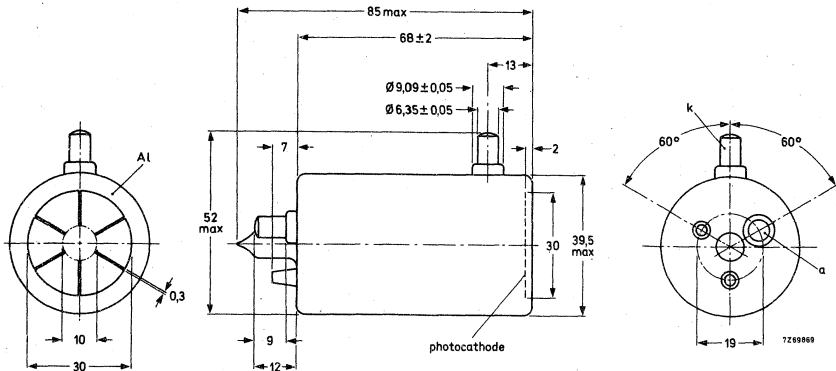
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

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 $2856 \pm K$.
- 2) Measuring equipment is calibrated by comparison with a Schwartz thermocouple.
- 3) Dark current is measured at $25^{\circ}C$ 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.

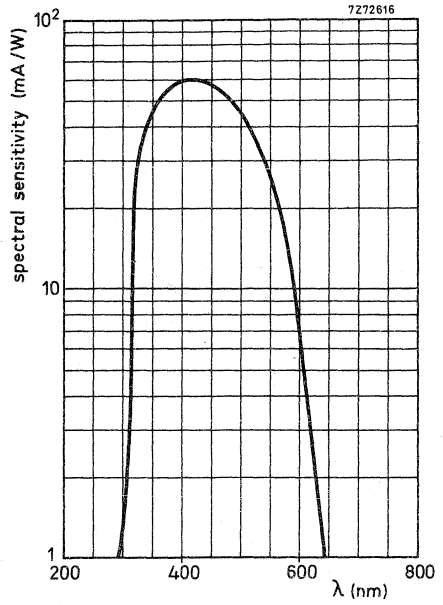


Fig. 3
Spectral sensitivity characteristic

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

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

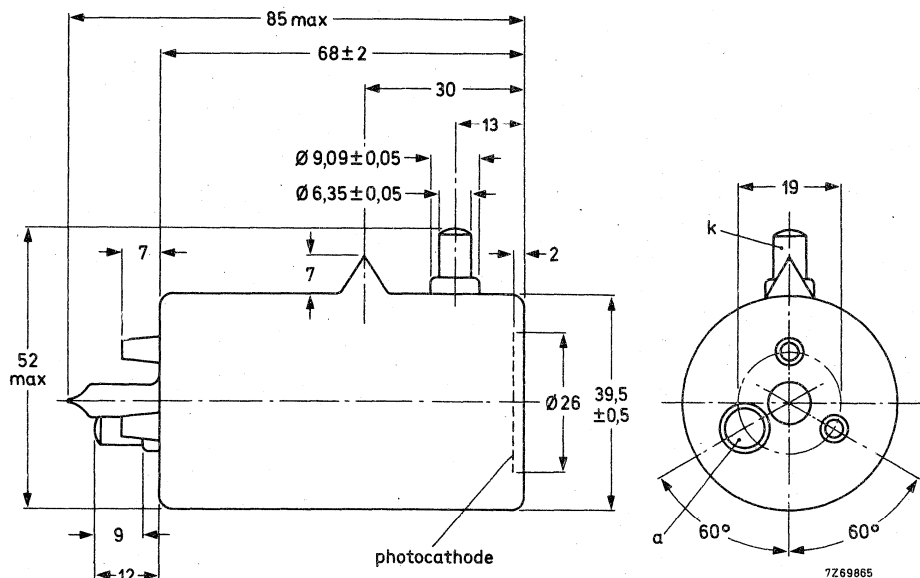
After an idle period of more than 8 days, the dark current needs some hours to return to its normal value.

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 $\approx 0,5$ 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.

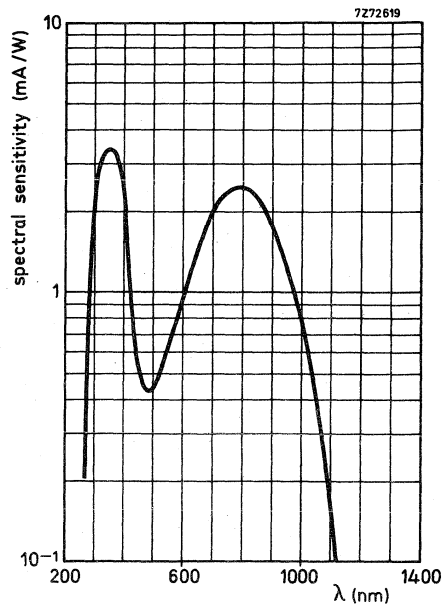


Fig. 1
Spectral sensitivity characteristic

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 $\mu\text{A}/\text{lm}$ > 100 $\mu\text{A}/\text{lm}$
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 1×10^{-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.

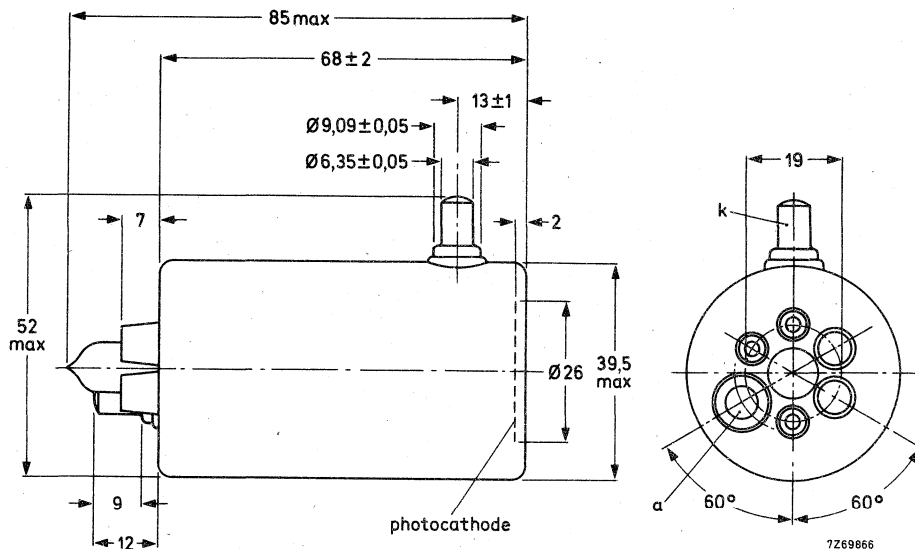
REMARKS

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 $\approx 0,5$ 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.

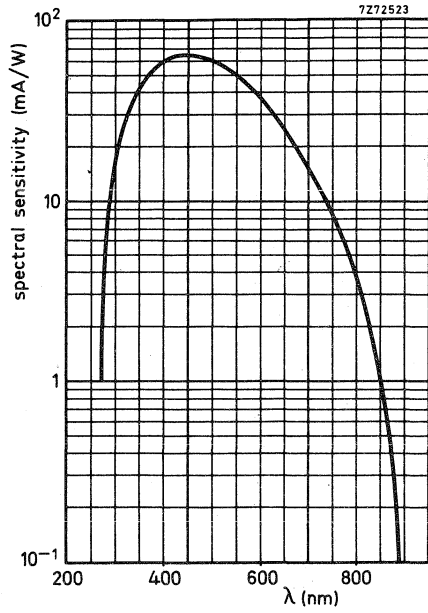


Fig. 1

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.

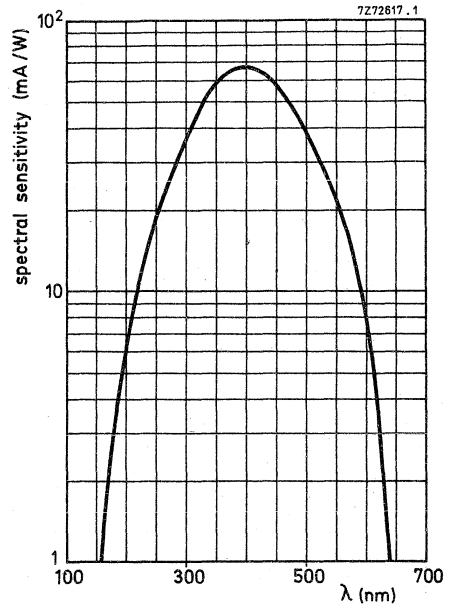


Fig. 1
Spectral sensitivity curve.

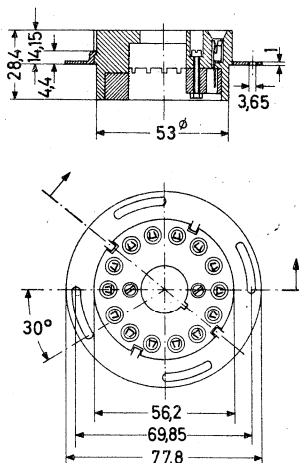
Associated accessories



DIHEPTAL SOCKET

H.F. moulding with 14 silver-plated phosphor bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle.

DIMENSIONS in mm

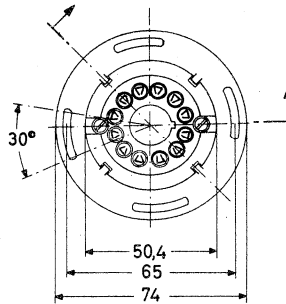
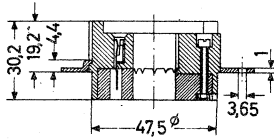


Maximum working voltage			
between two adjacent contacts		2600	V
Maximum working voltage			
between any contact and saddle		4500	V
Insulation resistance between two adjacent contacts (at V < 400 V)		$> 10^6$	M Ω
Insulation resistance between any contact and all other metal parts		$> 5 \times 10^4$	M Ω
Contact resistance		< 50	m Ω
Temperature	max.	60	$^{\circ}$ C
Insertion force	max.	112	N
Withdrawal force	min.	31	N
Weight		100	g

DUODECAL SOCKET

H.F. moulding with 12 silver-plated phosphor bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle.

DIMENSIONS in mm

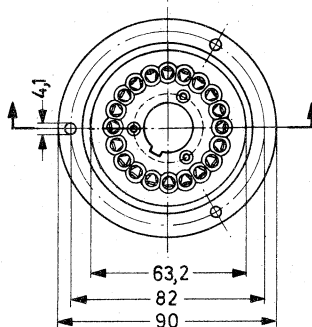
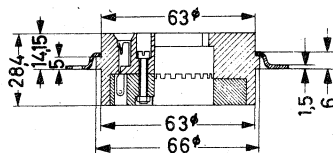


Maximum working voltage			
between two adjacent contacts		1800	V
Maximum working voltage			
between any contact and saddle		2800	V
Insulation resistance between two			
adjacent contacts (at $V < 400$ V)		$> 10^6$	$M\Omega$
Insulation resistance between			
any contact and saddle		$> 5 \times 10^3$	$M\Omega$
Contact resistance		< 50	$m\Omega$
Temperature	max.	80	$^{\circ}C$
Insertion force	max.	89,5	N
Withdrawal force	min.	7,5	N
Weight		95	g

BIDECAL SOCKET

H. F. moulding with 20 silver-plated phosphor bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle.

DIMENSIONS in mm

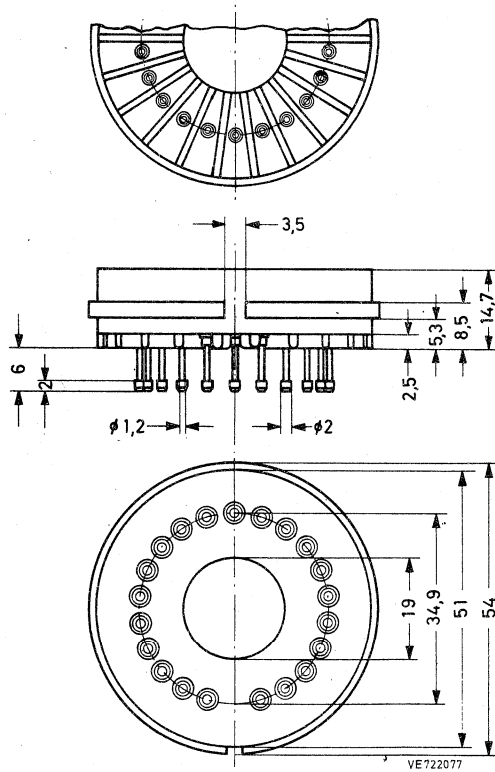


Maximum working voltage between two adjacent contacts	1850	V
Maximum working voltage between any contact and saddle	3200	V
Insulation resistance between two adjacent contacts	$> 10^8$	M Ω
Contact resistance	< 50	m Ω
Capacitance between two adjacent contacts	< 2	pF
Temperature	max. 80	$^{\circ}\text{C}$
Weight	170	g

SOCKET

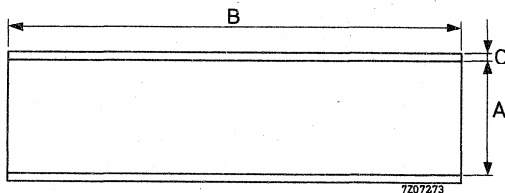
Teflon* moulding with 21 gold-plated contacts.

DIMENSIONS in mm



* Registered Trade Mark

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



INDEX OF TYPE NUMBERS

type number	section	type number	section
AVHC41	Pt	XP2230B	Pm T
AVHC201	Pt	56AVP	Pm T
FE1001	Acc	56CVP	Pm T
FE1002	Acc	56DUVP	Pm T
FE1003	Acc	56DVP	Pm T
FE1004	Acc	56TUVp	Pm T
FE2003	Acc	56TVp	Pm T
TVHC40	Pt	60DVP	Pm T
XA1002	Pt	60 DVP /H	Pm T
XA1003	Pt	90CG	Pt
XP1002	Pm T	90CV	Pt
XP1003	Pm T	92AG	Pt
XP1004	Pm T	92AV	Pt
XP1010	Pm T	150AV	Pt
XP1011	Pm T	150AVP	Pm T
XP1016	Pm T	150CV	Pt
XP1017	Pm T	150CVP	Pm T
XP1110	Pm T	150TV	Pt
XP1113	Pm T	150UV	Pt
XP1116	Pm T	150UVP	Pm T
XP1117	Pm T	56127 ... 56138	Acc
XP1118	Pm T		
XP2000	Pm T		
XP2020	Pm T		
XP2030	Pm T		
XP2040	Pm T		
XP2040Q	Pm T		
XP2041	Pm T		
XP2041Q	Pm T		
XP2230	Pm T		

Acc = Accessories

Pm T = Photomultiplier tubes

Pt = Phototubes

DEVELOPMENT, MAINTENANCE, AND OBSOLETE-TYPE LIST

Type	Status	Replacement type
XP1000	O	XP2000
XP1001	O	XP2000
XP1005	O	
XP1006	O	XP2000
XP1015	O	XP1011
XP1020	O	XP2020
XP1021	O	XP2020
XP1023	O	56DUVP
XP1030	O	XP2030
XP1031	O	XP2030
XP1032	O	
XP1034	O	XP2030
XP1040	O	XP2040
XP1041	O	XP2041
XP1114	O	
XP1115	O	XP1110
XP1119	O	XP1110
XP1143	O	
XP1180	M	
XP1210	O	XP2020
XP1220	O	
XP1230	D	
XP2050	D	
50AVP	O	150AVP
51AVP	O	150AVP

Type	Status	Replacement type
51UVP	O	150UVP
52AVP	O	
53AVP	O	XP2000
53DVP	O	XP2000
53UVP	O	XP1004
54AVP	O	
54DVP	O	XP2050
54UVP	O	
56SBUVP	O	
56UVP	O	56DUVP
57AVP	O	60DVP
58AVP	O	XP2040
58DVP	O	XP2041
58UVP	O	XP2041
60AVP	O	60DVP
150DVP	O	
152AVP	O	XP1110
153AVP	O	XP2000
PM2007	O	XP1017
PM2054	O	XP2050
PM2203	O	XP2230
XP2008	D	
XP2010	D	

Status

D = Development type.

M = Maintenance type. Available for equipment maintenance. No longer recommended for equipment production.

O = Obsolete type. No longer available.

Loose-leaf data on development types available on request.


Data on maintenance and obsolete types are not given in this book.



Photomultiplier tubes



Phototubes



Associated accessories



Index

Argentina: FAPESA I.y.C., Av. Crovara 2550, Tel. 652-7438/7478, BUENOS AIRES.
Australia: Philips Industries Ltd., Elcoma Division, 67 Mars Road, Tel. 42 1261, LANE COVE, 2066, N.S.W.
Austria: Österreichische Philips, Bauelemente Industrie G.m.b.H., Zieglergasse 6, Tel. 93 26 11, A-1072 WIEN.
Belgium: M.B.L.E., 80, rue des Deux Gares, Tel. 523 00 00, B-1070 BRUXELLES.
Brazil: IBRAPE S.A., Caixa Postal 7383, Av. Paulista 2073-S/Loja, Tel. 287-7144, 01311 SAO PAULO, SP.
Canada: Philips Electron Devices, 116 Vanderhoof Ave., Tel. 425-5161, TORONTO 17, Ontario.
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